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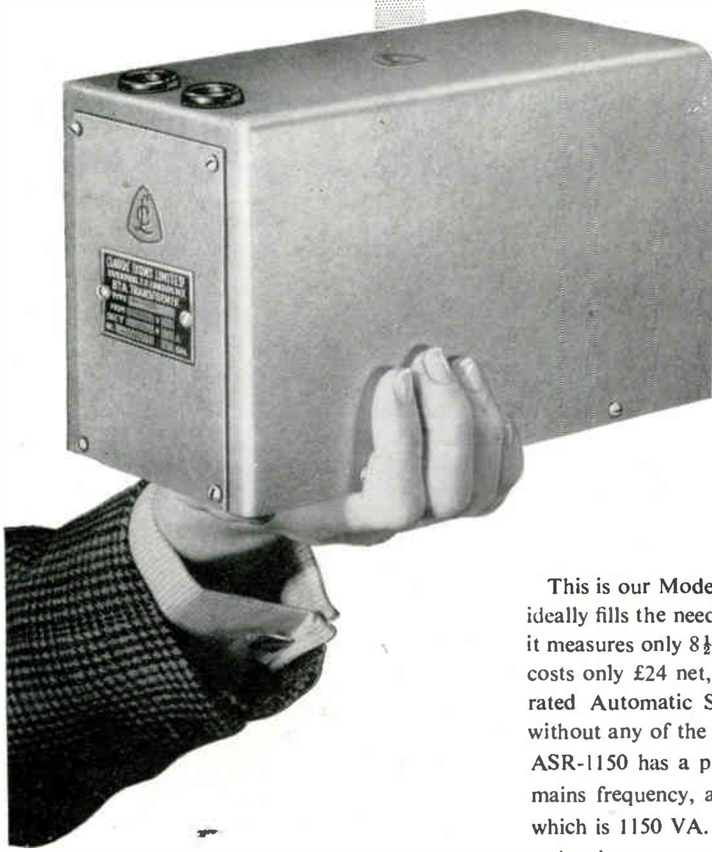

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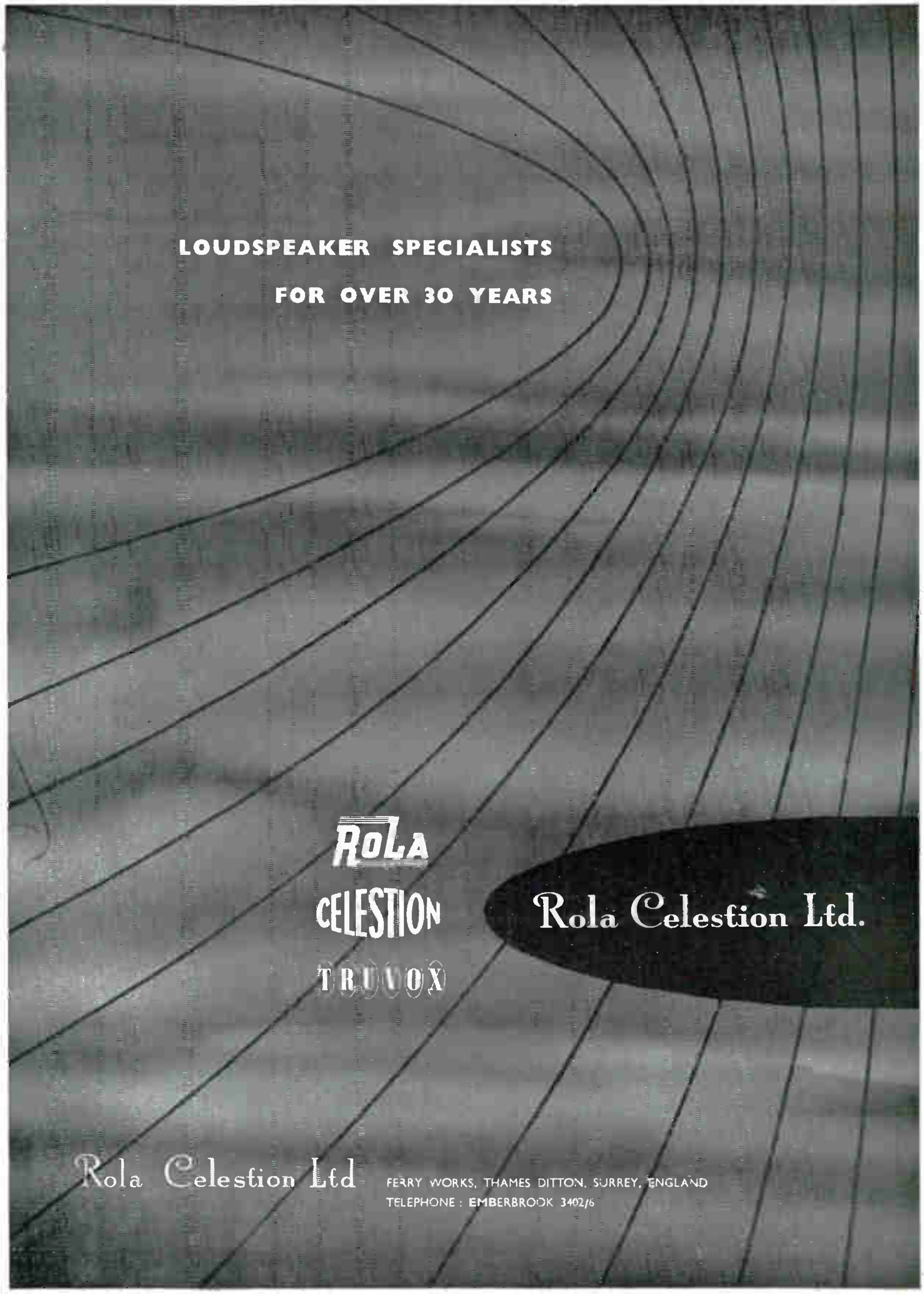
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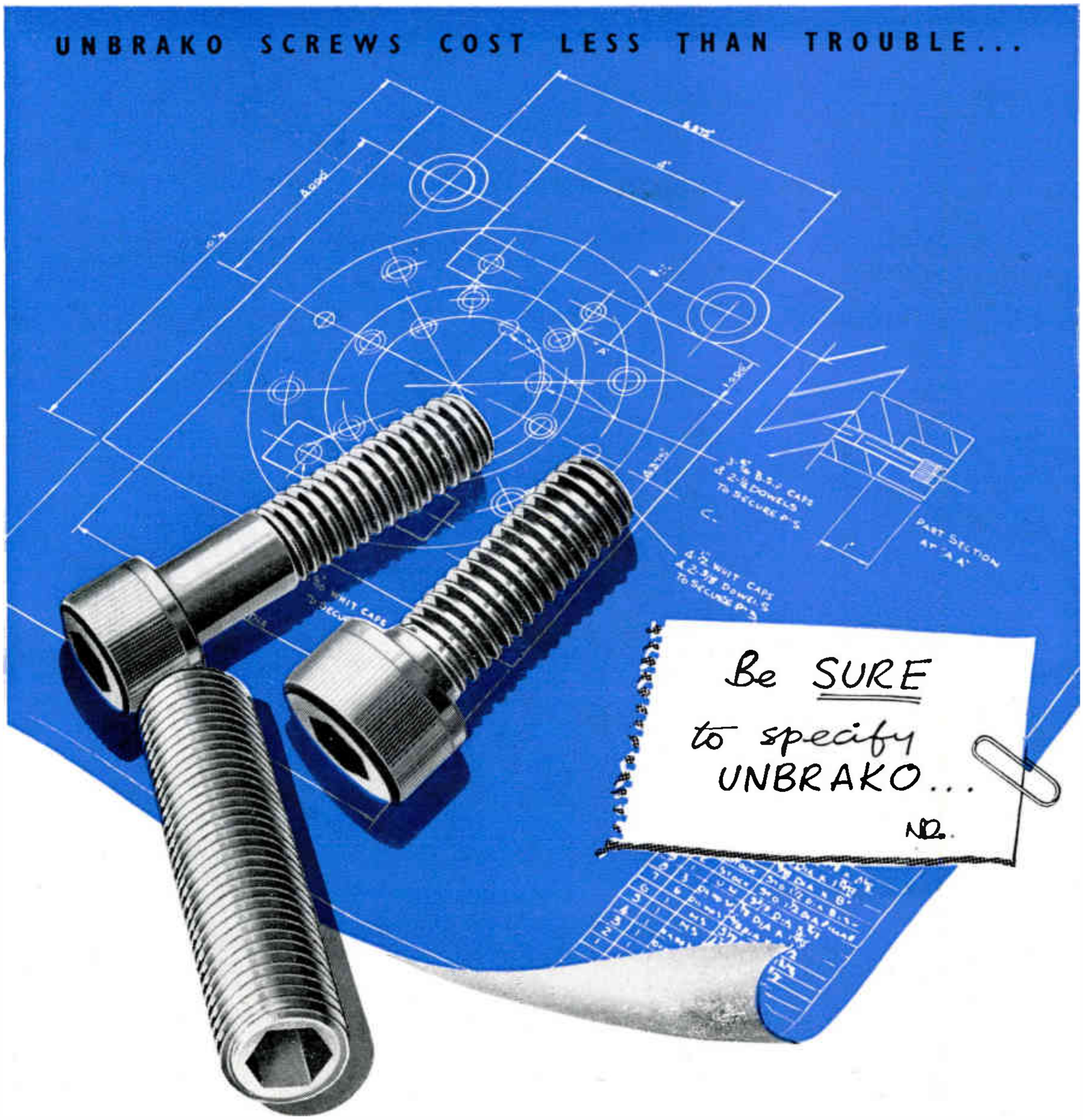

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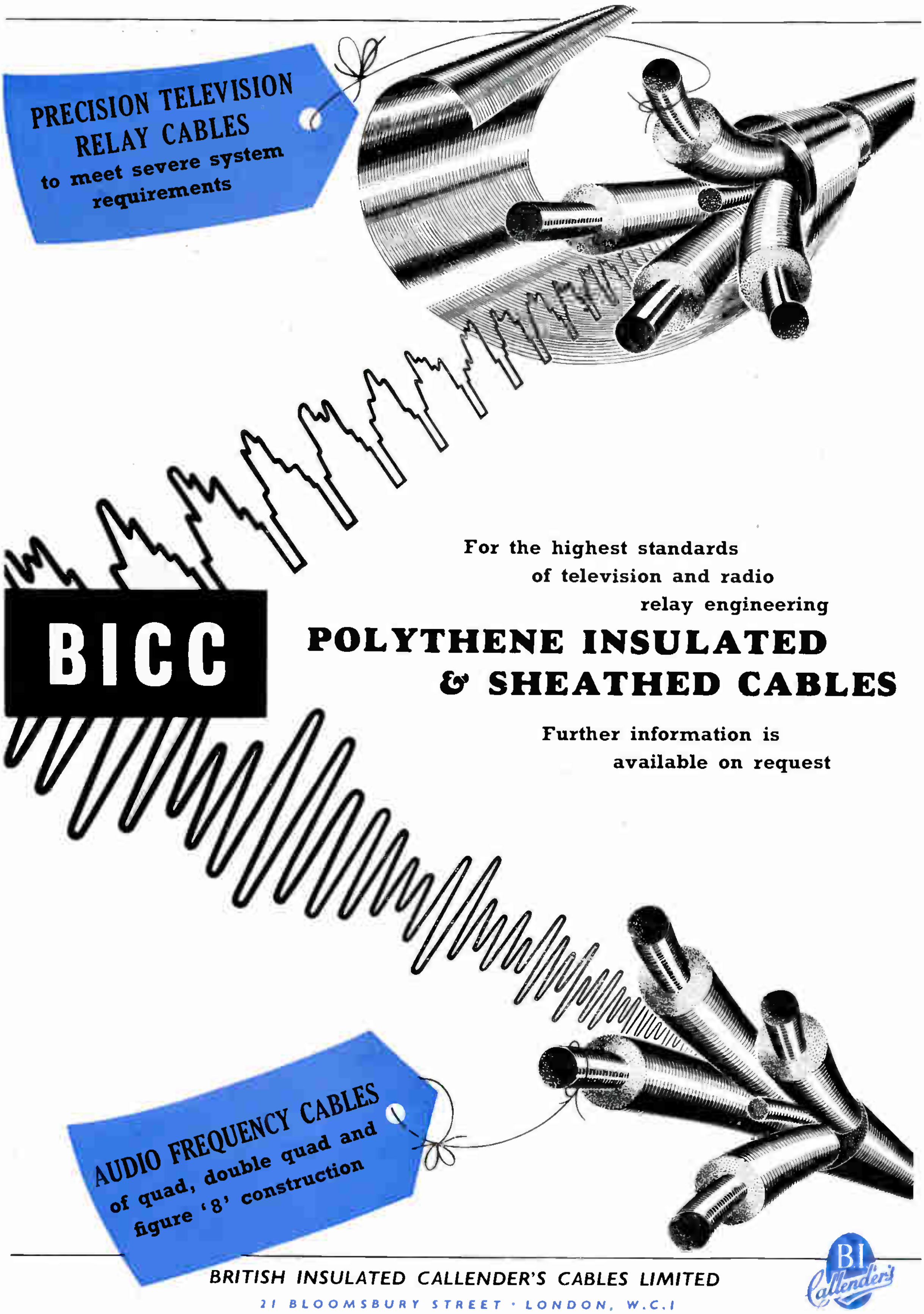
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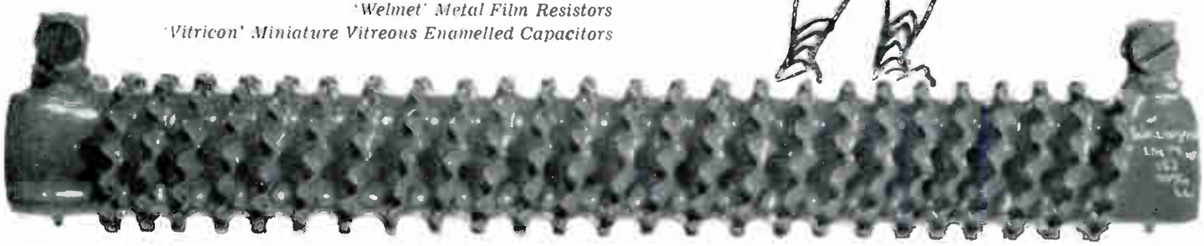

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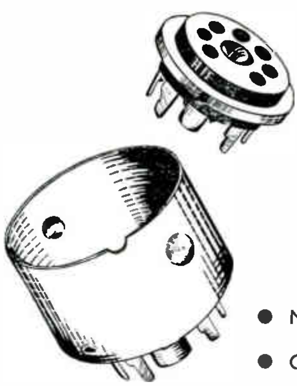

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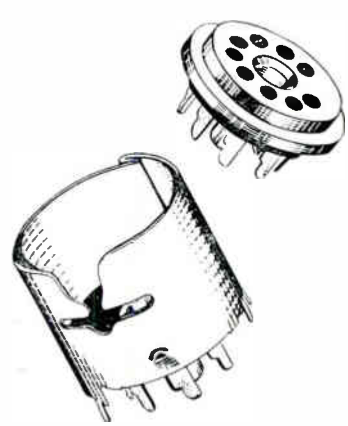

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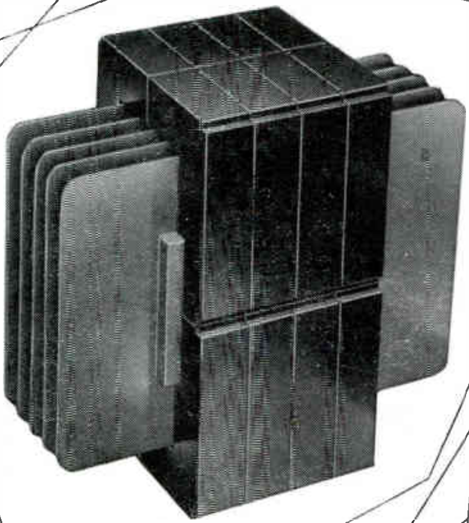

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The Electrostatic Loudspeaker Again

ELSEWHERE in this issue, we publish a letter referring to our May 1955 Editorial on the electrostatic loudspeaker. We there considered, among other things, the case of a conductive diaphragm, which is fed from a source of polarizing voltage through a resistance of such a high value that the total charge on the diaphragm cannot change during any signal excursion. We did not investigate this under signal conditions but calculated the static force on the diaphragm under constant-charge conditions as

$$F = \frac{2\kappa_0 A V^2}{d^2} \cdot \frac{x}{d}$$

Although we did not actually say so, we must admit that we rather implied that this force, due only to the position of the diaphragm, would be a distorting force under signal conditions. Since then, we have analysed the signal conditions and we agree with Mr. Nuttall that it is of the nature of a negative stiffness, and does not produce any non-linearity of response.

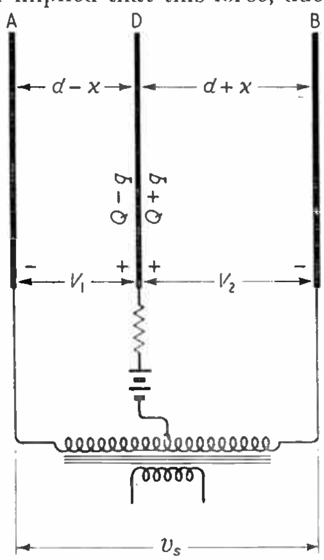

Fig. 1.

Referring to Fig. 1, a diaphragm D of negligible thickness carries a total charge of $2Q$ and is between two plates a distance $2d$ apart to which the signal voltage v_s is applied. When the diaphragm is displaced from the mid-point between A and B by the distance x there is separation of charge in the diaphragm so that one face bears $Q + q$ and the other $Q - q$.

We assume that the diaphragm is positively charged. Potentials V_1 and V_2 must exist between it and the plates A and B and must be commensurate with the charges and the separations of the plates.

We can, consequently, write

$$Q + q = \frac{\kappa_0 A V_1}{d - x}; \quad Q - q = \frac{\kappa_0 A V_2}{d + x} \qquad \ldots \qquad (1)$$

where A is the area of the plates and κ_0 is the permittivity of free space, assuming the relative permittivity of air to be unity.

Around the closed loop formed by the signal source v_s and the plates forming the loudspeaker we have

$$0 = v_s + V_2 - V_1 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

From these three equations we can eliminate q and compute V_1 and V_2 in terms of x and v_s as the only variables.

Now between D and A there is a force F_1, tending to move D to the left, and between D and B a force F_2, tending to move D to the right. The resultant is

$$F = F_1 - F_2 = \frac{\kappa_0 A V_1^2}{2(d-x)^2} - \frac{\kappa_0 A V_2^2}{2(d+x)^2}$$
$$= \frac{2Q^2}{\kappa_0 A} \cdot \frac{x}{d} + \frac{Q v_s}{d} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

on substituting the values of V_1 and V_2 derived from (1) and (2).

Let us now assume that the properties of the diaphragm with its air loading can be represented by the equation of motion

$$F = (p^2m + p\rho + S)x \quad \ldots \quad \ldots \quad (4)$$

where $p = d/dt$, m = mass, ρ = total 'resistance', S = stiffness. This equation may seem unfamiliar, but that is due to the p-notation; it should be remembered that $px = dx/dt$ is the velocity of the diaphragm.

If we now combine (3) and (4) to eliminate force we get

$$v_s = \frac{d}{Q}\left[p^2m + p\rho + S - 2Q^2/\kappa_0Ad\right]x \quad (5)$$

This shows clearly that the term $2Q^2x/\kappa_0Ad$ of (3) is of the nature of a negative stiffness. It represents the force due to the charge on the diaphragm and is opposed by the stiffness of the mounting of the diaphragm.

It is of interest to determine the signal current i which flows as a result of applying v_s. When the diaphragm moves, a charge q is displaced from one side to the other. When, as in Fig. 1, the charge is $-q$ on the left of D and $+q$ on the right, there must also be charges $+q$ on A and $-q$ on B. The movement of charge from one face of D to the other as D moves, thus produces an equal movement of charge between A and B through the signal source and the rate of change of this charge constitutes the signal current. From (1), (2) and (3)

$$q = \frac{Qx}{d} + \frac{\kappa_0A}{2d}v_s$$

and

$$i = \frac{dq}{dt} = pq$$

$$= \frac{Q}{d}px + \frac{\kappa_0A}{2d}pv_s$$

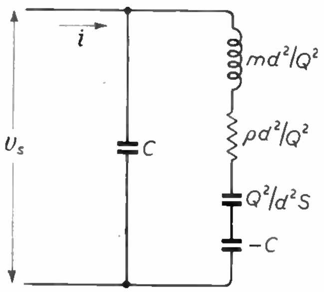

Fig. 2.

It is convenient to let $\kappa_0A/2d = C$. Physically, it is the direct capacitance between A and B. We then have, substituting for v_s

$$i = \frac{Q}{d}\cdot px\left[1 + C\frac{d^2}{Q^2}\left\{p^2m + p\rho + S - Q^2/Cd^2\right\}\right] \quad \ldots \quad \ldots \quad (6)$$

and the admittance is

$$Y = \frac{i}{v_s} = pC + \frac{1}{\dfrac{d^2}{Q^2}\left(pm + \rho + S/p\right) - 1/pC} \quad (7)$$

This equation is at once recognizable as one which can represent a capacitance C in shunt with a series resonant circuit and so an equivalent circuit for the loudspeaker is of the form shown in Fig. 2. The mechanical constants of the diaphragm are represented by inductance md^2/Q^2, resistance $\rho d^2/Q^2$ and capacitance Q^2/d^2S, while the electrical constants are represented by the shunt capacitance C between the fixed plates of the loudspeaker and a negative capacitance of the same value in series with the diaphragm elements.

In deriving these equations, no assumptions about the waveforms of voltage, current or displacement have been made. In all cases, the steady-state sinusoidal response is obtainable merely by writing $p = j\omega$ in the equations.

Under the conditions considered, the electrostatic speaker is perfectly linear and can be represented by quite a simple equivalent circuit.

It is of interest to notice that, since the electrical equivalents of mass and stiffness depend on d^2/Q^2, their values effective in the equivalent circuit can be altered by changing Q, which is simply done in practice by varying the polarizing voltage. This does not change the frequency of series resonance of the diaphragm itself for the 'LC' product $(= md^2/Q^2 \times Q^2/d^2S = m/S)$ is independent of d^2/Q^2. However, it does alter the series resonance frequency of the whole circuit, for the negative capacitance is independent of Q. This frequency depends on

$$\frac{m/S}{1 - Q^2/d^2SC}$$

However, the parallel resonance of the circuit as a whole is unaffected, for the positive and negative capacitances are in series around the circuit and cancel out. The main effect of varying the polarizing voltage is thus on the 'L/C' ratio of the resonant branch of the equivalent circuit and so on the total impedance of the loudspeaker.

In its practical forms, the diaphragm of the electrostatic loudspeaker is now made of an insulator, not a conductor. Since no insulator is perfect, it can acquire charge if given sufficient time and so, in the static condition, its surfaces will carry similar charges to a conducting diaphragm.

We may regard this diaphragm as being equivalent to one of a perfect insulator of relative permittivity κ_r and thickness t carrying conductive surfaces D and F, as in Fig. 3. Some straightforward, but tedious, calculation shows that under static conditions the

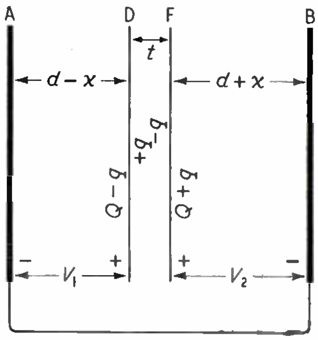

Fig. 3.

force is

$$F = \frac{2Q^2}{\kappa_0 A} \cdot \frac{x}{d} \cdot \frac{1}{1 + t/\kappa_r d}$$

If the equation quoted at the beginning for the static force on a conducting diaphragm is re-written in terms of Q, it will be found to equal the first terms of this equation. The law of variation of F with x is, therefore, unchanged but the magnitude of the force is altered. It is reduced with the insulating diaphragm.

We have not considered this case any further. It would not be difficult to work out the signal conditions on the same lines as we have done for the conducting diaphragm. It does involve some rather laborious algebra, however, and it may not be worth while to do it, for we feel some doubt about whether it does truly represent the insulating diaphragm in practice.

As we showed in the May 1955 Editorial, the internal time constant is adequate to keep the dynamic conditions close to those of a perfect insulator, but this does pre-suppose that the charge distribution over the surface of an insulator can be regarded as the same thing as the same charge in a conducting surface. For it to be the same, we must suppose that within a thin, almost surface, layer of the material, it is possible to have an almost instantaneous movement of charge to simulate the redistribution of charge in a conducting surface.

It is, of course, open to anyone to suppose that in practice there is always a sufficient layer of moisture over the surface to make the diaphragm really an insulator with conducting surfaces. This will certainly happen on occasion, but we doubt if it is always the explanation of what goes on.

W.T.C.

PARABOLIC CYLINDER AERIALS

By K. Foster, M.A.

(A. C. Cossor, Ltd., London)

SUMMARY.—For centimetric aerials with large beam-width ratios (greater than about 8:1) it is impracticable to use a paraboloidal reflector with a single horn feed. A reflector in the form of a parabolic cylinder has been suggested for this purpose and its focusing properties and performance have been discussed in the literature. In this paper, consideration is given to the details of the broad radiation pattern of the parabolic-cylinder type of aerial. An approximate theory is developed which yields the beam-widths and general shapes of these patterns and design criteria are established. Comparison with published figures show that the theory is accurate enough for practical design purposes.

Introduction

It is often required that a radar aerial shall have a large ratio of beam-widths (greater than about 8:1) in two orthogonal planes, which are usually vertical and horizontal. An example of this occurs, for instance, in the case of shipborne radars where the rolling of the ship produces difficulties if the vertical beam-width of the aerial is small. Consequently, unless the designer resorts to mechanical stabilization, the vertical beam-width of a shipborne aerial must be made large enough to nullify the effects of rolling. Since many such radars are used to detect the presence of surface obstacles, the resultant loss of discrimination in the vertical plane can often be accepted. Thus the vertical beam-width may be of the order of 20° whereas the horizontal beam-width (which must be small to maintain the required azimuthal discrimination) may be of the order of 1° to 2°. The aerial designer, therefore, is led to beam-width ratios of between 10:1 and 20:1. These large ratios create serious difficulties if a normal paraboloidal reflector with a single feed-horn is envisaged. As an example of these difficulties the case can be considered for which a vertical-to-horizontal beam-width ratio of 16:1 is required. For a paraboloidal reflector, the ratio of beam-widths obtained is roughly given by the inverse ratio of the respective reflector aperture dimensions and, hence, in the example quoted the ratio of horizontal-to-vertical aperture dimensions must be about 16:1. Furthermore, it is not advisable, for reasons of good aerial gain and sidelobe performance, to make the focal length of the reflector less than one quarter of the broad dimension of the reflector (and, in fact, it is better to have a greater focal length than this). This means that the ratio of focal length to vertical aperture must be at least 4:1 in the case above and, since the horn feed at the focus concentrates the radiated power into the reflector, it can be shown that the vertical beam-width required from the horn is of the order of 14°, a value which, if not impossible, is usually impracticable.

Various types of aerials have been proposed for this purpose[1] one of the best using a reflector in the form of a parabolic cylinder fed by a single feed horn. The performance of this type of aerial has been discussed in the literature[2,3] and the focusing properties of the parabolic cylinder have

MS accepted by the Editor, March 1955

been considered. However, no attention appears to have been given to the form of the vertical (broad) pattern and it is the purpose of this paper to derive the necessary information from which the length of the cylinder (that is to say, the vertical aperture of the reflector) can be obtained. The formation of the horizontal (narrow) pattern, the choice of horizontal aperture and focal length are governed by much the same criteria as those found for paraboloidal reflectors.

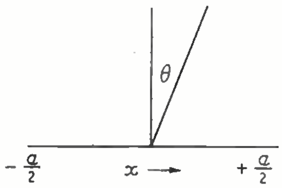

Fig. 1. *Co-ordinate system of line source of length 'a'.*

The method of analysis assumes that the aperture phase distribution for a parabolic-cylinder reflector follows a square law in the vertical direction and is constant in the horizontal direction[3]. (The use of the words vertical and horizontal here is convenient as, in practice, the parabolic cylinder usually has its generators near vertical and intercepts of the cylinder with horizontal planes are parabolic curves.) Consequently the main details of the vertical-radiation pattern of this type of reflector can be derived by consideration of the radiation pattern of a line source with a square-law phase distribution. The general form of the expression used to determine this radiation pattern [designated here by $g(\theta)$] is

$$g(\theta) = \int_{-a/2}^{+a/2} F(x) \exp.\left\{ j\frac{2\pi x}{\lambda} \sin\theta \right\} dx \quad .. \quad (1)$$

where the co-ordinate system is as shown in Fig. 1, a is the total length of the line source, $F(x)$ is a function representing the field distribution along the line source and λ is the wavelength. It should be noted that this integral is, strictly speaking, only true for a constant phase distribution and even then only for narrow beam-widths. In all cases used here, however, the correction term is small enough to be neglected, since only the structure of the main beam of the radiation pattern will be considered. The details of this structure will be dealt with in the following two sections for the two cases of constant- and cosinusoidal-amplitude distributions respectively. In the final section the relationship of this analysis to parabolic-cylinder reflector design is considered.

