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CONTENTS

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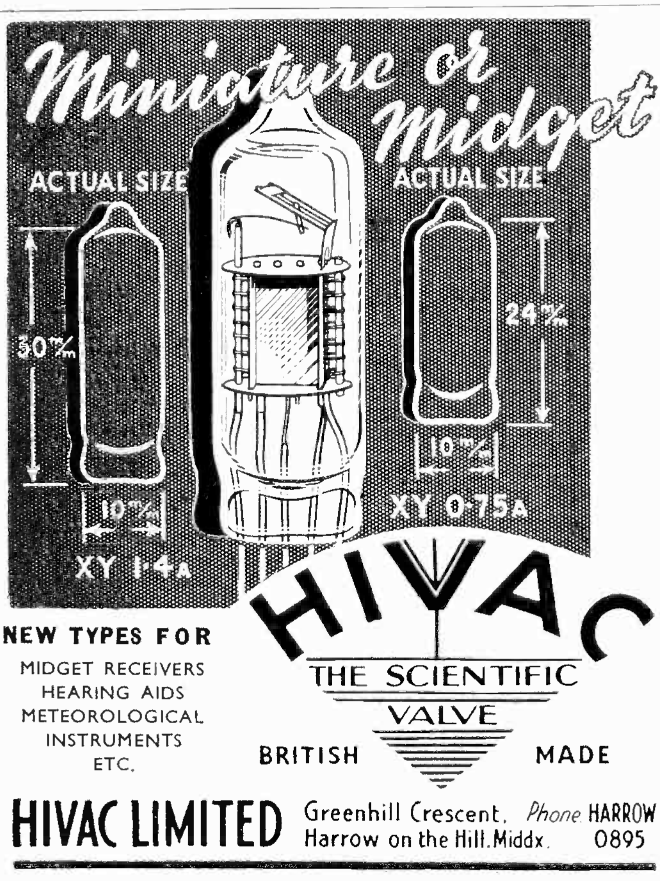
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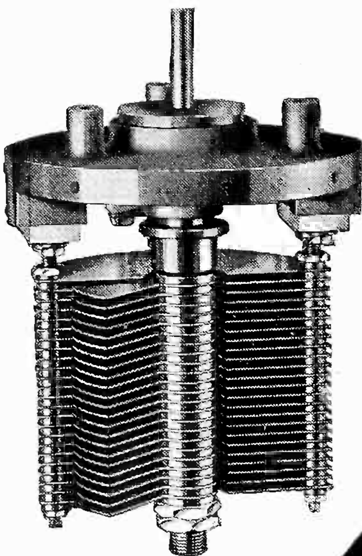

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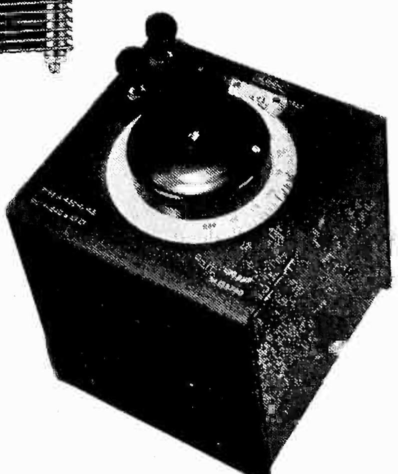

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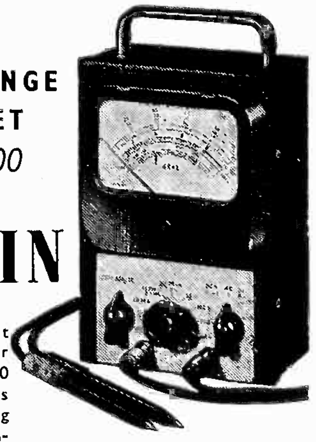

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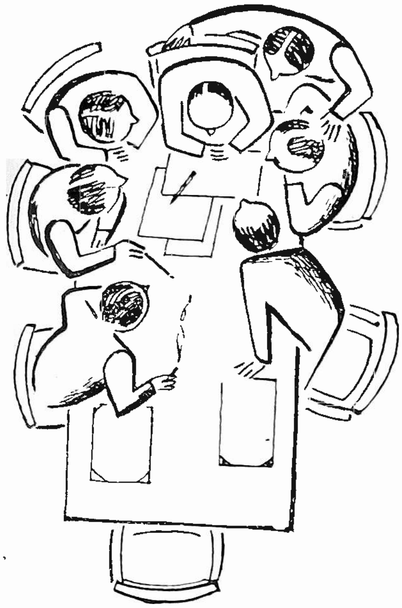

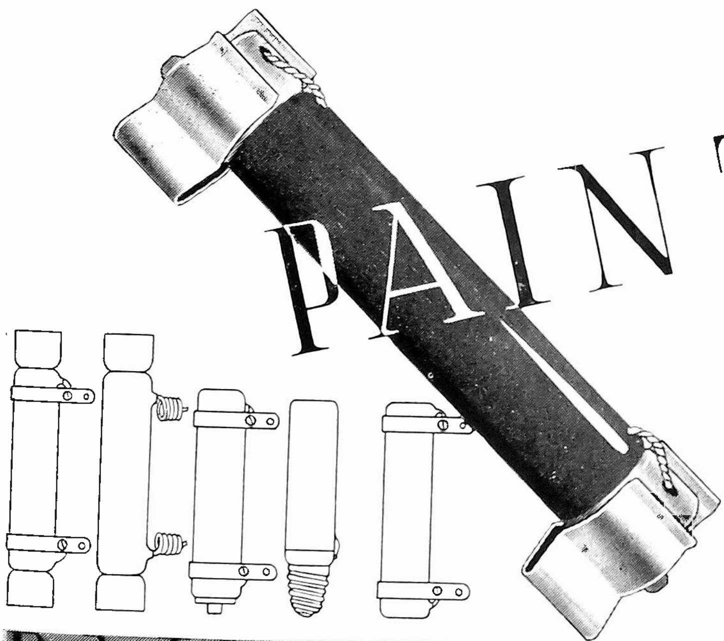

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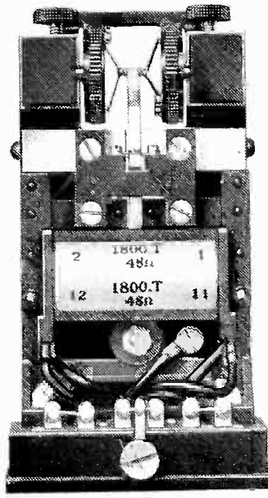

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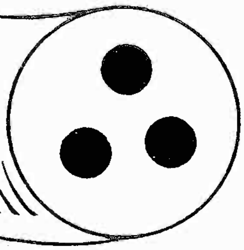

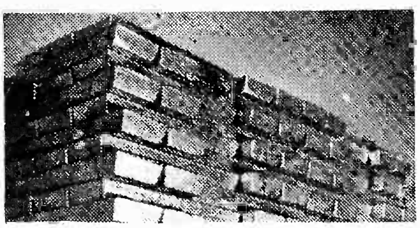
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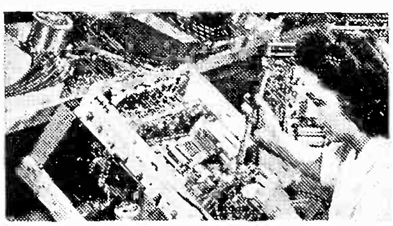
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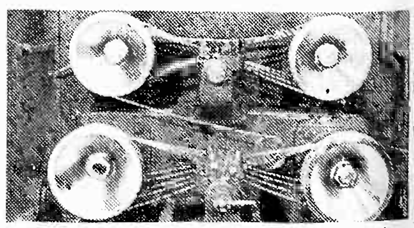
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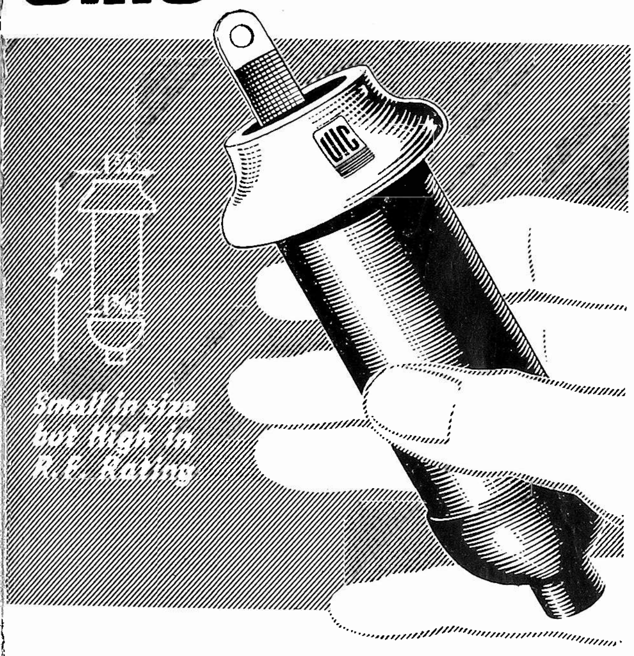

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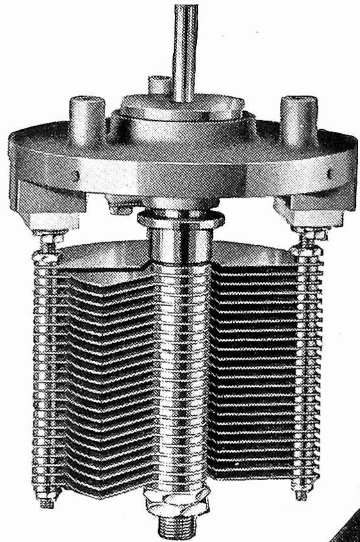

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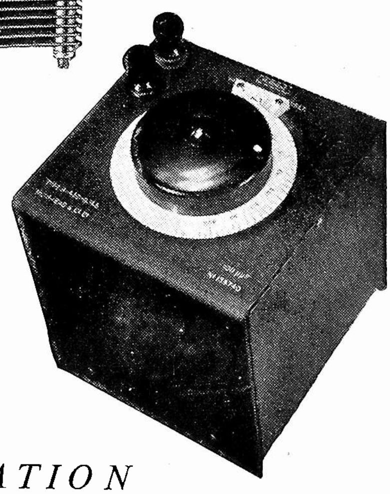

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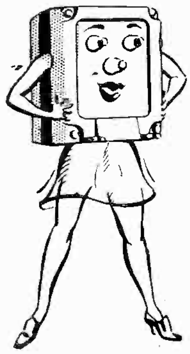

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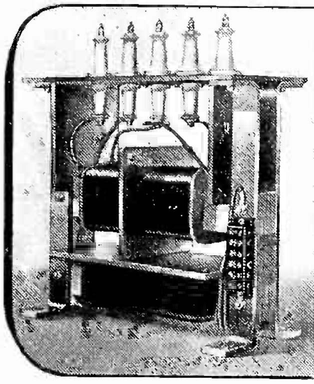

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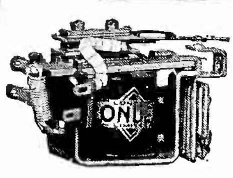

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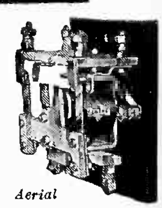

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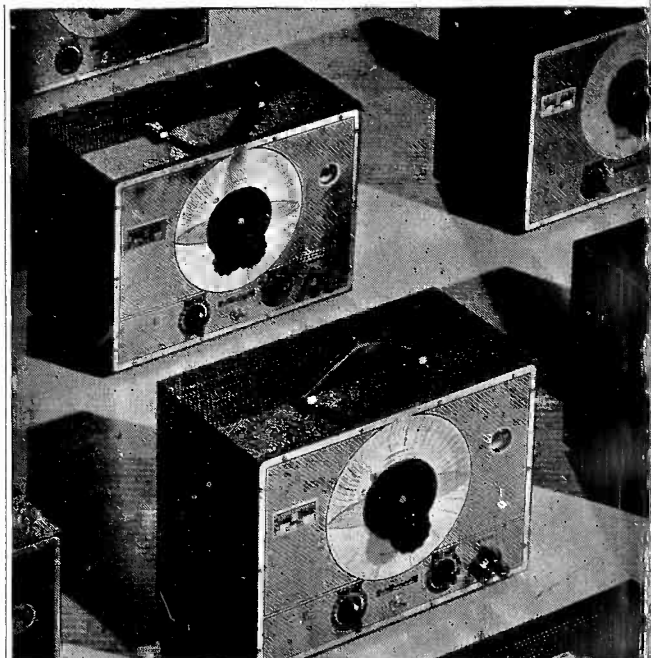

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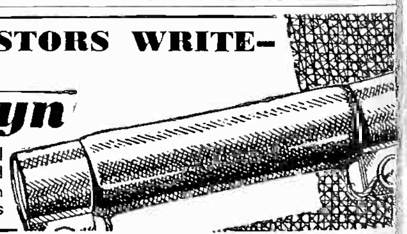

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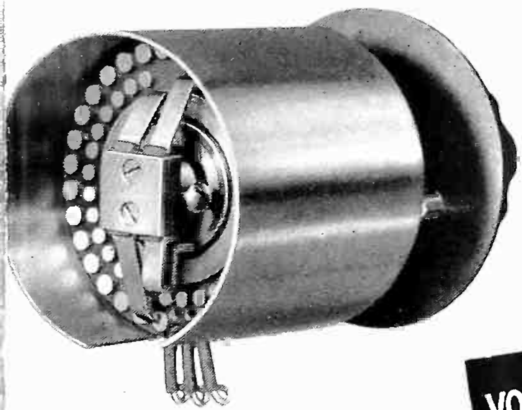

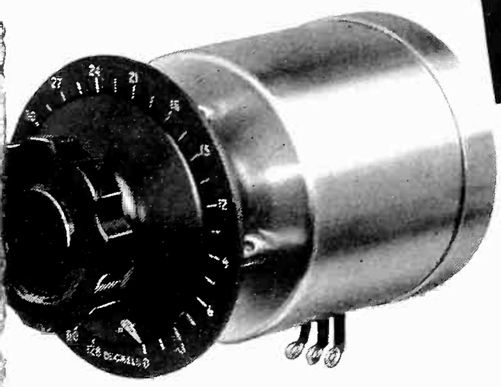

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VOL. 23 No. 275

WIRELESS ENGINEER

AUGUST 1946

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Managing Editor
HUGH S. POCOCK, M.I.E.E.

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

EDITORIAL

The Unit-pole Definition of Magnetic Field Strength

HAVING defined unit pole as a pole of such strength that if placed 1 cm away from a similar pole in air it experiences a force of 1 dyne, one then generally proceeds to define the strength of the magnetic field at any point in space as the force in dynes experienced by unit pole if placed at the point. This suggests that H is a measurable magnitude. In reviewing Lanchester's "Theory of Dimensions," in *Nature*, of January 9th, 1937, we showed, however, that E and B are measurable characteristics of the electric and magnetic fields, the former by the force on a stationary charge and the latter by the force on a current or moving charge, irrespective of the medium, whereas D and H are not directly measurable concepts.

The displacement D is calculable at any point by dividing a charge by an area; and similarly the magnetizing force H is calculable by dividing a current—or a number of ampere-turns—by a length. From this point of view H or the ampere-turns per cm must be regarded as a localized cause producing at every point a magnetic induction B depending on the medium. Similarly D appears as a localized phenomenon related at every point to a condition of space designated by E, the relationship depending on the medium. We pointed out the parallel phenomena in the theory of elasticity where the localized cause is called the stress at the point and the effect is called strain, and we quoted from Prof. Southwell's "Theory of Elasticity" that "stress has never been measured directly, and we can assert with some confidence that it never will." Hence we have three non-measurable magnitudes, viz., stress = force/area, H = current/length, and D = quantity of electricity/area, and three related measurable magnitudes, viz., strain, B, and E. The latter can be determined by measurements made at the point; the former have to be calculated on certain assumptions as to the distribution of mechanical force or electric charge over an area or of the ampere-turns over the magnetic path-length.

How is this to be reconciled with the determination of H at any point by measuring the force on unit pole placed there? So long as we confine our attention to experiments in air or any medium of unit permeability one might be tempted to regard it as immaterial whether we regard the measurement as one of H or B. In a medium of permeability other than unity the force on unit pole raises some interesting questions, and is well worth considering. The first question is, what happens to the magnet of unit pole strength when it is immersed in a magnetic medium?

It is pointless to say that one must assume it to remain of unit strength, because unit strength has only been defined in air. Two unit poles certainly do not retain the property of repelling each other with a force of 1 dyne when placed 1 cm apart in the new medium. One is forced to assume that the magnetic flux of the magnet remains unchanged, but this is introducing a new concept and undermining the fundamental character of the unit pole. As we have pointed out on a previous occasion, if the magnet of unit pole strength is not a permanent magnet but an empty solenoid of which the current is adjusted until it repels a similar pole with a force of one dyne at a distance of one centimetre, and if two such solenoids are then immersed in a magnetic medium the force between the poles is increased to μ times its value in air. This follows at once from the fact that the value of B is everywhere increased in this ratio since the current has been kept constant. If, however, the current in each solenoid is reduced in the ratio $1/\mu$, B will have its original value and the force on the pole will be reduced in the same ratio as the current, that is $1/\mu$. This agrees with the formula usually given for the force between two poles, viz., $f = m_1 m_2/\mu d^2$, which bears out what we said above as to the unit pole being based on the assumption of a constant magnetic flux.

One can make a solenoid, however, in which the flux remains constant whatever the external medium without any adjustment of current, merely by winding it on a solid core and making the length very great compared with the diameter. The value of H, and therefore also of B, within such a solenoid depends only on the ampere-turns per cm and is unchanged by immersing the solenoid in a medium of high permeability. If now the medium be subjected to a magnetizing force H_x, the magnetic induction $B_x = \mu H_x$ but the forces on the solenoid will be the same as they were in air for the same value of H_x, that is to say, the solenoid appears to measure H and not B in the medium in which it is immersed. We say "appears to" because on looking into the matter more closely it is seen that we have carried out a cavity experiment. We have constructed a long narrow cavity filled with a material of unit permeability—assuming the coil to be wound on such a material—and in that cavity or on its walls we have placed a coil carrying a certain fixed current. Any force on the coil will depend on the value of B in the cavity, which is numerically equal to H in the cavity since $\mu_1 = 1$.

Consider two positions of the solenoid or cavity, one in the direction of the external field and the other in the opposite direction. In one case the solenoid field H_s will be increased to $H_s + H_x$ and in the other it will be decreased to $H_s - H_x$. If the solenoid has a cross-sectional area A and a length l, and carries a current of I e.m. units, the energy supplied to the circuit on reversing the coil will be $2AH_xTI$ ergs, which, putting $TI = H_s l/4\pi$, is equal to $H_s H_x Al/2\pi$. This will be equal to the work done in turning the solenoid from one position to the other, and if the pole strength is m this should be equal to $2lmH_x$ which, putting $m = H_s A/4\pi$, is equal to $H_s H_x Al/2\pi$. Hence the force on the pole is proportional to H_x and is independent of the permeability of the surrounding medium, but, as we saw in the preceding editorial, this idea of the torque on the solenoid being due to forces acting on poles near the ends gives an erroneous picture of the nature of the forces acting on the coil.

A very interesting problem is the calculation of the torque on the above solenoid when placed at right-angles to the direction of the field. At first sight it gives a surprising result. For the sake of simplicity we assume the solenoid to be inside a glass tube filled with some material of unit permeability and the outer medium to have a very high permeability. We assume that the length is very great compared with the diameter and, to avoid trouble with end effects, we assume that the tube is longer than the solenoid. Fig. 1 shows a section of the tube.

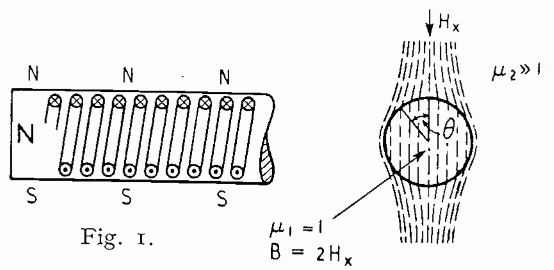

Fig. 1.

It has been shown* that in such a case the radial magnetic force H_r on the inner surface is equal to

$$\frac{2\mu_2}{\mu_2 + \mu_1} H_x \cos \theta$$

where H_x is the applied uniform value of H in the external medium apart from local distortion due to the presence of the tube, μ_1 and μ_2 the internal and external permeabilities, and θ the angle between the radius

* B. Hague. *Journ. Instn. Elec. Engrs.*, Vol. 64, p. 476, April 1926.

considered and the direction of H_x. In our case $\mu_1 = 1$ and $H_r = \frac{2\mu_2}{\mu_2 + 1} H_x \cos\theta$. If μ_2 is very great this approximates to $2H_x \cos\theta$, that is to say, the uniform field in the tube is equal to $2H_x$. Hence we arrive at the surprising result that the solenoid is situated in a uniform magnetic field having twice the magnetizing force of the external uniform field in which we have placed it, and that the resulting torque on the solenoid will be twice the value corresponding to H_x. This is true of the solenoid if free to move within the glass tube, but it is not true of the tube and solenoid regarded as a unit, because half the torque on the solenoid is counterbalanced by the reaction on the polarity at the interface between the two media, and only the other half is externally measurable. Hence, although the actual force on the solenoid, as on any current-carrying conductor, is proportional to the magnetic induction B in which it is situated, the arrangement under discussion gives a measure of the magnetic force H_x in the permeable medium in which it is placed. It is really a cavity experiment.

We propose now to prove that half the torque on the actual solenoid is counterbalanced by the polarity at the interface.

When magnetic flux passes normally across the interface from a medium of permeability μ to another of unit permeability, B undergoes no change, but H is increased from B/μ to B. This change of H can be regarded as due to polarity of the interface, and if m_1 is the strength of pole per square centimetre, $4\pi m_1 = B(1 - 1/\mu)$. To an observer inside the tube in Fig. 1 the upper surface would appear to be a north pole and the lower surface a south pole. If the tube were filled with the external medium of very high permeability, the field would be everywhere uniform and H within the tube would be equal to H_x; but on decreasing the permeability within the tube to unity, H within the tube increases to $2H_x$ although the external magnetizing agent has not changed. This increase in the magnetizing force is due to the polarity of the interface. That this is so can be proved as follows: if μ_2 is very great $4\pi m_1 = B(1 - 1/\mu_2) \approx B$ where B is the radial flux density at the interface, i.e.

$$B = H_r = 2H_x \cos\theta\,;$$

hence $m_1 = 2H_x \cos\theta/4\pi$ per cm².

If Fig. 2 represents a strip along the tube of width $rd\theta$ and of pole strength $m_1 r d\theta$ per unit length, the magnetic force at a point P at distance r from the strip is given by the formula

$$H = 2m_1 r d\theta \int_0^\infty \frac{dx}{x^2 + r^2} \times \frac{r}{\sqrt{x^2 + r^2}}$$

$$= 2m_1\, d\theta$$

assuming the strip to be very long compared with r.* Hence substituting for m_1 we have for the value of H at the centre of the tube, due to the top and bottom half-cylinders,

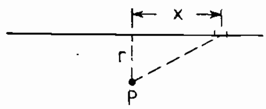

Fig. 2.

$$H = 4\int_{-\pi/2}^{+\pi/2} \frac{2H_x \cos^2\theta}{4\pi}\, d\theta$$

$$= \frac{2H_x}{\pi}\int_{-\pi/2}^{+\pi/2} \cos^2\theta\, d\theta = H_x$$

Hence, assuming the external medium to have an infinitely great permeability, the field strength $2H_x$ within the tube is made up of two equal parts, one due to the external magnetizing agent and the other to the polarity on the walls of the tube. For simplicity we have assumed the medium within the tube to have unit permeability; for any other value of μ_1, the transverse magnetic force in the tube will still be made up of two components, one equal to H_x as before, but the other less than H_x. The former will produce an induction $B = \mu_1 H_x$ and since the current to produce unit pole strength in the solenoid has been reduced in the ratio $1/\mu_1$, the externally measurable torque remains unchanged. The internal torque between the tube and coil is reduced, and of course vanishes entirely when μ_1 is made equal to μ_2 of the external medium.

The exact nature of the internal forces between the solenoid and the polarity of the tube walls is easily seen when one remembers that in a very long solenoid of small diameter the flux is almost constant except near the ends, where it rapidly drops—to a half at the end and then to zero at a short distance beyond the end. Hence the whole flux Φ of the solenoid leaves radially at the end, and if, for simplicity, we assume it to leave uniformly over a short length s, the radial

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* $\int \frac{dx}{(x^2 + r^2)^{3/2}} = \frac{1}{r^2} \cdot \frac{x}{\sqrt{(x^2 + r^2)}}$

flux density will be $\Phi/2\pi rs$ which, putting $\Phi = 4\pi ITA/l$, gives

$$H_r^1 = 2ITA/rsl$$

This is the radial field strength due to the solenoid in which the polarity m_1 per cm^2 of the walls is situated. We have seen that $m_1 = H_x \cos\theta/2\pi$. The radial force per cm^2 will be $m_1 H_r^1$ and its component in the vertical direction $m_1 H_r^1 \cos\theta$. This acts over an area of $2\pi rs$, hence the total resultant vertical force will be

$$\frac{H_x}{2\pi} \times \frac{2ITA}{rsl} \times 2\pi rs \times \text{average value of } \cos^2\theta$$

$$= H_x ITA/l$$

The torque is the product of this force and the length of the solenoid; i.e., $H_x ITA$. Since the pole strength $m = ITA/l$ this is equivalent to $H_x ml$. This, then, is the internal torque exerted mutually between the coil and the tube, and, in this case in which $\mu_1 = 1$ and μ_2 is very large, it is seen to be exactly equal to the external torque.