Constant-Amplitude Distribution

The field distribution $F(x)$ will be taken in this section to be of the form

$$F(x) = \exp. j\phi(x)$$

with

$$\phi(x) = (x/2a)^2 \Phi \quad .. \quad .. \quad .. \quad (2)$$

Use of equation (1) then yields the radiation pattern as

$$g(\theta) = \int_{-a/2}^{+a/2} \exp. j\left\{ (x/2a)^2 \Phi - \frac{2\pi x}{\lambda} \sin\theta \right\} dx \quad (3)$$

This equation can be simplified somewhat by making the substitutions

$$\alpha = \frac{\pi a}{\lambda} \sin\theta$$

$$\nu = \sqrt{\frac{2\Phi}{\pi}} \left\{ \frac{2x}{a} - \frac{\alpha}{2\Phi} \right\} \quad .. \quad .. \quad (4)$$

Writing it as a function of α rather than θ, the radiation pattern is then given by

$$g(\alpha) = \frac{a}{2}\sqrt{\frac{\pi}{2\Phi}} \exp.\left\{ -j\frac{\alpha^2}{4\Phi} \right\} \int_{-\nu_1}^{+\nu_2} \exp.\left\{ j\frac{\pi\nu^2}{2} \right\} d\nu \quad .. \quad .. \quad .. \quad (5)$$

where the limits of integration are

$$\nu_1 = \sqrt{\frac{2\Phi}{\pi}} \left\{ 1 + \frac{\alpha}{2\Phi} \right\}$$

$$\nu_2 = \sqrt{\frac{2\Phi}{\pi}} \left\{ 1 - \frac{\alpha}{2\Phi} \right\}$$

The integral involved in equation (5) is the Fresnel integral and can be evaluated either from tables or from the Cornu spiral. It is not necessary, however, to compute $g(\alpha)$ to find the broad features of the pattern. Let the integral be rewritten as

$$\int_0^{\nu_1} \exp.\left\{ j\frac{\pi\nu^2}{2} \right\} d\nu + \int_0^{\nu_2} \exp.\left\{ j\frac{\pi\nu^2}{2} \right\} d\nu$$

and consider the Cornu spiral, one half of which is shown in Fig. 2. Each of the integrals above can be represented as a suitable vector as shown in Fig. 2 and $g(\alpha)$ is proportional to the resultant of these two vectors [neglecting the phase term in equation (5)]. When $\alpha = 0$, $\nu_1 = \nu_2 = \sqrt{2\Phi/\pi}$

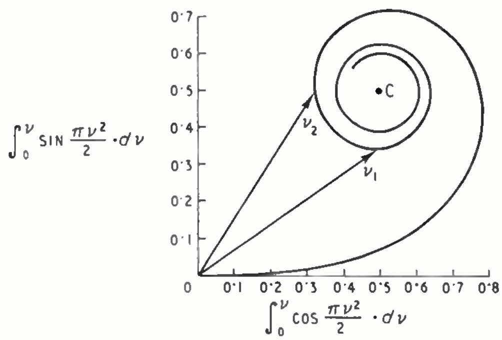

Fig. 2. *One half of Cornu spiral.*

and as α increases, the point ν_1 will move in an anticlockwise direction and the point ν_2 will move in a clockwise direction around the spiral. Thus, as long as ν_1 and ν_2 are large enough (note that

ν is the path length on the spiral from the origin) the resultant of the two vectors will oscillate about 2OC.

As α increases ν_2 decreases and thus, if α is large enough to make ν_2 vanish, only one vector will remain. This value of α is the value which gives the approximate half-field-strength width of the radiation pattern. From the equation defining ν_2, the value of α required, denoted by α_v, is

$$\alpha_v = 2\Phi \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

The condition for this to be valid is approximately given by

$$\nu(\alpha = 0) > \sqrt{2} \text{ or } \Phi > \pi \quad \ldots \quad \ldots \quad (7)$$

The value of α_v obtained from equation (6) can be compared with the value of α obtained for the equivalent constant phase source which is given approximately by $\alpha'_v = 0{\cdot}6\pi$. The ratio of these two will be called the broadening factor and denoted by μ which is given by

$$\mu = \frac{\alpha_v}{\alpha'_v} = \frac{3{\cdot}3\Phi}{\pi} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

To confirm the above formulae the patterns were calculated for several values of Φ and are shown in Fig. 3. (The decrease with increasing Φ due to the term $\sqrt{\pi/2\Phi}$ has been ignored in these curves.) From these the values of the broadening factor were calculated and are presented for comparison with equation (8) in Fig. 4. Values of μ for $\Phi > \pi$ are difficult to determine with accuracy due to the complexity of the patterns. They have therefore been calculated using the values of α for which the field strength has an amplitude of OC (see Fig. 2).

It would appear from Fig. 3 that for certain values of Φ the radiation pattern should be reasonably flat-topped (for instance one value should lie between $1{\cdot}0\pi$ and $1{\cdot}5\pi$). These values can be derived approximately by consideration of

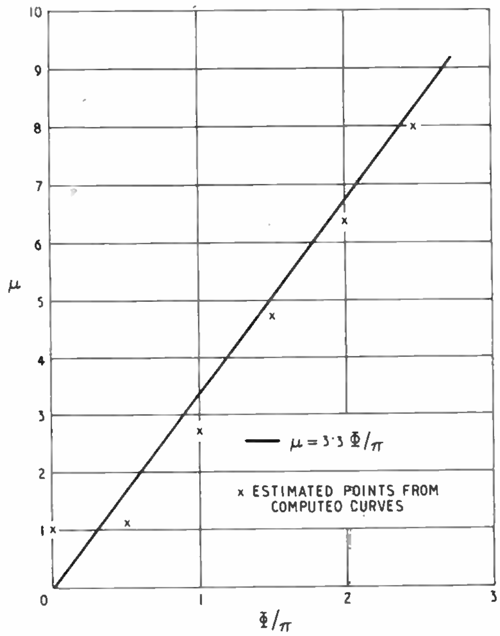

Fig. 4 (above). *Constant-amplitude illumination (half-field-strength broadening factor).*

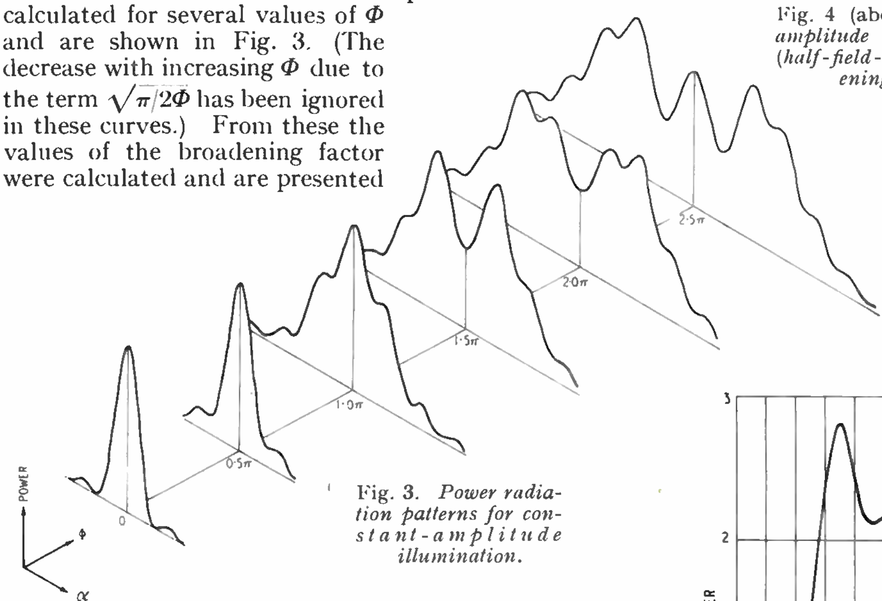

Fig. 3. *Power radiation patterns for constant-amplitude illumination.*

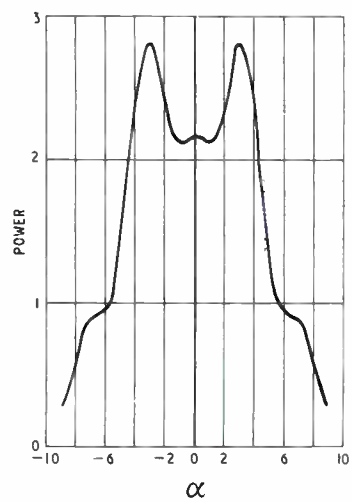

Fig. 5. *Power pattern for* $\Phi = 1{\cdot}28\pi$.

the Cornu spiral and the two vectors. Since these two vectors have a common starting point and their end-points move in opposite directions around the spiral the pattern is likely to be flattest if the amplitude of one vector increases when the amplitude of the other decreases. While this cannot be ensured throughout the pattern a good approximation, especially near the centre of the pattern, is obtained for starting points lying in a line through C perpendicular to OC. The first of these points which satisfies the inequality (7) is the point $\Phi = 1{\cdot}28\pi$ (cf. reference 3) and the pattern for this is shown in Fig. 5. This particular pattern is not very flat since it is for the first of the points, but it does show the tendency for the centre undulations to be ironed out leaving only the side peaks. Even here, however, there is an improvement over the patterns for $1{\cdot}5\pi$, $2{\cdot}0\pi$, and $2{\cdot}5\pi$, in which the troughs amount to almost half the peak value. The side peaks are a natural consequence of the widening of the Cornu spiral for small values of ν.

Cosinusoidal-Amplitude Distribution

In this section the field distribution function $F(x)$ is assumed to taper in amplitude to zero at the ends of the line source but to maintain, as before, a square-law phase distribution. The substitution to be made into equation (1) is now

$$F(x) = \cos\frac{\pi x}{a}\,\exp.\,j\phi(x)$$

with

$$\phi(x) = (x/2a)^2\Phi \qquad \ldots \quad \ldots \quad \ldots \quad (9)$$

The radiation pattern is thus given by

$$g(\theta) = \int_{-a/2}^{+a/2}\cos\frac{\pi x}{a}\,\exp.\,j\left\{(x/2a)^2\Phi - \frac{2\pi x}{\lambda}\sin\theta\right\}dx$$
$$= \frac{1}{2}\int_{-a/2}^{+a/2}\exp.\,j\left\{(x/2a)^2\Phi - \frac{2\pi x}{\lambda}\sin\theta + \frac{\pi x}{a}\right\}dx$$
$$+ \frac{1}{2}\int_{-a/2}^{+a/2}\exp.\,j\left\{(x/2a)^2\Phi - \frac{2\pi x}{\lambda}\sin\theta - \frac{\pi x}{a}\right\}dx \qquad \ldots \quad \ldots \quad \ldots \quad (10)$$

This equation can be simplified as before, by making the substitutions

$$\alpha = \frac{\pi a}{\lambda}\sin\theta$$

$$\left.\begin{aligned}\nu &= \sqrt{\frac{2\Phi}{\pi}}\left\{\frac{2x}{a} - \frac{\alpha - \pi/2}{2\Phi}\right\} \text{ in the first integral of (10)}\\ \nu &= \sqrt{\frac{2\Phi}{\pi}}\left\{\frac{2x}{a} - \frac{\alpha + \pi/2}{2\Phi}\right\} \text{ in the second integral of (10)}\end{aligned}\right\} \quad (11)$$

After some rearrangement the expression for the radiation pattern becomes

$$g(\alpha) = \frac{a}{2}\sqrt{\frac{\pi}{2\Phi}}\exp.\left\{-j\frac{\alpha^2 + (\pi/2)^2}{4\Phi}\right\}\left[\exp.\left\{j\frac{\pi\alpha}{4\Phi}\right\}\int_{-\nu_1}^{+\nu_2}\exp.\left\{j\frac{\pi\nu^2}{2}\right\}d\nu + \exp.\left\{-j\frac{\pi\alpha}{4\Phi}\right\}\int_{-\nu_3}^{\nu_4}\exp.\left\{j\frac{\pi\nu^2}{2}\right\}d\nu\right] \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

where the limits of integration are given by

$$\nu_1 = \sqrt{\frac{2\Phi}{\pi}}\left\{1 + \frac{\alpha - \pi/2}{2\Phi}\right\}$$
$$\nu_2 = \sqrt{\frac{2\Phi}{\pi}}\left\{1 - \frac{\alpha - \pi/2}{2\Phi}\right\}$$
$$\nu_3 = \sqrt{\frac{2\Phi}{\pi}}\left\{1 + \frac{\alpha + \pi/2}{2\Phi}\right\}$$
$$\nu_4 = \sqrt{\frac{2\Phi}{\pi}}\left\{1 - \frac{\alpha + \pi/2}{2\Phi}\right\} \qquad \ldots \quad \ldots \quad (13)$$

The integrals involved in equation (12) can be written as before and represented as vectors as was done in Fig. 2. The system is more complicated than in the previous section and it is convenient to simplify the notation by defining

$$I(\nu) = \int_0^{\nu}\exp.\left\{j\frac{\pi\nu^2}{2}\right\}d\nu$$

It is clear from equation (12) that only the term in the brackets has any influence on the shape of the radiation pattern and it can be shown that the power-radiation pattern is proportional to

$$\left|\cos\frac{\pi\alpha}{4\Phi}\left\{I(\nu_1) + I(\nu_2) + I(\nu_3) + I(\nu_4)\right\} + j\sin\frac{\pi\alpha}{4\Phi}\left\{I(\nu_1) + I(\nu_2) - I(\nu_3) - I(\nu_4)\right\}\right|^2 \qquad \ldots \quad \ldots \quad \ldots \quad (14)$$

Since all the integrals in (14) will oscillate, as α varies, about the complex value OC, provided that Φ is large enough, the second term in this expression will be small. By the same argument the sum of all four integrals in the first term will be substantially constant and, therefore, the dominant feature of the power pattern is the law $\cos^2(\pi\alpha/4\Phi)$. The value of α, for which this term is one half of its maximum value (the latter value being unity at $\alpha = 0$), is simply given by

$$\alpha_P = \Phi \qquad \ldots \quad \ldots \quad \ldots \quad (15)$$

the quantity α_P designating the half-power beam-width of the radiation pattern. The first zeros of the dominant term occur for

$$\alpha_0 = 2\Phi \qquad \ldots \quad \ldots \quad \ldots \quad (16)$$

although the actual pattern will not, in general, show these zeros, due to the presence of the second term in expression (14) which was neglected to obtain (15) and (16). As in the previous section, a broadening factor can be defined by comparing α_P

with the equivalent value for a constant-phase source, in this case given by $\alpha'_P = 0{\cdot}6\pi$. The result for the cosinusoidal distribution is then

$$\mu = \frac{\alpha_P}{\alpha'_P} = \frac{1{\cdot}67\Phi}{\pi} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

It should be remembered that in the case of (17) the broadening factor relates to half-power values whereas in the case of (8) the values concerned are half-field-strength values.

In order to check the accuracy of equation (17) patterns were computed using expression (14). These patterns are shown in Fig. 6,

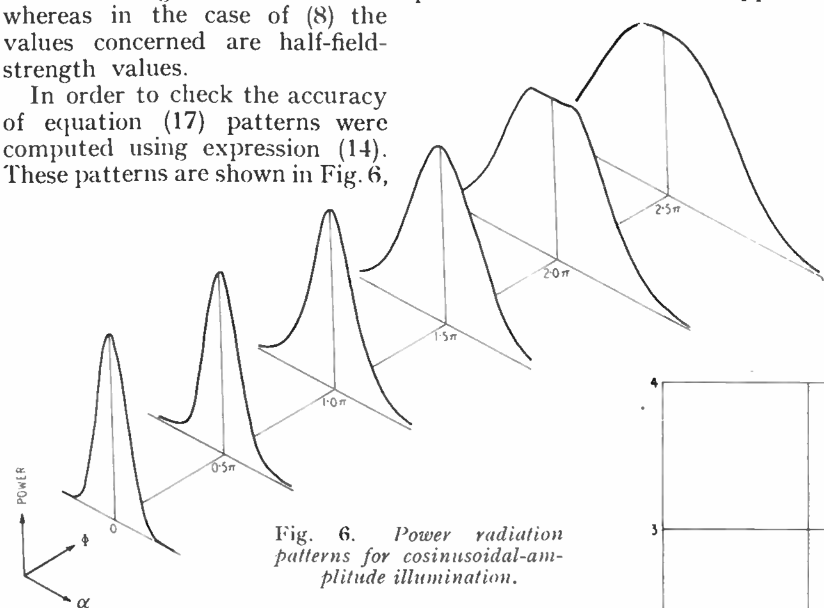

Fig. 6. *Power radiation patterns for cosinusoidal-amplitude illumination.*

and a comparison between (17) and the computed broadening factors is shown in Fig. 7. As before, the representation can be expected to hold for

$$\Phi \geqslant \pi \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

There is a marked difference between these results and those of the previous section. First, the patterns show very little evidence of the violent undulations obtained in the constant-amplitude case. This is partly to be expected since four vectors are now employed in the summation instead of two. Fine structure is present, of course, and can be noticed on the pattern for $\Phi = 2{\cdot}0\pi$ as well as being responsible for the flat top of the curve for $\Phi = 2{\cdot}5\pi$. For the rest of the patterns slight undulations are obtained on the slopes of the curves when these are plotted on a decibel scale, but the scale of Fig. 6 is not sensitive enough to show these. Secondly, because of the absence of fine structure, the half-power values are more accurately determined and also the agreement with (16) is more marked, especially for the higher values of Φ.

A further insight into the behaviour of the four vectors in producing a smooth pattern can be obtained by the following argument. The main part of the Cornu spiral, as far as the centre section of the pattern is concerned, is almost a circle about the point C. An approximate representation of the situation can therefore be obtained as in Fig. 8 in which P_1 and P_2 are the two starting points at $\alpha = 0$. The resultant field-strength is the sum of the four vectors as shown and, due to (13), the end points of these vectors can be considered to be moving round the circle at approximately equal rates. Now it is clear that, if $\gamma_1 + \gamma_2 = \pi$, the resultant of the four vectors in this representation will be just 4(OC), which is independent of the angle β and hence of α. Thus the sum of the integrals in the first, and dominant, term of (14) is, under this condition, almost independent of α. This condition means that the two starting points lie on opposite

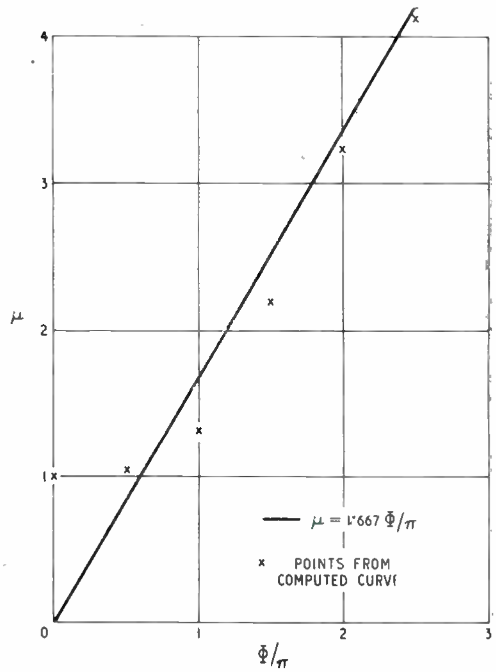

Fig. 7. *Cosinusoidal-amplitude illumination (half-power broadening factor).*

ends of a diameter through C. Consider now Table 1 in which are tabulated values of

TABLE 1

Φ/π	ν_{P_1}	ν_{P_2}	ν_{diam}
0·5	0·50	1·50	1·44
1·0	1·06	1·76	1·75
1·5	1·44	2·02	2·01
2·0	1·75	2·25	2·24
2·5	2·02	2·46	2·46

ν_{P1}, ν_{P2} and the value of ν at the opposite end of the diameter $C\nu_{P1}$.

It can be seen that, in fact, the two starting points very nearly satisfy the condition derived above, and thus in practice the sum of the integrals, which would form the main fine structure contribution to the centre of the pattern, is almost independent of α.

A final point to notice is that the broadening factor in this case is not so great as in the constant amplitude case. This behaviour would be expected due to the tapering of the amplitude distribution.

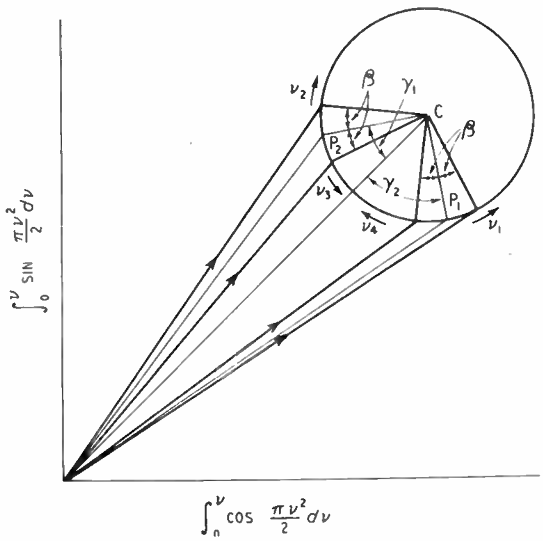

Fig. 8. *Approximate representation of the Cornu spiral valid for $\nu > \sqrt{2}$. The end points of the vectors are functions of the variable α [c.f. equation (13)]. If this parameter is zero, ν_1 and ν_4 coalesce to P_1, ν_2 and ν_3 coalesce to P_2. With increasing α these end points move round the circle in the directions indicated. The angle β is a measure of the distance moved, and its main use here is to emphasize the fact that, in this approximation, the four angles so labelled are equal.*

Application to Parabolic-Cylinder Aerials

In this section, the operation of the parabolic-cylinder aerial is discussed with relation to the preceding analysis. Since, in practice, the cosinusoidal-amplitude distribution is obtained across the reflector aperture rather than the constant distribution, the analysis in the last section will form the starting point.

A vertical cross-section of the aerial assembly is illustrated in Fig. 9. The line AB represents the reflector, f is the focal length of the horizontal parabola and there is a feed horn at F (the focus of this parabola) which will be assumed to have a sinusoidal distribution of field amplitude in the vertical plane. The vertical aperture of this horn is of such a length that ψ_0 is the first zero of the radiation pattern.

First of all, the relationship of the reflector pattern to the horn pattern can be formed. For the assumed sinusoidal distribution across the horn aperture the half-power level of the horn-radiation pattern occurs approximately at

$$\psi_P = \frac{0{\cdot}6}{1{\cdot}5}\psi_0 \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

and, since the resultant amplitude distribution across the reflector in the vertical plane is substantially of the form discussed in the previous section, the phase distribution being of square-law form, the half-power level of the reflector-radiation pattern can be obtained from equation (15) which can be written approximately as

$$\alpha_P \approx \frac{\pi a}{\lambda}\theta_P = \Phi$$

whence

$$\theta_P = \frac{\lambda\Phi}{\pi a} \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

Now, from the geometry of the system, it can be shown that

$$\psi_0 \approx \frac{a}{2f}$$

$$\Phi \approx \frac{2\pi}{\lambda}\cdot\frac{a^2}{8f} = \frac{\pi a^2}{4\lambda f} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

and thus, using (19), (20) and (21), the half-power levels of the two radiation patterns are given by

$$\begin{aligned}\theta_P &\approx a/4f\\ \psi_P &\approx a/5f\end{aligned} \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

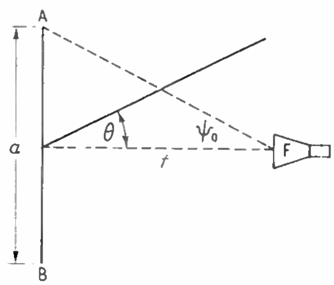

Fig. 9. *Vertical cross-section of aerial assembly.*

The relationship between these two angles is clearly

$$\theta_P \approx 1{\cdot}25\,\psi_P \quad \ldots \quad \ldots \quad \ldots \quad (23)$$

This equation shows that the reflector substantially images the horn pattern although there is a slight broadening. It should be noted that, if the zeros of the patterns are considered [as defined for the reflector by (16)], the broadening is no longer obtained. The condition for equation (23) to hold is just that given by equation (18). Use of equation (21) to write this condition in terms of the reflector geometry yields

$$\frac{a}{\lambda} \geqslant 2\sqrt{\frac{f}{\lambda}} \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

and it can now be seen that the condition establishes a minimum vertical height for the reflector.

An alternative interpretation of the condition can be obtained by consideration of small values of a/λ; i.e., small compared with those involved in equation (24). For these values the phase distribution across the reflector aperture can be considered as constant and the half-power level is given by the normal relation

$$\theta_P \approx \frac{108}{\pi} \cdot \frac{\lambda}{a} \text{ degrees} \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

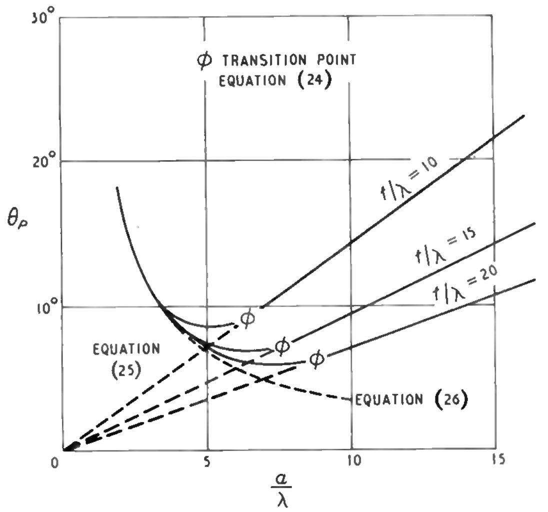

Fig. 10. *Plot of equations* (25) *and* (26). *The transition points indicate the region of changeover from a diffraction to a horn-image pattern.*

The first equation in (22) can be written as

$$\theta_P \approx \frac{45}{\pi} \cdot \frac{a}{\lambda} \cdot \frac{\lambda}{f} \text{ degrees} \quad \ldots \quad \ldots \quad (26)$$

which is valid under condition (24). If these last two equations are combined the curves of Fig. 10 can be drawn, on which are shown points corresponding to the limiting condition. These points represent a region of transition between a normal diffraction pattern and a horn-image pattern. These curves are also illuminating in that they show that for a given value of f/λ there is a minimum half-power beam-width which can be obtained using the parabolic-cylinder aerial.

Conclusion

In conclusion, the results of the last section can be compared with the vertical-radiation pattern published by Kiely[3] which shows an overall beam-width between the half-power points of about 18°. Based on the quoted dimensions the values to be inserted into equation (26) are

$$\frac{a}{\lambda} = 9{\cdot}62, \quad \frac{f}{\lambda} = 14{\cdot}44$$

and, since condition (24) is satisfied, the value of θ_P obtained should be valid. The beam-width between the half-power points (which, it should be noted, is $2\theta_P$) is then calculated as 19·04°, a value in fair agreement with that measured. Further, it can be seen from Fig. 7 that the approximate theory tends to over-estimate the broadening factor and this could account for part of the discrepancy. It would appear, therefore, that the approximations made in the preceding sections are accurate enough for most practical design details.

Acknowledgments

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In consequence of printing difficulties, publication of this issue of *Wireless Engineer* has been greatly delayed. Subsequent issues will appear at intervals of less than a month until the normal publication date can be resumed.

MICROWAVE VEHICLE-SPEED INDICATOR

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SUMMARY.—A new form of microwave vehicle-speed indicator† which has been developed at the Dominion Physical Laboratory for operational use by the New Zealand Transport Department is described.

It is much less complex than earlier forms of equipment using radar technique to measure speed as indicated by the Doppler frequency shift caused by a moving target. A hybrid waveguide junction is used to provide both transmitting and receiving channels so that only a single aerial is required, and by using the leakage between opposite arms of the junction the klystron oscillator, used as a c.w. transmitter, also provides local-oscillator power for the homodyne detection process employed. The complexity of a superheterodyne receiver, as used in earlier equipments, is removed.

The present operating wavelength is in the 3-cm region and, using an 18-in. diameter paraboloid reflector, ranges of several hundred yards on small modern cars are obtained.

A description of the initial circuit is given and the subsequent modifications following experimental trials. These include an automatic gain-control circuit which increases the sensitivity of the trigger circuits as the signal level increases. Various forms of indicator and recording methods are briefly considered, and the significance of the aerial beam-width is discussed in so far as coverage and siting problems are concerned.

The accuracy of the speed indication is discussed in the Appendix with an analysis of the errors arising throughout the equipment.

1. General

THE Doppler principle is well known and in the radar application it can be shown that, for a transmitter frequency f, the frequency of a signal received by reflection from a moving target is:—

$$f(1 \pm 2v/c)$$

where v is the radial velocity of the target and c is the velocity of e.m. waves.

The Doppler frequency shift which can be obtained by heterodyning the transmitted and received frequencies is

$$2vf/c$$

so that a circuit capable of measuring this frequency may be suitably calibrated and used to indicate the target velocity.

A difficulty in devising a practical system is that a detector sufficiently sensitive to detect the very small reflected signals (e.g., a silicon crystal) would be damaged if exposed directly to the comparatively high-level transmitter power. It has been the usual practice, therefore, to use separate transmitting and receiving aerials, so screened one from the other that only a small portion of transmitter power, sufficient for comparison purposes with the received power, leaks into the receiver aerial and thence to the detector. In addition, in an earlier model of a vehicle-speed indicator, a superheterodyne receiver with a separate local oscillator has been used to detect the received signal and the small portion of the transmitted signal. Separation of the Doppler frequency shift has been carried out in subsequent intermediate and audio-frequency circuits.

The major part of the complexity of such systems has been removed in the equipment to be described. A single aerial is used and one klystron oscillator provides both transmitter and local-oscillator power. A three-stage audio amplifier follows the microwave crystal detector and a further four valves provide trigger circuits and a frequency-measuring circuit to complete the system.

2. Description of Equipment

The complete equipment, which is intended for installation in a motor car, is divided into three main parts:—

The aerial head, comprising the aerial, which at present is a paraboloid of 18-in. diameter, the waveguide circuit and the klystron oscillator. It is normally mounted on a short pillar attached to the rear of the operations car.

The electronics unit comprises amplifier and frequency-measuring circuits and, on a separate chassis, a vibrator power unit which is operated from a 12-volt battery. This complete unit is mounted in the boot, or other convenient position in the car.

A remote-control unit contains the speed-indicating meter and operating controls, and may be mounted inside or outside the car to suit the operational requirements.

It is proposed to describe the basic equipment and then to deal with various modifications and

* Now at Civil Aviation Administration, Air Department, N.Z.

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†N.Z. Patent Application No. 109385

additions which have been incorporated as a result of experimental tests.

The waveguide circuit used is shown schematically in Fig. 1. The basis of the arrangement is the hybrid junction, and the 'rat race' form is illustrated. Two properties of the 'rat race' are used.

When transmitting, the klystron oscillator, operating in the 10,000-Mc/s region in the present model, supplies energy to arm 3 of the junction and this energy divides equally between arms 2 and 4. That going into arm 2 is absorbed in a matched load consisting of carbon-coated card.

The energy entering arm 4 is fed to the aerial, and radiated in a beam of approximately 5° total angular width between the half-power points. The total power radiated is of the order of 10 mW.

Although a theoretically perfect rat race has the property that arms, such as 1 and 3, are completely isolated, in practice there is a small leakage of power between them. The attenuation factor is in general greater than 30 dB; thus a small portion of the transmitted power leaks across to arm 1 in which is a standard microwave crystal detector. This leakage of power provides the local-oscillator power for mixing purposes.

A similar process occurs when reflected signals are received by the aerial. From arm 4 the energy divides equally between arms 3 and 1 with a negligible amount lost to arm 2. That going into the klystron arm is very small compared with the klystron power and its effect on the operation of the klystron can be ignored. The half of the received signal power entering arm 1 is mixed with the leakage power from the klystron and a process of homodyne detection occurs.

The resultant output from the crystal is the difference frequency between transmitted and received signals; i.e., the Doppler frequency shift due to movement of the target. For a radio-frequency in the 10,000-Mc/s region the resultant Doppler frequency shift for a target speed of 1 m.p.h. is about 30 c/s so that, for speeds up to 60 m.p.h., the circuits following the detector receive audio-frequency signals up to 1,800 c/s.