Although this case is interesting and simple, a much more practical case is that in which the core of the solenoid has a high permeability and the surrounding medium unit permeability. We assume that the coil is embedded in a rod of high permeability and, to avoid end effect, we assume, as before, that the rod is longer than the coil. Conditions will now be as shown in Fig. 3 with $B = 2H_x$ and $H = 2H_x/\mu_1$; the latter will be very small since the magnetizing force due to the polarity is upwards and nearly neutralizes H_x. If we had started

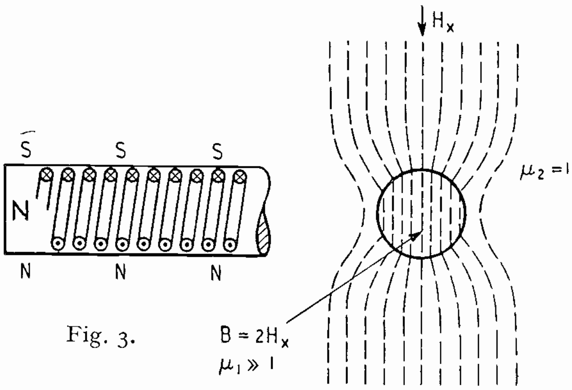

Fig. 3.

with the surrounding medium also of the same high permeability μ_1, there would have been no interface polarity, and the torque would have been

$$mlH_x = ITA\mu_1 H_x$$

exerted solely on the current carrying coil, but as the external permeability was decreased, keeping H_x and I unchanged, the external B would decrease to H_x and the internal B to $2H_x$. Since the internal B has decreased from $\mu_1 H_x$ to $2H_x$ while I has remained constant, the torque exerted on the coil must be reduced in the ratio $2/\mu_1$, that is, to a small fraction of its former value although the resultant torque on the coil and core must have remained unchanged since m and H_x are still the same. In the previous example the calculated torque on the coil was twice the expected value mlH_x, the excess being counterbalanced by the torque due to the polarity of the interface; in the present example the calculated torque on the coil is only a small fraction of the expected value, but the deficit must be made up by torque due to the interface polarity, which is, as we have seen, the reverse of the previous polarity. In the limit when μ_1 is very great, the torque on the coil is negligible and the whole torque mlH_x is due to the polarity of the interface.

Instead of considering the torque as being caused by the interaction between the polarity of the interface and the flux leaving the coil at the ends, one may regard the problem from a simpler but more fictitious point of view by picturing the flux density across the tube as the resultant of two flux densities each causing their own force on the current-carrying coils. In the first example there was $B = H_x$ due to the external agency plus $B = H_x$ due to the surface polarity, giving a double torque on the coil. In the second example there was $B = \mu_1 H_x$ due to the external agency minus $B = (\mu_1 - 2)H_x$ due to the surface polarity, exerting opposing torques on the coil with a very small resultant.

In the more general case the two opposing values of B are

$$H_x\mu_1 \text{ and } H_x\mu_1(\mu_1 - \mu_2)/(\mu_1 + \mu_2).$$

Our last example approximates closely to a permanently magnetized knitting needle. It is a rod of high permeability in which the constant magnetism is maintained, not by an embedded solenoid, but by myriads of circulating electrons.

We have seen that although such a permanently magnetized needle or a solenoid can be used to determine H, the measurement is primarily of the force on a current due to the magnetic induction B in which it is situated, the determination of H being derived by what is really a cavity experiment.

G. W. O. H.

ANOMALOUS ATTENUATION IN WAVEGUIDES*

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SUMMARY.—The puzzling phenomenon of decreasing attenuation constant with increasing frequency which occurs in a few isolated instances is here elucidated by treating the guides concerned as limiting cases of a guide of more general shape in the interior of which the waves display the normal properties characteristic of waves in guides generally. The equations of the electromagnetic field, cut-off frequency and attenuation constant describing the isolated cases are then, in like manner, deduced as limiting cases from those appropriate to a guide of general shape. The isolated cases thus lose their character of isolation and assume that of straightforward limits instead. According to the point of view developed in the paper these limiting cases imply an electromagnetic field which extends to infinity along one of the transverse co-ordinates but, being wrapped around the axis of the guide, the field is constrained to exist in finite space where it continues to display the properties characteristic of a field of infinite extent.

1. Introduction

It is a well-known fact that when an electromagnetic wave is traversing a transmission line of any conventional type, it is always possible to find a frequency above which the attenuation constant of the wave is a steadily increasing function of frequency. This property also appertains to waves propagated through the interior of hollow metal tubes with the exception, however, of a few seemingly isolated cases. There is, for instance, the case where the *H*-wave (also known as the transverse electric or *TE*-wave) of zero order is propagated through a tube of circular cross-section. Here, as in two further cases to be dealt with below, the attenuation constant follows a course precisely opposite to that normally encountered; that is to say, in each case a frequency can be found above which the attenuation steadily *decreases* and ultimately vanishes altogether.

This striking anomaly may be accounted for satisfactorily by means of Ampère's Law of electromagnetic induction, whereby the current induced in the metal tube may be stated in terms of the tangential components of the magnetic field at the surface of the metal, the longitudinal component of the current in terms of the transverse component of the field, and the transverse component of the current in terms of the longitudinal component of the field. Now in the exceptional case of the *H*-wave of zero order in a guide of circular cross-section all lines of magnetic force are at any frequency restricted to radial planes (Fig. 1) and in consequence the transverse tangential component is always zero. There thus remains only the longitudinal tangential component and as this component—in common with the longitudinal component of all other waves in hollow metal tubes—is a steadily decreasing function of frequency, the attenuation of the wave is of necessity also a diminishing function of frequency.

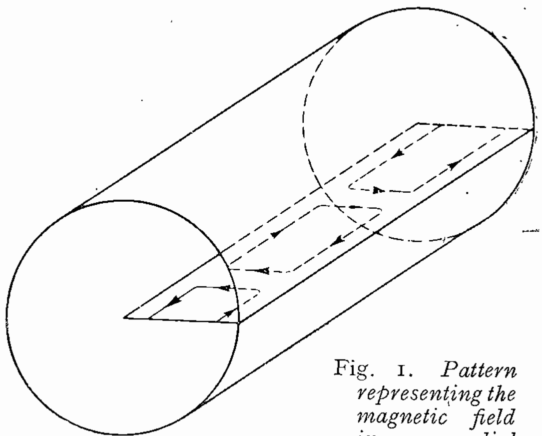

Fig. 1. Pattern representing the magnetic field in any radial plane of a circular guide transmitting an H-wave of zero order and principal mode. If the plane is turned full circle the pattern describes a set of toroidal surfaces which completely represent the magnetic field in space.

As an instructive alternative explanation it is here suggested that a guide of circular cross-section might be regarded as an extreme case of a guide having a cross-section of sector shape (Fig. 2). In such a guide the *H*-wave of zero order displays the normal properties characteristic of waves in guides generally and from these there emerge as straightforward limiting cases those appropriate to waves in a circular guide.

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By this procedure the appearance of an anomaly is completely eliminated. Moreover, by extending the analysis to guides encompassed by two coaxial circular cylinders and two radial planes (Fig. 3) the properties

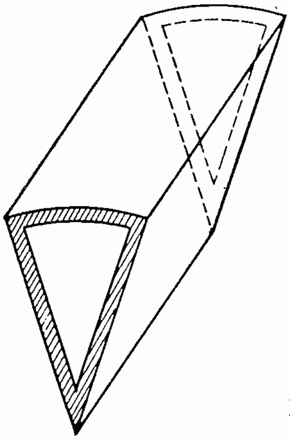

Fig. 2. *Guide of sector-shaped cross-section.*

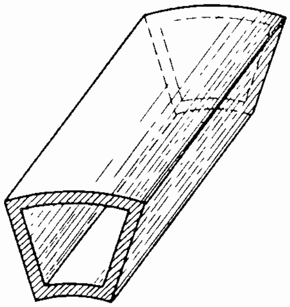

Fig. 3. *Guide composed of portions of coaxial circular cylinders and radial planes.*

of *H*-waves of zero order may be stated in a general form which includes as particular cases those associated with guides of rectangular, circular, sector- and ring-shaped cross-sections, with and without baffle planes.

We shall first recapitulate for ready reference the well-known relevant formulae relative to a rectangular guide. We shall then establish the corresponding formulae for a guide of sector shape leading to those for circular guides. Finally we shall proceed to the general case and identify as particular cases the results recorded for the guides of more special shape.

2. Principal Symbols

a = width of rectangle in metres

b = height of rectangle in metres

r_0 = radius of sector in metres

r_1, r_2 = inner and outer radii of ring-sector in metres

ϕ = sector angle in radians

$\mu, \bar{\mu}$ = permeability of dielectric and conductor respectively in henrys per metre; for vacuum $\mu_0 = 4\pi \times 10^{-7}$

$\epsilon, \bar{\epsilon}$ = permittivity of dielectric and conductor respectively in farads per metre; for vacuum, $\epsilon_0 = \frac{1}{36\pi} \times 10^{-9}$

$g, \bar{g}$ = conductivity of dielectric and conductor respectively in mhos per metre; for pure copper $\bar{g} = 5.8 \times 10^7$

$c = \frac{1}{\sqrt{\mu\epsilon}}$ = characteristic velocity of waves in the unrestricted medium in metres per second; for vacuum $c = 3 \times 10^8$

= frequency in cycles per second

f_{0m} = cut-off frequency of the mth mode in cycles per second

$\nu_{0m} = \frac{f_{0m}}{f}$

$\omega = 2\pi f$

α_{0m} = attenuation constant corresponding to the mth mode in nepers per metre

Γ = propagation constant in the Z-direction per metre

k_{1m} = mth non-vanishing root of $J_1(x) = 0$; i.e. $k_{11} = 3.83$; $k_{12} = 7.02$; $k_{13} = 10.17$.

3. Guides of Rectangular Cross-Section

The electric and magnetic intensities of an *H*-wave of zero order and *m*th mode* in a guide of rectangular cross-section, having metal walls of infinite conductivity, and a dielectric that is nondissipative are given by

$$\left.\begin{aligned} E_x &= 0,\ E_z = 0,\ H_y = 0, \\ E_y &= -\frac{m\pi}{a}\sin\left(\frac{m\pi}{a}x\right)e^{-\Gamma z} \\ H_x &= \frac{\sqrt{1-\nu_{0m}^2}}{\sqrt{\mu/\epsilon}}\frac{m\pi}{a}\sin\left(\frac{m\pi}{a}x\right)e^{-\Gamma z} \\ H_z &= \frac{1}{j\omega\mu}\left(\frac{m\pi}{a}\right)^2\cos\left(\frac{m\pi}{a}x\right)e^{-\Gamma z} \end{aligned}\right\} \quad (1)$$

If the conductivity of the metal walls is finite but high, the above expressions of the field become approximations but remain amply accurate for our purpose. As usual the time factor exp $j\omega t$ is omitted.

Since both E_x and E_z are zero the lines of electric force may be represented by patterns of parallel lines stretching from top to bottom with densities that vary sinusoidally across any transverse section of the guide. For the case where $m = 1$ (Fig. 4) the electric field is a maximum along the middle line of the section and zero at each of the two side walls. This pattern is subject to the usual cyclic variation with time, that is to say, the pattern fades away, increases in the opposite direction to its original intensity,

* The characteristic feature of any *H*-wave is a prominent magnetic field in the direction of propagation. To rank as a wave of "zero" order it is required that in the direction of one of the transverse co-ordinates of the guide—for instance, the height of a rectangular guide—every one of the six components of the electromagnetic field is independent of that co-ordinate, that is to say, is of "zero variation" in that direction. The mode *m* specifies the number of half-cycles to which the non-vanishing components of the field are subjected in the direction of the other transverse co-ordinate of the guide—for instance, the width of a rectangular guide. The first mode is frequently referred to as the principal mode.

fades again, and finally re-assumes the original configuration from which the next cycle begins.

The lines of magnetic force are restricted to horizontal planes, and since both H_x and H_z are independent of the height of the guide the magnetic pattern is identical in all

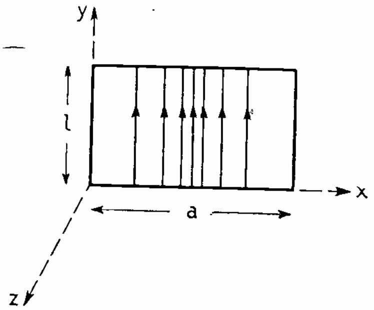

Fig. 4. *Pattern representing the electric field of an H-wave, of zero order and principal mode, propagated through a rectangular guide.*

horizontal planes. For $m = 1$ (Fig. 5) there is a single row of closed curves. The distance between recurring configurations of the pattern indicates the wavelength. With falling frequency the loops lengthen and finally, at cut-off frequency, they break up into two sets of parallel lines as shown in Fig. 6. The magnetic field is now divided into two halves pointing in *opposite* directions and being separated from one another by the vertical mid-plane (shown dotted in Fig. 6) where the magnetic intensity is

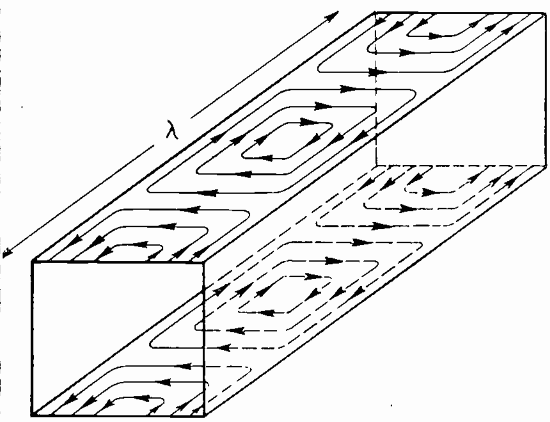

Fig. 5. *Pattern representing the magnetic field in any horizontal plane of a rectangular guide transmitting an H-wave, of zero order and principal mode. λ indicates the length of the wave.*

permanently zero. While the magnetic field is thus being broken up, no corresponding change takes place in the electric field. This field retains at cut-off frequency the character indicated in Fig. 4; that is, at any given instant the electric intensities in both halves of the guide point in the *same* direction. In consequence we are led to the conclusion that energy is simultaneously thrust from the interior towards each of the side walls whence it is reflected back towards the mid-plane.

There are thus two transverse pulsations of energy, between mid-plane and side walls, without any concurrent transmission of energy along the guide. The frequency at which this resonant state is reached is given by

$$f_{0m} = \frac{m\pi}{2\pi a} c \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

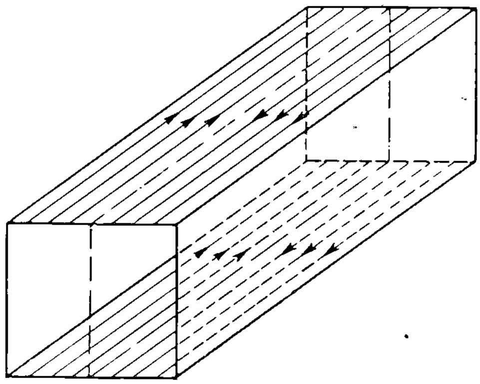

Fig. 6. *Pattern representing the magnetic field in any horizontal plane of a rectangular guide supporting an H-wave, of zero order and principal mode, at the cut-off frequency.*

Assuming that the dielectric medium is non-dissipative, as in the case of air, we have for the attenuation constant of the wave

$$\alpha_{0m} = \frac{\sqrt{\frac{\mu\pi f}{g}}}{\sqrt{\frac{\mu}{\epsilon}}} \left[\frac{1}{b}\frac{1}{\sqrt{1-\nu_{0m}^2}} + \frac{2}{a}\frac{\nu_{0m}^2}{\sqrt{1-\nu_{0m}^2}} \right] \quad \ldots \quad \ldots \quad (3)$$

The first term is due to currents induced in the top and bottom walls by the tangential magnetic intensities H_x and H_z. For all frequencies above $\sqrt{3}f_{0m}$ this term is an increasing function of frequency (Fig. 7). The second term arises from currents induced in the side walls. These are due to the longitudinal magnetic field H_z only; for H_x, being perpendicular to the side walls, is prevented from setting up currents in them. This second term is a decreasing function of frequency (Fig. 7). As the cut-off frequency (2) is independent of b, the height of the guide may be increased indefinitely without

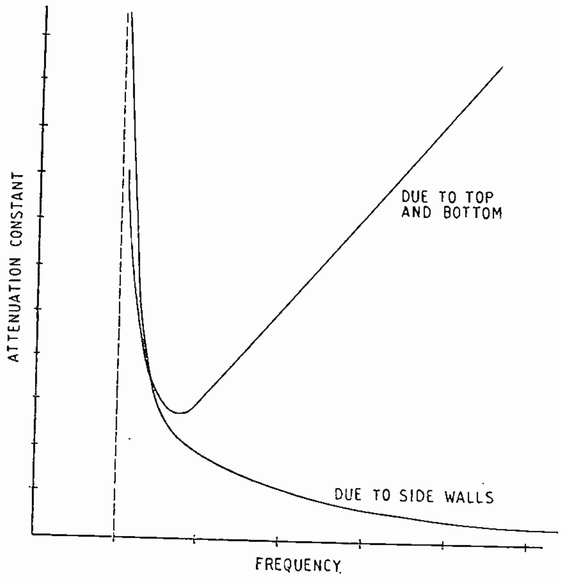

Fig. 7. *Analysis of the attenuation constant of an H-wave of zero order propagated through a guide of rectangular cross section.*

affecting the character of the wave. At the same time the first term of the attenuation constant (3) diminishes and ultimately, when the rectangular guide becomes a guide composed of two parallel planes, only the second term of (3) remains ; and now, with increasing frequency the attenuation actually tends towards zero. Although this case is of no practical importance it is, as we shall presently see, the exact counterpart of a physically realizable guide, namely the guide of circular cross-section.

4. Guides of Sector Cross-Section

In so far as H-waves of zero order are concerned there is a close correlation between a guide of rectangular cross-section in a cartesian system of co-ordinates (x, y, z) and a guide of sector-shaped cross-section in a cylindrical system of co-ordinates (ρ, ϕ, z) (Fig. 8). The form of the equations of the electromagnetic field is exactly the same in the two cases ; in place of the circular functions we now have Bessel functions of the first kind, and in place of the non-vanishing roots of $\sin x = 0$ we now have the non-vanishing roots of $J_1(x) = 0$, which are denoted below by k_{1m}. Thus

$$\left.\begin{aligned} &E_\rho = 0,\ E_z = 0,\ H_\phi = 0, \\ &E_\phi = -\frac{k_{1m}}{r_0} J_1\left(\frac{k_{1m}}{r_0}\rho\right)e^{-\Gamma z} \\ &H_\rho = \frac{\sqrt{1-\nu_{0m}^2}}{\sqrt{\mu/\epsilon}}\,\frac{k_{1m}}{r_0} J_1\left(\frac{k_{1m}}{r_0}\rho\right)e^{-\Gamma z} \\ &H_z = \frac{1}{j\omega\mu}\left(\frac{k_{1m}}{r_0}\right)^2 J_0\left(\frac{k_{1m}}{r_0}\rho\right)e^{-\Gamma z} \end{aligned}\right\} \quad (4)$$

The pattern of the electric field now consists of concentric arcs (Fig. 8) and that of the magnetic field of closed curves in radial planes (Fig. 9).

The cut-off frequency is given by

$$f_{0m} = \frac{k_{1m}}{2\pi r_0} c \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

which differs from the expression found for the rectangular guide merely in that the root of the Bessel function takes the place of that of the corresponding circular function.

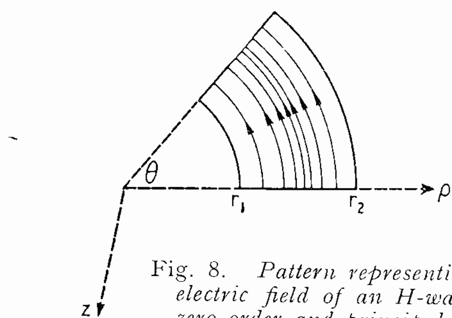

Fig. 8. *Pattern representing the electric field of an H-wave, of zero order and principal mode, propagated through a guide composed of a portion of a circular cylinder and two radial planes.*

As the attenuation constant may be calculated by Schelkunoff's well-known general formula* in a perfectly straightforward manner it may suffice here merely to state the result.

$$\alpha_{0m} = \frac{\sqrt{\frac{\mu\pi f}{g}}}{\sqrt{\frac{\mu}{\epsilon}}}\left[\frac{2}{\phi r_0}C_{1m}\frac{1}{\sqrt{1-\nu_{0m}^2}} + \frac{2}{\phi r_0}\cdot\frac{\nu_{0m}^2}{\sqrt{1-\nu_{0m}^2}} + \frac{1}{r_0}\frac{\nu_{0\,m}^2}{\sqrt{1-\nu_{0m}^2}}\right] \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where

$$C_{1m} = \frac{\int_0^{k_{1m}}\left[J_1(x)\right]^2 dx}{k_{1m}\left[J_0(k_{1m})\right]^2}$$

* *Proc. I.R.E.*, 1937, Vol. 25, p. 1482.

The factor C_{1m} is always greater than unity. The lowest value occurs for $m = 1$ in which case C_{1m} is approximately 1.01. The first term in (6) arises from currents induced in the radial planes, partly by H_ρ and partly by H_z. After a minimum is passed this term is an increasing function of frequency. The second and third terms arise respectively from currents in the radial planes and in the cylindrical surface in consequence of the longitudinal field; both of these terms are decreasing functions of frequency. Since the cut-off frequency (5) is independent of the sector angle, equation (6) is applicable to the case of $\phi = 2\pi$, that is to say, to a circular guide with a single radial baffle plane (Fig. 10).

A sector angle of 2π appears to be the imiting value for a guide in physical space, out this restriction need not be applied to he equations of the field or the equations of the cut-off frequency and attenuation onstant. Although originally established or physical space their range of validity xtends into the region of ϕ beyond 2π— fictitious region, known also as Riemann pace,* where the sector angle may, indeed, e increased indefinitely. In consequence he length of the arc ϕr_0 increases corre-pondingly, with the result that the first wo terms of (6) tend towards zero. As he radial planes of the guide are thus ltimately of no effect they may be removed, nd now the barrier between physical and ctitious space effectively breaks down, and here remains a guide of circular cross-ection. On this view then a guide of ircular cross-section is the extreme case of

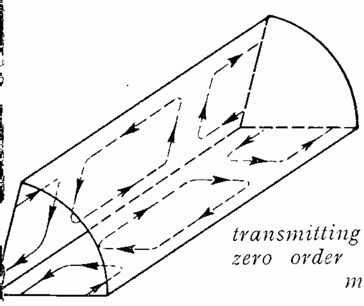

Fig. 9. *Patterns representing the magnetic field in any radial plane of a guide of sector-shaped cross-section transmitting an H-wave of zero order and principal mode.*

guide of sector-shaped cross-section, for hich the length of the arc becomes infinite— exact correspondence to the extreme case f the rectangular guide for which the height creases indefinitely. As the first two terms (6) vanish, the attenuation constant is applied by the third term alone, which is a falling function with increasing frequency.

As a check of our last result we may employ a method that does not require the notion of a fictitious space. Let us assume that while the conductivity of the metal of the cylinder retains a high, but finite, value

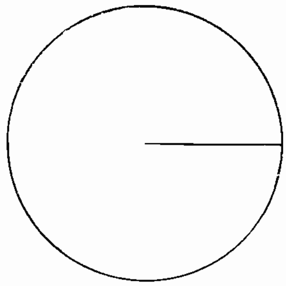

Fig. 10. *Guide composed of a circular cylinder and a radial baffle plane.*

that of the baffle plane is allowed to increase indefinitely. If then, instead of being given as a product of two factors, (6) is re-written as a sum of three separate terms, the first two terms, which refer to the baffle plane, again tend towards zero. Moreover, as the baffle plane does not constrain the field, the plane may be deleted altogether. There thus again remains a guide of circular cross-section for which the attenuation constant is as before correctly given by the third term of (6).

5. Guides of Ring-Sector Section

The treatment of this case (Fig. 11) is identical with that of the sector-shaped guide except that to the Bessel function of the first kind there must now be added that of the second kind. If we put

$$Z_n(\chi\rho) = AJ_n(\chi\rho) + BN_n(\chi\rho)$$

where A and B are real and χ is a function of the radii r_1 and r_2, the electromagnetic field is given by

$$\left.\begin{aligned}
E_\rho &= 0 \\
E_\phi &= -\frac{\nu_{1m}}{r_2 - r_1} Z_1\left(\frac{\nu_{1m}}{r_2 - r_1}\rho\right)e^{-\Gamma z} \\
E_z &= 0 \\
H_\rho &= \frac{\sqrt{1-\nu_{0m}^2}}{\sqrt{\mu/\epsilon}}\frac{\nu_{1m}}{r_2 - r_1} Z_1\left(\frac{\nu_{1m}}{r_2 - r_1}\rho\right)e^{-\Gamma z} \\
H_\phi &= 0 \\
H_z &= \frac{1}{j\omega\mu}\left(\frac{\nu_{1m}}{r_2 - r_1}\right)^2 Z_0\left(\frac{\nu_{1m}}{r_2 - r_1}\rho\right)e^{-\Gamma z}
\end{aligned}\right\} \quad (7)$$

where ν_{1m} denotes the mth root of the equation

$$J_1(\chi r_1)N_1(\chi r_2) - J_1(\chi r_2)N_1(\chi r_1) = 0\,;$$

moreover $m\pi \leqslant \nu_{1m} \leqslant k_{1m}$

* J. H. Jeans, "The Mathematical Theory of lectricity and Magnetism," 5th Edition, p. 283.

The cut-off frequency is given by

$$f_{0m} = \frac{\nu_{1m}}{2\pi(r_2 - r_1)} c \qquad \ldots \quad \ldots \quad (8)$$

If r_1 approaches zero, equations (7) and (8) become identical with those appropriate to a sector-shaped guide, that is, equations (4) and (5). If both r_1 and r_2 are very large, the Bessel functions in (7) may be replaced by their asymptotic expansions whereby (7) assumes the form of (1); i.e., that of the field within a rectangular guide.