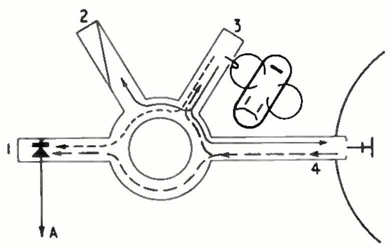

Fig. 1. *Hybrid waveguide junction connecting klystron transmitter, aerial and receiver.*

The basic amplifier and frequency-measuring circuit is shown in Fig. 2. The first three stages, V_1, V_2 and V_3, constitute a high-gain audio amplifier designed for minimum hum pickup and microphony. It is important to ensure that the noise arising from all sources, including the vibrator power supply, which is contributed to the output of this amplifier is small compared with the noise arising from the crystal detector. Then the limiting sensitivity of the system is that set by the r.f. portion of the equipment. The remaining stages, V_4, V_5 and V_6 constitute the controlled trigger circuits and frequency-measuring circuit.

V_4 is a further amplifier acting as a squaring stage but with an adjustable bias control. This is provided by current flowing through the cathode resistor via a variable resistor to the h.t. line.

V_5 is a bistable multivibrator which produces a square wave with steep edges when operated by the somewhat variably-shaped waveform output from the previous stage. The object of this stage is to provide, by differentiation of its output and passage through a crystal diode D_1, a narrow negative-going pulse to trigger the final stage. This trigger pulse occurs for each cycle of the initial sinusoid input signal to the amplifier.

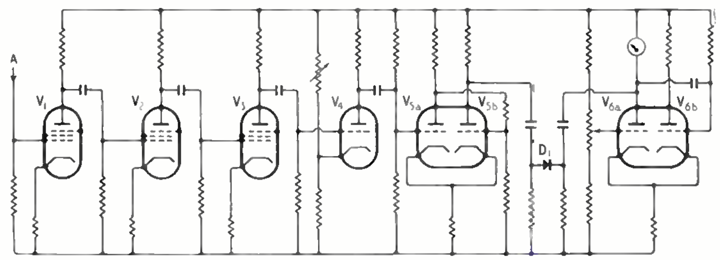

Fig. 2. *Circuit diagram of experimental receiver.*

The final stage V_6 is a monostable multivibrator, producing a current pulse of constant amplitude and duration in the triode V_{6A}, which is normally cut off, each time the circuit is triggered. A meter in this anode circuit measures the mean current through the valve and can thus be calibrated to indicate frequency or speed.

It should be noted that the triggering sensitivity of the circuit is fixed by the bias condition of the squaring stage V_4. It is found, in fact, that a small signal, comparable or even somewhat less than the noise level, will 'capture' the trigger circuits and produce a steady meter reading of the correct value. However, to avoid an intermittent meter deflection in the absence of a moving target, the sensitivity was adjusted so that peaks of noise did not trigger the circuits. A modification to this condition will be dealt with later.

The vibrator power-supply unit, when operated from a 12-V battery, provides a positive supply of 300 volts which has a total ripple and hash content of less than 5 mV and also a negative supply of 180 volts which has a ripple and hash level of less than 1 mV. Both supplies are stabilized with standard regulator valves.

Heater supplies for the valves are obtained, through suitable filter circuits, from the battery.

3. Initial Tests

The equipment as described was used for experimental tests designed to prove the system as a whole and to determine the general sensitivity for different road vehicles. The overall performance will be discussed later, but these trials showed that although the basic performance was satisfactory certain modifications were desirable.

It was found advantageous to have some audible output of the Doppler frequency to assist the operator in aligning the aerial beam. Using headphones or a loudspeaker the aerial is readily aligned by adjusting its position to give maximum audio output from a vehicle travelling in the traffic lane being investigated.

A phenomenon occurred, disturbing to satisfactory operational use, in the form of intermittent 'flicks' of the meter indication under certain conditions. This was observed when a vehicle was first coming within range or just going out of range and, more seriously, in so far as operational use is concerned, when a vehicle well within range passed over a severe bump in the road surface. A typical example which could be examined at one test site was a railway crossing, when the meter reading dropped momentarily although it had been perfectly steady for several seconds previously.

There is a considerable variation in signal level returned from a road vehicle which, in general, is not important, as the signal stays well above the noise and trigger-sensitivity level and constant triggering and steady meter readings result. However, for a vehicle approaching from beyond maximum range, momentary increases in the signal level to above the triggering sensitivity level cause intermittent kicks of the meter. These disappear as the vehicle moves into range and a steady reading continues. The action as the vehicle moves out of range is similar.

In the case of a severe bump in the road the signal level can be reduced sufficiently to fall below the sensitivity level, which has been adjusted as indicated above, and triggering will cease for a short interval.

It was apparent that an increase in sensitivity would overcome this latter difficulty as the signal did not fall completely to zero. At such bumps in the road surface, with the triggering sensitivity increased, the signal could be followed audibly and the meter would continue to operate in the normal manner. However, with the sensitivity increased to this extent the noise level was sufficient to trigger the frequency-measuring circuit in the absence of a moving target.

To overcome these difficulties, some modification and additions were made to the circuit and, at the same time, a tuning-fork oscillator was added to provide a means of checking the calibration of the frequency-measuring circuits during operations.

4. Modifications

The final circuit incorporating the modifications is shown in Fig. 3. It will be seen that V_1, V_2, V_3 which constitute the audio amplifier, V_5 the bistable multivibrator and V_6 the frequency-measuring monostable multivibrator, are unchanged.

V_{4B} is a cathode follower driven in parallel with V_{4A} and provides the audible output of the Doppler frequency through a loudspeaker or headphones.

The circuit of valve V_{4A} has been changed to act as calibration oscillator or as a squaring amplifier. When the relay RL/1 is operated, this valve is connected with the drive and pick-up coils of the tuning fork to provide an oscillator of high frequency stability which is suitable to provide a frequency-measuring-circuit calibration check. The relay is operated by a switch in the remote control unit and the oscillation amplitude reaches a sufficient level within a few seconds to drive the subsequent circuits and operate the meter. The frequency generated by the fork corresponds to a certain meter reading—35 m.p.h. in this case—and by a remote control of the grid potential of V_{6A} the operator can make a correction to the frequency-circuit calibration if required. In practice, it has been found that after a few minutes' operation of the equipment, subsequent adjustments to the calibration are not necessary. In operation a calibration check takes between 5 and 10 seconds.

In the non-operated or normal position of the relay, V_{4A} still operates as an amplifier and squaring stage but its bias condition is now controlled by V_{7A} and V_{7B} which constitute an automatic sensitivity-control circuit having the property of increasing sensitivity as the signal level increases.

It operates in the following manner:—

The cathodes of V_{4A} and V_{7A} are connected to a common resistor, thus adjustment of the grid potential of V_{7A}, which is a cathode follower, controls the bias condition of V_{4A} by changing the potential of the cathode.

Consider the grid circuit of V_{7B}. Audio signals from the output of the amplifier valve V_3 are rectified by the crystal diode D_2 and the resulting waveform is smoothed by the resistance-capacitance circuit to provide a steady potential at the grid of the valve V_{7B}. This potential increases positively as the audio-signal level increases and vice versa. As a result of an increasing input signal, therefore, the anode potential of V_{7B} falls, which results in a fall in potential of V_{7A} grid circuit via the crystal diode D_3 and the resistance-capacitance combination in that circuit. It will be noted that a fall in potential is rapidly transferred to the grid V_{7A} as the capacitor is charged through the comparatively low forward resistance of the crystal diode. However, if the applied potential subsequently rises, the capacitor discharges through the high back resistance of the crystal diode and the parallel adjustable high resistance, and consequently the grid potential will rise comparatively slowly. In turn, this means that the cathode potential of V_{4A} can be reduced quickly but will increase slowly, as a result of variation of signal level from the audio-amplifier stages.

In effect, therefore, the circuit modification provides an automatic bias circuit operating so that the triggering sensitivity increases as the input signal increases, but falls only slowly if the input signal falls in level.

As a result the intermittent triggering at maximum ranges, and due to severe bumps at shorter ranges, is prevented in the following manner. Consider a vehicle approaching from beyond maximum range. Very small signals with instantaneous rises in level cannot operate the trigger circuits as the preset sensitivity is low. As the vehicle approaches, the signal level increases and the sensitivity increases due to the action of the automatic bias circuit. The sensitivity increase will follow the mean signal level rather than its fluctuation, due to the smoothing action of the component parts of the circuit. At a well-defined level of input signal the sensitivity will have so increased that the triggering action commences. The circuit has prevented early instantaneous triggering due to sudden signal peaks when the vehicle is beyond the normal maximum range. Sensitivity further increases and any subsequent fall in signal level occurs with the circuits at high sensitivity. Therefore once triggering has commenced it continues even if the signal level varies considerably.

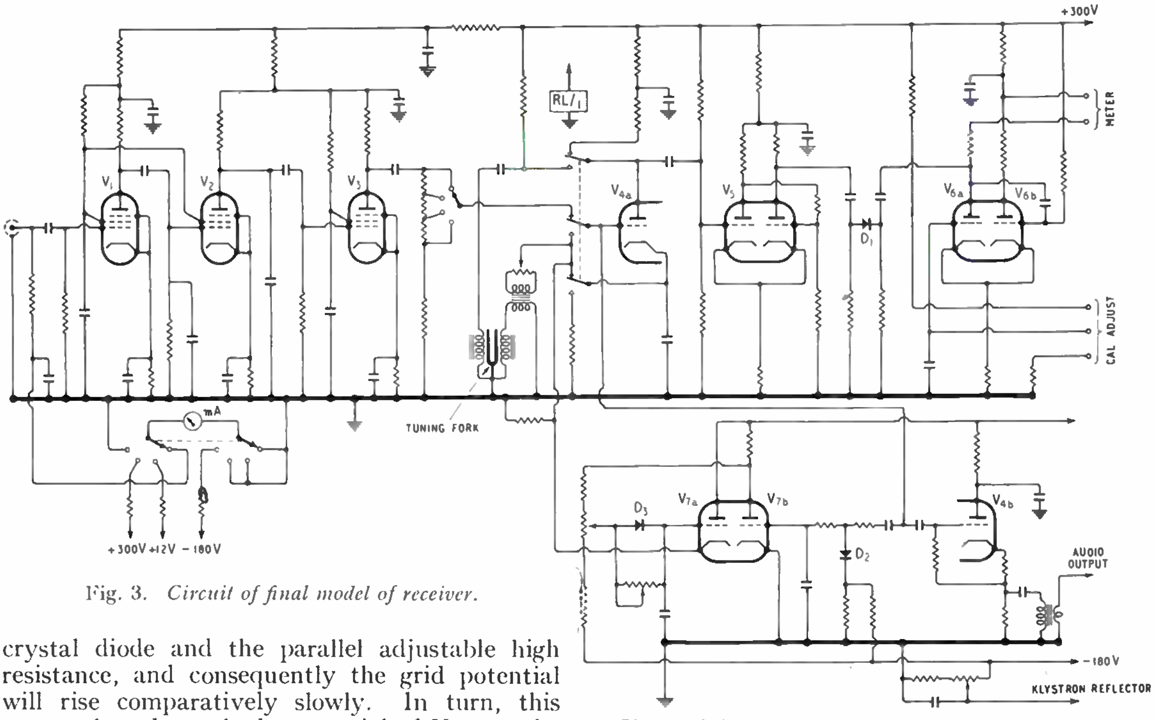

Fig. 3. *Circuit of final model of receiver.*

Since high sensitivity can only be realized with an input signal present it is possible to operate this circuit at a considerably higher ultimate sensitivity than the original circuit. In the original circuit operation by noise peaks in the absence of a signal had to be avoided, but since the trigger circuits will 'capture' the signal in the presence of noise the modification allows the ultimate sensitivity to be much higher than that of the original circuit. This means that since the sensitivity can fall only slowly, short-term low-level signals continue to give steady meter readings if the sensitivity has previously been raised by high-level signals. Thus the variations of signal at severe bumps (i.e., railway crossings) do not cause interruption to the triggering action.

The other addition to the circuit is a switched meter to check the various supply voltages and the rectified current from the crystal detector. This current is adjusted to a maximum for the optimum setting of the klystron reflector voltage and, because the voltage supplies are stabilized, no further attention is required during an operation. It has been found in practice that in general no further adjustment is required over a period of several operations.

5. Experimental Model of Equipment

In the experimental equipment the aerial head has a domed Perspex front cover, and a cylindrical metal cover behind the aerial protects the klystron and the associated waveguide components. The unit when assembled is weatherproof and is so constructed that when mounted on a short pillar at the rear of a car it can be carried over rough roads and up to speeds of 70 m.p.h. without damage. The assembled electronic units are on shock-absorbing mounts and installed in the boot of the car.

The remote-control unit contains the essential operating controls, a headphone jack and the indicating meter. In future models, apart from a mechanical redesign of the electronic-circuit units, the fixed meter will be replaced in the control unit by a loudspeaker, and portable meters will be jacked into this unit on extended leads.

The trial installation in an operations car is shown in Fig. 4. It will be seen that with the car placed at an angle to the highway, the aerial head can be aligned to cover vehicles approaching from either direction.

Fig. 4. *Experimental installation in car.*

In the illustration the remote-control unit is placed on the dashboard of the car but, as circumstances require, it could be placed inside or outside to suit the operator.

6. Experimental and Operational Trials

Following the modifications to the equipment, an extended series of tests and trials have been carried out, both in laboratory vehicles and as a trial installation in a Transport Department car. The results are summarized below and some of the technical problems affecting operational use are discussed on the basis of the information gained. A number of further operational facilities are also briefly considered.

In general, the tests of the equipment have shown the system employed to be completely satisfactory, the ranges on all types of vehicles are more than adequate and the advantages in weight, power consumption, ease of operation and maintenance to be expected from the simplicity of the arrangement have been realized.

Using an 18-in. diameter paraboloid aerial ranges on medium-sized cars were in excess of 300 yards, on lorries, trucks, buses and similar large vehicles 600–800 yards was normally obtained on a straight road. The ranges varied more with the body shape of cars than with size, the modern streamlined version producing a signal noticeably smaller than the older types of bodywork. However, the smallest modern car produced steady meter readings to ranges in excess of two hundred yards which corresponds to a time greater than 7 seconds for a speed of 60 m.p.h. A man could be observed walking at about one hundred yards and small birds passing through the aerial beam at ranges up to about 50 yards produced audible notes and distinct meter deflections.

A suitable height for the aerial is between 4 ft and 6 ft. There is some reduction in range with the aerial placed at heights much below 4 ft but, even so, ranges in excess of 100 yards were obtained on medium-sized cars with the aerial placed on the road surface. No evidence has been obtained of an interference pattern in the vertical polar diagram due to reflections from any type of road surface.

Difficulty arises when a number of vehicles are observed simultaneously, and in general it is desirable to limit the coverage in an attempt to observe one vehicle at a time. The equipment indicates the speed of the target producing the largest signal and laboratory checks show that interference between signals occurs when the smaller is greater than about 0·7 of the larger, measured as a voltage at the amplifier input. A confused meter reading occurs when two or more vehicles produce signals of comparable level. This can occur, for example, with a small car at a short range and a bus at much greater range.

Various palliatives can be applied to the problem of isolating single vehicles. The parameters of the system which affect the coverage are the receiver sensitivity and aerial beam-width. The aerial beam-width can be varied by change of aerial size or wavelength used; the general discussion is unaffected.

It may appear at first sight that a reduction in beam-width by increasing the aerial diameter would immediately solve the difficulty of reducing the horizontal coverage. However, if, for example, the 18-in. paraboloid is changed to a 36-in. paraboloid the beam-width is halved, but the maximum range is doubled. Consequently, the maximum width of the horizontal coverage is unchanged. The same maximum width of coverage is obtained by halving the size of the aerial as illustrated in Fig. 5(a). It is apparent that, if the aerial size is changed in this way, the sensitivity of the system must be adjusted to maintain the same maximum range if the benefits of change of horizontal beam-width are to be fully realized. Fig. 5(b) shows the effect of the 36-in., 18-in. and 9-in. paraboloids with the sensitivity adjusted for 200 yards maximum range in each case.

Since it has been found in practice that a vertical beam-width of about 5° is satisfactory for general use, it is desirable that the vertical dimension should be maintained and the horizontal aperture varied for changes in horizontal cover. Maintaining full receiver sensitivity and varying only the horizontal beam-width, the coverage obtained for a horizontal aperture of 36 in., 18 in. and 9 in. for a target on which the maximum range for an 18-in. × 18-in. aerial is 200 yards is shown in Fig. 5(c). A road width of 30 ft is indicated and an ideal site on a slight bend is used.

For a more usual site at the edge of a straight road the coverage obtained is less complete but still adequate as Fig. 5(d) indicates.

It can be seen that for different traffic conditions somewhat different alignments of the beams and beam-widths are desirable, L_1, L_2 and M_1, M_2 in (c) and (d). The mid-size aerial gives suitable cover for a low traffic density on the 30-ft road; traffic in both lanes can be followed. For observation of a single lane it is aligned as indicated along the edge of the road. The narrower beam of the 36-in. aperture is clearly more useful for single-lane traffic observation but for broad coverage of a roadway much in excess of 30 ft, it is inadequate and may require a certain amount of following of vehicle to be carried out. The broad beam of the 9-in. aperture is suitable for general coverage of a wider road, although the maximum range obtained is reduced.

In addition to the variation of aerial size and alignment a further modification of coverage is possible by reducing the receiver sensitivity. The general effect is a shrinking of cover for a particular aerial with results which can be visualized for the various diagrams.

As an indication of practical results it has been found that, operating on a wavelength of 3 cm, the 18-in. paraboloid, which produces a horizontal and vertical angular beam-width of about 5°, gives a reasonable compromise, for New Zealand traffic conditions, between general cover and the possibility, by alignment along the road edge, of coverage of a single traffic lane.

It should be noted that the coverage patterns are for a vehicle of a given size; for a smaller vehicle they will be reduced, and enlarged for a larger vehicle. Thus, if interference by a second vehicle is to be considered, the appropriate cover diagram for its size and hence maximum range must be used.

It is apparent that reducing the maximum range by operation within several hundred yards

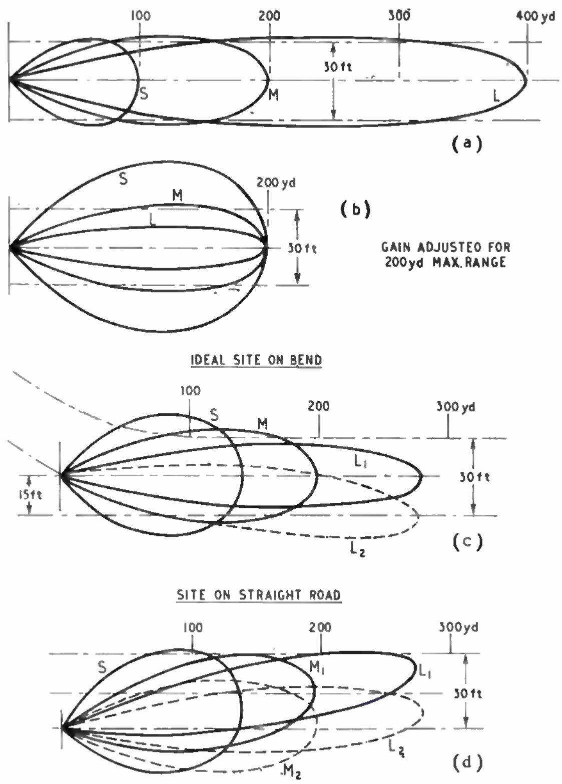

Fig. 5. *Variation of beam-width and coverage for various aerial sizes. In (a) and (b) S, M and L are for mirrors of 9-in., 18-in., and 36-in. diameter respectively; in (c) and (d) these letters represent mirrors of 9 in. × 18 in., 18 in. × 18 in. and 36 in. × 18 in.*

of a road bend will reduce the number of vehicles within the coverage. Vehicles beyond the corner rapidly pass out of the aerial beam and cannot cause confusion with vehicles within cover.

7. Subsidiary Tests

Further details of operational techniques are more appropriate to discussion elsewhere but some indication of various subsidiary tests are of interest.

Interference by slow-moving traffic which could screen faster-moving vehicles (e.g., bicycles and motor cars) can be removed by the use of a high-pass audio filter. A filter designed to pass frequencies above approximately 900 c/s was placed in the input circuit to the audio amplifier. This removed indications of vehicles travelling at less than 30 m.p.h. but speeds above this were displayed normally. This technique could be developed to cover speed ranges required operationally.

Various types of frequency-measuring systems have been considered as alternatives to that described. Vibrating-reed indicators have the property of displaying a number of frequencies and thus the speed of several vehicles simultaneously. Similarly, a bank of filters operating indicators would provide the same facility. Modifications to the circuits would be considerable and, in particular, a large dynamic range would be required in the amplifier stages to avoid saturation effects by which a large signal could obliterate a smaller one.

In other applications of the system, where post-detector integration is desirable to exploit the maximum sensitivity possible with the homodyne detector, the complication of filter circuits may well be justified. To maintain the simplicity of the equipment as a vehicle speed indicator they have not been pursued further to date.

It is apparent that recording of vehicle speeds can be accomplished by replacing the visual meter by a recording meter of the type in which a pen writes on a moving-paper strip. This has not been requested as an operational aid for New Zealand use, although the need for the method or a similar one has been foreseen.

A number of tests have been made with a commercial magnetic tape recorder as a means of making a permanent record of a vehicle speed. The audio output from the equipment was fed into the recorder and the operator could, by means of a switch and a microphone, make a verbal statement of the characteristics of the vehicle being recorded. At a later time, in the laboratory, the recording was played back through a loudspeaker and into a counting circuit and meter as used in the equipment. The levels of speech and Doppler frequency were so arranged that only the latter operated the meter. The result was a meter indication of speed, a verbal description of the vehicle, the time, etc., and then a return to the meter indication until the vehicle moved out of range. To remove inaccuracies due to speed variations of the recorder it is suggested that double track recording should be employed, the second track being used to record a constant frequency generated at the site, e.g., a tuning-fork oscillator as used at present for calibration checks.

It has been found that an operator very quickly learns to interpret the approximate speed of a vehicle from the audible Doppler frequency. The loudspeaker provides a very suitable warning to him of the approach of a vehicle and the pitch of the note emitted indicates whether or not he is required to take any further action. Some checks were carried out to determine if, in fact, an observer could rapidly compare the Doppler frequency with a standard frequency such as that provided by the tuning fork. With untrained and unskilled personnel it was found that, given the facility of a switch to alternate the tones heard, frequencies above 1,050 c/s and below 950 c/s could be distinguished immediately from a standard frequency of 1,000 c/s. At present the use of the audible Doppler frequency is considered a convenient warning technique only, apart from the assistance it gives in aerial alignment.

8. Accuracy

A detailed discussion of the possible errors which can arise throughout the equipment is given in the Appendix. In this estimation the various errors have been added to show the maximum error which could occur under the most pessimistic conditions.

The resulting figure is a maximum possible error of

$(v/36 + 1)$ m.p.h.

for a true speed of v m.p.h.

It should be emphasized that in practice the error will always be less than this figure and, if circumstances are at all favourable, considerably less. Practical checks of accuracy against vehicles fitted with calibrated speedometers have not produced differences of measured speed greater than 1 m.p.h. and a significant part of this difference could well be associated with observation of the speedometer and the speedometer error itself.

9. Conclusion

The equipment described and discussed in this paper has proved, as a result of experimental tests and quasi-operational trials, that the new form of radio-frequency circuit and the associated electronic circuits employed are satisfactory. The sensitivity is more than adequate for use as a vehicle-speed indicator, and the expectation that the overall simplicity would give obvious advantages in size, weight, operating and maintenance problems has been confirmed. The experimental equipment has been transported by air to Australia and the United Kingdom for demonstration by personnel unfamiliar with it. The demonstrations have been successful and so far as is known no maintenance has been required. A number of models are being manufactured in a suitably engineered form for the New Zealand Transport Department and authorities in other countries have expressed interest in the development. It is considered that further development and trials using a higher radio frequency, possibly 24,000 Mc/s, would be worth while, particularly since the aerial size could be appreciably reduced.

Acknowledgments

The author wishes to acknowledge the assistance of his colleagues at the Dominion Physical Laboratory, in particular, Mr. E. S. Gilfillan, who carried out much of the initial experimental work, and Mr. W. A. Penton who provided invaluable assistance throughout and who was responsible for the development of the tuning-fork oscillator.

In addition, the co-operation of the New Zealand Transport Department and the members of that Department who assisted in trials is gratefully acknowledged.

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APPENDIX

(Overall Error in Speed Indication)

Total Error

It is proposed to consider the various errors which can arise throughout the equipment, and it is emphasized that the overall error in practice will always be less than the figure derived here by summation of the individual errors. This process of summation produces a figure which is satisfactory from a legal aspect when the equipment is used for enforcement purposes.

The overall stability and accuracy of the method of determining the speed of a road vehicle, using this equipment, depends upon a number of factors.

(1) Radio-frequency measurement and stability
(2) Calibration-oscillator stability
(3) Frequency-measuring circuit stability
(4) Accuracy of meter indication and reading of meter

Klystron Stability

From the basic equation

$$\text{Doppler frequency} = \frac{2vf}{c}$$

it is apparent that a change in f will produce a corresponding change in the Doppler frequency.

Using a standard commercial wavemeter, the klystron could readily be set to 3 parts in 10,000, giving a possible initial error of 0·03%.

Variation of klystron frequency must now be considered; it depends on the change of resonator volume and the voltage applied to the reflector. For the 723 A/B klystron the following characteristics are given:—

(a) Temperature Coefficient: between (0 and −0·20 Mc/s)/°C at 9,000 Mc/s.

Allowing a temperature change of 20°C after the initial warm-up period—a pessimistic estimate—the resultant error would be 0·04%.

(b) Reflector Voltage—this is stabilized by gas-discharge regulator valves which can have a short-period variation of a few millivolts and a long-term variation of about 0·2 volt.

As a result, the frequency change due to voltage variation of the reflector, normally about (2 Mc/s)/volt, can be neglected as the resultant error should not exceed 0·004%.

The total error which could be attributed to the klystron is therefore 0·03% + 0·04%; i.e., 0·07%.

Calibration Oscillator Stability

It has been found experimentally that the simple valve-maintained tuning fork used has a temperature coefficient of the order of 1 part in 10,000 per °C. Allowing a temperature change of 20°C after initial calibration the error introduced would be 0·2%.

Frequency-Measuring Circuit

Investigations of the circuit show it to have several possible errors:—

(a) variation of current with h.t. voltage = 0·4% per volt

(b) variation of current with heater voltage = 1·7% per volt

(c) a departure from a linear relationship of current against frequency

Since the h.t. voltage is stabilized and the heater supply is direct from a battery, the errors arising from variations in these voltages can be neglected, particularly as calibration checks are carried out at intervals of a few minutes. It has been found, however, that the departure of a current value for a particular frequency injected into the circuit may vary by an amount up to 0·4% from the value determined by mean linear relationship of current against frequency. This figure is of significance since, if it occurs at the calibration point, it introduces an equivalent error of up to 0·4% throughout the range. If at some other point there is also an error of 0·4% the overall error may be the sum of both, giving a possible maximum of 0·8%.

The transfer of the error at the calibration point throughout the range will also occur for errors in calibration frequency, meter error, and meter reading error.

Meter

High-quality laboratory instruments are not suitable for an operational equipment of this type but a commercial meter of robust construction capable of retaining an accuracy of 0·5 m.p.h. over a calibrated range up to 60 m.p.h. maximum is used.

The direct meter error is thus 0·5 m.p.h. As indicated, this introduces a further possible error throughout the range of 0·5/35 or 1·4%, calibration being carried out at a frequency corresponding to a speed of 35 m.p.h.; thus the total error due to the meter is 1·4% + 0·5 m.p.h., or

$$\frac{v}{70} + 0{\cdot}5 \text{ m.p.h. at } v \text{ m.p.h.}$$

Observation Error

It is proposed to allow the operator a maximum reading error of 0·5 m.p.h. during operations; with a large-scale meter this is a liberal allowance.

For calibration purposes he is required to adjust the needle to a specific mark and an accuracy of 0·1 m.p.h. can be expected. This results in a possible error of

$$\frac{0{\cdot}1}{35} \times 100 = 0{\cdot}3\% \text{ throughout the range.}$$

Overall Accuracy

From the discussion it is apparent that the accuracy of a speed determination depends upon the speed and further that the errors associated with the meter are greater than those due to all other causes.

The possible maximum errors due to klystron, calibration oscillator and frequency-measuring circuit total 1·07%, and those due to the meter 1·7% + 1 m.p.h., giving a total maximum error at v m.p.h. of $\left(\frac{v}{36} + 1\right)$m.p.h. It should be emphasized that this is the maximum error obtained by adding individual errors, and the error in practice should always be considerably less.

Error due to Non-Radial Motion of Target

Since the equipment will, in general, not be sited directly in line with the direction of motion of the target it will measure the component of the velocity radial to the equipment. If the site is 10 ft from the line of motion the target velocity will not exceed the measured velocity by more than 1% until the target is within 70 ft, and for a 2% error, within a range of 59 ft.

For a siting error of 20 ft, such as may apply to vehicles on the far side of a road, the minimum ranges for the error not to exceed 1% is 140 ft, and 2% it is 118 ft; the errors are always such that the measured speed is less than the true speed.

CORRESPONDENCE

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

Electrostatic Loudspeakers

SIR,—Your Editorial of May 1955, on this subject, has just come to my attention by being quoted and amplified in the issue of *Wireless World* dated February 1956, page 54. This is my excuse for referring to your Editorial so long after its publication.

When a symmetrical electrostatic loudspeaker is fed from a push-pull amplifier there is no necessity for any signal current to flow in the connection of the diaphragm to the supply of polarizing voltage. This connection can therefore have a high resistance. The resistance can indeed be made so high that the electrostatic charge on the moving diaphragm has no chance of varying during the audio-frequency cycle in spite of large diaphragm excursions and consequent changes of capacitance. Several advantages accrue, such as greater freedom of choice of diaphragm material, but pride of place must be given to the virtual elimination of the non-linear distortion which was a serious fault of earlier designs. All this you freely acknowledge in your Editorial, but apparently you are still not satisfied and you are looking for something even better. (This idea is amplified and made more explicit in the *Wireless World* article.)

You calculate that, even under constant-charge conditions, a force is developed on the diaphragm when it moves away from its mid position and you promptly assume, without any explanation, that this force must be objectionable and should be eliminated if possible. But why? Your calculation shows that the force is strictly proportional to displacement, so that it will not introduce non-linear distortion. The sign of the force corresponds to negative stiffness; perhaps you are anxious about stability? But at zero frequency the negative stiffness effect is equally present and further aggravated by non-linearity (the series resistance being ineffective at zero frequency). The positive mechanical stiffness which it is necessary to give the diaphragm (by suitable tensioning) to ensure stability at zero frequency will be more than adequate to ensure stability under dynamic conditions. The negative electrical stiffness merely reduces the total effective stiffness of the diaphragm system. The effect is small, but entirely beneficial.