As before, the attenuation constant may be calculated by the general formula in a straightforward manner with the result

$$\alpha_{0m} = \frac{\sqrt{\frac{\mu\pi f}{g}}}{\sqrt{\frac{\mu}{\epsilon}}} \left[\frac{2}{\phi} \frac{\int_{r_1}^{r_2} \left[Z_1(\chi\rho)\right]^2 d\rho}{r_2^2\left[Z_0(\chi r_2)\right]^2 - r_1^2\left[Z_0(\chi r_1)\right]^2} \frac{1}{\sqrt{1 - \nu_{0m}^2}} \right.$$

$$\left. + \frac{2}{\phi} \frac{r_2\left[Z_0(\chi r_2)\right]^2 - r_1\left[Z_0(\chi r_1)\right]^2}{r_2^2\left[Z_0(\chi r_2)\right]^2 - r_1^2\left[Z_0(\chi r_1)\right]^2} \frac{\nu_{0m}^2}{\sqrt{1 - \nu_{0m}^2}} + \frac{r_2\left[Z_0(\chi r_2)\right]^2 + r_1\left[Z_0(\chi r_1)\right]^2}{r_2^2\left[Z_0(\chi r_2)\right]^2 - r_1^2\left[Z_0(\chi r_1)\right]^2} \frac{\nu^2_{0m}}{\sqrt{1 - \nu_{0m}^2}} \right] \quad (9)$$

The first term in (9) is due to the currents induced in the two radial planes, partly by H_ρ and partly by H_z. This is the rising term. The second and third terms are due to currents induced by H_z in the radial planes and in the two cylindrical surfaces respectively. If r_1 tends to zero, or if both

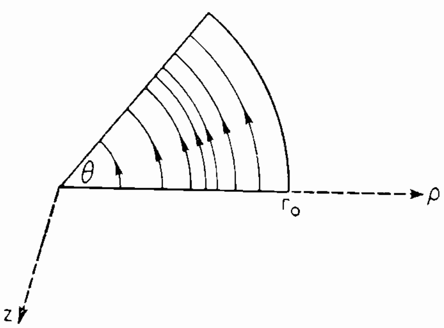

Fig. 11. *Pattern representing the electric field of an H-wave, of zero order and principal mode, propagated through a guide composed of portions of two coaxial circular cylinders and two radial planes.*

r_1 and r_2 become large, (9) assumes the forms appropriate to guides of sector or rectangular cross-sections. For $\phi = 2\pi$ the guide becomes a pair of coaxial cylinders with a single radial baffle plane (Fig. 12). As before we make use of the notion of Riemann Space and extend the validity of our equations into regions for which the sector angle exceeds 2π. And then with ϕ increasing indefinitely the first two terms of (9) again tend towards zero; and again the radial planes become ineffective and may be removed. On this view then a guide of two coaxial circular cylinders is an extreme case of a guide composed of portions of two

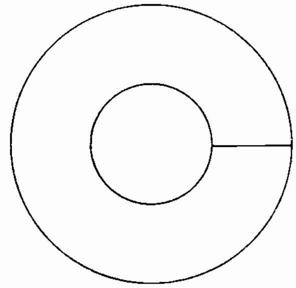

Fig. 12. *Guide composed of two coaxial circular cylinders and a radial baffle plane.*

coaxial cylinders and two radial planes and the attenuation constant is simply given by the third term in (9). This is the general case in which the attenuation approaches zero with increasing frequency.

In this, as in the special cases considered, the equations reveal that the anomalous falling off of the attenuation constant with frequency may be ascribed to the indefinite increase of one of the transverse dimensions of the guide, with the consequent disappearance of all terms that normally account for the rise with frequency. Thus all surfaces at which lines of electric force begin or end are relegated to regions infinitely far apart from one another where their existence can no longer be of any practical consequence. In the rectangular case the guide ceases thereby to be of finite height, but in the two circular cases, where the field is wrapped around an axis or around a circular cylinder, the guide retains a finite form, and the field within it, so constrained, continues to display the properties characteristic of a field of infinite range.

6. Acknowledgement

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AERIAL-TO-LINE COUPLINGS*

Cathode-Follower and Constant-Resistance Network

By R. E. Burgess, B.Sc.

(Communication from The National Physical Laboratory)

SUMMARY.—Considerable loss in signal/noise ratio may occur when a substantially reactive receiving aerial is connected to a receiver through a transmission line. Coupling systems which provide a match to the line at its sending end are therefore of interest. Such systems result in a reduction of the line loss which is, however, offset to a greater or lesser extent by the loss in the coupling network itself.

In the present paper two systems are considered :—(*a*) the constant-resistance network, and (*b*) the cathode follower. The overall loss in signal/noise ratio for these systems is compared with that which occurs for direct connection of the aerial to the line. The loss which occurs at the receiving end of the line is likely to be smaller and more constant with coupling networks at the sending end which match to the line than for direct connection.

Criteria are derived to show in what conditions each of the systems is preferable and these are expressed in terms of the line attenuation αl and the ratio of the aerial reactance to the characteristic impedance of the line; i.e., $|X|/R_0$. It is found that when $|X|/R_0$ is less than about unity, direct connection is best unless the line attenuation is very large, in which case the constant-resistance network may have an advantage. If $|X|/R_0$ is greater than about 3, the cathode follower is generally best, its superiority being the greater the larger the line attenuation. The conclusions of the analysis are considered to be valid for frequencies up to about 30 Mc/s., assuming the aerial to be substantially reactive over the range concerned.

A numerical example for a typical case of a capacitive aerial operating over a wide range of frequency is given.

1. Introduction

IT is frequently required to couple a receiving aerial through a transmission line to a receiver and it is desirable that the loss in signal/noise ratio due to the line shall be a minimum over a wide frequency range.

If the aerial be substantially reactive, serious loss will usually arise from the mismatch between the impedance Z of the aerial and the characteristic impedance R_0 of the line. This loss is the greater the more pronounced the mismatch and the greater the attenuation αl of the line (α = attenuation constant, l = length). If the line were loss free ($\alpha = 0$), the signal/noise ratio would be unaffected, for the line would then behave as a purely reactive network.

It is therefore of interest to consider coupling networks between the aerial and line which provide a sending-end impedance equal to the characteristic impedance of the line over a wide band of frequencies in order that the line loss will be a minimum. The coupling network itself introduces loss and the question at issue is the extent to which the reduction in line loss is offset by the loss in the network.

Two types of network are considered in the present paper :

(i) the cathode follower, and

(ii) the constant-resistance network.

The losses due to these networks are compared with that which occurs for direct connection of the aerial, the case of a substantially reactive aerial being considered throughout.

In comparing the losses in signal/noise ratio due to the various systems, it is useful to employ the concept of "equivalent noise resistance" R_n as a measure of the loss in sensitivity introduced by the line and coupling network. This resistance R_n is defined in an analogous manner to the equivalent noise resistance of a valve :—if R is the resistive component of the aerial impedance Z, the loss in signal/noise ratio at the output terminals relative to that at the source is equal to the loss which would occur if a noise resistance R_n were connected in series with the aerial. Thus, if S_0 and N_0 are the signal and noise e.m.f.s at the aerial, and S and N are the corresponding quantities at the open-circuited output terminals of the line (Fig. 1), the relation defining R_n is

$$\left|\frac{S}{N}\right|^2 = \frac{R}{R + R_n}\left|\frac{S_0}{N_0}\right|^2 \quad \dots \quad \dots \quad (1a)$$

It is assumed that the effective noise temperature of the aerial is equal to the ambient temperature of the circuit elements.

The equation for R_n can be written explicitly

* MS. accepted by the Editor, February 1946.

$$R_n = R\left(\left|\frac{S_0}{S}\frac{N}{N_0}\right|^2 - 1\right) \quad \ldots \quad \ldots \quad (1b)$$

Thus, if R_n is known, the loss in signal/noise ratio can be expressed as

$$\text{Loss} = 20 \log_{10}\left|\frac{S_0}{N_0}\frac{N}{S}\right|$$

$$= 10 \log_{10}\left(\frac{R + R_n}{R}\right) \text{db}$$

$$= 10 \log_{10}\left(\frac{R_n}{R}\right) \text{db approx.} \quad \ldots \quad (2)$$

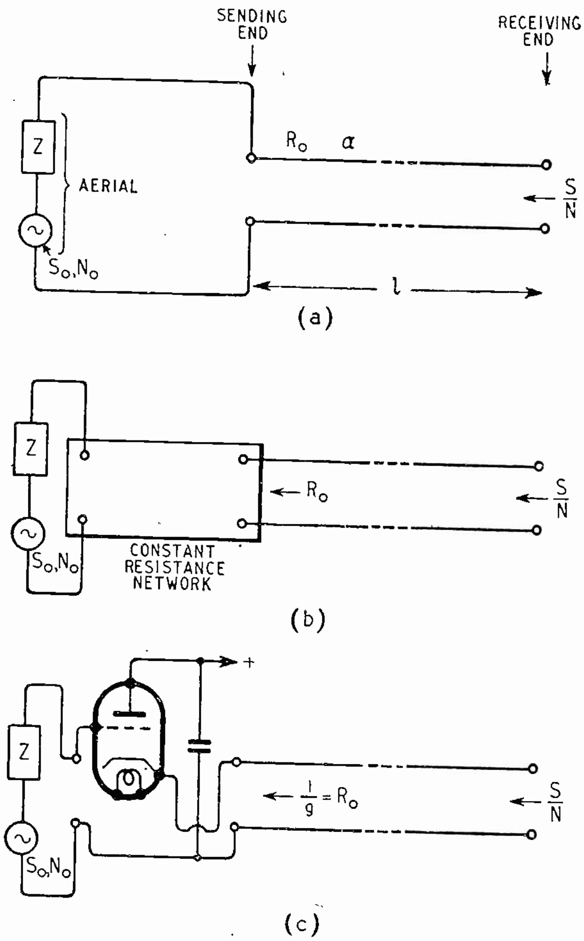

Fig. 1. *Schematic circuits of the cases considered; (a) is for direct connection of the source to the line, (b) for a constant-resistance network as a coupling, and (c) for a cathode follower.*

the latter approximation holding when R is small compared with R_n which will usually be the case for substantially reactive aerials.

It may readily be shown that the additional loss in signal/noise ratio due to connecting the receiving load impedance across the end of the line is given by

Receiving-end loss

$$= 10 \log_{10}\left(1 + \frac{G_2 T_2}{G_1 T_1}\right) \text{db} \quad \ldots \quad (3)$$

where G_1 = conductance (at temperature T_1) presented by the receiving end of the line, and

G_2 = conductance of the load (at temperature T_2).

This loss must be added to the loss up to the open-circuited end of the line given by equation (2) in order to obtain the overall loss.

2. Direct Connection of the Aerial to the Line

It will be assumed throughout that the characteristic impedance of the line is a pure resistance R_0 and thus the primary constants R_1, L_1, G_1 and C_1 are related to the derived constants by the equations

$$R_0 = \sqrt{\frac{L_1}{C_1}}; \quad \alpha = \frac{R_1}{R_0} = R_0 G_1 \text{ nepers/unit length } (1 \text{ neper} = 8.7 \text{ db}).$$

It has been shown[1] that the loss in signal/noise ratio due to a line of attenuation αl when connected to a source of impedance $Z(= R + jX)$ is given by

$$\left|\frac{S_0}{N_0}\frac{N}{S}\right|^2 = \cosh 2\alpha l + \frac{\sinh 2\alpha l}{2R}\left(R_0 + \frac{|Z|^2}{R_0}\right)$$

and thus from equation (1b) the equivalent noise resistance is

$$R_n = R_0 \sinh \alpha l \left[\frac{2R}{R_0} \sinh \alpha l + \left(1 + \frac{|Z|^2}{R_0^2}\right) \cosh \alpha l\right] \quad \ldots \quad (4a)$$

For a substantially reactive aerial, which is the case considered in the present paper, this equation can be simplified to

$$R_n = \tfrac{1}{2} R_0 \sinh 2\alpha l \left(1 + \frac{|X|^2}{R_0^2}\right) \quad \ldots \quad (4b)$$

When a substantially reactive aerial is connected to a line, the impedance presented by the receiving end of the line is markedly variable with frequency. It is therefore difficult to arrange coupling of the line to the receiver which shall be suitable for operation over a wide range of frequencies[1]. This implies that the receiving end loss, given by equation (3) is likely to be appreciable at some frequencies; i.e., where the conductance G_1 presented at the receiving end of the line is small compared with the conductance G_2 of the load impedance.

A further disadvantage of direct connection lies in the existence of resonances in the combined aerial and line circuit which lead to difficulty in the maintenance of phase and amplitude equality between two or more aerials as, for example, in direction-finding systems.

These disadvantages are absent in the two matched systems discussed in the following sections since the impedance presented by the receiving end of the line is constant and resistive.

3. The Constant-Resistance Network

It is well known that certain two-terminal networks comprising resistances and reactances possess a purely resistive impedance at all frequencies[2]. In Fig. 2 three examples of this type of network are shown and in each case the impedance presented at the terminals is a constant resistance R_0 when the following condition, which is independent of frequency, is satisfied :

$$L/C = R_0^2$$

In the present problem L or C would represent the substantially reactive aerial and the two terminals would be connected to the line. It is assumed that the resistance of the aerial and of the other reactive elements is negligible and that the effective L or C of the aerial is substantially independent of frequency over the range of operating frequencies.

In all these circuits the voltage transfer ratio S/S_0 to the end of the line is given by

$$\left|\frac{S_0}{S}\right|^2 = \left(1 + \frac{|X|^2}{R_0^2}\right) e^{2al}$$

where X is the aerial reactance at the frequency considered. Thus the equivalent noise resistance is given by

$$R_n = R_0\left(1 + \frac{|X|^2}{R_0^2}\right) e^{2al} \quad \ldots \quad \ldots \quad (5)$$

The additional loss when the line is terminated in its characteristic impedance at the receiving end is 3 db.

4. The Cathode Follower

It is assumed that the input admittance of the valve is negligible compared with the admittance of the aerial. Then it may be shown[3] that the equivalent noise resistance of a triode cathode-follower stage having an infinite cathode load is given by

$$R_n = R_v = n/g$$

where R_v = equivalent noise resistance of the valve.

g = mutual conductance of the valve

$n \equiv gR_v$ = a numerical factor depending upon the valve structure and cathode temperature.

Since the output impedance of the cathode follower is $1/g$ and the transfer ratio of signal voltage between input and output is unity, the factor n is readily identified as the ratio of the equivalent noise temperature of the output impedance $1/g$ to the ambient temperature T. Theory and experiment[4] show that n has a value of approximately 2.5 for triodes with oxide-coated cathodes at about 1000° K, which is the condition in most modern valves.

If a line of characteristic impedance

$$R_0 = 1/g$$

be attached to the cathode follower (Fig. 1c) it will be matched at its sending end and the signal at the receiving end is given by

$$S = S_0\, e^{-al}$$

Although the impedance at the end of the line is still R_0, the noise voltage there will be

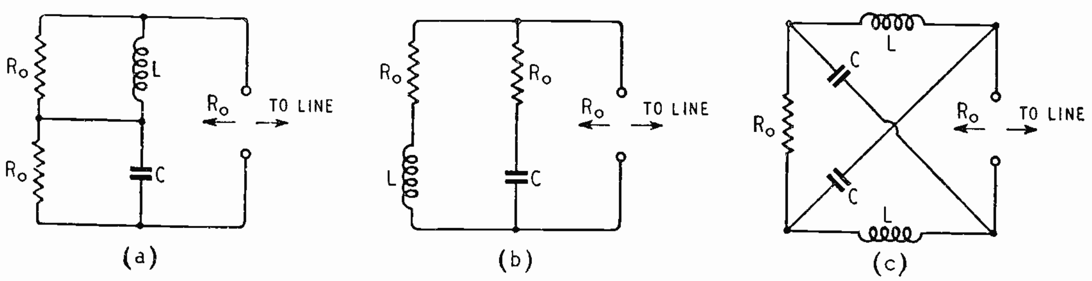

Fig. 2. *Constant-resistance networks suitable for coupling a reactive source (L or C) to a line of characteristic impedance R_0. The circuits are :—(a) full-series type, (b) full-shunt type and (c) lattice type. In all cases the constant resistance is $L/C = R_0^2$.*

less than at the cathode, since the noise from the valve (at effective temperature nT) is attenuated and replaced by noise from the line at the lower temperature T. It can be shown that the square of the noise voltage at the receiving end of the line is less than that at the sending end by the factor

$$\{1 + (n - 1)\, e^{-2\alpha l}\}/n$$

The overall effect of the line is to increase the square of the noise/signal ratio by the factor

$$(e^{2\alpha l} + n - 1)/n$$

Thus, the equivalent noise resistance of the cathode follower with the line is given by

$$R_n = R_v \frac{e^{2\alpha l} + n - 1}{n}$$

$$= R_0\,(e^{2\alpha l} + 1.5) \text{ when } n = 2.5 \quad (6)$$

Since the impedance presented at the receiving end of the line is effectively at a temperature T_1 (above the ambient temperature T the loss in signal/noise ratio due to terminating the line in its characteristic impedance will be less than 3 db.

From the above, the temperature T_1 is found to have the value

$$T_1 = T\,(1 + 1.5\, e^{-2\alpha l})$$

and thus in the matched condition

$$G_1 = G_2 = \frac{1}{R_0}\,; \quad T_2 = T$$

which gives from equation (3) for the receiving-end loss

$$10 \log_{10} \left(\frac{2 + 1.5\, e^{-2\alpha l}}{1 + 1.5\, e^{-2\alpha l}}\right) \text{db}$$

which lies between 1.5 db for αl small and 3 db for αl large.

5. Comparison of the Methods of Coupling

The following conclusions may be drawn from the results derived in the preceding sections :—

(a) In the case of direct connection, the impedance appearing at the receiving end of the line is variable with frequency and considerable additional loss [cf. equation (3)] may occur at some frequencies. In the case of the constant-resistance network and the cathode follower, the receiving-end loss can be made small since the impedance presented at the end of the line is a constant resistance. It is therefore necessary to bear in mind the likelihood of the greater receiving-end loss of direct connection when comparing it with the matched systems.

(b) The cathode follower is superior to direct connection when the magnitude of the aerial reactance is greater than the value given by equating the right-hand sides of equations (4b) and (6) :

$$\frac{|X|}{R_0} = \sqrt{\frac{2\, e^{2\alpha l} + 3}{\sinh 2\alpha l} - 1} \quad \ldots \quad (7)$$

This function of αl has been plotted in Fig. 3 which enables the useful range of application of the cathode follower to be estimated. As αl increases, it tends to a limiting value of 1.73, while for small values of αl it increases indefinitely.

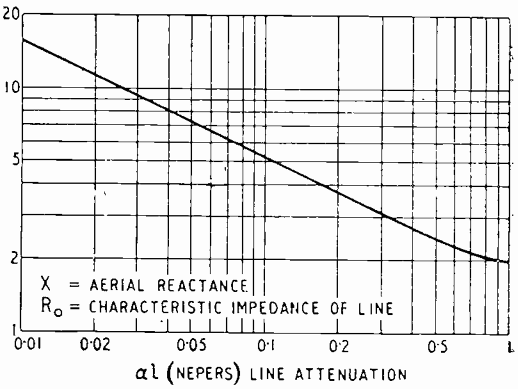

Fig. 3. *The magnitude of aerial reactance for which the cathode follower and direct connection give the same signal/noise ratio at the end of the line.*

By virtue of the considerations in (a) regarding the receiving-end loss, the cathode follower will in practice be advantageous with aerials of reactance somewhat lower than indicated by Fig. 3. Curves in Fig. 4 show the gain in signal/noise ratio provided at the end of the line by the cathode follower relative to direct connection. The intersections with the zero line occur at the values of $|X|/R_0$ already given in Fig. 3. The upper limit to the gain is represented by the curve for $\alpha l = \infty$.

(c) The constant-resistance network is inferior to direct connection as may be seen from comparing equations (4b) and (5) which give for the ratio of the equivalent noise resistances :

$$\frac{R_n \text{ (const. res. network)}}{R_n \text{ (direct connection)}} = \frac{2e^{2\alpha l}}{\sinh 2\alpha l} = \frac{4}{1 - e^{-4\alpha l}} \quad \ldots \quad (8)$$

The corresponding loss in signal/noise ratio of the constant-resistance network relative to the direct connection is shown in Fig. 5 from which it is seen that this loss has a lower limit of 6 db for αl large. The constant-resistance network is likely to be of practical value only when the line attenuation αl is large and the aerial reactance is small. In this condition it is superior to the cathode follower if

$$|X|/R_0 < 1.22e^{-\alpha l}$$

but it will always be inferior to the direct connection. When αl is large, this inferiority is a minimum and may be more than offset by the constant resistance presented at the receiving end, as indicated in (*a*).

(d) The conclusions of the analysis are considered to be valid for frequencies up to the order of 30 Mc/s provided that the main hypothesis of a substantially reactive aerial is still satisfied. At higher frequencies the input admittance and inter-electrode capacitances of the cathode follower are no longer negligible. In practice, however, at V.H.F. only direct connection of the aerial to the line is likely to be suitable, since the aerial will usually be of relatively low reactance if not actually resonant.

The only significance of bandwidth (not to be confused with the range of operating frequency) is that the impedances concerned shall be substantially constant within it.

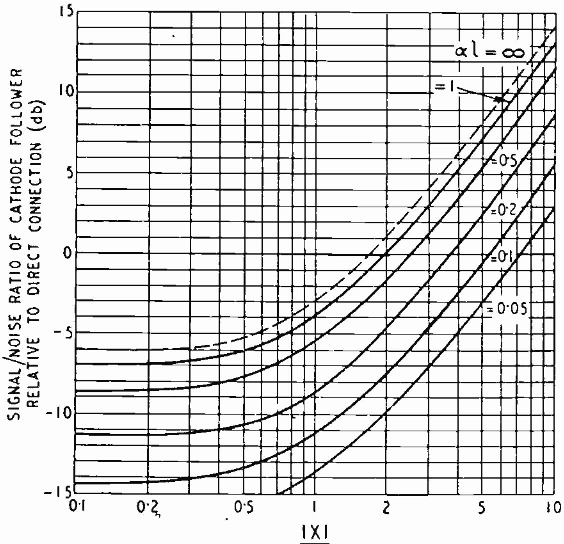

Fig. 4. *Comparison of the signal/noise ratio of the cathode follower and direct connection for various values of line attenuation αl (nepers).*

6. Numerical Example

It may be of interest to consider a typical numerical example. An aerial has a capacitance of 50 $\mu\mu$F and is required to work into a line of characteristic impedance 100 ohms and attenuation 0.2 neper (1.7 db) over the frequency band 3 to 10 Mc/s.

The aerial reactance $|X|$ varies between 1000 ohms and 300 ohms and thus $|X|/R_0$ varies between 10 and 3. From Fig. 4 the signal/noise ratio for the cathode follower is seen to be between + 8.5 db and − 1.5 db relative to direct connection ; in view of the matching property of the cathode follower, it may be regarded as markedly superior to

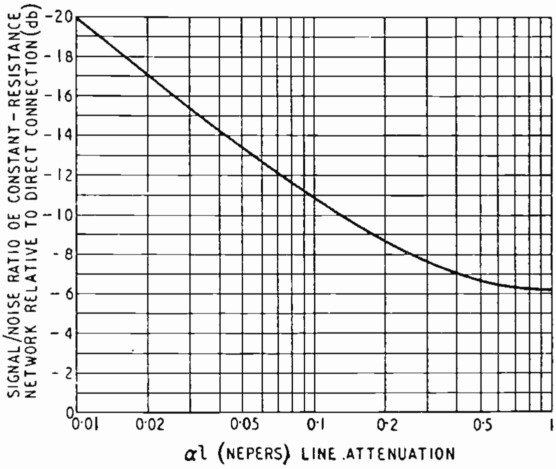

Fig. 5. *Comparison of the signal/noise ratio of the constant-resistance network and direct connection.*

direct connection. From Fig. 5 it is seen that the constant-resistance network provides a signal/noise ratio 8.5 db down on the direct connection and is therefore much inferior to the cathode follower.

If the line is terminated in its characteristic impedance at the receiving end the additional loss is 1.8 db for the cathode follower and would be 3 db for the constant-resistance network. In the case of direct connection the receiving end loss is dependent on the electrical length of the line and is likely to vary between wide limits.

7. Acknowledgements

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OSCILLATION HYSTERESIS IN GRID DETECTORS*

By E. E. Zepler

SUMMARY.—The conditions under which grid-leak detectors employing variable regeneration may exhibit oscillation hysteresis are discussed. A theory covering the principal effects responsible for hysteresis is given, together with its experimental verification. Various measures against oscillation hysteresis are recommended.

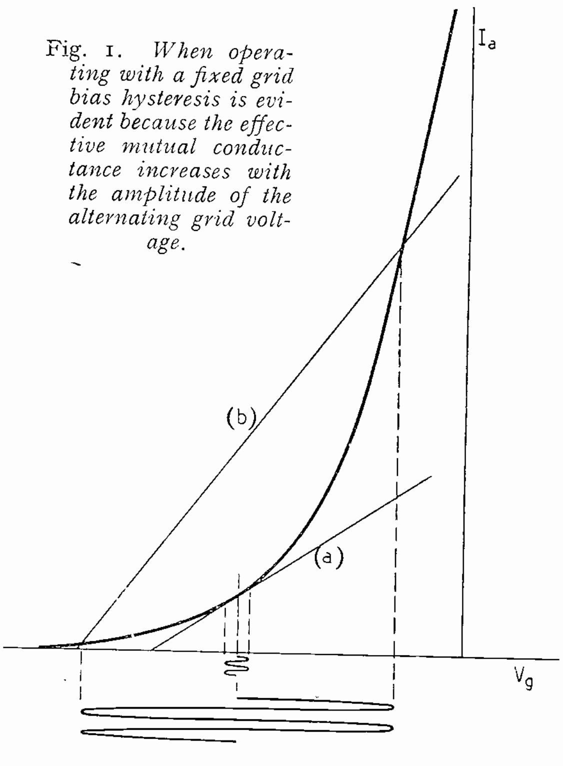
1. Introduction

REGENERATIVE grid-leak detectors are now less widely used than they were some years ago. Nevertheless, in the hands of a skilled operator, they are capable of giving more gain and selectivity than any other circuit of equal simplicity. Consequently, the regenerative detector has considerable usefulness when saving of weight and space is more important than tonal quality and ease of handling, and it is probable that the circuit will continue to be used in these cases.

For the circuit to produce optimum results it is important that the regeneration should work smoothly; i.e., the amplitude of oscillation should increase with increasing regeneration steadily and without discontinuities, and decrease in the same manner when the regeneration is decreased. In the case of jumpy regeneration, known as oscillation hysteresis or backlash, oscillation starts suddenly with a finite, sometimes fairly large, amplitude. If the regeneration is then decreased the amplitude falls steadily to some finite value, after which oscillation stops suddenly for a value of regeneration well below that for which it started. In this case a valve adjusted near the point of oscillation may oscillate strongly when a signal is applied and maintain oscillation after the signal has been removed. It is evident that under these conditions the valve cannot be used with maximum efficiency.

Oscillation hysteresis was a serious problem in the early development of valve oscillators some 25 years ago. The effect was due to the valves being worked with a fairly large fixed grid bias. Under these conditions it is possible for the average mutual conductance of a valve to increase at first with increasing amplitude, until eventually it falls again (Fig. 1). If, therefore, the regeneration is adjusted so that oscillation can just begin, the state of oscillation is not stable, because with increasing amplitude the feedback factor $A\beta$ increases. The effect has been discussed and has been rightly attributed to the peculiarities of the valve characteristic.† With the introduction of the grid-leak resistance and capacitance, oscillation hysteresis in ordinary oscillators has been largely overcome because of the self-biasing effect of the

Fig. 1. *When operating with a fixed grid bias hysteresis is evident because the effective mutual conductance increases with the amplitude of the alternating grid voltage.*



valve. The grid bias produced by the grid current is not constant, but increases with increasing amplitude of oscillation; this causes the mutual conductance to drop and thus prevents hysteresis.