It is interesting to speculate on what will happen if (in spite of the above argument) you are still determined to avoid the effect. You have proposed the use of a diaphragm material having high volume resistivity and this could certainly be provided. This would prevent migration of charges from one surface to the other. However, a dielectric is 'transparent' to electrostatic fields so that the charge, irrespective of its distribution between the two surfaces, is equally 'visible' from both signal electrodes so that your object is defeated. You might attribute this failure to the fact that, although you have provided good d.c. insulation, the two surfaces are still connected together for a.c. by the large capacitance existing between the surfaces separated by a thin dielectric. You might then try a very thick diaphragm (thick compared with the working air gaps) or, with great ingenuity, two diaphragms connected mechanically to take the electrostatic pull but sufficiently separated to reduce the capacitance to a negligible value. If you succeeded in this, your loudspeaker would then fail for another reason—you would find that you had open-circuited the only path through which the amplifier could send its signal.

The situation may be summarized briefly thus: Providence has decreed that the diaphragm be endowed with a small measure of negative stiffness; you may disdain the gift, but you can refuse it only by the drastic expedient of keeping your loudspeaker permanently disconnected.

T. C. NUTTALL

Cinema-Television Ltd.,
London, S.E.26.
30th January 1956.

NATIONAL PHYSICAL LABORATORY

Professor G. B. B. M. Sutherland, Sc.D., F.R.S., Professor of Physics and Director of the Biophysics Research Centre in the University of Michigan, has been appointed Director of the National Physical Laboratory in succession to Sir Edward C. Bullard, Sc.D., F.R.S. Until Professor Sutherland takes up his appointment, R. L. Smith-Rose, C.B.E., D.Sc., M.I.E.E., Director of Radio Research in the Department of Scientific and Industrial Research, has been appointed Acting Director. Prior to his appointment at the University of Michigan, Professor Sutherland was Reader in Spectroscopy at Cambridge.

D.S.I.R.

Professor H. W. Melville, F.R.S., has been appointed Secretary to the Committee of the Privy Council for Scientific and Industrial Research in succession to Sir Ben Lockspeiser, K.C.B., F.R.S., who is retiring.

INSTITUTE OF RADIO ENGINEERS

L. C. Jesty, B.Sc., M.I.E.E., Chief of the Television Research Group, Marconi Research Laboratories, has been elected a Fellow of the Institute of Radio Engineers "for leadership and personal contributions in the development and evaluation of television systems".

NEW BOOKS

Transistor Electronics

By ARTHUR W. LO, RICHARD O. ENDRES, JAKOB ZAWELS, FRED D. WALDHAUER and CHUNG-CHIH CHENG. Pp. 521 + xii. Prentice-Hall, Inc., U.S.A. British Agents:—Bailey Bros. & Swinfen Ltd., 46 St. Giles High Street, London, W.C.2. Price 96s.

The initial chapters cover physical concepts, equivalent circuits, the basic forms of amplifier circuit and bias circuits. Two chapters are then devoted to low-frequency and power amplifiers.

In Chapter 7, the additional concepts required for high-frequency operation are introduced and, in Chapter 8, there is a return to the physical aspects of the transistor. The remaining four chapters deal with high-frequency amplifiers, oscillators, modulation and demodulation and pulse circuits.

Except in Chapter 8, on the interpretation of transistor parameters, the mathematical level does not often go beyond the ordinary algebra of circuit analysis although, in a few places, equations are expressed in matrix form.

The book deals, in the main, with the junction transistor and the authors have invented a new graphical symbol for it, so that it may be readily distinguished from the point-contact transistor. It is very similar in its general effect to the ordinary valve symbol.

The treatment generally is based upon equivalent circuits for the transistor. There are the usual ones for low frequencies, but at high frequencies other, much more complex, types make their appearance.

The book gives a good general treatment of the transistor and can be recommended to those who want more than an elementary discussion but yet do not wish to venture into the higher mathematics.

W.T.C.

Impulstechnik

A series of lectures edited by DR. F. WINCKEL. Pp. 346 + viii with 242 illustrations. Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price D.M. 37.50.

This is a series of lectures arranged by the extra-mural department of what is now called the Technical University of Berlin-Charlottenburg, in conjunction with the Berlin Elektrotechnischen Verein.

In all transmission systems there is an increasing use of pulse modulation in place of amplitude modulation. In these lectures the various problems that arise in the production and use of pulse modulation are explained and discussed by a number of experts who have specialized in the various fields.

The first lecture by Dr. Fischer of Darmstadt deals very fully with the mathematical analysis of pulses and their modulation. The second lecture by Dr. Meyer-Eppler of Bonn University discusses the application of information theory to pulse problems, while the third by Prof. Kroebel of Kiel explains the use of pulse technique in measurements in physics. The fourth lecture is by Dr. Holzwarth of Siemens and Halske, Munich, and deals with frequency bandwidth, noise and interference. The fifth lecture is by W. Bruch of the Telefunken Co. and discusses the application of pulse technique to television, while the sixth, by Dr. Kramar of the Lorenz Co., Stuttgart, explains its application to radio navigation. The seventh lecture by Dr. W. Dieminger is on the application of pulse technique to exploration of the ionosphere, and the eighth by Dr. Speiser of the Zurich Institute for Applied Mathematics is on impulse problems in electronic calculating machines. The ninth lecture by Dr. Hermann of the A.E.G., Berlin, deals with pulse technique in optics, the tenth by Dr. H. Fack with the transmission of pulses in the nervous system. The final chapter, also by Dr. Fack, is outside the series of lectures on which the book is based and is added as a complementary appendix to his lecture on the nervous system. It deals with the application of information theory to the nervous system, with special reference to hearing and, as an indication of the thoroughness of the treatment, we may mention that thirty-five pages are devoted to the information capacity of the ear.

Most chapters conclude with a large number of references to the literature of the subject, the total for the eleven chapters being 347. The book is very well produced and illustrated; it is undoubtedly a valuable addition to the literature of the subject.

G.W.O.H.

Die Laplace-Transformation und ihre Anwendung in der Regelungstechnik

Compiled by R. HERSCHEL. Pp. 142 with 71 illustrations. Verlag R. Oldenbourg, Rosenheimer Strasse 145, Munich, Germany. Price D.M. 12.80.

In April 1954, the Society for Applied Mathematics and Mechanics in Munich established a committee to deal specially with the mathematics of control circuits and systems. This committee held their first public meetings in Essen in October 1954, when three days were devoted to the reading and discussion of eleven papers on the application of the Laplace transformation to the calculation of control systems. A general knowledge of the fundamental theory of such systems and of their practical applications was assumed, the main object of the lectures being to show the important part that the Laplace transformation can play in the subject.

The eleven papers which are contained in this volume, have been revised by the authors and modified and extended to take into account points raised in the discussion. R. Herschel, who gave one of the lectures, has acted as editor, and has made the eleven papers, so far as possible, into one organic whole. Some overlapping is an advantage, as the reader will be shown things from several different points of view.

The authors of the eleven papers are as follows:—Dr. W. Oppelt, Frankfurt; Prof. G. Doetsch, Freiburg; R. Herschel, Constance; Dr. St. Schottlaender, Würzburg; Dr. J. Dörr, Darmstadt; Prof. A. Leonhard, Stuttgart; Prof. O. Schäfer, Frankfurt; Prof. K. Küpfmüller, Darmstadt; Dr. R. C. Oldenbourg, Munich; Prof. H. F. Schwenkhagen, Wuppertal; J. Peters, Hamburg. The first paper lays foundations by developing the formulae of the feedback or servo system; the second paper, which occupies about a quarter of the book, is devoted to a very complete description of the Laplace transformation. In the following eight papers the Laplace transformation is applied in various ways to various problems that arise in connection with control systems. The final paper deals with the application to control systems of the methods employed in communication systems, the Laplace transformation being regarded as a sort of common denominator.

The book has evidently been carefully prepared and as the joint effort of eleven scientists it can be unreservedly recommended to anyone with the necessary knowledge of German.

G.W.O.H.

Electronic Transformers and Circuits (2nd Edition)

By REUBEN LEE. Pp. 360 + xvi. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 60s.

This book is mainly concerned with the operating principles and design of small power transformers and is noteworthy for the large number of design charts included. The value of some of these is limited slightly to the British user because of the adoption, natural enough in an American book, of American wire gauges.

The theory is very elementary, but probably adequate, since most users of the book will doubtless rely mainly on the charts for design purposes. Rectification, and its effect on the transformer, is dealt with on the basis of Schade's work and, again, largely by means of graphs.

It is a good feature of the book that the treatment is not restricted to 60 c/s. "High-frequency" supplies of up to a few kc/s are covered. Audio-frequency transformers are dealt with, though much less thoroughly, and there is a chapter on pulse transformers in which line-scan transformers are mentioned.

Ferrites and dust-iron are considered rather superficially and in one chapter things like i.f. transformers and r.f. tuning coils are discussed. These seem out of place, for the treatment is quite inadequate and they are, in any case, but little related to the main theme of the book.

W. T. C.

I.E.E. Awards

The 34th award of the Faraday Medal has been made by the Institution of Electrical Engineers to Professor G. W. O. Howe, D.Sc., LL.D, M.I.E.E., for "his pioneering work in the study and analysis of high frequency oscillations and on the theory of radio propagation; and for his outstanding contributions to engineering education".

Professor G. W. O. Howe, D.Sc., LL.D.

From 1921 until his retirement in 1946, Professor Howe was the James Watt Professor of Electrical Engineering in Glasgow University. For nearly 30 years he has been Technical Editor of *Wireless Engineer.*

The Institution of Electrical Engineers has elected to Honorary Membership, Colonel Sir Arthur Stanley Angwin, K.B.E., D.S.O., M.C., T.D., D.Sc.(Eng.), "in recognition of his outstanding life's work in the field of telecommunication".

OBITUARY

Dr. Eric C. S. Megaw, director of physical research at the Admiralty since 1951, died on 25th January at the age of 48. He was for 16 years in the G.E.C. Research Laboratories and left in 1946 to join the Admiralty Signal and Radar Establishment where he became superintendent of research. He received the Duddell Premium of the I.E.E. for his work on methods of generating super-high frequencies.

Norman Charles Robertson, C.M.G., M.B.E., died on 1st April at the age of 47. He had been with E. K. Cole, Ltd., since 1930 except for two years' voluntary service with the Ministry of Supply when, in 1951, he became director-general of electronics production. He was appointed tc the Board of Directors of E. K. Cole, Ltd., in 1943 and became deputy managing director in 1945.

MECHANICAL HANDLING EXHIBITION

This exhibition, which is organized by *Mechanical Handling*, is being held at Earls Court from 9th to 19th May. There will be more than 250 exhibitors and associated with the exhibition will be the first international Convention with papers from Britain, Ceylon, Switzerland, U.S.A., Canada, Australia and Germany.

Tickets for the various sessions of the Convention and also tickets of admission to the exhibition are obtainable from Mechanical Handling Exhibition, Dorset House, Stamford Street, London, S.E.1. The exhibition is open to the public, admission 2s. 6d., from 10 a.m. to 6 p.m.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for January 1956

Date 1956 January	Frequency deviation from nominal: parts in 10^8	
	MSF 60 kc/s 1429-1530 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.
1	−0·1	−1
2	−0·1	−1
3	−0·2	−1
4	−0·2	0
5	−0·2	0
6	−0·2	−1
7	−0·1	0
8	−0·1	+1
9	−0·1	+1
10	−0·1	0
11	−0·4	0
12	−0·4	0
13	−0·4	+1
14	N.M.	+2
15	N.M.	N.M.
16	−0·3	0
17	−0·3	+1
18	−0·3	+1
19	−0·3	+1
20	−0·3	+1
21	−0·3	+1
22	−0·3	+2
23	−0·3	+2
24	−0·2	+2
25	−0·3	+2
26	−0·2	+2
27	−0·3	+1
28	−0·3	+3
29	−0·3	+1
30	−0·2	+1
31	−0·2	+1

The values are based on astronomical data available on 1st February 1956.

N.M. = 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 + 538.566 — 641

On the Focusing Effect of Reflection and Refraction in a Velocity Gradient.—Noble. (See 729.)

534.2 + 538.566 — 642

Dispersion and Simple Harmonic Point Sources in Wave Ducts.—Tolstoy. (See 730.)

534.2-14 — 643

Theory of Continuous-Tone [underwater] Reverberation.—G. A. Klotzbaugh. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 956–961.)

534.2-14 — 644

Continuous-Tone Underwater Reverberation.—P. Conley. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 962–966.)

534.23-8 : 546.431.824-31 — 645

Ultrasonic Shutter.—C. L. Darner & R. J. Bobber. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 908–912.) The transmission of ultrasonic radiation by a $BaTiO_3$ transducer can be controlled by connecting a suitable electrical network to the electrodes. An intensity range of 40 dB can be covered at resonance conditions. The network can be constituted by a carbon microphone, when the ultrasonic beam can be modulated by speech.

534.232 — 646

Directed Sound.—K. Feik. (*Hochfrequenztech. u. Elektroakust.*, Sept. 1955, Vol. 64, No. 2, pp. 35–62.) Comprehensive analysis is presented leading to the derivation of the radiation characteristics of arrays with linear, ring, spherical, and other arrangements. 40 references.

534.232 : 537.228.1 — 647

On the Determination of Electromechanical Coupling Coefficients in a Polyresonant Piezoelectric Vibrator.—E. A. G. Shaw. (*Canad. J. Phys.*, Sept. 1955, Vol. 33, No. 9, pp. 504–508.) The well known relation between the electromechanical coupling coefficient and the separation σ of resonance and antiresonance frequencies requires modification where several significant modes occur within a small frequency interval. An approximate expression is given for the values of σ which would arise if each mode existed alone, in terms of the many-moded system.

534.613-8 — 648

Experimental Studies on Acoustic Radiation Pressure.—E. M. J. Herrey. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 891–896.) Experiments are discussed in which a beam of ultrasonic radiation in water is intercepted by an absorbing or a reflecting disk. Evaluation of the normal and shearing components of the radiation pressure indicates that the latter is properly represented by an anisotropic stress tensor. The technique provides a simple means for measuring the power of a transducer or the reflection, transmission and absorption coefficients of materials. Results of some measurements on cork, Al and steel plates are presented.

534.75 — 649

Localization of Sound from Single and Paired Sources.—T. T. Sandel, D. C. Teas, W. E. Feddersen & L. A. Jeffress. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 842–852.) Experiments are described in which a listener indicates the direction of (*a*) a single loudspeaker source, (*b*) a pair of phase-aiding loudspeakers, or (*c*) a pair of loudspeakers in phase opposition, by pointing a further loudspeaker in the direction of the source. The loudspeakers to be located emit tone signals alternating with the wide-band noise emitted by the pointer loudspeaker.

534.75 — 650

Listening to Differentially Filtered Competing Voice Messages.—W. Spieth & J. C. Webster. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 866–871.) Continuation of investigations described previously [2837 of 1954 (Spieth et al.)]. In nearly all cases, differential filtering produced an improvement in the ability of an air-control-tower operator to attend to two messages overlapping in time. Details are given of results for different cut-off frequencies.

534.78 651

Vowel Synthesis by means of Resonant Circuits.—E. S. Weibel. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 858–865.) "Various ways of creating artificial vowels are discussed and compared from the viewpoint of coding efficiency. A method which requires seven parameters to specify any vowel is then introduced and described in detail. It is based on the realization of the transfer impedance of a nonuniform transmission line by lumped elements."

534.78 652

Phonemic Confusion Vectors.—H. M. Moser & J. J. Dreher. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 874–881.) Experiments are described on the recognition of words used for indicating the letters of the alphabet in telecommunications, with special reference to air-traffic procedure.

534.78 653

Auditory Testing of a Simplified Description of Vowel Articulation.—A. S. House & K. N. Stevens. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 882–887.)

534.79 654

The Measurement of Loudness.—S. S. Stevens. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 815–829.) Data regarding the relation between subjective loudness and objective sound intensity are reviewed. The evidence suggests that for the typical listener a loudness ratio of 2:1 corresponds to a pair of sound signals differing by 10 dB. At levels below about 50 dB the loudness of white noise grows more rapidly than that of a 1-kc/s tone; above that level the two increase more nearly proportionally.

534.833.1 655

New Method of Recording the Sound Transmission Loss of Walls as a Continuous Function of Frequency.—R. V. Waterhouse & R. K. Cook. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 967–969.) Voltages derived from microphones in the 'loud' and 'quiet' rooms separated by the wall under test are applied to a potentiometer recorder which balances itself by driving an attenuator. The difference between the sound levels in the two rooms is nearly identical with the loss in the wall. Results for several types of partition are presented graphically.

621.395.61 + 621.395.623.7 656

Limits of Quality of Electroacoustic Transducers.—F. Spandöck. (*Elektrotech. Z.*, *Edn A*, 1st Sept. 1955, Vol. 76, No. 17, pp. 598–604.) The efficiency of transducers is considered; the value for good-quality microphones is about 0·2%, and for loudspeakers about 5%. On the basis of the reciprocity theorem, a general formula is derived for the transmission factor of all reversible transducers; this formula is used to examine the individual importance of the various factors involved. For transducers of known types, no appreciable improvement is to be expected except by development of the magnetic, piezoelectric and mechanical properties of the materials used. 62 references.

621.395.61.089.6 : 534.612 657

Reversion to the Theory of the Gold-Leaf Thermophone.—P. Riéty. (*Ann. Télécommun.*, July/Aug. & Sept. 1955, Vol. 10, Nos. 7/8 & 9, pp. 169–178 & 195–201.) The problem of the absolute calibration of microphones is considered. Past work on the thermophone, on which the C.C.I.T. method is based, has left unexplained discrepancies between the calculated and observed values of the acoustic pressure produced. Analysis is given for static and oscillating conditions; the acoustic pressure is calculated from the value of the estimated temperature close to the gold leaf. Formulae derived are compared with those published previously. For early work see, e.g., *Phys. Rev.*, July 1917, Vol. 10, No. 1, pp. 22–38 (Arnold & Crandall).

621.395.623.52 658

Analysis of Hypex Horns.—R. I. Ścibor-Marchocki. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 939–946.) Impedance transformations for hyperbolic-function horns [829 of 1946 (Salmon)] are derived using the Smith chart.

621.395.623.7 : 537.523.3 659

Corona - Wind Loudspeaker.—D. M. Tombs. (*Nature, Lond.*, 12th Nov. 1955, Vol. 176, No. 4489, p. 923.) Brief note of experimental results obtained using arrays of triodes comprising two point electrodes and an interposed ring electrode which controls the corona wind without requiring a.f. electrical power. The frequency response is good up to 15 kc/s; the radiation pattern is adjustable.

AERIALS AND TRANSMISSION LINES

621.315.212 660

Extremely Uniform Wide-Band Cables.—L. Krügel. (*Telefunken Ztg*, June 1955, Vol. 28, No. 108, pp. 107–115. English summary, p. 134.) In order to achieve adequate uniformity in Type-2·6/9·5 cable, the outer conductors are ribbed to prevent deformation, and diamond dies are used for drawing the inner conductors; the spacers are rigid-dielectric disks.

621.315.212 : 621.372.8 661

Investigations on a Wide-Band Junction between a Coaxial Line and a Waveguide.—E. Belohoubek. (*Arch. elekt. Übertragung*, Sept. & Oct. 1955, Vol. 9, Nos. 9 & 10, pp. 432–440 & 469–474.) Junctions are discussed of the type in which the inner conductor of the coaxial line serves as an aerial inside the waveguide, the latter being provided with a short-circuiting piston. The dependence of bandwidth on aerial length, the eccentricity of the coupling, the position of the piston and aerial diameter is examined. Bandwidth is greatest for mid-band wavelengths about 1·4 a, where a is the width of the waveguide. A description is given of an arrangement for measuring the bandwidth at different frequencies; bandwidths of 20% are realizable at 10-cm λ, with a reflection coefficient $< 2\%$.

621.372.2 662

Reflection in Helical Lines at a Change in the Helix Pitch: Part 2—Mathematical Treatment of the Problem.—G. Piefke. (*Arch. elekt. Übertragung*, Sept. 1955, Vol. 9, No. 9, pp. 402–410.) Part 1: 322 of February.

621.372.2.029.64 : 538.6 663

Application of Electron Plasma in the Production of Nonreciprocal Systems.—A. L. Mikaelyan. (*Bull. Acad. Sci. U.R.S.S., tech. Sci.*, July 1955, No. 7, pp. 23–33. In Russian.) A study of the propagation of e.m. waves between parallel planes or in a coaxial line containing a layer of electron plasma in a steady magnetic field. Nonreciprocal systems for TEM waves are discussed generally; a brief note suggests that an artificial dielectric could be used in place of the plasma or ferrite;

the Hall effect would then be made use of, and no resonance effects would occur in the medium. A similar account is given in *C. R. Acad. Sci. U.R.S.S.*, 1st & 11th Sept. 1955, Vol. 104, No. 1, pp. 72–75 & No. 2, pp. 233–236, also in Russian.

621.372.22 : 621.372.51 **664**

Nonuniform Transmission Lines as Impedance-Matching Sections.—J. Willis & N. K. Sinha. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, p. 1975.) Design analysis is given for lines having better matching properties than the parabolic line described by Yang (3148 of 1955).

621.372.8 **665**

Degenerate Oscillations in Waveguides.—B. Z. Katsenelenbaum. (*Bull. Acad. Sci. U.R.S.S., tech. Sci.*, July 1955, No. 7, pp. 9–22. In Russian.) The perturbation of oscillations in a waveguide due to slight deformations in the walls is considered theoretically.

621.372.8 **666**

Dielectric Transformers for X-Band Waveguide.—I. D. Olin. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 146–147.) Teflon sections are described for (*a*) matching circular to rectangular waveguide, and (*b*) providing a pressure seal for circular waveguide.

621.372.8 : 621.318.134 **667**

Magnetically Controlled Microwave Directional Coupler.—R. W. Damon. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1281–1282.) The coupling effected by a Ni-Zn ferrite cylinder linking two stacked rectangular waveguides is controlled by changes in the sense and magnitude of an applied magnetic field parallel to the electric vector. The coupling in dB is shown plotted against the magnetic field for a typical device operating at 8·4 kMc/s.

621.396.67 : 621.317.3 **668**

Measurements on Receiving Aerials : Part 2.—I. Grosskopf. (*Arch. tech. Messen*, Sept. 1955, No. 236, pp. 195–196.) Part 1 : 3492 of 1955.

AUTOMATIC COMPUTERS

681.142 **669**

On Starting Routines for the C.S.I.R.O. Mark I Computer.—G. W. Hill & T. Pearcey. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 412–416.) This computer was noted in 640 and 641 of 1954 (Pearcey & Hill).

681.142 **670**

An Assessment of the System of Optimum Coding used on the Pilot Automatic Computing Engine at the National Physical Laboratory.—J. H. Wilkinson. (*Phil. Trans. A*, 20th Oct. 1955, Vol. 248, No. 946, pp. 253–281.) Simple examples are given of programs prepared for the pilot ACE, and an assessment is made of the gain in speed resulting from the use of optimum coding in general. The design of the full-scale ACE is described.

681.142 **671**

A Criterion for the Operational Stability of Analogue Mathematical Machines.—M. Parodi. (*C. R. Acad. Sci., Paris*, 24th Oct. 1955, Vol. 241, No. 17, pp. 1104–1105.)

681.142 : 512.831 **672**

Matrices in Analogue Mathematical Machines.—P. M. Honnell & R. E. Horn. (*J. Franklin Inst.*, Sept. 1955, Vol. 260, No. 3, pp. 193–207.) Discussion indicates the usefulness of matrix methods for solving linear differential equations by means of electronic analogue machines.

681.142 : 621.372 **673**

The use of Electronic Analogue Computers with Resistance Network Analogues.—W. J. Karplus. (*Brit. J. appl. Phys.*, Oct. 1955, Vol. 6, No. 10, pp. 356–357.) In the solution of partial differential equations by resistance-network analogues the appropriate voltage required at the nodes of the network may be provided automatically by connecting standard electronic-analogue-computer units to each node. This procedure combines the speed of the computer method of solution with the inherent accuracy of the resistance-network analogue.

681.142 + 621.318.5](47) : 016 **674**

List of Russian and Translated Literature on the Theory of Relay-Contact [switching] Circuits for 1950–1954.—Povarov. (See 680.)

681.142 : 517 **675**

Approximations for Digital Computers. [Book Review]—C. Hastings, Jr. Publishers: Princeton Univ. Press, Princeton, N.J., 1955, 201 pp., $4. (*Science*, 30th Sept. 1955, Vol. 122, No. 3170, p. 602.) The adaptation of special functions for purposes of machine computing is described and illustrated; Tchebycheff approximations are used.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.012 : 537.312.6 **676**

The A.C. Admittance of Temperature-Dependent Circuit Elements.—R. E. Burgess. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 766–774.) The general relations between the isothermal and steady-state I/V characteristics of a temperature-dependent device are deduced. Analysis is presented for the small-signal admittance in terms of the thermal admittance. The reactive components due to the thermal inertia and the turnover characteristics exhibited when the a.c. resistance is negative are examined with reference to equivalent circuits. Where heat loss from the device is by a path which is not 'thermally short', the thermal admittance is determined from the diffusion equation. This is done for the case of one-dimensional conduction along the supporting wires of a thermistor or lamp, and for the case of radial conduction from the contact in a point-contact rectifier.

621.314.2 : 621.375.227.029.3 **677**

UL ['ultralinear'] Output Transformers.—D. M. Leakey & R. B. Gilson. (*Wireless World*, Jan. 1956, Vol. 62, No. 1, pp. 29–32.) Factors affecting the stability, particularly at high frequencies, of 'ultralinear' push-pull output stages are discussed and a practical circuit is described. Avoidance of cross-coupling between the push-pull valves and correct design of the output transformer, details of which are presented, will usually ensure stability without additional circuitry.

621.316.825 : 621.3.011.21 **678**

Impedance of a Thermistor at Low Frequencies.—F. J. Hyde. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 303–313.) The small-signal impedance of a directly heated thermistor has been measured at frequencies between 0·116 and 2·34 c/s, and the effective circuit time-constant of the same thermistor has been measured as a function of the magnitude of an external series resistance. Assuming the cooling process is Newtonian, the results are in accord with the equivalent circuit proposed by Burgess (676 above).

621.318.5 : 621.318.134 679

New Type Ferrite Microwave Switch.—R. F. Sullivan & R. C. LeCraw. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1282–1283.) Discussion of a switch comprising a ferrite rod arranged axially in a cylindrical cavity fed and terminated by rectangular waveguides. When a longitudinal magnetic field is applied the cavity is detuned for certain modes and the plane of polarization is rotated; the output waveguide acts as a polarization filter. Good isolation is obtained over a wide range of magnetic-field values. Advantages over the rotation-type switch are indicated.

621.318.5 + 681.142](47) : 016 680

List of Russian and Translated Literature on the Theory of Relay-Contact [switching] **Circuits for 1950–1954.**—G. N. Povarov. (*Avtomatika i Telemekhanika*, July/Aug. 1955, Vol. 16, No. 4, pp. 411–420 and correction sheet.) A bibliography on computers is included.

621.318.57 : 621.383.4 : 535.37 681

Opto-electronic Devices and Networks.—Loebner. (See 931.)

621.372 : 512.8/.9 682

Tensor Analysis and Linear Network Theory.—R. Braae. (*Trans. S. Afr. Inst. elect. Engrs*, Aug. 1955, Vol. 46, Part 8, pp. 233–239.) Discussion on 2553 of 1955.

621.372 : 512.9 683

Examination of the 'Negative Frequency' Concept.—A. P. Bolle & J. L. Bordewijk. (*J. Brit. Instn Radio Engrs*, Nov. 1955, Vol. 15, No. 11, pp. 582–587. Reprinted from *PTT Bedrijf*, Oct. 1954, Vol. 6, No. 2.) Circuit-operation analysis is simplified by considering the angular velocity of the vectors representing signals as a combination of a positive and a negative velocity. Applications include the study of time-variable networks, intermodulation noise, Fourier series and the Fourier integral.

621.372.4.011.1 684

Derivation of Two-Pole Function with Prescribed Complex Values within a Partial Range of Real Frequencies.—W. Krägeloh. (*Arch. elekt. Übertragung*, Aug.–Oct. 1955, Vol. 9, Nos. 8–10, pp. 375–380, 419–431 & 479–483.) Two solutions are presented in detail for the problem of deriving a two-pole (positive) function which is a satisfactory approximation to a complex function prescribed graphically.

621.372.413 685

Cavity Resonators with Non-orthogonal Boundaries.—E. Ledinegg & P. Urban. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 335–350.) Analysis based on the particular-integral method described by Hahn (1336 of 1941) is presented for resonators of arbitrary cylindrical form.

621.372.413 686

On Representation of Electromagnetic Fields in Cavities in Terms of Natural Modes of Oscillation.—S. A. Schelkunoff. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1231–1234.) Statements made by Teichmann & Wigner (2268 of 1953) are discussed. The assumption that when a cavity is short-circuited one mode is automatically suppressed is shown to be incorrect.

621.372.45 687

Circuits with Nonlinear Resistance.—A. Liebetegger. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, pp. 24–29.) Analysis is presented for circuits comprising a diode in series with linear impedances which may consist of *R*, *L*, *C*, or a combination of these.

621.372.5 688

Transformation Rules for Noisy Quadripoles.—W. Dahlke. (*Arch. elekt. Übertragung*, Sept. 1955, Vol. 9, No. 9, pp. 391–401.) Experimental determination of the noise parameters [2568 of 1955 (Rothe & Dahlke)] becomes difficult at h.f. because of lead reactances; formulae for the transformations thus introduced are derived and tabulated.

621.372.5 689

Transient Response Calculation.—O. P. D. Cutteridge. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, pp. 29–30.) Advantages of the method using standard gain/frequency curves over the linear-segment method described by Sarma (2559 of 1955) are indicated.

621.372.5 : 621–526 690

The Response Functions and Vector Loci of First and Second Order Systems.—D. Morris. (*Electronic Engng*, Sept.–Dec. 1955, Vol. 27, Nos. 331–334, pp. 402–404, 442–444, 499–501 & 546–548.) Techniques for applying Nyquist's stability criterion to determine the behaviour of automatic control systems operating according to equations of the first degree in frequency are summarized; constructions are given for determining the vector loci of the functions relating performance and frequency. Second-order low-Q systems having a circular vector response locus, giving symmetrical resonance curves, are discussed and the theory of the bandwidth method for determining Q is deduced. Passive and active second-order systems are considered which have finite response at zero frequency and an antiphase or a quadrature zero-limit at infinite frequency, with 'cordiform' vector loci. All second-order response loci may be expressed in terms of two basic loci.

621.372.5 : 621.396.822 691

The Noise Factor of Four-Terminal Networks.—A. G. T. Becking, H. Groendijk & K. S. Knol. (*Philips Res. Rep.*, Oct. 1955, Vol. 10, No. 5, pp. 349–357.) A simple formula is derived on the basis that the noise properties of the network can be characterized by two noise sources introduced at the input; these sources and their correlation are determined by four quantities which can be evaluated from measurements.

621.372.5.024 : 621.387 692

A D.C.-Coupled Circuit using Voltage-Stabilizing Valves.—G. W. G. Court. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 549–550.) Voltage-stabilizing valves connected in series are used to transfer d.c. voltage variations from an initial reference level of +150 V to a level of −450 V, providing the reflector potential of a klystron oscillator.

621.372.543.2 693

Staggered Triple Crystal Filter.—D. E. Hildreth. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 166–167.) Narrow-band filters with very sharp cut-off characteristics are more simply obtained with piezoelectric crystals than by the usual lattice construction over the frequency range 400 kc/s–5 Mc/s. A typical filter has a bandwidth of 400 c/s at 3 dB attenuation and 800 c/s at 40 dB attenuation, centred on 400 kc/s.

621.372.56.027.7 **694**

Compensated Precision High-Voltage Attenuator.—J. G. Cottingham. (*Rev. sci. Instrum.*, Sept. 1955, Vol. 26, No. 9, pp. 876–877.) The frequency response of a voltage divider consisting of twelve 2·5-MΩ units enclosed by metal corona shields is made linear up to 200 kc/s by connecting capacitances between the shields and the high-voltage source, thus compensating for the capacitance to ground.

621.372.57 : 621.316.721 **695**

Some High-Impedance Current-Generating Circuits.—J. H. McGuire. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 529–531.) A basic circuit is described and practical designs are developed for the efficient generation of current waveforms which are independent of the load impedance.

621.373 : [621.314.632 + 621.316.825 **696**

Electrical Oscillations in Thermistors and Germanium Point-Contact Rectifiers.—R. E. Burgess. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 297–302.) The conditions for small-amplitude oscillations in nonlinear temperature-dependent circuit elements are deduced analytically and discussed in relation to thermistors and Ge point-contact rectifiers, whose impedance comprises inductive reactance in series with a resistance which can be made negative, so that these devices can sustain oscillations when shunted with a suitable capacitance. The upper limiting frequency and the dependence of frequency on the shunt capacitance are deduced in terms of the fundamental parameters. Departures from the postulated model which can arise with the point-contact rectifier are discussed.

621.373.421 **697**

Constant-Frequency Oscillators.—A. S. Gladwin. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, pp. 13–19.) "The conditions for the frequency of a regenerative oscillator to be independent of changes in the input and output resistances of the maintaining amplifier are derived. It is shown that the input, output, and transfer impedances of the feedback network must be resistive at the oscillation frequency. This can be achieved by inserting reactances of definite specified values in the input and output leads. Expressions for the value of these reactances are derived for the usual type of *LC* oscillator with mutual-inductance coupling. The values depend greatly on whether the losses in the coils can be represented mainly by a series or by a parallel resistance. Expressions for the stability of an imperfectly-stabilized oscillator are also derived. The results are compared with those obtained by Llewellyn. It is shown that the values of stabilizing reactances specified by Llewellyn are not in general satisfactory, though in some instances they may produce a marked improvement in stability. Full experimental confirmation is given."

621.373.43 **698**

A Sufficiently Fast and Economical Sweep Circuit.—D. Brini, L. Peli, O. Rimondi & P. Veronesi. (*Nuovo Cim.*, 1st Sept. 1955, Vol. 2, No. 3, pp. 644–646. In English.) A circuit giving sweep times from 40 mμs to 3 μs is based on a design described by Moody et al. (2730 of 1952) using secondary-emission valves.

621.375.2.029.3 : 621.396.712.2 **699**

Peak-Limiting Amplifiers.—R. Yadav. (*J. Instn Telecommun. Engrs, India*, Sept. 1955, Vol. 1, No. 3, pp. 147–154.) A description is given of a circuit designed by All India Radio; the steps taken to reduce the attack time to $<16\ \mu s$ are indicated. The control range above threshold is 15 dB and the compression ratio is 10:1.

621.375.221.029.63 **700**

Wide-Band Amplifier for U.H.F. Receivers.—R. B. McWhirt. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 158–160.) A detailed design is given for an amplifier using a Type-416B planar triode, providing 5–10 dB gain, with a bandwidth $>$ 200 Mc/s centred on 1·1 kMc/s.

621.375.23.029.3 **701**

Tetrodes with Screen Feedback.—(*Wireless World*, Jan. 1956, Vol. 62, No. 1, pp. 24–26.) The operation of the 'ultralinear' a.f. amplifier [1512 of 1952 (Hafler & Keroes)] is discussed; the advantage is that triode performance as regards low inherent distortion is combined with power efficiency approaching that of a pentode.

621.375.4 : 621.314.7 **702**

Some Properties and Circuit Applications of Super-Alpha Composite Transistors.—Pearlman. (See 927.)

621.375.4 : 621.314.7 **703**

Bases for the Calculation of Transistor Amplifiers with Series and Parallel Feedback.—W. Benz. (*Telefunken Ztg*, June 1955, Vol. 28, No. 108, pp. 95–107. English summary, pp. 133–134.) The various possible arrangements are classified and discussed in terms of network theory. Relevant definitions, inter-relations, equivalent circuits and formulae are set out in ten tables.

621.375.4 : 621.314.7 **704**

The Equations and the Equivalent Circuit of the Transistor.—Skalicky. (See 928.)

621.375.4 : 621.314.7 **705**

Germanium Transistor Amplifiers Stable to 95°C.—W. Greatbatch & W. Hirtreiter. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, p. 1974.) Though transistors are available whose current gain does not change greatly on heating up to 100°C, the operating point of the corresponding amplifier circuit may shift appreciably at far lower temperatures. In a particular circuit using two transistors the operating point can be stabilized by including a parallel-*RLC* network in a feedback loop. Si units can be stabilized at temperatures above 100°C.

GENERAL PHYSICS

53.088.3 **706**

Correcting for Running Means by Successive Substitutions.—R. N. Bracewell. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 329–334.) The proposed procedure leads to a divergent result but is nevertheless useful in many practical cases.

530.145.6 : 621.385.833 **707**

Wave Mechanics Theory of Electron-Optical Image Formation: Part 2.—W. Glaser & G. Braun. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 267–296.) Part 1 : 2253 of 1955.

534.372 **708**

Connection between the Logarithmic Decrement of Attenuation and the Fractional Attenuation of the Amplitude of Potential Energy (Cyclical Viscosity).—D. I. Shil'krut. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1955, Vol. 104, No. 2, pp. 237–238. In Russian.) Earlier experimental evidence on torsional and other oscillations suggests that the logarithmic decrement, δ, is time-dependent. It may be expressed by the formula

$2\delta = \Delta a/a - \Delta c/c$, where a is the total energy of oscillation, Δa the energy loss per cycle, c the potential energy for unit amplitude and Δc the change in c per cycle; c is a function of time.

535.376 **709**

Reinforcement of the Electroluminescence of Certain Crystals by Rotation in the Field.—G. Destriau. (*C. R. Acad. Sci., Paris*, 3rd Oct. 1955, Vol. 241, No. 14, pp. 869–870.) When electroluminescent crystals are embedded in a dielectric and not in contact with the field electrodes, luminescence is normally observed only in alternating fields, though it can be produced in direct fields by rotating the crystals. Experimental evidence is now reported that the luminescence in an alternating field is enhanced by rotating the crystals. Long-term falling off of electroluminescence may be partly due to surface effects at the crystal/dielectric boundary, these effects being eliminated when the crystals are continually displaced.

535.41 : 535.215 **710**

Photoelectric Mixing of Incoherent Light.—A. T. Forrester, R. A. Gudmundsen & P. O. Johnson. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1691–1700.) Experiments are described in which beats were obtained between incoherent light sources by mixing Zeeman components of a visible spectral line at a photoemissive surface. A 3-cm-λ cavity-resonator arrangement was used for detection. The results are consistent with the view that the photoelectric emission probability is proportional to the square of the resultant electric-field amplitude, implying interference between light from independent sources. The results also indicate that any time delay between photon absorption and electron emission must be significantly less than 10^{-10} sec.

537.311.62 **711**

Effect of Collisions between Electrons on Electrical Conductivity and Skin Effect in Metals.—V. L. Ginzburg & V. P. Silin. (*Zh. eksp. teor. Fiz.*, July 1955, Vol. 29, No. 1 (7), pp. 64–74.) Theoretical considerations indicate that the results of the theory of the anomalous skin effect are not greatly affected by taking electron collisions into account. The work on the anomalous skin effect and the reflectivity of metals by Benthem & Kronig (3523 of 1954) is criticized.

537.322.3 **712**

Measurements of the 3rd-Order Thermoelectric Single-Material Effect (1st Benedicks Effect).—G. Kocher. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 210–226.) The coefficient c_3 in the formula $u = c_3 . \Delta t^3$, where u is the e.m.f. and Δt is the temperature difference, was determined experimentally using small rectangular loops of Pt, Au, and Ag, heated and cooled at two diametrically opposite points. For a loop of dimensions 38 × 58 mm made of material with cross-section 4 mm², the value of c_3 was about $-2{\cdot}7 \times 10^{-14}$ V/deg³ for Pt, $-4{\cdot}6 \times 10^{-15}$ for Au, and $-2{\cdot}6 \times 10^{-15}$ for Ag.

537.322.3 **713**

Remarks on the 1st Benedicks Effect.—W. Meissner. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 227–228.) Comments on paper by Kocher (712 above). The coefficient c_3 may be a function of Δx, the distance between the two points with temperature difference Δt; this is of importance when Δx is smaller than the mean free path of the conduction electrons.

537.5 **714**

Traveling Density Waves in Positive Columns.—S. Watanabe & N. L. Oleson. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1701–1704.) "The continuity equations for positive ions and for electrons coupled to each other by the Coulomb force and the effect of ionizing collisions have a solution representing traveling density waves whose frequencies are widely different from the usual plasma oscillations."

537.52 : 538.56 **715**

Amplification of 1-cm Waves in the Helium Negative Glow.—Z. Geller & W. Low. (*Nature, Lond.*, 26th Nov. 1955, Vol. 176, No. 4491, pp. 1021–1022.) A detailed examination was made of the attenuation of 1·25-cm-λ waves in an abnormal discharge in He at a pressure of 1–3 mm Hg, by directing a beam from a klystron at right angles to the discharge and detecting the radiation transmitted. A graph shows attenuation as a function of distance from the discharge-tube cathode for given discharge conditions. Negative attenuation values are observed at distances around 13 mm; the electron density in this region is estimated to be about 7×10^{12}/cm³. The amplification may be due to plasma oscillations; a secondary dip in the attenuation curve may be due to a harmonic.

537.525 : 621.3.029.53/.55 **716**

Influence of a Transverse Magnetic Field on the Breakdown Voltage of a Gas Discharge at High Frequency.—L. Ferretti & P. Veronesi. (*Nuovo Cim.*, 1st Sept. 1955, Vol. 2, No. 3, pp. 639–643.) Measurements were made on tubes with cylindrical electrodes containing air at pressures of 0·1, 0·5 and 1 mm Hg, at frequencies from 10 to 50 Mc/s, with magnetic fields of strength 0–650 G. Results are presented graphically and discussed in relation to those of Herlin & Brown (3390 of 1948).

537.533 : 537.311.33 **717**

Field Emission from Semiconductors.—R. Stratton. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 746–757.) Theory is presented derived from that developed by Fowler & Nordheim for field emission from metals (*Proc. roy. Soc. A*, 1st May 1928, Vol. 119, No. 781, pp. 173–181). If there are an appreciable number of surface states, the emission current is very low until the field is strong enough to break down the internal barriers. When this occurs, or if there are no surface states, the field penetrates into the semiconductor, lowering the conduction-band edge. This causes degeneracy near the surface and greatly enhanced emission. Emission associated with surface states is temperature dependent while emission associated with field penetration is not.

537.533 : 621.385.83 **718**

Relation between an Arbitrary Field $\vec{B}(r, \phi, z)$ and the Field of Revolution $\vec{B^R}(r, z)$ such that $B^R{}_z(0, z) = B_z(0, z)$. Applications.—P. Gautier. (*C. R. Acad. Sci., Paris*, 10th Oct. 1955, Vol. 241, No. 15, pp. 930–932.) Electron-optical analysis using cylindrical coordinates leads to a theorem on the measurement of an arbitrary magnetic field by means of search coils with rotational symmetry.

537.533.74 : [546.74 + 546.77 **719**

Inelastic Scattering of Electrons by Ni and Mo Targets.—A. R. Shul'man & I. I. Farbshtein. (*C. R. Acad. Sci. U.R.S.S.*, 1st Sept. 1955, Vol. 104, No. 1, pp. 56–59. In Russian.) An experimental investigation is briefly reported. Energy-loss peaks for electrons inelastically scattered by Mo were observed at 5·5, 11·6 and 17 ± 0·8 V and these values were independent of the energy of the incident electrons in the range from 40 to 120 eV. In scattering by Ni the peak occurred at 12·5 ± 0·5 V. The results for the Mo target agree to within 11% with the values calculated for molybdenum oxide, and evidence that such a film was probably present in spite of precautions was also obtained from secondary-emission measurements.

537.533.8 720
Theory of Secondary Electron Emission from Solids.—H. Fröhlich. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 657–660.) In the derivation of a formula permitting the calculation of the yield of secondary electrons from the yield of photoelectrons, the primary particle is replaced by a moving point charge. The electric displacement is developed in a Fourier series in time and to each frequency a photoelectron yield is ascribed.

537.56 : 538.56 721
Eigen Oscillations of Compressible, Ionized Fluids.—R. E. Loughhead. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 416–418.) The frequencies of eigen-oscillations are derived from the hydromagnetic equations for a compressible fluid of infinite electrical conductivity for uniform-magnetic-field regions bounded by cylindrical and plane-parallel surfaces.

537.56 : 538.6 722
Hydromagnetic Stability of a Current Layer.—R. E. Loughhead. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 319–328.) "The hydromagnetic stability of a uniform current flowing along a magnetic field and confined within a pair of parallel planes is discussed by the method of normal modes. The condition for marginal stability is derived and discussed with reference to two special cases. It is also shown that the velocity of Alfvén waves along a magnetic field in a region bounded by parallel planes is reduced due to the inertia of the surrounding medium."

537.56 : 538.6 723
Solution of Problems involving the Hydromagnetic Flow of Compressible Ionized Fluids.—R. E. Loughhead. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1678–1681.) "The characteristic forms of the hydromagnetic equations for a compressible fluid are examined from the viewpoint of obtaining by the method of finite differences numerical solutions for continuous initial value problems involving unidimensional motion of the fluid."

537.562 : [537.29 + 538.69 724
Velocity-Distribution Function of Electrons in Alternating Electric and Constant Magnetic Fields.—A. V. Gurevich. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1955, Vol. 104, No. 2, pp. 201–204. In Russian.) A calculation similar to that of Jancel & Kahan (1995 of 1953) on the e.m. effects in the ionosphere is presented and some errors in that paper are indicated. Using the calculated velocity distribution, the mean electron energy and the plasma conductivity are calculated.

538 : 536.48 725
Conference on Low-Temperature Magnetism: Kharkov, 1st–3rd July 1954.—(See 822.)

538.11 726
The Spin-Wave Theory of Antiferromagnetism.—W. Marshall. (*Proc. roy. Soc. A*, 11th Oct. 1955, Vol. 232, No. 1188, pp. 69–77.) Following a discussion of antiferromagnetism (*ibid.*, pp. 48–68) with particular reference to the calculations of Kubo (*Rev. mod. Phys.*, Jan. 1953, Vol. 25, No. 1, pp. 344–351), various criticisms of the spin-wave theory are considered; conclusions drawn from this theory, particularly as to the conditions required for antiferromagnetism, are not to be relied upon.

538.114 727
Quantum Theory of Ferromagnetism.—S. V. Vonsovski, K. B. Vlasov & E. A. Turov. (*Zh. eksp. teor. Fiz.*, July 1955, Vol. 29, No. 1 (7), pp. 37–50.)

538.24 728
Dependence of Magnetic Viscosity on Dimensions of Specimens.—A. N. Remizov. (*C. R. Acad. Sci., U.R.S.S.*, 21st Sept. 1955, Vol. 104, No. 3, pp. 389–390. In Russian.) Results are presented graphically of an experimental investigation on cylindrical armco specimens of lengths up to 50 cm and diameters up to 10 mm.

538.566 + 534.2 729
On the Focusing Effect of Reflection and Refraction in a Velocity Gradient.—W. J. Noble. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 888–891.) Analysis based on geometrical optics is presented for wave propagation in a stratified medium. Divergence factors are tabulated for four different system configurations.

538.566 + 534.2 730
Dispersion and Simple Harmonic Point Sources in Wave Ducts.—I. Tolstoy. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 897–907.) Analysis is presented for wave propagation in stratified media. An exact solution is obtained for the general case of waves from a point source in a duct by introducing an integral solution due to Brekhovskikh (1394 of 1950).

538.566 : 537.56 731
Theory of Propagation of Plane Waves in Homogeneous Plasma.—G. Winkler. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 414–428.) The theory combines the macroscopic-phenomenological and microscopic-statistical approaches. Assumptions made include: (*a*) that charge-carrier velocity is very much smaller than the velocity of light; (*b*) that the plasma is homogeneous and stationary; (*c*) that the amplitudes of disturbances due to the wave propagation are small; (*d*) that collisions between charge carriers and neutral particles are inelastic; and (*e*) that the electric and magnetic moments of neutral molecules and of ions and the magnetic moments of free electrons may be neglected.

538.566 : 538.6 : 537.56 732
Investigation of the Faraday Effect in a Plasma at 10 kMc/s.—M. Bonnet, M. Matricon & É. Roubine. (*Ann. Télécommun.*, July/Aug. 1955, Vol. 10, Nos. 7/8, pp. 150–158.) Experimental and theoretical investigations are reported. An arrangement comprising a circular waveguide containing a pulsed neon tube was used to demonstrate rotation of the plane of polarization; the magnetic field obtainable in the experimental arrangement was not strong enough to produce gyro-magnetic resonance at the frequency used. Analysis based on bicomplex numbers is presented for propagation in an ionized medium in a magnetic field.

538.566.2/.3 : 537.56 : 538.6 733
The Four Possible Waves in a Magneto-ionic Medium.—J. H. Piddington. (*Phil. Mag.*, Oct. 1955, Vol. 46, No. 381, pp. 1037–1050.) The theory presented shows that a magneto-ionic medium composed mainly

of electrons and heavy ions is quadruply refracting, transmitting four, and only four, different waves. The hydromagnetic ordinary and extraordinary waves are identical with the radio O and E waves, the latter being the limiting case of the former for frequencies at which the motion of the heavy ions is negligible. The other two waves comprise a 'magnetic sound' wave (a type of hydromagnetic wave) and a 'magnetic plasma' (P) wave. The P wave is discussed using transport equations and an explanation is given of non-thermal solar radio noise. The effect of electron pressure on the O and E waves is determined quantitatively. A short account of the work is given in *Nature, Lond.*, 5th Nov. 1955, Vol. 176, No. 4488, pp. 875–876. See also 91 of January and back references.

538.569.4 : 535.34 : 546.21 **734**

Microwave Absorption in Compressed Oxygen.—A. A. Maryott & G. Birnbaum. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, p. 1886.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **735**

Galactic Survey at 400 Mc/s between Declinations −17° and −49°.—R. X. McGee, O. B. Slee & G. J. Stanley. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 347–367.) The survey was carried out using an aerial with beam width of 2° between half-power points. Results are tabulated and contour diagrams of equivalent sky temperature are given. The method of calibrating the equipment in terms of temperature is described.

523.16 : 538.561 **736**

The Observation and Interpretation of Radio Emission from some Bright Galaxies.—B. Y. Mills. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 368–389.) Observations are reported of eight southern galaxies in the magnitude range 7 to 11, the Magellanic Clouds, and the Milky Way in the region of the galactic centre. A radiotelescope operating at 3·5-m λ was used. The results obtained tend to support the ideas of Shklovski (*Astr. J., Moscow*, 1952, Vol. 29, p. 418 & 1953, Vol. 30, p. 15) according to which the galactic emission comprises two subsystems, one showing a discoidal distribution highly concentrated towards the galactic plane, the other a very dispersed and approximately spherical distribution centred on the galactic centre. Contrary to Shklovski's interpretation, the contribution of thermal emission from ionized hydrogen to the discoidal distribution is likely to be small.

523.2 : 538.12 **737**

The Magnetic Field in the Vicinity of the Solar System.—W. L. Kraushaar. (*Progr. theor. Phys.*, July 1955, Vol. 14, No. 1, p. 77.) A brief discussion of the significance for particle trajectories of the assumption of the existence of an approximately uniform magnetic field in the vicinity of the solar system. See also *ibid.*, pp. 78–79.

523.5 : 621.396.11 **738**

Diurnal Variations in the Number of Shower Meteors detected by the Forward-Scattering of Radio Waves: Part 1—Theory.—C. O. Hines. (*Canad. J. Phys.*, Sept. 1955, Vol. 33, No. 9, pp. 493–503.) System factors affecting the observations are combined to provide a weighting factor varying in correspondence with the diurnal variation of the shower-radiant position, so that the effect of this variation can be distinguished from that of random changes in the incidence rate of the meteors.

523.53 : 621.396.96 **739**

The Radar Determination of Meteor Showers in the Southern Hemisphere.—C. D. Ellyett & K. W. Roth. (*Aust. J. Phys.*, Sept. 1955, Vol. 8, No. 3, pp. 390–401.) A report is presented of observations made during 1953, at a frequency of 69 Mc/s, using radar pulses of peak power 75 kW, duration 3·5 μs and recurrence rate 145/sec.

523.72 : 538.56.029.6 **740**

Three-Millimeter Wave Radiation from the Sun.—W. Gordy, S. J. Ditto, J. H. Wyman & R. S. Anderson. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, p. 1905.) Radiation of wavelength 3·2 mm has been received with a signal/noise ratio of about 25. Typical records obtained with movable and fixed aerials are reproduced.

523.72 : 621.396.822 **741**

A Method of discriminating Disturbances in V.H.F. Solar Noise Observation.—K. Kawakami, T. Takahashi & M. Onoue. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 111–123.) Continuous records are made of the total noise signal received at 200 Mc/s and of the signal after passage through a waveform discriminator which separates out the atmospheric and man-made noise. Solar noise, being random in character, appears only on the first record.

523.78 : 551.510.535 **742**

Solar Eclipses and the Ionosphere.—W. J. G. Beynon. (*Nature, Lond.*, 19th Nov. 1955, Vol. 176, No. 4490, pp. 947–948.) Report of a symposium held in London in August 1955.

550.372 **743**

The Electrical Conductivity of the Earth's Mantle.—S. K. Runcorn. (*Trans. Amer. geophys. Union*, April 1955, Vol. 36, No. 2, pp. 191–198.)

550.385 : 551.593 **744**

Changes in Brightness, Polarization, and Colour of the Zenith Day Sky accompanying Geomagnetic Activity.—D. R. Barber. (*J. atmos. terr. Phys.*, Sept. 1955, Vol. 7, No. 3, pp. 170–172.) Observed effects are attributed to variations in the size of the particles causing the magnetic disturbance.

551.510.5 **745**

The Molecular Diffusive Rate of Change of Composition in the Atmosphere.—S. Chapman. (*J. Met.*, April 1955, Vol. 12, No. 2, pp. 111–116.) Calculations are made for an atmosphere uniformly mixed, for heights up to 80 km.

551.510.5 : 621.396.96 **746**

Resolution in Height of a Radar Pulse.—Miles. (See 764.)

551.510.53 **747**

The Aeronomic Problem of Nitrogen Oxides.—M. Nicolet. (*J. atmos. terr. Phys.*, Sept. 1955, Vol. 7, No. 3, pp. 152–169.) The concentration of nitric oxide in the upper atmosphere is calculated for various heights; its vertical distribution follows that of the atmosphere. Maximum production occurs in the E layer; diffusion and atmospheric mixing can provide an explanation of the ionization of the D layer.

551.510.534 **748**

New Experimental and Theoretical Investigations on the Atmospheric Ozone Layer.—H. K. Paetzold. (*J. atmos. terr. Phys.*, Sept. 1955, Vol. 7, No. 3, pp. 128–140.) For altitudes from 24 km to 60 km the ozone distribution determined experimentally is in satisfactory agreement with theory; below 24 km the predicted values of ozone content are higher than the measured values. Further world-wide measurements are required and an ozone radiosonde apparatus is being developed for the purpose.

551.510.535 **749**

Chapman Theory of Photo-ionization for a Nonisothermal Atmosphere.—F. Mariani. (*Ann. Geofis.*, Jan. 1955, Vol. 8, No. 1, pp. 59–73.) The atmospheric temperature is assumed to vary linearly up to a certain height, beyond which it is constant. Analysis indicates that the assumption of a plane earth makes no appreciable difference to the value found for the ionization density, at least for zenith angles $< 60°$. The ionization distribution and the height of maximum ionization are appreciably different from the values given by Chapman's original theory.

551.510.535 **750**

Critical Considerations on the Ionosphere F Layer.—P. Dominici & F. Mariani. (*Ann. Geofis.*, Jan. 1955, Vol. 8, No. 1, pp. 103–120.) From general considerations of the layer-formation processes, observed anomalies are found to be associated with the F_2 layer. They cannot be explained by thermal expansion alone, but can be explained by the dynamo theory. Superposition of the F_1 and true F_2 layers can account for some anomalies, but calculations depend on the correct estimation of the virtual height of the F_2 layer. The importance of the temperature/height distribution is indicated in relation to the hypothesis that the whole of the F layer is formed by the same ionization process. To reduce experimental $h'(f)$ curves to $N(z)$ curves it is necessary to use numerical methods not based on a priori models.

551.510.535 **751**

On the Influence of Electron-Ion Diffusion on the Electron Density and Height of the Nocturnal F_2 Layer.—T. Yonezawa. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 125–136.) Analysis indicates that electron-ion diffusion will not change the distribution in a Chapman layer, but will cause a fall in the height of maximum density. Since the height of the F_2 layer does not change measurably after sunset, this suggests a lower limit to the molecular density in the F_2 region, considered as a Chapman layer, of 5×10^9 cm^{-3}.

551.510.535 **752**

Distortion of the E Layer of the Ionosphere by Electrical Currents flowing in it.—E. Appleton, A. J. Lyon & A. G. Turnbull. (*Nature, Lond.*, 12th Nov. 1955, Vol. 176, No. 4489, pp. 897–899.) The divergence of actual ionospheric conditions from conditions corresponding to an ideal Chapman layer is investigated in the light of the asymmetrical diurnal variation of E-layer properties and its dependence on latitude. The evidence indicates that the apparent values of recombination factor are affected by a factor depending on electron transport, and that the S_q current system exerts a marked influence on the maximum value N_m of ionization in the E layer and on the height at which the maximum occurs. Abnormal diurnal asymmetry and the latitude dependence of N_m (*Proc. Fourth Meeting Mixed Commission on the Ionosphere*, 1955, p. 14) together confirm the presence of ionospheric currents of the type predicted by Balfour Stewart in 1882.

551.510.535 : 523.78 **753**

Electron Production and Recombination in the E-Layer.—C. M. Minnis. (*J. atmos. terr. Phys.*, Sept. 1955, Vol. 7, No. 3, p. 172.) An error in a previous paper is pointed out; corrected values reinforce the conclusion reached.

551.510.535 : 621.3.087.4 **754**

Measurement of Ionospheric Heights by the Method of Delayed Coincidence.—H. Rakshit & S. D. Chatterjee. (*Z. Phys.*, 20th Sept. 1955, Vol. 141, No. 5, pp. 540–549. In English.) See 713 of 1955.

551.510.535 : 621.396.11 **755**

The Physics of the Ionosphere.—Publishers: The Physical Society, London, 1955, 406 pp., 40s. This report contains the text of the following papers presented at the conference noted previously (1340 of 1955):—

Survey: The Lowest Ionosphere.—A. H. Waynick (pp. 1–13).

Ionospheric Absorption at Low and Medium Frequencies.—G. McK. Allcock (pp. 14–19).

Ionospheric Layer Formation under Quasi-stationary Conditions.—E. Appleton & A. J. Lyon (pp. 20–39).

A Study of Vertical-Incidence Ionospheric Absorption at 2 Mc/s.—W. J. G. Beynon & K. Davies (pp. 40–52).

Short-Wave Echoes from the Lower Ionosphere.—W. Dieminger (pp. 53–57).

Solar X-Ray Emission and the Height of the D Layer during Radio Fade-Out.—H. Friedman & T. A. Chubb (pp. 58–62).

D-Region Echoes with a Radio Wave of Frequency 1·4 Mc/s.—S. Gnanalingam & K. Weekes (pp. 63–70).

Self-Gyrointeraction.—S. N. Mitra (pp. 71–73).

The Observed Polarization of High-Frequency Sky-Wave Signals at Vertical Incidence.—M. G. Morgan & W. C. Johnson (pp. 74–77).

M-Type Ionospheric Reflections at 150 kc/s.—R. L. Schrag (pp. 78–87).

Survey: A Survey of Existing Knowledge of Irregularities and Horizontal Movements in the Ionosphere.—J. A. Ratcliffe (pp. 88–98).

Scattering at Oblique Incidence from Ionospheric Irregularities.—Summary by J. A. Ratcliffe of informal talk by D. K. Bailey (pp. 99–100).

Variations of the F_2-Layer Critical Frequency during Undisturbed Ionospheric Conditions.—W. Becker (pp. 101–103, in German with English abstract).

Interpretation of Drift of Field-Strength Nonuniformities as Ionospheric Winds.—H. Berg (pp. 104–112, in German with English abstract).

Some Observations of Ionospheric Movements.—K. Bibl, E. Harnischmacher & K. Rawer (pp. 113–118).

An Empirical Study of Random Functions which arise in the Interpretation of Ionospheric Movements.—B. H. Briggs & E. S. Page (pp. 119–122).

The Variability of Time Shifts in Measurements of Ionospheric Movements.—B. H. Briggs & M. Spencer (pp. 123–135).

A Note on the Motion of a Cylindrical Irregularity in an Ionized Medium.—P. C. Clemmow, M. A. Johnson & K. Weekes (pp. 136–139).

Statistical Analysis of Star Scintillations as a Means for investigating Atmospheric Disturbances.—R. Fürth (pp. 140–149).

Irregularities in the E Region caused by Atmospheric Electricity.—G. A. Isted (pp. 150–162).

Interpretation of Observed F_2 'Winds' as Ionization Drifts associated with the Magnetic Variations.—D. F. Martyn (pp. 163–165).