Even with this self-biasing effect hysteresis is frequently met with in grid leak detectors.

* MS. accepted by the Editor, February 1946.

† E. V. Appleton and B. Van Der Pol, "On a Type of Oscillation Hysteresis in a simple Triode Generator," *Phil. Mag.*, January 1922.

It is almost absent on short waves, quite marked on medium waves and very strong towards the longer wavelengths. This fact suggests that there are additional causes other than the valve characteristic. When examining these causes we consider as the basic fact that oscillation hysteresis is present whenever the feedback factor $A\beta$ increases with increasing amplitude. But, in calculating the feedback factor as a function of amplitude, we have to keep in mind that the frequency of oscillation may be a function of amplitude; i.e., the feedback factor must be calculated for that frequency at which $A\beta$ is real. Hence, if V_g is the alternating grid voltage and f the frequency of oscillation, the condition for the presence of hysteresis is that

$$\frac{d(A\beta)}{dV_g} > 0, \text{ where } \frac{d(A\beta)}{dV_g}$$

$$= \frac{\partial(A\beta)}{\partial V_g}(f = \text{const}) + \frac{\partial(A\beta)}{\partial f}(V_g = \text{const}) \times \frac{df}{dV_g}.$$

Among the various factors that may produce oscillation hysteresis in a grid-leak detector the most important are (*a*) variation in the Q-factor of the tuned grid circuit due to grid current, (*b*) phase displacement of the anode current because of the reactance of the feedback capacitor. The two causes will be discussed separately.

2. Q-Factor Variation

The basic circuit in Fig. 2(*a*) may be treated as an ordinary feedback amplifier. For the sake of simplicity we assume that the reactance of the anode coil and the transferred impedance of the grid circuit are small compared with the valve impedance; then the anode current is always in phase with the grid voltage. From the equivalent circuit shown in Fig. 2 (*b*) we obtain

$$I_a = g_m V_g, \text{ and}$$

$$V_g' = I_a j\omega M \frac{1/j\omega C_g}{r + j(\omega L - 1/\omega C_g)}$$

$$= V_g g_m \frac{M/C_g}{r + j(\omega L - 1/\omega C_g)}$$

The phase condition is fulfilled when $\omega L = 1/\omega C_g$, i.e. for the resonant frequency $\omega_0/2\pi$ of the grid circuit, independently of the amplitude of oscillation (df/dV_g in the above equation is zero). Then the feedback factor becomes $\frac{V_g'}{V_g} = \frac{g_m M}{r C_g} = g_m \omega_0 MQ$, where Q is the magnification factor of the grid circuit. Oscillation starts when $M = \frac{1}{g_m \omega_0 Q}$. The amplitude of oscillation should then be infinitely small and should be prevented from increasing by the decrease of g_m. In actual fact, however, the grid-cathode path of the valve is equivalent to a resistance which increases with increasing amplitude of oscil-

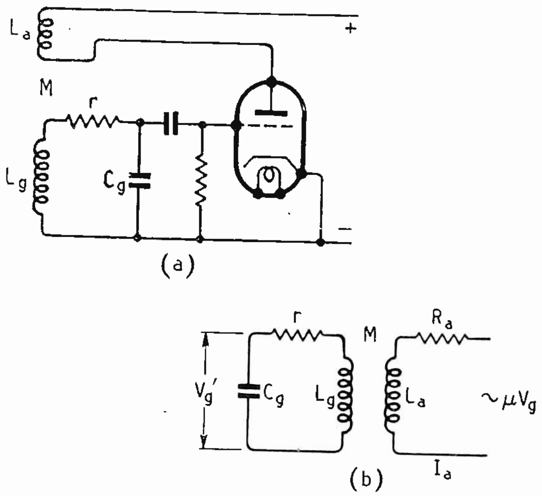


Fig. 2. *A typical grid-leak biased oscillator is shown at (a) with its equivalent circuit at (b).*

lation. Therefore, in the expression for the feedback factor, both g_m and Q are functions of amplitude. If, with increasing amplitude, the fractional increase of Q is larger than the fractional decrease of g_m, the differential coefficient $\frac{d(A\beta)}{dV_g} = \omega_0 M \frac{d(g_m Q)}{dV_g}$ is positive and oscillation hysteresis is present.

3. Experimental

As a check on the above theory both the mutual conductance and the equivalent grid-cathode resistance of the oscillator valve were measured as a function of the alternating voltage between grid and cathode. The methods used are shown in Fig. 3 (*a* and *b*), the circuits being of a conventional bridge type. In these measurements the valve acted in a way typical of its behaviour as an oscillator valve; i.e., when the voltage V_g across AB increased, the working bias of the valve increased as well, so that g_m decreased while the equivalent resistance between A and B increased. The measuring frequency was identical with the frequency at which the valve was used as an oscillator, the indicator being tuned to the measuring frequency to rule out the influence of harmonics caused by the valve. (Measurements at audio frequency with a telephone as indicator gave identical results, provided the grid leak capacitor was increased inversely proportional to the frequency).

The results are shown in Fig. 4. The value of R_g includes the grid-leak resistance ($1 M\Omega$), in accordance with the practical

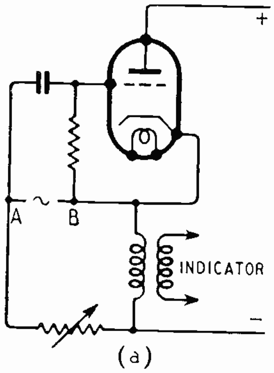
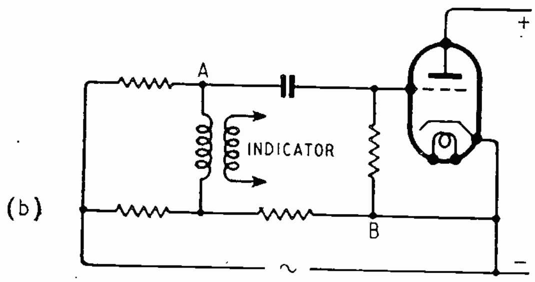


Fig. 3. *Circuits for the measurement of mutual conductance and grid–cathode resistance as functions of alternating grid voltage are shown at (a) and (b) respectively.*



conditions; the grid capacitor was 100 $\mu\mu$F. The valve used was a type ML4 working with 100 volts H.T. In the tuned grid circuit shown in Fig. 2 (*a*) $C_g = 500\ \mu\mu F$, $f_0 = 230$ kc/s, $Q_0 = 90$, where Q_0 refers to the circuit alone. For the calculation of the feedback factor as a function of amplitude a knowledge of the Q-factor under working conditions is required. This is found from Q_0 and from R_g by the relation $1/Q = 1/Q_0 + \omega_0 L/R_g$. The values of Q and of $g_m Q$ are plotted in Fig. 5, as a function of the voltage between A and B.

We see that, although g_m decreases with increasing V_g, the feedback factor increases at first and then falls off. Therefore it follows that, as soon as M has reached the value necessary for oscillation to start, the amplitude of oscillation will increase until the factor $g_m Q$ has again reached the initial value of 200. Oscillation hysteresis is fairly prominent, oscillation starting with a grid amplitude of 3.7 volts. If now M is decreased, stable oscillation can persist, until the value of $g_m Q$ becomes approximately 262. The grid amplitude is then only 1 volt and oscillation must break off suddenly if M is further decreased.

The condition under which hysteresis would just be absent is that

$$\frac{d(A\beta)}{dV_g} = 0 \text{ for } V_g = 0$$

that is

$$\omega_0 M\left(\frac{dg_m}{dV_g} Q + \frac{dQ}{dV_g} g_m\right) = 0,$$

and therefore

$$\frac{dg_m}{dV_g}\frac{1}{g_m} = -\frac{dQ}{dV_g}\frac{1}{Q}$$

If Z_0 is the impedance of the parallel-tuned circuit without additional grid damping, then $Q_0 = Z_0/\omega_0 L$, and the Q-factor under working conditions is $Q = \dfrac{Z_0 R_g}{Z_0 + R_g}\dfrac{1}{\omega_0 L}$, hence

$$\frac{dQ}{dV_g} = \frac{dQ}{dR_g}\frac{dR_g}{dV_g} = \frac{Z_0^2}{(Z_0 + R_g)^2\,\omega_0 L}\frac{dR_g}{dV_g}$$

$$\frac{1}{Q}\frac{dQ}{dV_g} = \frac{1}{R_g}\frac{dR_g}{dV_g}\frac{Z_0}{Z_0 + R_g}$$

From Fig. 4 we see that the fractional change of g_m for zero grid amplitude is approximately

$$\frac{1}{g_m}\frac{dg_m}{dV_g}_{(V_g = 0)} = -0.05 \text{ per volt } V_g;$$

the fractional change of R_g is 4.5 per volt V_g. Hence oscillation hysteresis will be absent when $4.5\dfrac{Z_0}{Z_0 + R_g} < 0.05$; i.e., when $Z_0 < 2{,}900$ ohms. This explains why in the above example a resistance of 10,000 ohms placed in parallel with the grid circuit did not prevent hysteresis, but only reduced it so

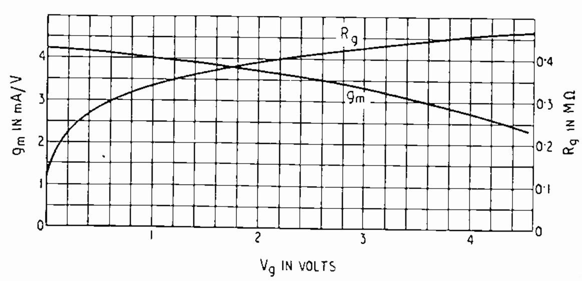


Fig. 4. *Mutual conductance and grid–cathode resistance of a ML4 valve with 100 volts H.T. supply.*

that the initial amplitude of oscillation was about 0.5 volt. The absence of hysteresis on short waves is due to the fact that the impedances of parallel tuned circuits are ısually a few thousand ohms, whereas R_g s independent of frequency (unless transit ime effects are considered).

Conditions may be improved in various vays such as lowering the H.T. or increasing he grid-leak resistance. The former moves he working point of the valve nearer to the ower bend of the characteristic where g_m lecreases more quickly with increasing bias. The second measure increases the bias for

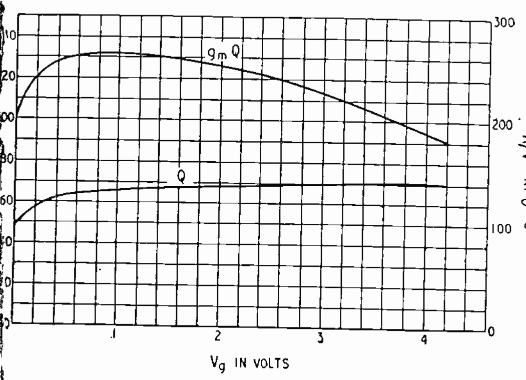


Fig. 5. *Values of effective Q and g_mQ for the valve of Fig. 4 with a tuned circuit having $Q = 90$ at 230 kc/s.*

ero grid amplitude so that R_g increases. When, in the above example, an H.T. of 5 volts and a grid leak resistance of 8 negohms were used, oscillation started with n amplitude of only 0.3 volt, instead of bout 4 volts with 1 MΩ and 100 volts H.T.

If the anode load is a large resistance, the oltage at the anode rises with increasing ias. This keeps g_m more constant with icreasing bias and tends to increase hysteresis. A diode, biased to its cut-off point nd placed in parallel with the tuned circuit, asily eliminates hysteresis in this case, ue to the Q-factor decreasing with increasing

$$\frac{V_a'}{V_g} = \mu\frac{M}{C_g}\,\frac{1}{rR_a + \dfrac{L_g}{C_a} - \dfrac{1}{C_aC_g\left(\dfrac{1}{L_gC_g} + \dfrac{r}{R_aL_gC_a}\right)}} = \mu\frac{M}{C_g}\,\frac{1}{rR_a + \dfrac{L_g}{C_a}\dfrac{rC_g}{rC_g + R_aC_a}}$$

nplitude. It is also effective when the ysteresis is caused by the anode current aving a phase displacement with respect the grid voltage.