Investigation of F-Region Drift Movements by Observations of Radio Star Fading.—A. Maxwell (pp. 166–171).

Radio Star Scintillations due to Ionospheric Focusing.—J. L. Pawsey (pp. 172–173).

Diffuse Ionospheric Reflection of Medium Waves at Night.—G. J. Phillips (pp. 174–180).

Travelling Disturbances in the Ionosphere.—R. E. Price (pp. 181–190).

Measurement of Ionospheric Wind from the Drift Velocity of a Condition (e.g. Field Strength of Echo) along the Surface of the Earth.—P. St. Pütter (pp. 191–201, in German with English abstract).

A Method for studying Large-Scale Irregularities in Region E of the Ionosphere.—R. L. Schrag (pp. 202–211).

Survey: A Survey of Present Knowledge of the F_2 Region.—D. F. Martyn (pp. 212–218).

Storm Phenomena and the Solar-Cycle Variations of the F_2-Layer Ionization at Noon.—E. Appleton & W. R. Piggott (pp. 219–228).

Electrodynamics of the Outer Atmosphere.—J. W. Dungey (pp. 229–236).

The Ionospheric F_2 Region.—R. J. Havens, H. Friedman & E. O. Hulburt (pp. 237–244).

Geomagnetic Distortion in the F_2 Layer.—K. I. Maeda (pp. 245–253).

Theory of Height and Ionization Density Changes at the Maximum of a Chapman-Like Region, taking account of Ion Production, Decay, Diffusion and Tidal Drift.—D. F. Martyn (pp. 254–259).

Geomagnetic Anomalies of the F_2 Region and their Interpretation.—D. F. Martyn (pp. 260–264).

Ionospheric F_2 Variations associated with Geomagnetic Disturbances at the Equatorial Zone.—S. Matsushita (pp. 265–269).

Information about the F_2 Layer taken from Ionization Maps.—K. Rawer (pp. 270–275).

Survey: The Mathematics of Wave Propagation through the Ionosphere.—K. G. Budden (pp. 276–287).

Propagation of a Plane Wave in a Transparent Anisotropic Ionized Medium and Propagation in a Heterogeneous Ionized Medium.—É. Argence (pp. 288–298, in French).

Electron Density and Ray Tracing in the Ionosphere Layers.—P. A. Bricout (pp. 299–307).

The Transient Response of the Ionosphere at Low Frequencies.—S. A. Bowhill (pp. 308–319).

The Nonexistence of a 'Fourth Reflection Condition' for Radio Waves in the Ionosphere.—K. G. Budden (pp. 320–331).

A Method for determining the Variation of Electron Density with Height ($N(z)$ curves) from Curves of Equivalent Height versus Frequency (h', f curves).—K. G. Budden (pp. 332–339).

The Dependence of the Refractive Index in Magneto-ionic Theory on the Direction of the Wave Normal.—P. C. Clemmow & R. F. Mullaly (pp. 340–350).

Methods of solving the Coupled Equations of Plane Wave Propagation in the Ionosphere.—J. J. Gibbons (pp. 351–354).

Ray Theory and a New Method for Ray Tracing.—J. Haselgrove (pp. 355–364).

Statistical Mechanics of Lorentz-Type Electron Plasmas and Applications to the Ionosphere.—R. Jancel & T. Kahan (pp. 365–373, in French).

Analysis of the Coupling of the Ordinary and Extra-ordinary Electromagnetic Waves in a Lorentz-Type Plasma and Application to the Ionosphere.—R. Jancel & T. Kahan (pp. 374–383, in French).

Graphical Constructions for Ray-Tracing in the Ionosphere.—R. F. Mullaly (pp. 384–393).

Studies of the Refractive Index in the Ionosphere: the Effect of the Collision Frequency and of Ions.—W. Pfister (pp. 394–401).

Tables of Group Refractive Index for the Ordinary Ray in the Ionosphere.—D. H. Shinn (pp. 402–406).

551.510.535 : 621.396.812.3 756

Three Components of the Field Strength of the Wave reflected from the Surface of the Ionosphere, their Level and Time Variation.—Uyeda, Ogata, Uchikura, Arima & Obayashi. (See 900.)

551.515.4 : 621.396.96 757

Radar Observations of a Thunderstorm.—Mitra. (See 765.)

LOCATION AND AIDS TO NAVIGATION

621.396.93 758

Adcock Direction Finder.—W. C. Bain. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, pp. 20–24.) "It was found that the pull of the triatics (supporting the central sense aerial) on the main aerials of an Adcock h.f. direction finder caused the main aerials to bend inwards, so that a large polarization error was produced on frequencies near 20 Mc/s. Theoretical calculations are made for the case of aerials with an overall slope of 1°, with a distant loop transmitter at 6·3° elevation and with a loop tilt of 6° from the horizontal: the total polarization error found is 6° for a perfectly-reflecting ground and 19° for ground of conductivity 0·02 mho/m. In practical direction finding the errors are not likely to be as high as this on the average; but the figure of 3° is obtained for the root-mean-square error from a transmitter on 20 Mc/s at 20° elevation despite the small amount of aerial bending assumed."

621.396.932/.933 759

Night Effect in the Consol Navigation System.—R. Kümmich. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, pp. 494–500.) It is shown that the combination of the ground wave with the sky wave causes deviation of all the beams except the main one; in some cases the rhythm of the signal is also disturbed.

621.396.932/.933 760

Accuracy of the 'Sonne' [consol] Navigation System.—K. Rawer. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, p. 501.) Brief note summarizing results of an unpublished 1944 report on an extensive series of observations. Night-time deviations and scatter of observations were consistent with present-day knowledge of ionospheric propagation.

621.396.933 761

Long-Range Radio Navigation in the Long-Wave Band.—E. Roessler. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, pp. 485–489.) The Navaglobe-Navarho system [432 of 1955 (Clark et al.)] is discussed and compared with other systems in use, from the point of view of the number of ground stations required, the bandwidth requirements and the sensitiveness to noise.

621.396.933.1 : 621.397.5 762

Telegee.—D. A. Levell. (*Wireless World*, Jan. 1956, Vol. 62, No. 1, pp. 41–42.) The possibility of using existing synchronized television transmitters for determining the position of aircraft is discussed. An aircraft would need to receive three television stations; the times of arrival of corresponding frame synchronizing pulses could be measured and position determined as in the Gee and Decca systems.

621.396.96 763

Experimental Study of Rain Echoes using 3-cm-λ Pulsed Radar with Circular Polarization.—M. Bouix, M. Clément & C. Frémiot. (*Ann. Télécommun.*, July/Aug. 1955, Vol. 10, Nos. 7/8, pp. 159–168.) Observations were made using radar equipment with two different types of aerial permitting rapid transition from linear to circular polarization; constructional details are given. Results confirm that rain clutter is reduced by using circular polarization at this wavelength.

621.396.96 : 551.510.5 **764**

Resolution in Height of a Radar Pulse.—V. G. Miles. (*J. Met.*, April 1955, Vol. 12, No. 2, pp. 107–110.) "An analysis is made of the ability of a radar pulse to resolve, either completely or partially, the echoes from two closely-spaced horizontal reflecting layers situated close to the radar. The general expressions obtained are illustrated graphically." See also 3306 of 1953.

621.396.96 : 551.515.4 **765**

Radar Observations of a Thunderstorm.—H. Mitra. (*Indian J. Met. Geophys.*, April 1955, Vol. 6, No. 2, pp. 119–136.) A detailed illustrated account. The radar echoes as displayed on a 3-cm-λ Type-AN/APQ-13 set are explained by reference to meteorological data.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 : 535.33 **766**

The Emission of Light from Gas Discharges in High Vacuum.—K. H. Reiss. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 433–437.) A method of analysing gases at low pressure is based on their emission spectra. A specially constructed ionization manometer with cold electrodes is used as light source. Apparatus including filter, photomultiplier and recorder is described. The technique is useful for testing vacuum apparatus for leaks.

533.5 : 621.3.032.73 **767**

Outgassing of Glass.—B. J. Todd. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1238–1243.) The temperature dependence of the water-diffusion rate in vacuum has been determined for several glasses. From the results it is possible to calculate the amount of water that will be evolved from glass for any time-temperature conditions following any bake-out in which the surface gases have been removed.

535.215 : [537.311.33 + 537.226 **768**

Performance of Photoconductors.—A. Rose. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1850–1869.) A survey paper. A phenomenological analysis is made of processes whereby the conductance of a semiconductor or insulator material is increased by exposure to radiation (including particle radiation but excluding thermal radiation); the theory is based on consideration of bound energy states. The lifetime of free carriers is an important characteristic parameter. The mechanism of conduction at barriers is discussed and noise phenomena are examined. 54 references.

535.215 : 537.311.33 **769**

Photoeffects in Intermetallic Compounds.—H. P. R. Frederikse & R. F. Blunt. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1828–1835.) "The intermetallic semiconductors are classified with respect to their crystal structure and to the place of the component elements in the periodic system. A survey is given of the properties of compounds with the zincblende and fluorite lattice. Photoeffects of individual members of these two groups are discussed. Such phenomena include photoconduction, photovoltage, and the photo-electro-magnetic effect." 40 references.

535.215 : 537.311.33 **770**

Photoconductivity of the Sulfide, Selenide, and Telluride of Zinc or Cadmium.—R. H. Bube. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1836–1850.) Recent research on evaporated, powder and sintered layers and on single-crystal specimens is reviewed. The aspects discussed include spectral response, impurity sensitization, electrode contact problems, speed of response, dependence of photocurrent on illumination intensity and on temperature, infrared quenching and thermal stimulation, as well as related luminescence, photovoltaic and photoemissive effects. 118 references.

535.215 : 537.311.33 : 546.26-1 **771**

Photoelectric Emission from Polycrystalline Graphite.—E. Taft & L. Apker. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1831–1832.) Results of measurements of the energy distribution of the photoelectrons are reported. The photoelectric yield from graphite is about a tenth that from common metals.

535.215 : 537.311.33 : [546.28 + 546.289 **772**

Photoconduction in Germanium and Silicon.—M. L. Schultz & G. A. Morton. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1819–1828.) A general account based on energy-band theory is presented explaining the photoconducting properties of Ge and Si both with and without added impurities. 58 references.

535.215 : 537.311.33 : 621.383.4 **773**

Lead Salt Photoconductors.—T. S. Moss. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1869–1881.) A review paper discussing the mechanism of photoconductivity in PbS, PbTe and PbSe and its application in high-sensitivity infrared-radiation detectors. The manufacture of photocells using these materials is outlined. 130 references.

535.37 : 535.34 : 546.482.21 **774**

The Absorption Spectrum of Excited Crystals of Cadmium Sulphide.—A. Halperin & G. F. J. Garlick. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 758–765.) Single crystals of CdS excited by light of wavelength 0·546 μ exhibited absorption bands extending from the excitation wavelength to 1·4 μ with a maximum intensity at 0·78 μ. Variations caused by temperature changes are discussed on the basis of electron and hole trapping and recombination.

535.37 : 546.472.21 **775**

Investigation of the Accumulation Property and Origin of Levels of Localization of Electrons in Zinc-Sulphide Phosphors.—N. V. Zhukova. (*C. R. Acad. Sci. U.R.S.S.*, 21st Aug. 1955, Vol. 103, No. 6, pp. 1001–1004. In Russian.)

535.37 : 546.472.21 **776**

Luminescent Centres in ZnS:Cu:Cl Phosphors.—R. Bowers & N. T. Melamed. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1781–1787.)

535.37 : 546.472.21 : 535.215 : 537.311.33 **777**

Photoluminescent Modulation in Nonuniformly Excited ZnS Phosphors.—R. E. Halsted. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, p. 1897.) Experiments are briefly described in which phosphors were excited by radiation of wavelengths shorter than that corresponding to the fundamental absorption edge, while subjected to an alternating field of frequency ranging from 20 c/s to 20 kc/s. The results demonstrate the *n*-type photoconductivity of the phosphors and clarify the role of conduction electrons in the luminescence process.

535.37.07 : 548.0 778

The Physical Chemistry of Crystal Phosphors.—F. A. Kröger. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1941–1944.) A brief survey of inorganic crystal phosphors, with particular attention to the incorporation of atoms with a valency different from that of the main material, and to the stabilization of atoms in a particular valency.

535.376 779

Cathodoluminescence.—G. F. J. Garlick. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1907–1911.) A brief review of recent advances in knowledge of the fundamental mechanisms involved. Observed brightness/voltage characteristics are related to the microcrystalline form of the phosphor; simpler behaviour is exhibited by single crystals. Factors affecting screen efficiency are discussed, as are also current saturation and 'electron burn'.

535.376 780

Electroluminescence and Related Topics.—G. Destriau & H. F. Ivey. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1911–1940.) A comprehensive review with 162 references.

535.376 : 546.472.21 781

Electroluminescence in Single Crystals of Zinc Sulphide.—G. F. Alfrey & J. B. Taylor. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 775–784.) Experimental work is described and the bearing of the results on previously proposed theories of the mechanism of electroluminescence is discussed. Predicted temperature and frequency variations of electroluminescence in good agreement with observed values are obtained on the basis of a field-emission theory assuming a particular formation of the surface barrier.

535.376 : 546.472.21 : 537.226.2 782

The Electrical Properties of Electroluminescent Phosphors.—A. N. Ince & C. W. Oatley. (*Phil. Mag.*, Oct. 1955, Vol. 46, No. 381, pp. 1081–1103.) The frequency variations of ϵ_1 and ϵ_2, the components of the complex permittivity $\epsilon_1 - j\epsilon_2$, were experimentally determined for activated ZnS both in the dark and under ultraviolet illumination. Results suggest that two different mechanisms are involved. One, which is present in the dark, produces dispersion at low frequencies; it is characteristic of electroluminescent phosphors. The other, which is stimulated by ultraviolet light, produces dispersion similar to that found in ordinary non-electroluminescent phosphors. The effects are explained on the assumption that electronic barriers are formed in the specimen and that some of the ions in the barrier region are mobile.

535.376 : 621.385.832 : 535.623 783

Phosphors for Tricolour Television Tubes.—A. Bril & H. A. Klasens. (*Philips Res. Rep.*, Oct. 1955, Vol. 10, No. 5, pp. 305–318.) Measurements of the efficiency and spectral distribution of various phosphors indicate that the properties of the red phosphor are most important; compromise is necessary between colour rendering and efficiency. (Zn,Cd)S-Ag and (Zn,Cd) Se-Cu phosphors can be produced with higher efficiencies for near-white colours than ZnP-Mn. The properties of a number of phosphors are shown in tables and graphs.

537.226/.228 784

Nonlinear Dielectric Materials.—E. T. Jaynes. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1733–1737.) A brief discussion of materials in which dielectric properties depend on applied field strength. Since ferroelectric materials have high dielectric constants they may be expected to exhibit a high degree of nonlinearity.

537.226/.227 785

Some Aspects of Ferroelectricity.—G. Shirane, F. Jona & R. Pepinsky. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1738–1793.) A survey with over 160 references. The behaviour of ferroelectric and antiferroelectric materials is related to their domain and crystal structure. Numerous photographs and diagrams illustrate the phenomena described.

537.226/.227 : 546.817.824 786

X-Ray Study of Phase Transition of Ferroelectric $PbTiO_3$ at Low Temperature.—J. Kobayashi & R. Ueda. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1900–1901.)

537.226.2 787

The Permittivity of Two-Phase Mixtures.—C. A. R. Pearce. (*Brit. J. appl. Phys.*, Oct. 1955, Vol. 6, No. 10, pp. 358–361.) Experimental results obtained by various workers are compared with predictions from published formulae relating the properties of a mixture with those of the phases composing it. An empirical expression is presented which gives adequate agreement with all relevant available results.

537.226.2 : 546.431.824-31 788

Permittivity of Barium Titanate.—I. P. Kozlobaev. (*C. R. Acad. Sci. U.R.S.S.*, 21st Sept. 1955, Vol. 104, No. 3, pp. 387–388. In Russian.) Experimental results, presented graphically, show that ϵ decreases as the hydrostatic pressure increases from atmospheric to 4 000 kg/cm². A mechanical hysteresis effect was also observed; in a specimen with a Curie temperature Θ of about 127°C, the final value of ϵ at atmospheric pressure was greater than the initial value at high pressure, while in specimens with Θ about 10°–20°C above room temperature this difference was smaller, and in a specimen with Θ = 1°C the final value was smaller than the initial one. The relaxation of internal stresses, as indicated by changes in ϵ, is practically complete in about 20 min.

537.228.1 789

Anisotropy of Polarized Polycrystalline Barium Titanate.—D. S. Moseley. (*J. acoust. Soc. Amer.*, Sept. 1955, Vol. 27, No. 5, pp. 947–950.) Observations were made of the longitudinal vibrations of $BaTiO_3$ specimens subjected to a range of polarization conditions; pairs of bars $1 \times \frac{3}{8} \times \frac{3}{8}$ in. were used, one of each pair having electrodes applied to the ends and the other having electrodes on opposite long sides. The effect of different treatments on the ratio between the elastic compliances at constant electric field and at constant electric displacement is indicated and discussed.

537.311.31 : 546.56-1 790

Effect of Point Imperfections on the Electrical Properties of Copper: Part 1—Conductivity.—F. J. Blatt. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1708–1716.) Detailed calculations are presented for the scattering of conduction electrons by lattice imperfections in Cu.

537.311.33 791

Unipolar Conduction at the Semiconductor/Metal Boundary.—E. Wallauschek. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 351–366.) Measurements on silver/silver-iodide cells are reported; the current/time characteristics for the forward and reverse directions are different. A unipolar conduction mechanism responsible for this asymmetry is discussed.

537.311.33 792

Carrier-Concentration Disturbances in Semiconductors.—R. E. Burgess. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, p. 793.) Critical comment on a paper by Low (3296 of 1955).

537.311.33 793

Fluctuations of the Numbers of Electrons and Holes in a Semiconductor.—R. E. Burgess. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 661–671.) Fluctuations are calculated by either (*a*) a thermodynamical method, in terms of the electronic free energy of the system whose minimal properties are used to determine the equilibrium distribution and fluctuations of electrons between the conduction and valence bands and the impurity levels, or (*b*) a statistical method based on the probabilities of the elementary processes of electron transitions between energy levels. The first method is particularly useful in complex cases. Both intrinsic and extrinsic semiconductors are discussed, as well as the case of a nearly intrinsic semiconductor.

537.311.33 794

Theory of the Infrared Absorption by Carriers in Semiconductors.—R. B. Dingle. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1901–1902.) Critical discussion of theory presented by Kahn (2649 of 1955).

537.311.33 795

Surface Recombination and the 'Light-Disk' Method of measuring Bulk-Lifetime in Semiconductors.—J. Butterworth. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 293–296.) The method considered is broadly the same as that discussed e.g. by van Roosbroeck (2644 of 1955), but the linear dimensions of the illuminated area at which minority carriers are injected are assumed to be comparable with the diffusion length. Two expressions useful for analysing experimental data are derived, valid for complementary ranges of the system parameters.

537.311.33 796

A Comparison of some Methods for the Determination of Trace Impurities in Semiconductors.—A. A. Smales. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 327–332.) A discussion of analytical methods; coulometry, X-ray spectroscopy, microbiological and magnetic-resonance techniques are excluded.

537.311.33 797

History of Semiconductor Research.—G. L. Pearson & W. H. Brattain. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1794–1806.) An account going back to Faraday's observation in 1833 of the negative temperature coefficient of resistance of silver sulphide; most of the emphasis is on the work leading up to the development of the transistor. 118 references.

537.311.33 : 535.37 798

Radiative Transitions in Semiconductors.—R. Braunstein. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1892–1893.) Observations are reported of radiation produced by carrier injection into thin plates of GaSb, GaAs, InP and Ge-Si alloys, at room temperature and at 77°K; an outline is given of the technique used. The spectral distributions exhibit peaks at energy values close to previously estimated values of the energy gaps.

537.311.33 : 536.2 799

Thermal Conductivity of Semiconductors.—J. M. Thuillier. (*C. R. Acad. Sci., Paris*, 24th Oct. 1955, Vol. 241, No. 17, pp. 1121–1122.) An exact calculation indicates that the ratio between the electrical contribution to the thermal conductivity and the electrical conductivity may be much greater than the value predicted by the Lorentz theory for an electron gas.

537.311.33 : 537.533.8 800

New Ni-Be Alloy with [high] Secondary Emissivity.—J. Millet. (*Le Vide*, July–Sept. 1955, Vol. 10, Nos. 58/59, pp. 96–102.) A description of the preparation of Ni-Be and Ni-Mg alloys suitable for use as nonlinear resistors. The structure and physical properties of the alloys are discussed with the aid of microphotographs. The electrical properties are discussed in a paper by Bobenrieth et al. (776 of 1955). See also 434 of 1954 (Teszner et al.).

537.311.33 : 538.632 801

Saturation Hall Constant of Semiconductors.—J. A. Swanson. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1799–1807.) Analysis is presented for the motion of electrons in semiconductor crystals in the presence of crossed electric and magnetic fields. For increasing values of the magnetic field the value of the Hall constant tends asymptotically to $1/(p-n)ec$ where p and n are the hole and electron concentrations and e and c have their usual significance; this value is unaffected by scattering. The saturation magnetoresistance is also discussed.

537.311.33 : 546.23 802

Fixation of Iodine in Selenium.—R. A. Hyman & D. H. Tomlin. (*Nature, Lond.*, 19th Nov. 1955, Vol. 176, No. 4490, p. 977.) Brief report of experimental results indicating that halogen atoms can be bound in the Se structure, probably at the ends of chains of Se atoms. This conclusion does not agree with that of Nijland (744 of 1955).

537.311.33 : 546.26-1 803

Recent Investigations on Graphite.—R. Arnold. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 453–460.) A review with 58 references.

537.311.33 : 546.27 804

Study of the Frequency Dispersion of the Conductivity of Boron and of $B_{12}Al$.—J. Lagrenaudie. (*J. Phys. Radium*, Aug./Sept. 1955, Vol. 16, Nos. 8/9, pp. 731–732.) Report of measurements at frequencies in the range 100 c/s–1 Mc/s and temperatures down to 110°K, using specimens solidified after fusion. The dispersion of conductivity is attributed to nonuniform distribution of impurities. Estimates are made of activation energies of impurities.

537.311.33 : [546.28 + 546.289 805

Effect of Water Vapor on Grown Germanium and Silicon *np* Junction Units.—J. T. Law & P. S. Meigs. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1265–1273.) Photoresponse and reverse current were measured over a wide range of water-vapour pressures. At low relative humidities the surface recombination rate for Ge decreases relative to the value in vacuum, but Si is not affected. Humidities above 30% produce channels on both Ge and Si units. Channel length varied with voltage as observed by McWhorter & Kingston (3587 of 1954). Steady illumination decreased the channel length on both Ge and Si units, but affected the excess reverse current only for Si; hence some mechanism other than channel conduction, probably an ionic mechanism, is operative at Ge surfaces. The existence of the two mechanisms is consistent with Christensen's results (3585 of 1954). See also 3586 of 1954 (Law).

537.311.33 : [546.28 + 546.289] : 548.0 **806**

The Electronic Energy-Band Structure of Silicon and Germanium.—F. Herman. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1703–1732.) This introduction to the physics of crystals covers electronic quantum states, the hole concept, the effective mass tensor, motion of electrons and holes, spin-orbit interaction, the energy-band structure of Si and Ge and their alloys, theory of lattice vibrations, the phonon concept, collisions between electrons or holes and phonons, electrical conductivity, and optical phenomena. Over 70 references.

537.311.33 : 546.289 **807**

Nature of the Water-Vapor-Induced Excess Current on Grown Germanium *p-n* Junctions.—E. N. Clarke. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1899–1900.)

537.311.33 : 546.289 **808**

Theory of Acceptor Levels in Germanium.—W. Kohn & D. Schechter. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1903–1904.) Calculations based on the coupled effective-mass equations applicable for a degenerate band structure give a value for the ionization energy in good agreement with observations.

537.311.33 : 546.289 **809**

Diffusion of Antimony, Arsenic and Indium into Solid Germanium.—W. Bösenberg. (*Z. Naturf.*, April 1955, Vol. 10a, No. 4, pp. 285–291.) Steep impurity-concentration profiles develop during the preparation of Ge single crystals by pulling, if impurities are incorporated in the melt. The flattening of the slope due to diffusion is determined by impedance measurements; impurity concentrations between 1 in 10^5 and 1 in 10^7 atomic parts are used. Values of the diffusion coefficients are hence derived. The same values are obtained when thin films of the impurity metals are evaporated on to the Ge and allowed to diffuse into the interior.

537.311.33 : 546.289 : 535.215 **810**

Analysis of the Decay of Photoconductance in Germanium.—B. H. Schultz. (*Philips Res. Rep.*, Oct. 1955, Vol. 10, No. 5, pp. 337–348.) "A method of analyzing surface and volume effects in the recombination of injected charge carriers is described. The influence of the capacity of a surface double layer is discussed and some of the results of measurements are given."

537.311.33 : 546.289 : 548.0 **811**

Structural Changes in Evaporated Ge Films in an Electron Microscope.—E. W. Fischer & H. Richter. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 193–209.) A photographically illustrated report of changes induced by the impact of the electron beam.

537.311.33 : 546.3-1-28-289 **812**

Electrical Properties of Germanium-Silicon Alloys.—A. Levitas. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1810–1814.) Various specimens were investigated; resistivity measurements were made over the temperature range 300°–800°K, and Hall-effect and resistivity measurements over the temperature range 77°–300°K. Intrinsic resistivity at room temperature is plotted against percentage Si in the alloy, by extrapolation from the high-temperature measurements. The observed variation of mobility with alloy composition is indicative of alloy scattering.

537.311.33 : 546.682.86 **813**

Thermoelectric Power of Indium Antimonide.—H. P. R. Frederikse & E. V. Mielczarek. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1889–1890.) Measurements of the thermoelectric power of a *p*-type and an *n*-type specimen over the temperature range 60°–400°K are reported; wide differences are found between the two characteristics.

537.311.33 : 546.682.86 **814**

Infrared Absorption in Indium Antimonide.—W. G. Spitzer & H. Y. Fan. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1893–1894.) Measurement results are presented as transmission/wavelength and reflectivity/wavelength curves.

537.311.33 : 546.682.86 **815**

Optical Absorption Limit and Effective Mass of Electrons in Indium Antimonide (InSb).—P. Aigrain & J. des Cloizeaux. (*C. R. Acad. Sci., Paris*, 3rd Oct. 1955, Vol. 241, No. 14, pp. 859–862.) Calculations are made which provide an explanation of the discrepancy between the values of the effective electron mass found by Burstein (2134 of 1954) and by Dresselhaus et al. (3011 of 1955). The analysis is based on the potential distribution due to impurity centres, and its application is not restricted to InSb.

537.311.33 : 546.817.221 **816**

Measurements on *p-n* Junctions in Lead Sulphide.—T. S. Moss. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 697–700.) "From measurements of the characteristics of several natural *p-n* junctions the intrinsic resistivity of lead sulphide is calculated to be 3·1 Ω.cm. Hence at room temperature the intrinsic carrier concentration is $2{\cdot}7 \times 10^{15}$ electrons or holes per cm^3 and the width of the forbidden zone 0·40 eV."

537.311.33 : 621.396.822 **817**

Contribution on the 1/*f* Law of Noise in Semiconductors.—H. Schönfeld. (*Z. Naturf.*, April 1955, Vol. 10a, No. 4, pp. 291–300.) Explanations of the 1/*f* spectral distribution of current noise in semiconductors given by van der Ziel (3035 of 1950) and by Surdin (1325 of 1952) are based on assumptions not previously justified. It is shown that discrete phenomena distributed according to a $t^{-\frac{1}{2}}$ time law also give rise to a 1/*f* spectral distribution. This is discussed in relation to Montgomery's hypothesis (122 of 1953) that the discrete phenomena correspond to the local injection of minority carriers.

537.311.33 : 621.396.822 **818**

Distribution Function of Semiconductor Noise.—D. A. Bell. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 690–691.) An experiment is described confirming that the Gaussian distribution of instantaneous values applying to 'white noise' applies also to current noise with inverse-frequency spectrum.

537.311.33 : 669.046.54/.55 **819**

Zone-Melting Processes under Influence of the Atmosphere.—J. van den Boomgaard. (*Philips Res. Rep.*, Oct. 1955, Vol. 10, No. 5, pp. 319–336.) Theory presented previously [e.g. 740 of 1955 (Reiss)] is extended to deal with the case of elements containing volatile solutes; it is possible to introduce a volatile impurity element homogeneously into an ingot by means of zone melting under a constant vapour pressure of that element.

537.311.33 : 669.046.54/.55 : 512.831 820

On Zone Refining.—J. L. Birman. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1195–1197.) "A matrix method is used to solve the difference equations which describe the zone refining of a bar. The matrix method is designed for direct numerical calculation of the solute distribution, after any number of passes, with any initial solute distribution. The method is illustrated with a simple example."

537.311.33.01 + 535.37.01 821

Statistical-Kinetic Theory of Luminescence and Electrical Conductivity of Impurity Semiconductors.—I. Broser & R. Broser-Warminsky. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 361–407.) By using statistical rather than kinetic considerations the mathematical analysis is simplified, and restrictive assumptions regarding discrete energy levels can be discarded.

538 : 536.48 822

Conference on Low-Temperature Magnetism: Khar'kov, 1st–3rd July 1954.—(*Bull. Acad. Sci. U.R.S.S., sér. phys.*, July/Aug. 1955, Vol. 19, No. 4, pp. 387–488. In Russian.) The issue contains a summary of the 20 papers read at the conference and texts of nine papers including:

Galvanomagnetic Phenomena and Properties of Conduction Electrons in Metals.—E. S. Borovik (pp. 429–443).

Investigation of Photomagnetoelectric Effect in Cuprous Oxide at Low Temperatures.—A. P. Komar, N. M. Reinov & S. S. Shalyt (pp. 444–446).

Electrical Conductivity of Ferromagnetic Metals at Low Temperatures.—E. A. Turov (pp. 474–480).

538.221 823

The Direct Separation of the Reversible and Irreversible Components of the Magnetothermal Effect.—L. F. Bates & N. P. R. Sherry. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 642–648.) The two components are separated by effecting small 'backward' increments in magnetization at given points in the hysteresis cycle. Results are reported for cobalt.

538.221 824

Investigation by Powder-Pattern Method of the Magnetic Structure of Silicon-Iron Crystals.—Ya. S. Shur & V. R. Abel's. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1955, Vol. 104, No. 2, pp. 209–210. In Russian.) From the photographs shown, general relations are deduced of the dependence of magnetic structure on the crystallographic orientation of the specimen surface.

538.221 825

Shape and Crystal Anisotropy of Alnico 5.—E. A. Nesbitt & H. J. Williams. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1217–1221.) An investigation made using the torque-measurement technique previously described [172 of 1955 (Nesbitt et al.)] indicates that the high coercive force of single crystals of alnico 5 depends on the shape anisotropy of the fine precipitated plates, the crystal anisotropy being negligible. The plates are composed of rods of diameter about 75 Å and length 400 Å, but exhibit single-domain properties.

538.221 826

Permanent-Magnet Properties of Elongated Single-Domain Iron Particles.—L. I. Mendelsohn, F. E. Luborsky & T. O. Paine. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1274–1280.) An account is given of measurements on magnets made by aligning and compacting single-domain particles of diameter 150 Å with a median length/diameter ratio of 3 and an intrinsic coercive force before packing of 1 600 oersted. The influence of packing fraction and degree of alignment were investigated. BH_{max} values $> 3 \times 10^6$ G. oersted were obtained. The results are compared with theoretical predictions and with the corresponding properties of existing permanent-magnet materials.

538.221 827

The Effect of Particle Interaction on the Coercive Force of Ferromagnetic Micropowders.—E. P. Wohlfarth. (*Proc. roy. Soc. A*, 25th Oct. 1955, Vol. 232, No. 1189, pp. 208–227.) Analysis is presented for an assembly of prolate-spheroidal single-domain particles, with either parallel or nonparallel arrangement. The principal effects discussed are the dependence of the shape-anisotropy coefficient on the interaction and a mutual magnetization change due to an interaction-dependent rotation of the magnetization vectors. A general expression is derived for the coercive force in terms of packing factor and saturation magnetization; this is contrasted with formulae obtained previously based on an 'effective field' treatment.

538.221 828

Production of Anisotropy in a Permanent Magnet by Pressure.—J. E. Gould & M. McCaig. (*Nature, Lond.*, 19th Nov. 1955, Vol. 176, No. 4490, p. 977.) The 'squareness' of the B/H curve of a rod of 35% Co steel was improved by shrinking a stainless-steel block around it so as to exert lateral pressure. The method is similar to that applied to ferroxcube by Wijn et al. (*Philips tech. Rev.*, 1954, Vol. 16, p. 49). See also 3608 of 1954 (Wijn).

538.221 : 538.569.4.029.6 829

Ferromagnetic Resonance in Nickel and in some of its Alloys.—K. J. Standley & K. H. Reich. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 713–722.) Report of determination of g values and line widths for polycrystalline specimens of Ni and of Ni-Cu, Ni-Al, Ni-Sb and Ni-Mn alloys with high Ni content, from resonance measurements at 1·22-cm λ, mainly over the temperature range from 20°C to 200°C.

538.221 : [621.318.124 + 621.318.134 830

Some Properties of Ferrites in connection with their Chemistry.—E. W. Gorter. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1945–1973.) Introductory and survey paper, including 63 references. Aspects discussed include ferromagnetic resonance, dimensional resonance, relaxation phenomena, and their relation to permeability.

538.221 : [621.318.124 + 621.318.134 831

Anisotropy and Magnetostriction of some Ferrities.—R. M. Bozorth, E. F. Tilden & A. J. Williams. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1788–1798.) Measurements are reported on Co, CoZn and other ferrites, some single-crystal and others polycrystalline. Crystal anisotropy was investigated by the torque technique; values up to 4×10^6 ergs/cm³ were found. Magnetostriction was determined by strain-gauge technique; values up to 800×10^{-6} were found. Magnetic annealing is effective at temperatures as low as 150°C, and causes the hysteresis loop to become 'square'. In polycrystalline Co ferrites magnetic annealing is most effective for compositions between $CoFe_2O_4$ and Fe_3O_4. The constants for the various specimens are tabulated and discussed.

538.221 : 621.318.124 **832**
Studies on the Oxide Magnets: Part 1—Effects of Bi_2O_3 on Barium Ferrites. Part 2—Effects of Bi_2O_3 on Strontium and Lead Ferrites.—T. Okamura, H. Kojima & S. Watanabe. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. A*, Aug. 1955, Vol. 7, No. 4, pp. 411–424.) The saturation and remanent magnetization of a BaO-Fe_2O_3 system were increased by 20% to 30%, and the coercive force by 30% to 50%, by addition of 1·5% Bi_2O_3; the mechanical properties improved simultaneously. The results in SrO-Fe_2O_3, SrO-CaO-Fe_2O_3 and PbO-Fe_2O_3 systems are more complex.

538.221 : [621.318.124 + 621.318.134] : 535.33/.34-1 **833**
Infrared Spectra of Ferrites.—R. D. Waldron. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1727–1735.)

538.221 : 621.318.134 **834**
First-Order Magnetic Anisotropy Constants of Ferrites.—J. B. Birks. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, p. 1821.) Potential sources of error in the method of calculation presented by Weisz (1413 of 1955) are indicated.

538.221 : 621.318.134 **835**
Frequency Dependence of Magnetocrystalline Anisotropy.—R. M. Bozorth, B. B. Cetlin, J. K. Galt, F. R. Merritt & W. A. Yager. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, p. 1898.) Differences are observed between the values of crystal anisotropy of Ni and Mn ferrites measured by static and microwave methods. Conclusions are drawn regarding the structure of the materials.

539.23 : 537.311.31 : 546.59 **836**
Study of Transparent, Highly Conducting Gold Films.—E. J. Gillham, J. S. Preston & B. E. Williams. (*Phil. Mag.*, Oct. 1955, Vol. 46, No. 381, pp. 1051–1068.) Thin gold films deposited on a substratum of bismuth oxide or, better, between two films of bismuth oxide, are found to have exceptionally high electrical conductivity and optical transmission. Typical values, for films of thickness 100 Å, are 3·5Ω/square for the resistance and 75% for the transmission.

546.681 **837**
Study of the Electrical Anisotropy of Gallium in the Neighbourhood of the Fusion Point.—I. Epelboin & M. Erny. (*C. R. Acad. Sci., Paris*, 24th Oct. 1955, Vol. 241, No. 17, pp. 1118–1121.)

548.0 : [537.311.33 + 549.514.51 **838**
Densities and Imperfections of Single Crystals.—A. Smakula, J. Kalnajs & V. Sils. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1747–1750.) The densities of Si, Al, $CaFe_2$, CsI, Ge, TlCl, TlBr and quartz have been computed from lattice constants and molecular weights and compared with values determined by hydrostatic weighing by a method described by Smakula & Sils (*ibid.*, pp. 1744–1746). Discrepancies between the two sets of values are discussed in relation to the reliability of the basic data, and conclusions are drawn regarding the crystal imperfections.

548.0 : 537.311.33 : [546.28+546.289 **839**
Energy Levels of a Crystal modified by Alloying or by Pressure.—R. H. Parmenter. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1759–1766.) A perturbation method of calculating the energy levels is discussed; application to crystals with diamond-type lattice is illustrated. See also *ibid.*, pp. 1767–1776.

548.0 : 537.311.33 : 621.386 **840**
A Scanning X-Ray Camera for the Detection of Crystal Imperfections.—P. J. Holmes. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 324–326.)

549.514.51 **841**
Liquid Inclusions in Artificial Quartz.—V. P. Butuzov & N. Yu. Ikornikova. (*C. R. Acad. Sci. U.R.S.S.*, 1st Sept. 1955, Vol. 104, No. 1, pp. 76–77. In Russian.) An experimental investigation of methods for eliminating bubbles is briefly reported.

549.514.51 **842**
Experimental Evidence for Dislocations in Crystalline Quartz.—H. E. Bömmel, W. P. Mason & A. W. Warner, Jr. (*Phys. Rev.*, 15th Sept. 1955, Vol. 99, No. 6, pp. 1894–1896.)

621.315.61 : 537.533.9 **843**
Effects Produced by Metal Electrodes in Studies of Electron-Bombardment Conductivity.—J. C. Firmin & C. W. Oatley. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 620–624.) The effect of the metallic film used as an electrode in the determination of electron-bombardment-induced conductivity of crystal insulators has been investigated and its bearing on the results of earlier workers is discussed. In thick films X rays may be generated, which penetrate the specimen and produce hole/electron pairs in the body of the material.

621.315.612 **844**
Phase Equilibrium Relations in the Systems Titania-Niobia and Zirconia-Niobia.—R. S. Roth & L. W. Coughanour. (*J. Res. nat. Bur. Stand.*, Oct. 1955, Vol. 55, No. 4, pp. 209–213.) Fundamental studies on ceramic dielectrics are reported.

621.315.613.1 : 621.396.822 **845**
Pre-breakdown Current and Noise in Insulators.—D. A. Powers & T. Suita. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1244–1247.) The frequency spectrum of noise associated with pre-breakdown currents has been investigated for mica over the a.f. range. The experimental results indicate that pre-breakdown avalanches are absent or rare; the noise is apparently due to fluctuations in field-emission current.

621.315.615 **846**
Conduction and Breakdown in Hexane.—W. B. Green. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1257–1264.) Report of an experimental investigation using field strengths up to 250 kV/cm.

MATHEMATICS

512.831 : 621.3.012.1 **847**
Matrix Representation of Complex Vectors.—S. Mayr. (*Elektrotech. u. Maschinenb.*, 1st Oct. 1955, Vol. 72, No. 19, pp. 460–464.) Technique useful for dealing with e.g. parallel-connected nonlinear resistors and nonlinear quadripoles is indicated.

MEASUREMENTS AND TEST GEAR

531.788 : 537.52 : 538.6 **848**

Methods for the Measurement of Low Gas Pressures by means of a Self-Maintained Gas Discharge in a Transverse Magnetic Field.—R. Haefer. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 200–215.) The gas pressure can be determined from measurements of (*a*) the value of magnetic induction at which ignition occurs for a given voltage, (*b*) the ignition voltage for a given magnetic induction, (*c*) the discharge current for given values of anode voltage, circuit resistance and magnetic induction, or (*d*) the running voltage of the discharge for given values of the same parameters. Gases considered are argon, air and hydrogen. Use of the short cylindrical electrode arrangement previously described (2914 of 1954 and back references) has proved satisfactory. The pressure range from 10^{-1} to 10^{-8} Torr can be covered using one or more of these methods.

621.317.3 : 537.533 **849**

Automatic Instrument for Electron Scattering Measurements.—L. Marton, J. A. Simpson & T. F. McCraw. (*Rev. sci. Instrum.*, Sept. 1955, Vol. 26, No. 9, pp. 855–858.) Measurements are made of the distribution in energy and angle of electrons scattered from solids irradiated by primary electrons having energies of 10–50 keV. Energy peaks less than 20 eV apart at 20 keV and angular details of less than 10^{-3} rad can be resolved.

621.317.3 : 537.533.8 **850**

Measurement of Electron Energies by Deflection in a Uniform Electric Field.—G. A. Harrower. (*Rev. sci. Instrum.*, Sept. 1955, Vol. 26, No. 9, pp. 850–854.) The parallel-plate analyser described is designed for the study of secondary electrons having energies in the range 100–900 V, and will separate electrons differing in energy by 2%.

621.317.3 : 537.533.8.08 **851**

Apparatus for the Measurement of Secondary-Emission Coefficients.—A. Bobenrieth. (*Le Vide*, July–Sept. 1955, Vol. 10, Nos. 58/59, pp. 103–104.) Primary electrons are provided by a directly heated tantalum cathode, and the secondary electrons are collected on a screen enclosing the specimen under test. The apparatus is enclosed in a continuously evacuated glass tube from which the specimen may easily be withdrawn.

621.317.444 **852**

An Electronic Magnetometer.—B. G. Cragg. (*J. sci. Instrum.* Oct. 1955, Vol. 32, No. 10, pp. 385–386.) An electron beam deflected by the magnetic field to be measured is automatically restored by an e.s. potential which is proportional to the field for fields alternating at frequencies up to 10 kc/s. With the instrument described, the weakest field measurable is 10^{-4} oersted.

621.317.7 **853**

New Methods for the Construction of Shockproof Indicating and Recording Measurement Instruments.—T. Staub. (*Bull. schweiz. elektrotech. Ver.*, 3rd Sept. 1955, Vol. 46, No. 18, pp. 837–840, 857–860.) The most important methods for testing shock-proof instruments are described. Tensioned-strip and pivoted mechanisms are compared as regards their shock resistance, as are also 90°- and 250°-deflection instruments.

621.317.72 : 621.396.812.3 **854**

Special Instruments for Observation and Analysis of V.H.F. Fading.—K. Hirao & H. Maruyama. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 207–216.) Description of the design of equipment suitable for the autocorrelation analysis of observations of fading of v.h.f. signals due to tropospheric refractive-index variations, with a discussion of the necessary duration of observation periods and intervals between readings.

621.317.723 **855**

Vibrating-Capacitor Electrometer.—M. Brière & J. Weill. (*J. Phys. Radium*, Aug./Sept. 1955, Vol. 16, Nos. 8/9, pp. 695–703.) Detailed description of an instrument capable of detecting d.c. down to 10^{-16} A or less and having very low zero drift.

621.317.725 : 621.375.2 **856**

Wide-Range Logarithmic Voltmeter.—F. V. Hunt & J. F. Hersh. (*Rev. sci. Instrum*, Sept. 1955, Vol. 26, No. 9, pp. 829–835.) A triode valve may be made to give a logarithmic output/input characteristic by including a diode rectifier in its grid circuit, increasing input then driving the valve towards cut-off. If the a.c. input signal is divided between the biasing diode and the triode to make the response curve symmetrical several stages may be cascaded without discontinuity. In the instrument described four such stages are used; on reaching cut-off each successive valve is clamped by a diode fed from the preceding stage, and the range of the voltmeter is approximately equal to the voltage gain of the cascade amplifier. The response is independent of frequency from 50 c/s to 100 kc/s and is logarithmic over the range 1 mV to 10 V.

621.317.725.029.4 : 621.317.733 **857**

Expanded-Scale Voltmeter for A.C. Measurements.—H. Galman. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 164–165.) Use of a hot wire in a bridge circuit gives a r.m.s. indication of the voltage to be measured. This is passed through a negative-feedback amplifier to a milliammeter. By use of a tapped input transformer a range of 100–500 V is obtained with a reading accuracy within 0·25%. The instrument is independent of frequency from 50 c/s to 2 kc/s.

621.317.742 **858**

Relationship between Eccentricities and Voltage Correction Factors for Concentric Slotted Lines.—Y. Kita. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 193–199.) The voltage correction factor for coaxial-line standing-wave detectors differs from unity by $2/(1-r^2)$ times the eccentricity, where r is the ratio of the radii of the inner and outer conductors.

621.317.742 **859**

Slotted-Section Standing-Wave Meter.—E. M. Wareham. (*J. Brit. Instn Radio Engrs*, Nov. 1955, Vol. 15, No. 11, pp. 539–564.) A detailed account is given of the theory and techniques of measurement, and some results are analysed; the design of a particular instrument is discussed.

621.317.755 **860**

An Automatic Cathode-Ray-Oscilloscope Beam Brightening Device for Transient Recordings.—J. Wood. (*J. sci. Instrum*, Oct. 1955, Vol. 32, No. 10, pp. 401–402.) By slight circuit alterations to a commercially available c.r.o. a brightening pulse of 70 V is automatically applied to the grid of the tube. The time taken for the beam to reach full brilliance, after the triggering of the timebase by a transient, is brought down to about 1 μs by setting the ordinary brightness control so that the spot is just visible in the absence of a transient.

621.317.755 861
Large-Screen Curve Tracer.—R. Duchamp. (*Télévision*, Oct. 1955, No. 57, pp. 249–253.) Details are given of a c.r.o. using a standard 43-cm television c.r. tube with magnetic deflection. The frequency range covered is 1–250 Mc/s, with a frequency sweep variable between 1 and 40 Mc/s. The vertical scale is linear or logarithmic, and the horizontal scale is in Mc/s.

621.317.755 862
Sawtooth Pulser gives Voltage/Current Curves.—N. Sclar & R. L. McFolin. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 156–157.) A thyratron pulse generator with external trigger enables the voltage/current characteristics of circuit elements to be displayed on a c.r.o. The load circuit includes a series resistance small compared with that of the specimen; the voltage across this gives a measure of the current passed. Heating of the specimen is minimized by the use of a short test pulse and a low repetition rate.

621.373.421.12 863
Audio-Standard Generator.—P. Koustas. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 161–163.) "Simultaneous output voltages are available at frequencies of 500 c/s, 1, 1·5, 2, 3, 5 and 10 kc/s from unit employing tuning-fork standard. Technique involves full-wave rectifiers as doublers to achieve desired frequencies."

621.374 864
Precision Digital Delay Generator.—W. Perzley. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 148–151.) A crystal-controlled 1-Mc/s pulse generator is followed by two cascaded divide-by-ten circuits, providing three ranges of pulse frequency. The output from these is passed through a ten-stage binary counter and pulses marking any required interval are selected by flip-flop controlled diode gates. The pulse timing is independent of flip-flop transition time.

621.385.001.4 865
The Rating of Thermionic Valves for Use under Abnormal Ambient Conditions.—Mills & Wright. (See 937.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.767 : 621.396.96 866
How Accurate are Radar Speed Meters?—J. Q. Brantley, Jr. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 132–134.) Tests on a type of motor-vehicle speed meter depending on the measurement of the Doppler shift in reflected signal frequency are described. Most of the possible errors are shown to result in speed indications which are too low.

539.32 : 534.2-8 867
Measurement of the Elastic Constants of Solids, using Ultrasonics.—G. Mayer & J. Gigon. (*J. Phys. Radium*, Aug./Sept. 1955, Vol. 16, Nos. 8/9, pp. 704–706.) A cylinder of the material under test is suspended in an ultrasonic field of continuously variable frequency, produced by an ionophone; the frequency is varied until the specimen resonates, this condition being detected e.g. by arranging a graphite or Ge point in light contact with the specimen and completing the circuit.

621-52 868
Automation—a Survey.—R. J. Bibbero. (*Elect. Engng, N.Y.*, Sept. 1955, Vol. 74, No. 9, pp. 775–780.) Historical and current aspects of development are discussed generally.

621.317.083.7(47) : 016 869
List of Russian and Translated Literature on Telemetering for 1950–1954.—V. P. Demeshin, I. A. Kostetskaya, A. I. Novikov, N. V. Pozin & V. A. Kashirin. (*Avtomatika i Telemekhanika*, July/Aug. 1955, Vol. 16, No. 4, pp. 409–410.)

621.317.39 870
Ice Detector for Lighter-than-Air Craft.—E. G. Thurston. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 142–144.) A piezoelectric Meacham-bridge oscillator system is used to determine the amount of ice or other deposit on the surface of balloons, etc., by cementing the piezoelectric element to the inside surface of the fabric so that the ice formation adds to its effective mass.

621.383.2 : 535.376 871
Realizable Light Gain in Photoelectronic Image Intensifiers.—L. Mandel. (*J. sci. Instrum.*, Oct. 1955, Vol. 32, No. 10, pp. 405–406.) By combining the most efficient photoelectric and luminescent surfaces an effective light gain of the order of 100 should be realizable. For photographic purposes two intensifiers in cascade, with optical focusing of the beam incident on each photocathode and on the photographic plate, should give a gain of about 115, with possibilities of further improvement.

621.384.6 872
Radiation Damping in Particle Accelerators with Circular Focusing Guiding Field.—W. Humbach. (*Z. Naturf.*, April 1955, Vol. 10a, No. 4, pp. 347–348.)

621.384.611/.612 873
The Extraction of the Beam from the Liverpool Synchrocyclotron.—(*Proc. roy. Soc. A*, 25th Oct. 1955, Vol. 232, No. 1189, pp. 236–251.)

Part 1—Theoretical.—K. J. Le Couteur (pp. 236–241). The beam is extracted by a magnetic deflector designed to produce radially unstable orbits while maintaining vertical stability; the theoretical specification of the apparatus is given.

Part 2—Experimental Work.—A. V. Crewe & J. W. G. Gregory (pp. 242–251). In the final result, 3% of the circulating beam was extracted from the cyclotron tank. The beam energy is 383 MeV, with no measurable energy spread. By means of an auxiliary magnet the beam has been focused to give a spot in which the proton flux density is at least 1 000 times greater than that obtained from any similar machine.

621.384.612 874
Three-Hundred-MeV Nonferromagnetic Electron Synchrotron.—W. B. Jones, H. R. Kratz, J. L. Lawson D. H. Miller, R. D. Miller, G. L. Ragan, J. Rouvina & H. G. Voorhies. (*Rev. sci. Instrum.*, Sept. 1955, Vol. 26, No. 9, pp. 809–826.) Description of an instrument in which electrons are injected at an energy of 100 keV, accelerated to 4 MeV by betatron action and then to 300 MeV by synchrotron action. The magnetic guiding fields for the betatron and synchrotron operation are produced by suitable coils.

621.384.612 875
The Accuracy of Alignment required for a Strong-Focusing Synchrotron.—W. Humbach. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 423–427.) Analysis for an alternating-gradient synchrotron shows that a statistical distribution of alignment errors causes the particles to diffuse from the prescribed orbit; the tolerances on alignment are governed by the permissible loss of particles due to this diffusion.

621.384.613 **876**

A 20-MeV Betatron for X-Ray Therapy.—D. Major, F. R. Perry & K. Phillips. (*Proc. Instn elect. Engrs*, Part A, Dec. 1955, Vol. 102, No. 6, pp. 845–856.) Full description of equipment installed at Manchester.

621.384.613 : 620.179.1 **877**

A 15-MeV Betatron for the Nondestructive Testing of Materials.—R. Schittenhelm. (*Arch. tech. Messen*, Sept., Oct. & Dec. 1955, Nos. 236, 237 & 239, pp. 205–208, 225–228 & 275–276.) Design details are given; emphasis is on low magnet weight and high electron-beam intensity.

621.384.622 **878**

Linear Acceleration of Charged Particles to High Energies.—C. W. Miller. (*Engineering, Lond.*, 9th & 16th Sept. 1955, Vol. 180, Nos. 4676 & 4677, pp. 340–343 & 374–377; *Metrop. Vick. Gaz.*, Dec. 1955, Vol. 26, No. 437, pp. 373–387.) An account is given of the development of linear accelerators, some post-war models are described and possible applications are reviewed. 45 references.

621.384.622.2 **879**

45-MeV Medical Linear Electron Accelerator.—C. L. Hsieh. (*Elect. Engng, N.Y.*, Sept. 1955, Vol. 74, No. 9, pp. 790–795.) Detailed description of a machine developed for a Chicago hospital.

621.385.833 **880**

The Field Distribution in Asymmetrical Magnetic Electron Lenses.—G. Liebmann. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 679–681.) The problem was investigated by the resistance-network analogue method (1954 of 1950). A series of typical characteristic curves is given.

621.385.833 **881**

The Magnetic Pinhole Electron Lens.—G. Liebmann. (*Proc. phys. Soc.*, 1st Sept. 1955, Vol. 68, No. 429B, pp. 682–685.) An asymmetrical lens is considered with bore radii R_0 and R_1, where R_1 is very small compared with R_0. The focal length is not greatly altered, but the spherical aberration may be considerably increased by the presence of the pinhole.

621.385.833 **882**

A Unified Representation of Magnetic Electron Lens Properties.—G. Liebmann. (*Proc. phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430B, pp. 737–745.) It is shown that many magnetic electron lenses, both symmetrical and asymmetrical, can be represented by a single focusing curve.

621.385.833 **883**

Experimental Investigation of Chromatic Aberration in the Electron Microscope.—S. Katagiri. (*Rev. sci. Instrum.*, Sept. 1955, Vol. 26, No. 9, pp. 870–873.) Experimental results indicate that chromatic field aberration can be completely compensated by a proper combination of two magnetic lenses. Micrographs with a resolution of about 5 mμ can be obtained with accelerating-voltage fluctuations as great as 1%.

621.385.833 **884**

On Electron Mirror Microscopy.—L. Mayer. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1228–1230.) A brief indication is given of the potentialities of electron-microscope systems in which the field in front of the specimen reflects the exploring beam. A resolving power comparable to that of the optical microscope has been obtained.

621.387.424 **885**

Behaviour of Externally Graphited Glass-Walled Geiger-Müller Counters exposed to Intense γ Radiation.—D. Blanc. (*J. Phys. Radium*, Aug./Sept. 1955, Vol. 16, Nos. 8/9, pp. 681–687.)

621.387.464 **886**

The Physics of the Scintillation Counter.—G. F. J. Garlick. (*J. sci. Instrum.*, Oct. 1955, Vol. 32, No. 10, pp. 369–371.) Factors limiting the performance of scintillation counters used as energy spectrometers are discussed. Spread in output-pulse magnitude when detecting mono-energetic particles results from statistical fluctuations in the photomultiplier cathode; in practice other variables can also contribute. The problem of non-linear variation of phosphor response is treated.

621.387.464 **887**

Problems of Large-Area Scintillation Counters.—F. X. Roser. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 297–323.) The various, sometimes conflicting, requirements for optimum resolving power are discussed. A method involving masking of the central region of the photomultiplier cathode has given good results. 102 references.

621.387.464 **888**

Portable Scintillation Counter for Applications in Geology.—H. Schneider. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 413–416.) The probe unit of the instrument described comprises a NaI/Tl crystal of diameter 30 mm and thickness 15–20 mm in combination with a German Type-FS9-A photomultiplier; the amplifier, batteries, etc. are in a separate case. Sensitivity is ten times that of a G-M counter with the same active area.

771.36 : [621.383.2 + 621.317.755 **889**

A [camera-] Shutter Tester using a Photoelectric Integrator.—R. J. Hercock & D. M. Neale. (*J. Brit. Instn Radio Engrs*, Nov. 1955, Vol. 15, No. 11, pp. 565–575.) An instrument comprising a photoelectric integrator together with a single-sweep c.r.o. is described.

534-8 : 62 **890**

Ultrasonic Engineering. [Book Review]—A. E. Crawford. Publishers: Butterworths Scientific Publications, London, 344 pp., 45s. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 355–356.) ". . . should prove of considerable help to the acoustics engineers interested in the effects and applications of ultrasonic waves."

PROPAGATION OF WAVES

621.396.11 **891**

Ground-Wave Propagation over a Nonhomogeneous Earth.—K. Venkitaraman. (*J. Instn Telecommun. Engrs, India*, Sept. 1955, Vol. 1, No. 3, pp. 155–171.) The relative merits of known methods of calculating the ground-wave field strength are assessed by reference to measurement results. The superiority of Millington's method is confirmed.

621.396.11 : 551.510.535 **892**

The Physics of the Ionosphere.—(See 755.)

621.396.11 : 551.510.535 **893**

The Influence on the Recordings of Ionosphere E-Layer Soundings of the Separation Level of Regions of Quasi-longitudinal (Q.L.) and Quasi-transverse (Q.T.) Propagation.—D. Lepechinsky. (*C. R. Acad. Sci., Paris*, 3rd Oct. 1955, Vol. 241, No. 14, pp. 897–900.) Continuation of previous discussion [1767 of 1955 (Lepechinsky & Durand)]. Conditions are considered for the four cases when the E-layer maximum-ionization level is (*a*) above, (*b*) coincident with, (*c*) a little below, and (*d*) considerably below the separation level. An indication is given of the nature of the *h'f* traces to be expected and of the significance of the various conditions for the evaluation of the maximum E-layer ionization from the f_0 value. Recordings made at Poitiers are reproduced showing absence of trace corresponding to case *b* and the inflection point corresponding to case *c*.

621.396.11 : 551.510.535 **894**

Characteristics of F_2-Layer Multiple Reflections (10–16 Times).—Y. Echizenya, S. Katano & Y. Ogata. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 137–141.) Routine vertical-incidence ionospheric soundings during 1953 and 1954 show that high-order multiple reflections occur only at night and are confined to the ordinary ray. The frequency of occurrence of the phenomenon is high in spring and autumn and low in summer and winter and shows marked correlation with the noon value of f_0F_2.

621.396.11 : 551.510.535 **895**

Magneto-ionic Triple Splitting over Delhi.—S. N. Mitra. (*J. Instn. Telecommun. Engrs, India*, Sept. 1955, Vol. 1, No. 3, pp. 124–129.) Records of triple splitting obtained on six occasions between 1951 and 1955 are discussed with particular reference to the low geomagnetic latitude of Delhi. The splitting may be caused by longitudinal propagation of the ordinary ray, associated with an increase in the collision frequency in the ionosphere.

621.396.11 : 551.510.535 **896**

Observations of Short-Wave Back-Scatter with Commercial Telegraphy Signals.—B. Beckmann & K. Vogt. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, pp. 473–481.) Observations were made using the 'ring' method, in which the back-scattered signal is transposed to i.f. and applied with 90° phase difference to the vertical and horizontal plates of a c.r.o. so that signal amplitudes are displayed as rings. Results show that the azimuthal distribution of back-scatter is governed by ionospheric conditions and by the radiation patterns of the transmitting aerial; when a directional aerial is used the main direction from which energy is received is that theoretically expected. The back-scatter mainly uses the great-circle path. The time variation of the back-scatter intensity agrees with that for ordinary propagation in the same wave-band. Determinations of the dead zone can be made from the variation of back-scatter transmission time with frequency.

621.396.11.029.62 **897**

On the Relationship between the Hourly Variation of Field Strength and the Structure of the Lower Atmosphere.—K. Tao. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 181–191.) Field-strength observations made on 60-Mc/s signals transmitted over a distance of 125 km are correlated with meteorological data.

621.396.11.029.63/.64 **898**

Experimental Studies on Diffracted Waves from a Mountain at 3 000 Mc/s.—T. Kono, K. Nishikori, M. Fukushima, M. Ikeda & N. Yoshida. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 163–180.) Continuous photographic records were made of the reception of pulsed transmissions over distances of 234 km and 166 km across a mountain 1 000 m high. The measurements were made in September and December 1954, respectively. For the first path, with the receiving station situated 90 km beyond the mountain, the observed field strength agreed approximately with that calculated by Fresnel's knife-edge-diffraction theory; for the second path, with the receiver 35 km beyond the mountain, the field strength was about 10 dB below the calculated value.

621.396.11.029.64 : 621.396.96 : 551.578.4 **899**

The Back-Scattering Coefficient of a Spherical Homogeneous Mixture of Ice and Air at Wavelengths between 1 and 10 Centimeters.—J. C. Johnson. (*J. Met.*, April 1955, Vol. 12, No. 2, pp. 188–189.)

621.396.812.3 : 551.510.535 **900**

Three Components of the Field Strength of the Wave reflected from the Surface of the Ionosphere, their Level and Time Variation.—H. Uyeda, Y. Ogata, K. Uchikura, Y. Arima & H. Obayashi. (*J. Radio Res. Labs, Japan*, April 1955, Vol. 2, No. 8, pp. 143–161.) Tentative theory is developed to account for observed variations in received field strength of 4-Mc/s signals. Formulae are derived for various configurations of the ionospheric reflecting surfaces, considered (*a*) at rest and (*b*) moving with constant horizontal velocity.

621.396.812.3 : 621.317.72 **901**

Special Instruments for Observation and Analysis of V.H.F. Fading.—Hirao & Maruyama. (See 854.)

RECEPTION

621.374 **902**

Frequency of Coincidence of Two Sets of Recurrent Pulses.—H. Rakshit & S. C. Mukherjee. (*J. Instn Telecommun. Engrs, India*, Sept. 1955, Vol. 1, No. 3, pp. 130–135.) Conditions are analysed for narrow and for broad pulses.

621.396.62 : 621.372.543.2 : 621.396.822 **903**

Bandwidths of Various Filter Circuits and C.C.I.R. Recommendations on Effective Noise Bandwidths.—E. Henze. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, pp. 512–515.) According to the C.C.I.R. recommendation, effective noise bandwidth of receivers is the width of a rectangle having the same area as the actual selectivity curve. The ratio of the effective noise bandwidth to the actual bandwidth is calculated for several practical selective circuits.

621.396.621 : 621.396.822 **904**

The Effect of a Random Noise Background upon the Detection of a Sinusoidal Signal.—H. S. Heaps. (*Canad. J. Phys.*, Sept. 1955, Vol. 33, No. 9, pp. 509–520.) Analysis is presented for the case when the signal envelope exhibits negligible fluctuations. The effect of large signal fluctuations is demonstrated by comparing these results with those obtained previously (2099 of 1955).

621.396.82 : 551.594.6 : 621.317.3 **905**

Atmospheric Noise Interference to Broadcasting in the 5-Mc/s Band at Poona.—K. R. Phadke. (*J. Instn Telecommun. Engrs, India*, Sept. 1955, Vol. 1, No. 3, pp. 136–146.) Measurements of atmospheric noise interference were made during the hours 1800–2300 I.S.T., using Aiya's method (257 of 1955). The results are used to discuss noise values for satisfactory broadcasting service, in comparison with Radio Research Board and Central Radio Propagation Laboratory estimates. Noise levels estimated from lightning-discharge data [3263 of 1955 (Aiya)] are in close agreement with the measured values.

621.396.828 **906**

Reducing Radio Interference.—(*Elect. Times*, 8th Sept. 1955, Vol. 128, No. 3331, p. 352.) Note on a new Code of Practice CP 1006:1955, published by the British Standards Institution, on the general aspects of radio-interference suppression in the medium- and long-wave bands as well as the 41–61-Mc/s television band. Requirements and tests for suppressor components and complete filter units are covered by the revised British Standard 613:1955.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.1 **907**

Theory of Pre-correction of Transmission Errors.—B. Mandelbrot. (*Ann. Télécommun.*, June 1955, Vol. 10, No. 6, pp. 122–134.) Feinstein's theorem (858 of 1955) is discussed and practical methods of pre-correction are derived.

621.395.44 : 621.315.212 **908**

Coaxial-Cable Carrier-Current Systems.—J. Bauer & J. Valloton. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Sept. 1955, Vol. 33, No. 9, pp. 337–368. In German and French.) Detailed description of the Swiss system providing 960 telephony channels in the frequency band 60 kc/s–4·028 Mc/s.

621.396.1 **909**

Future of European Broadcasting.—G. H. Russell. (*Wireless World*, Jan. 1956, Vol. 62, No. 1, pp. 18–22.) Failures of the Copenhagen plan (832 of 1949) are discussed and a suggested new plan is outlined providing 15 long-wave channels between 150 and 285 kc/s and 121 medium-wave channels in four bands between 525 kc/s and 1·602 Mc/s. Total power would be allocated to each country on an area basis.

621.396.41 : 551.510.52 **910**

Designing Over-Horizon Communications Links.—D. Davidson & A. J. Poté. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 126–131.) Existing knowledge on long-range tropospheric propagation is summarized, with references to original papers, and the design considerations necessary to achieve a system having a given reliability are discussed. See also 263 of January (Mellen et al.).

SUBSIDIARY APPARATUS

621-526 : 621.372.5 **911**

The Response Functions and Vector Loci of First and Second Order Systems.—Morris. (See 690.)

621.311.6 : 621.314.67 **912**

Reliable Power-Pack Design.—A. F. Standing. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 532–535.) "A method is described which reduces the design of capacitor-input power packs to simple calculations aided by graphs."

621.316.722 : [621.375.23+621.373.421 **913**

A Constant-Voltage Amplifier and Oscillator.—G. N. Patchett. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 536–539.) The equipment is based on the use of a thermistor bridge to regulate feedback and was designed for a frequency of 1 kc/s. The amplifier output voltage is constant to within 0·1% for an input-voltage range of 0–4 V, with load varying from zero to 10 W or supply voltage varying from 130 to 250 V. Used as an oscillator, the equipment gives an output-frequency change of 1 c/s for a supply-voltage change from 180 to 250 V when operating on full load, and < 3 c/s for maximum load variation at a given supply voltage.

621.318.435 : 621.316.722.076.25 : 621.372.54 **914**

Stabilization of Random Voltage Fluctuations by Ferroresonant [saturated-choke] **Stabilizer.**—A. N. Malakhov. (*Bull. Acad. Sci. U.R.S.S., tech. Sci.*, July 1955, No. 7, pp. 3–8. In Russian.) An investigation is reported of the transfer of voltage fluctuations by a stabilizer comprising an air-cored choke (L), in series with the input, and a saturated choke (D) in parallel with the load. The calculated and experimentally determined transfer-coefficient frequency characteristics presented in figs 3 and 4, respectively, show (a) that there is a maximum at a frequency $\Omega_0 < \omega$, where ω is the supply frequency, and (b) that the attenuation is high only for fluctuations with angular frequency $\Omega \ll \Omega_0$.

621.319.339 **915**

High-Voltage Generator of van de Graaff Type with Liquid Charge Carrier.—K. Janner, S. Magun & E. Schopper. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 446–450.)

TELEVISION AND PHOTOTELEGRAPHY

621.397.2 : 621.375.2 **916**

The 'Chasseral'-Type Video Distribution Amplifier.—H. A. Laett. (*Tech. Mitt. schweiz. Telegr.-Teleph-Verw.*, 1st Sept. 1955, Vol. 33, No. 9, pp. 369–374. In German and French.) The amplifier is designed to suit both 75-Ω and 150-Ω coaxial cable; the bandwidth is 10 Mc/s and the overall gain is unity with a reserve of 10 dB. Low-frequency equalization is effected by a series combination of integrating and differentiating *RC* networks. There are two separate feedback loops, one with a level frequency response and the other with a rising frequency response. Four parallel output stages are provided, using pentodes with negative current feedback.

621.397.5 : 535.623 **917**

Colour Television—B.B.C. Experiments.—(*J. Brit. Instn Radio Engrs*, Nov. 1955, Vol. 15, No. 11, pp. 576–581.) Details are given of the equipment and modified N.T.S.C. signal used.

621.397.5 : 778.5 **918**

The Suppressed-Frame System of Telerecording.—C. B. B. Wood, E. R. Rout, A. V. Lord & R. F. Vigurs. (*B.B.C. Engng Div. Monographs*, No. 1, pp. 1–14.) Description of apparatus comprising a high-grade television monitor [1753 of 1953 (Lord & Wood)] together with a commercially available 35-mm motion-picture camera.

621.397.5 : 778.5 **919**

16-mm Telerecording for Sequential Television Systems.—V. B. Hulme. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 516–522.) "A system of telerecording using continuous film motion through a shutterless gate is described. The camera motor speed is controlled by means of negative feedback components of phase, velocity and acceleration. A d.c. generator and pulse generator driven by the motor together with a phase-discriminator provide these components in the form of voltages." The picture is presented line by line on the screen of the c.r. tube, the frame scan being eliminated.

621.397.5(083.74) **920**

Television Waveform.—(*Wireless World*, Jan. 1956, Vol. 62, No. 1, p. 26.) The black level in the British 405-line waveform has been lifted by 5% of peak white amplitude and the suppression period preceding the synchronizing signal has been lengthened by 0·5 μs compared with the previous standards (2912 of 1952).

621.397.5(494) : 621.396.11 **921**

Television in Switzerland.—(*Wireless World*, Jan. 1956, Vol. 62, No. 1, pp. 33–35.) Service to thickly populated areas is provided by three stations working on frequencies in band I and a fourth using band III. The stations are sited at altitudes of 2 000–5 000 ft and the mean height of towns served is about half that of the corresponding transmitter. The transmitters are linked by a radio-relay system working on 2 kMc/s. A map shows the effective coverage of one of the transmitters. See also 277 of 1955 (Gerber).

TRANSMISSION

621.396.61 : 621.372.54 **922**

High-Frequency Filters and Tuning of Amplitude-Modulated Transmitters.—R. Guertler. (*Telefunken Ztg*, June 1955, Vol. 28, No. 108, pp. 116–123. English summary, pp. 134–135.) Transmitter output stages are discussed comprising coupled tuned circuits of which the primary one, in the output-valve anode circuit, is parallel resonant while the secondary is series resonant. A frequency response symmetrical with respect to carrier frequency, and hence absence of unwanted phase modulation, is attained by adjusting the secondary rather than the primary circuit to make the anode impedance purely resistive. Locus diagrams indicate the circuit operation.

VALVES AND THERMIONICS

621.314.63 : 546.28 **923**

Zener-Voltage Breakdown Uses in Silicon Diodes.—C. N. Wulfsberg. (*Electronics*, Dec. 1955, Vol. 28, No. 12, pp. 182..192.) For back voltages less than the Zener voltage the back resistance of a Si junction diode may exceed $10^{10}\,\Omega$. The Zener voltage may be made to have any value from 3 V to several hundred volts. A wide variety of applications is discussed.

621.314.7 **924**

Junction Transistor Electronics.—J. L. Moll. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1807–1819.) A review paper. The mechanism of current transport at semiconductor junctions is described and parameters of junction transistors are hence derived. Amplifying, oscillating and switching performance is discussed. Replacement rates as low as one per 20 000 transistor-hours are reported.

621.314.7 **925**

Temperature Variation of the 'Punch-Through' Voltage of a Transistor.—O. Garreta. (*C. R. Acad. Sci., Paris*, 3rd Oct. 1955, Vol. 241, No. 14, pp. 857–859.) The variation of the 'punch-through' voltage [3329 of 1953 (Dacey)] over the temperature range 14°–300°K was studied for *p-n-p* transistors. The potential distribution through the transistor exhibits its maximum value at a point within the base distant x_m from the emitter junction, where $x_m = T^{\frac{1}{2}}\,\phi(z_m)$ and z_m is a dimensionless parameter. A formula is derived indicating that the value of the punch-through voltage at any temperature is equal to the value at zero temperature less a term proportional to x_m. This formula is verified by experimental results on three Ge transistors. By extrapolating to zero temperature the thickness of the base can be determined exactly.

621.314.7 : 546.28 **926**

Recent Developments in Silicon Fusion Transistors.—R. A. Gudmundsen, W. P. Waters, A. L. Wannlund & W. V. Wright. (*Trans. Inst. Radio Engrs*, Jan. 1955, Vol. ED-2, No. 1, pp. 74–81.)

621.314.7 : 621.375.4 **927**

Some Properties and Circuit Applications of Super-Alpha Composite Transistors.—A. R. Pearlman. (*Trans. Inst. Radio Engrs*, Jan. 1955, Vol. ED-2, No. 1, pp. 25–43.) Circuits are discussed in which two junction transistors are interconnected in such a way that the gain of the combination is increased; α values $> 0{\cdot}99$ can be achieved. The properties of such arrangements are in many ways equivalent to those of a vacuum triode. Voltage-follower and voltage-amplifier circuits using composite transistors are described. Characteristics of two- and three-stage composite transistors are shown graphically.

621.314.7 : 621.375.4 **928**

The Equations and the Equivalent Circuit of the Transistor.—M. Skalicky. (*Elektrotech. u. Maschinenb.*, 1st Sept. 1955, Vol. 72, No. 17, pp. 422–423.) Analysis leads to the development of a passive-quadripole representation of the transistor.

621.383.27 : 621.396.822 **929**

Hysteresis Effect in Multiplier Phototube Noise.—C. A. Ziegler & H. H. Seliger. (*J. appl. Phys.*, Oct. 1955, Vol. 26, No. 10, pp. 1225–1227.) Measurements of the variation of noise with time and with operating parameters are reported for two types of photomultiplier. Possible explanations of the observed effects are discussed.

621.383.27.032.21 **930**

Dark Current of Secondary-Electron Multipliers with (Ag)-Cs_2O, Cs-Ag Photocathodes.—F. Eckart. (*Ann. Phys., Lpz.*, 20th Sept. 1955, Vol. 16, Nos. 5/8, pp. 322–330.) The temperature dependence of the thermionic emission of the cathode was investigated over the temperature range of about 20°C–40°C. At 19·7°C the dark current at the anode was $3{\cdot}2 \times 10^{-8}$ A with an amplification of $1{\cdot}4 \times 10^6$; this corresponds to a thermionic emission of 10^{-15} A cm². The work function, calculated from the specific-emission/reciprocal-temperature curve, is 0·95 eV, that calculated from the cut-off frequency of the external photoeffect is 1·06 eV. The construction and manufacture of the photomultiplier is described in detail.

621.383.4 : 535.37 : 621.318.57 **931**

Opto-electronic Devices and Networks.—E. E. Loebner. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1897–1906.) "The transducing properties of electroluminescent and photo-responsive cells are described. The light amplifying and spectrum-converting characteristics of a circuit consisting of an electric power supply and a series combination of the two types of cells whose impedances have been matched are discussed. The construction and operation of an opto-electronic bistable device—the 'optron'—employing positive radiation feedback, is reported. The optron is both a storage cell and a switch with dual (optical and electrical) signal input and output. Numerous logic networks, composed of electric series and parallel combinations of electroluminescent and photoconductive cells with selected optical couplings have been designed, constructed, and operated."

621.383.4 : 535.371.07 **932**

Theory and Experiments on a Basic Element of a Storage Light Amplifier.—J. E. Rosenthal. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1882–1888.) Theory is developed to explain the operation of solid-state image intensifiers of the type described e.g. by Orthuber & Ullery (3061 of 1954), in which a layer of a photoconductor such as CdS is used to control the voltage across an electroluminescent element. Optimum values of operating parameters deduced are in good agreement with experimental results.

621.383.4 : 535.371.07 **933**

An Electroluminescent Light-Amplifying Picture Panel.—B. Kazan & F. H. Nicoll. (*Proc. Inst. Radio Engrs*, Dec. 1955, Vol. 43, No. 12, pp. 1888–1897.) The construction of large-area solid-state image intensifiers of the general type described by Orthuber & Ullery (3061 of 1954) is made feasible by providing the photoconductive CdS in powder form [612 of February (Nicoll

& Kazan)]; the powder may be supported on a mesh or laid in grooves. Using an excitation frequency of e.g. 400 c/s, good resolution of half-tone pictures has been obtained with panels 12 in. square. Response time is 0·1 sec or more; other photoconductive materials may be found to give quicker response.

621.383.4 : 537.311.33 : 535.215 **934**

Lead Salt Photoconductors.—Moss. (See 773.)

621.383.5 : [621.314.63 + 621.314.7 **935**

Photodiodes and Phototransistors considered as Infrared-Radiation Detectors.—G. A. Boutry & F. Desvignes. (*Nuovo Cim.*, 1955, Supplement to Vol. 2, No. 3, pp. 541–563. In French.) A comprehensive survey with 59 references.

621.385 **936**

Some Factors affecting Transmitting Valve Life.—T. N. Basnett. (*J. Brit. Instn Radio Engrs*, Nov. 1955, Vol. 15, No. 11, pp. 588–592.) Reprint. See 3717 of 1954.

621.385.001.4 **937**

The Rating of Thermionic Valves for Use under Abnormal Ambient Conditions.—B. D. Mills & W. W. Wright. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 276–292.) Manufacturers' published ratings may need revision if valves are to be operated in either very high or very low ambient temperatures. An interim report is presented of a program of life tests designed to determine suitable maximum temperatures for various types of valve. The procedure adopted is to set the ambient conditions as desired and to measure the 'hot-spot' bulb temperatures for a range of input anode powers. Results are presented graphically, the variables being the total input power, the 'hot-spot' temperature, the ambient temperature, and the equivalent altitude. Simple tests can give enough information to evolve a whole family of rating curves.

621.385.029.6 **938**

Theory of the Pre-oscillating Magnetron: Part 2—Perturbations of a Double-Stream Steady State.—G. D. Sims & D. Gabor. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 231–262.) An attempt is made to determine theoretically the dispersion relation for oscillations in a cut-off magnetron on the assumption of a double stream in the steady state, and of a particular distribution of electron velocities. A perturbation method is used; the electron density of the perturbed cloud is deduced for the case of a finite cathode temperature. The implications of the results in relation to magnetron starting, back-bombardment and noise spectrum are discussed. Part 1: 3787 of 1955 (Gabor & Sims).

621.385.029.6 **939**

Comments on Magnetron Theory, with Particular Reference to some Recent Publications.—O. Buneman. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 314–323.) Recently published papers are criticized as being unduly preoccupied with symmetrical steady states and indicating possible ignorance of wartime development work on magnetrons. The question is posed, whether the magnetron is worth the intense theoretical effort required to solve the problems involved.

621.385.029.6 : 537.533 **940**

Energy Distribution of Electrons in Beams with Strong Space Charge.—W. Veith. (*Z. angew. Phys.*, Sept. 1955, Vol. 7, No. 9, pp. 437–443.) Experiments with specially constructed travelling-wave valves show that if the beam is retarded between the end of the helix and the collector electrode the range of electron energies is very greatly extended. The effect is attributed to a redistribution of energy occurring as the beam traverses the retarding path; the extra-high energy values increase with increasing length of the retarding path. The explanation is relevant also to phenomena observed with hollow cathodes.

621.385.029.6 : 537.533 : 621.386 **941**

An X-Ray Method for studying Radial Current Distributions in Electron Beams.—J. S. Thorp. (*Brit. J. appl. Phys.*, Oct. 1955, Vol. 6, No. 10, pp. 366–368.) The cathode producing the beam to be studied is mounted in a valve whose anode is a thin foil forming part of the envelope. Soft X rays, generated by the impact of electrons on the foil, are transmitted and produce an image of the transverse section of the beam on a photographic film pressed against the outer surface of the foil. The method has applications in the development of klystrons, etc.

621.385.029.6 : 621.372.2 **942**

Propagation in Linear Arrays of Parallel Wires.—J. R. Pierce. (*Trans. Inst. Radio Engrs*, Jan. 1955, Vol. ED-2, No. 1, pp. 13–24.) Analysis is presented for propagation in periodic structures incorporating transverse wires, of the general type used in the travelling-wave valves discussed by Leblond & Mourier (1204 of 1955) and Karp (1212 of 1955).

621.385.029.6 : 621.386 **943**

X-Ray Production by Magnetron.—A. C. Wesley. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, p. 29.) Incidental production of soft X rays by a Type-4J50 magnetron has been observed. A bend should be included in waveguide systems used with the magnetron, to act as an X-ray filter.

621.385.029.64 **944**

The Design and Performance of a High-Power Demountable Klystron Amplifier for X-Band.—J. D. Lawson, R. S. Barton, T. F. Gubbins, W. Millar & P. S. Rogers. (*J. Electronics*, Nov. 1955, Vol. 1, No. 3, pp. 333–354.) The design of a two-cavity klystron to give c.w. power of 1 kW and a gain of 10 at 9·375 kMc/s is discussed. Constructional techniques are described in detail. Performance is in fair agreement with basic theoretical predictions, except as regards the gain.

621.385.032.216 **945**

Thermionic Emission from Sintered Mixtures of Powdered Tungsten with Alkaline-Earth Carbonates.—G. Mesnard & R. Uzan. (*Le Vide*, July–Sept. 1955, Vol. 10, Nos. 58/59, pp. 105–118.) The chemical reactions occurring during the heat treatment of cathodes formed from mixtures of powdered refractory metals with emissive powders are discussed; emissivity/temperature curves for various mixtures are given. The cathodes considered are superior to the usual types as regards sensitiveness to the presence of gas and ionic bombardment, and they can readily be reactivated. See also 3728 of 1954 (Uzan & Mesnard), etc.

621.385.032.216 **946**

The Effect of Zirconium on Sintered Alkaline-Earth Oxide Cathodes.—G. Mesnard & R. Uzan. (*Le Vide*, July–Sept. 1955, Vol. 10, Nos. 58/59, pp. 124–134.) The addition of Zr as a reducing agent to the mixtures used in the formation of sintered cathodes is shown to have harmful effects on the emissivity. Heat treatment in an atmosphere of hydrogen gives bad results, favouring oxidation of the metals present. Amongst possible alternatives, the use of Ni gives best results. See also 3728 of 1954 (Uzan & Mesnard), etc.

621.385.2 : 621.396.822 947

The Rise of Noise Temperature in Space-Charge-Limited Diodes.—H. W. König. (*Arch. elekt. Übertragung*, Sept. 1955, Vol. 9, No. 9, pp. 411–418.) Continuation of previous discussion (2794 of 1955). Calculations made taking account of electron-velocity fluctuations at the cathode and of the correlation between velocity and current fluctuations give results in improved agreement with observations. Very small irregularities in cathode structure may cause a reduction of the space-charge factor of several thousandths below the ideal value of unity, leading to a very large rise of noise temperature with increasing anode voltage. The theory presented enables the imaginary part of the correlation factor to be determined from experiments.

621.385.2.029.6 948

Electron Trajectories in Coaxial Diodes.—R. Dehn. (*Wireless Engr*, Jan. 1956, Vol. 33, No. 1, pp. 10–12.) Calculations have been made for diodes in which the electron transit time corresponds to several cycles at 3 kMc/s. Depending on the r.f. phase at which they are emitted, electrons may proceed to the anode or may return to the cathode either within a single r.f. cycle or in the course of several r.f. cycles. Experimental results indicate that the numbers of electrons reaching the anode and returning to the cathode are about equal.

621.385.832 949

A Theory of determining the Dynamic Sensitivity of Cathode-Ray Tubes at Very High Frequencies by Means of Fourier Transforms.—E. F. Bolinder. (*Trans. Inst. Radio Engrs*, Jan. 1955, Vol. ED-2, No. 1, pp. 44–50.)

621.385.832.032.2 950

The Electron Gun of the Cathode-Ray Tube—Tetrode or Triode?—J. A. Darbyshire. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 523–528.) The triode gun gives a smaller spot at the centre of the screen and is therefore preferable for some applications, but for television purposes the tetrode gun is better since it has a narrower beam width in the region of the scan coils and hence better deflection defocusing characteristics, together with lower cathode loading.

621.387 951

Initiation of Hot-Cathode Discharges.—N. R. Daly & K. G. Emeleus. (*Brit. J. appl. Phys.*, Oct. 1955, Vol. 6, No. 10, pp. 370–372.) Report of an experimental study of the effect of a voltage fall along a hot cathode on the initiation of a gas discharge in a diode at low pressure. Observations were made of the appearance of the discharge before and after the formation of plasma, and of the oscillations generated by the discharge.

621.387 952

Running-Voltage/Current Characteristics of some Glow-Discharge Tubes.—F. A. Benson & G. Mayo. (*Electronic Engng*, Dec. 1955, Vol. 27, No. 334, pp. 540–542.) Conclusions arrived at in a previous paper (3422 of 1954) concerning the important influence of the gas filling on the running-voltage/ambient-temperature characteristics of glow-discharge tubes are shown to apply also to running-voltage/current characteristics. Running-voltage drift and hysteresis effects also vary with the kind of gas used.

621.387 : 621.318.57 953

Response Times of Gas-Filled Valves for Switching Purposes in Communication Engineering.—K. Braun. (*Fernmeldetech. Z.*, Sept. 1955, Vol. 8, No. 9, pp. 490–493.) Equipment for measuring firing time is described. For a coincidence thyratron with anode voltage 60 V and grid overvoltage 1 V, a value of 10 μs was found; for some cold-cathode triodes with anode voltage 180–250 V and starter overvoltage 5–10 V the value was 100 μs.

621.387 : 621.385.3 954

Amplifier Action of Gas-Filled Triodes.—A. Székely. (*Acta phys. austriaca*, Aug. 1955, Vol. 9, Nos. 3/4, pp. 258–266.) Continuation of experiments reported previously (599 of 1954). If it is assumed that the internal resistance of the gas-filled triode is determined by the resistance of the positive space-charge layer around the grid, the amplifier action can be described by means of the Barkhausen formula for the vacuum triode and the dependence of the amplification on the frequency and amplitude of the grid voltage and on the intensity of the auxiliary grid-anode discharge can be explained. High gain is obtainable only for frequencies below about 150 kc/s. Gain is constant only for grid alternating voltages below about 0·5–1 V; the value for the Type-4690 valve used is 44.

MISCELLANEOUS

061.3 : [55 + 621.396.11 955

The XIth General Assembly of the International Scientific Radio Union (U.R.S.I.), held at The Hague, 1954.—(*Onde élect.*, June 1955, Vol. 35, No. 339, pp. 555–629.) Nine papers are presented summarizing the work of the assembly in the fields of standards, tropospheric and ionospheric propagation, noise, radio astronomy, circuitry and general electronics. For a short report see *Nature, Lond.*, 3rd Sept. 1955, Vol. 176, No. 4479, pp. 451–452.

061.3 : 621.3 956

Electronics and Television Convention: Proceedings. [Book Notice]—Supplement to *Ricerca sci.*, Milan, 1954, 2 vols, 10 000 lire. (*J. Telev. Soc.*, July–Sept. 1955, Vol. 7, No. 11, p. 482.) Includes all the papers given at this international convention, in the original languages, with summaries in French, German and English. The subjects discussed included magnetic, dielectric and semiconductor materials, electron optics, radar, servomechanisms, computers and cybernetics.

061.6 : 621.3 957

The 'Galileo Ferraris' National Electrotechnical Institute.—P. Lombardi. (*Ricerca sci.*, July 1955, Vol. 25, No. 7, pp. 1988–2047.) Report of activities for the two years 1951–1953. The subjects covered include properties of ferromagnetic materials, electroacoustics, electronics, radio engineering and television.

539.1 (44) 958

Nuclear Energy and its Industrial Applications: Part 1—Atomic Piles and Radioisotopes.—(*Onde élect.*, Oct. 1955, Vol. 35, No. 343, pp. 783–945.) This issue comprises a group of papers providing a survey of developments of atomic energy in France, with descriptions of equipment and methods used.

621.3.002.2 959

Automatic Circuit Production.—(*Wireless World*, Jan. 1956, Vol. 62, No. 1, p. 23.) Improvements to the E.C.M.E. machine [1913 of 1947 (Sargrove)] will reduce the preparatory period before a production run from three months to a few days.

621.3.002.2 960

Punched Cards control Job-Lot Assembly System.—G. W. Gamble, C. J. Godwin & F. S. Feldheim. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 122–128.) An automatic assembly system for producing complete subassemblies of electronic equipment in batches of up to 20 is described. Etched wiring and dip soldering are used.

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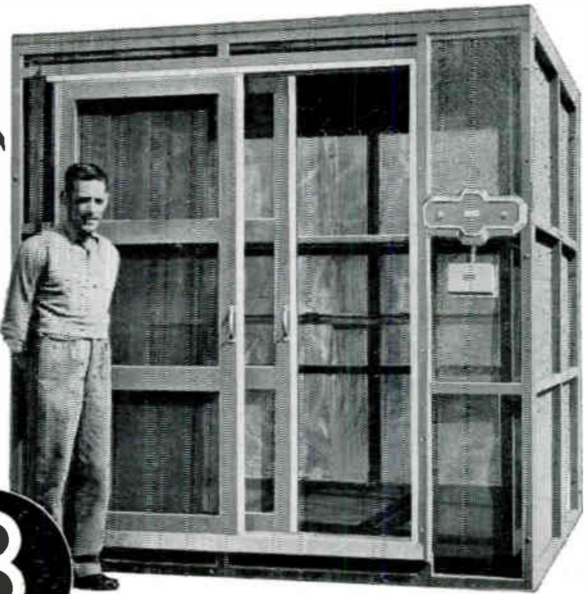

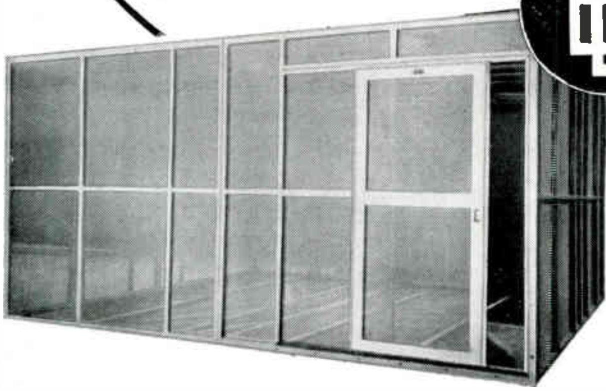

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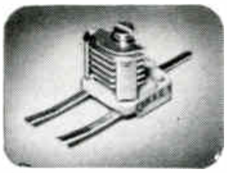

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0·25	500	350	2¼	¾	CP47S	2/10
0·5	500	350	2¼	1	CP91S	3/10
0·02	750	500	1½	½	CP45U	1/10
0·001	1000	650	1½	⅜	CP49W	1/10
0·002	1000	650	1½	⅜	CP49W	1/10
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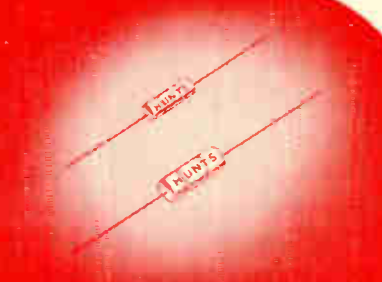

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BM8	0.004	0.610	0.135
BM11	0.004	0.500	0.180
BM9	0.005	0.610	0.135
BM12	0.005	0.500	0.180
BM13	0.01	0.500	0.180
BM14	0.02	0.610	0.180
BM15	0.03	0.610	0.260
BM16	0.04	0.610	0.260
	400 volts D.C.	Wkg.	
BM4	0.0004	0.610	0.135
BM5	0.0005	0.610	0.135
BM6	0.001	0.610	0.135
BM18	0.002	0.500	0.180
BM19	0.003	0.500	0.180
BM20	0.005	0.610	0.180
BM21	0.01	0.610	0.260
	600 volts D.C.	Wkg.	
BM25	50 pF.	0.500	0.180
BM1	0.0001	0.610	0.135
BM26	0.0001	0.500	0.180
BM2	0.0002	0.610	0.135
BM27	0.0002	0.500	0.180
BM28	0.00022	0.500	0.180
BM29	0.00025	0.500	0.180
BM3	0.0003	0.610	0.135
BM30	0.0003	0.500	0.180
BM36	0.0004	0.500	0.180
BM31	0.0005	0.500	0.180
BM32	0.001	0.500	0.180
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