Anode Current Phase Angle

The conventional circuit of a grid-leak etector using a variable feedback capacitor ay be seen in Fig. 6. The A.F. load in the anode circuit has been omitted in order to simplify the conditions. If we neglect, as in Sect. 2, the reactance of L_a and the transferred impedance of the grid circuit, the feedback factor of the circuit becomes:

$$A\beta = \frac{V'_g}{V_g}$$
$$= \mu\frac{M}{C_g}\,\frac{1}{\left(R_a - \dfrac{j}{\omega C_a}\right)\left(r + j\omega L_g - \dfrac{j}{\omega C_g}\right)}$$

The phase is correct for oscillation when the imaginary terms disappear, hence:

$$R_a\left(\omega L_g - \frac{1}{\omega C_g}\right) - \frac{r}{\omega C_a} = 0$$

$$\omega^2 = \frac{1}{L_g C_g} + \frac{r}{R_a L_g C_a}$$

$$\omega \approx \omega_0\left(1 + \frac{1}{2}\,\frac{rC_g}{R_aC_a}\right)$$

From this it is seen that oscillation is possible only at a frequency higher than the resonant frequency of the grid circuit. The deviation from resonance must be such that the phase displacement of the anode current caused by the reactance of C_a is corrected in the grid circuit. The influence of C_a advances the phase hence the R.F. current in the grid circuit must lag behind the e.m.f. induced in L_g. This is the case if the frequency of oscillation is higher than the resonant frequency of the grid circuit. Under these conditions the feedback factor is:

$$\frac{V_g'}{V_g} = \mu\frac{M}{C_g}\,.\,\frac{1}{rR_a + \dfrac{L_g}{C_a} - \dfrac{1}{\omega^2C_aC_g}}$$

where ω is a function of R_a and is given by the above relation. Hence:

The feedback factor, expressed as a function of R_a, becomes a maximum when

$$r - \frac{L_g}{C_a}\,\frac{rC_gC_a}{(rC_g + R_aC_a)^2} = 0$$

R_aC_a is large compared with rC_g, whence

$$R_a^2C_a^2 = L_gC_g = \frac{1}{\omega_0^2}$$

$$\therefore\ R_a = \frac{1}{\omega_0 C_a}$$

From this it follows that hysteresis exists when, for infinitely small grid amplitudes, the valve impedance is less than $1/\omega_0 C_a$. With increasing amplitude R_a increases, the frequency for which $A\beta$ is real decreases and $A\beta$ itself goes up. If, under these conditions, C_a or M has been adjusted to a value such that oscillation can just start, i.e. such that $A\beta = 1$, the amplitude will increase until R_a reaches the second value for

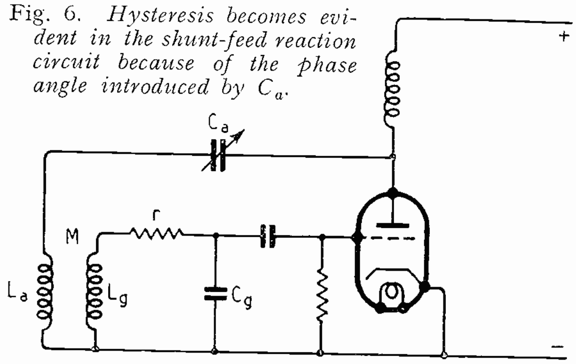


Fig. 6. *Hysteresis becomes evident in the shunt-feed reaction circuit because of the phase angle introduced by C_a.*

which the feedback factor is unity. The phase difference between anode current and grid voltage is then less than 45°, and the oscillation is stable (squegging is not taken into consideration). If now M or C_a is decreased, the amplitude of oscillation falls steadily until R_a equals the reactance of C_a, after which oscillation ceases suddenly.

The two values of R_a for which the feedback factor is unity may be found from the above equation, viz.

$$1 = \mu \frac{M}{C_g} \frac{1}{rR_a + \frac{L_g}{C_a} \cdot \frac{rC_g}{rC_g + R_a C_a}}$$

rC_g can be neglected in comparison with $R_a C_a$, hence

$$R_a = \frac{\mu M}{2rC_g} \pm \sqrt{\left(\frac{\mu M}{2rC_g}\right)^2 - \frac{L_g C_g}{C_a^{\,2}}}$$

$$= \frac{\mu\omega_0 MQ}{2} \pm \sqrt{\left(\frac{\mu\omega_0 MQ}{2}\right)^2 - \left(\frac{1}{\omega_0 C_a}\right)^2}$$

We assume that M is fixed and that the value of R_a for infinitely small amplitudes is known, then the magnitude of C_a for which oscillation starts is obtained from the last equation. The same equation then gives the second value of R_a for which the feedback factor is unity.

The above conclusions were checked experimentally, and results agreed well with the theory. In order to eliminate the effect of grid damping, the circuit shown in Fig. 7 was used. The self-biasing effect is maintained, but the oscillator valve never passes grid current. A circuit of this type may prove useful in practice.

The result of another experiment is of theoretical interest. The oscillator valve was operated with a fixed bias so that the working point was near the anode bend. Then hysteresis was present when C_a was very large; this was explained at the beginning as being due to an increase of g_m with amplitude. Since μ is fairly constant, an increase of g_m is equivalent to a decrease of R_a. Therefore hysteresis disappeared when M was increased to such a value that oscillation started when $1/\omega_0 C_a$ was larger than R_a. Numerical agreement was not too good, no doubt due to the fact that with small anode currents μ varies with amplitude.

When the oscillator triode of Fig. 7 was replaced by a pentode and the R.F. choke by a resistance of 5,000 ohms, there was no sign of hysteresis for any value of C_a. This

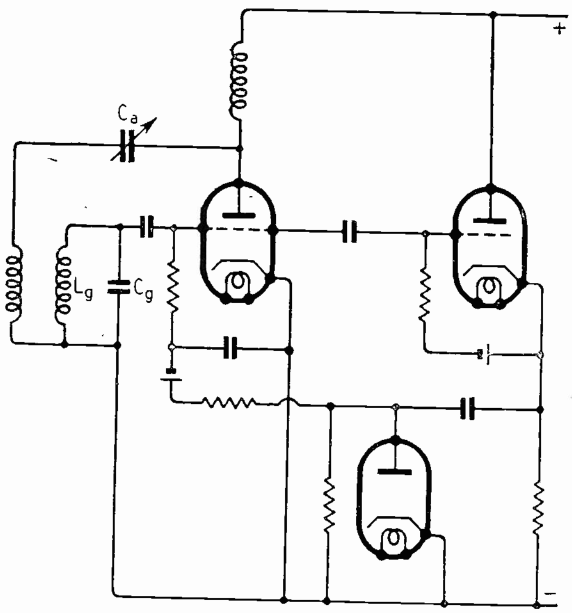


Fig. 7. *Circuit used to check the effect of C_a on hysteresis. A diode is used to obtain grid bias so as to avoid grid current effects.*

is to be expected because the phase displacement of the R.F. current flowing through C_a is determined by the reactance of C_a, and by the 5,000 ohm resistance. The valve impedance is so large that its influence on the phase is negligible. There remains only the decrease of g_m with increasing amplitude which leads to smooth starting of oscillation.

Experience shows that, even when hysteresis is absent, the amount of regeneration which can be applied when receiving a modulated carrier is often less than might be expected. The larger the signal the less satisfactory is the effect of regeneration. This is easily understood from the above. Usually, when hysteresis is absent, the feedback factor falls quickly with increasing signal strength. When the signal is modulated, the regeneration must be adjusted so that oscillation is absent when the signal amplitude is zero. The amount of effective regeneration is therefore smaller for a larger carrier. For this reason high selectivity with a large signal can only be obtained if the graph of $A\beta$ against amplitude is almost horizontal for low amplitudes, and if the frequency for which $A\beta$ is real is independent of amplitude. With a well designed circuit a bandwidth of a few hundred cycles per second can be achieved at frequencies as high as 10 Mc/s.

MODULATION PRODUCTS*

Calculation from Equidistant Ordinates

By A. Bloch, Dr.-Ing., M.Sc.

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

SUMMARY.—Tables and formulae for the calculation of modulation products from valve characteristics are given which are similar to those customarily used for the determination of the amplitude of harmonics from a series of equidistant ordinates. The derivation of the method is also described.

Introduction

IF a valve possesses a non-linear characteristic and the input e.m.f. contains more than one frequency, the output contains not only these components and their plain harmonics but also all possible additive and subtractive combinations thereof, the so-called intermodulation products.† The purpose of the present article is to put on record a set of formulae for the calculation of their amplitudes from equidistant ordinates of the valve characteristic; they are quite similar to the well-known formulae for the calculation of the harmonic output in the case of one input frequency.‡

Two tables are given with formulae ready for use, which cover the cases most likely to be encountered; these are followed by the derivation of the formulae. It will be seen that the new formulae follow very easily from those used for the calculation of harmonic output for a single input frequency, so that there is no necessity for extensive tabulation. It will also be seen that it is just as easy to construct formulae which deal with more than two input frequencies.

Description of Tables

The Tables give the coefficients with which the equidistant ordinates have to be multiplied, these ordinates being numbered so that the one coinciding with the working point of the valve has the number zero. A factor common to all the coefficients in one line appears in the column headed "Common Factor."

The amplitudes of the input e.m.fs. of different frequencies are denoted by "A" and "B," these amplitudes being measured in units which equal the potential difference between two neighbouring ordinates.

We read, for instance, from Table I that

* MS. accepted by the Editor, February 1946.

† This term includes, of course, "fundamentals" and "simple harmonics"; such components of the output correspond to modulation products in which the "other" frequencies participate to zero order (e.g., the output component $2\omega_a$ arises as modulation product $2\omega_a + 0.\omega_b + \ldots$)

‡ Sets of such formulae, giving up to the 6th harmonic and taking into account up to 7 equally spaced ordinates of the characteristic, were given by D. C. Espley in *Proc. I.R.E.*, Vol. 21 (1933), pp. 1439–1446.

From this it follows that hysteresis exists when, for infinitely small grid amplitudes, the valve impedance is less than $1/\omega_0 C_a$. With increasing amplitude R_a increases, the frequency for which $A\beta$ is real decreases and $A\beta$ itself goes up. If, under these conditions, C_a or M has been adjusted to a value such that oscillation can just start, i.e. such that $A\beta = 1$, the amplitude will increase until R_a reaches the second value for which the feedback factor is unity. The phase difference between anode current and grid voltage is then less than 45°, and the oscillation is stable (squegging is not taken into consideration). If now M or C_a is decreased, the amplitude of oscillation falls steadily until R_a equals the reactance of C_a, after which oscillation ceases suddenly.

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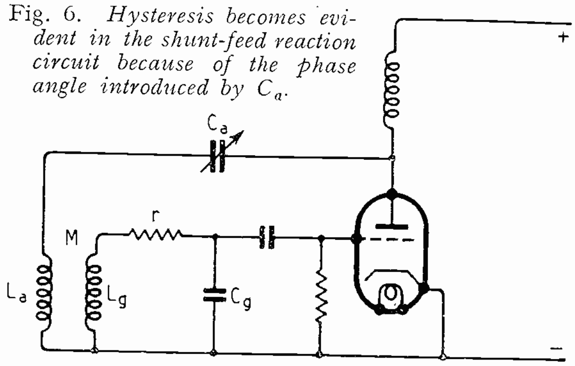

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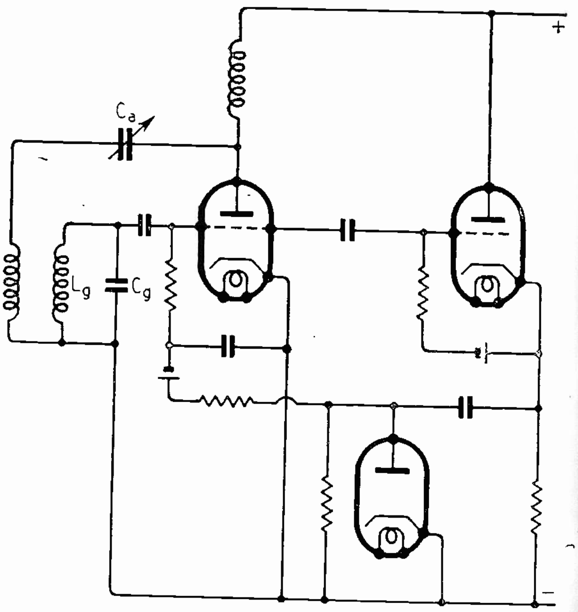

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TABLE I: COEFFICIENTS $r_k/2$ FOR OUTPUT $\omega_a \pm \omega_b$

Amplitudes A	Amplitudes B	Common Factor	Ordinates −4	−3	−2	−1	0	+1	+2	+3	+4
1	1	1/8			+ 1	0	− 2	0	+ 1		
1	2	1/12		+ 1	+ 1	− 1	− 2	− 1	+ 1	+ 1	
1	3	1/2560	+ 167	+ 252	− 212	− 252	+ 90	− 252	− 212	+ 252	+ 167
2	2	1/18	+ 1	+ 2	+ 1	− 2	− 4	− 2	+ 1	+ 2	+ 1

TABLE II: COEFFICIENTS $r_k/2$ FOR OUTPUT $\omega_a \pm 2\omega_b$

Amplitudes A	Amplitudes B	Common Factor	Ordinates −4	−3	−2	−1	0	+1	+2	+3	+4
1	1	1/16			− 1	+ 2	0	− 2	+ 1		
1	2	1/16		− 1	0	+ 3	0	− 3	0	+ 1	
1	3	1/10240	− 559	− 486	+ 1774	+ 146	0	− 146	− 1774	+ 486	+ 559
2	1	1/24		− 1	+ 1	+ 1	0	− 1	− 1	+ 1	
2	2	1/24	− 1	− 1	+ 2	+ 3	0	− 3	− 2	+ 1	+ 1
3	1	1/5120	− 167	+ 82	+ 382	− 342	0	+ 342	− 382	− 82	+ 167

the output of frequency $\omega_a + \omega_b$, for the case where the input frequencies ω_a and ω_b have each an amplitude of unity, is given by

$$\tfrac{1}{8}[I_{-2} - 2I_0 + I_{+2}]$$

Derivation of Formulae

If an excitation $e_g = A\cos\omega_a t$ is applied to the grid of the valve we get an output of the form

$$i_a = C_0 + C_1\cos\omega_a t + C_2\cos 2\omega_a t + \ldots$$
$$= \sum_{p=0}^{p=P} C_p \cos p\omega_a t \quad \ldots \quad \ldots \quad (1)$$

Each of the coefficients C_p can be calculated by an expression of the type

$$C_p = \sum_{m=-M}^{m=+M} a_{pm} \,.\, I_m \quad \ldots \quad \ldots \quad (2)$$

where the values of I_m are the current values for equidistant steps of grid potential given by the valve characteristic, and those of a_{pm} are known constants (given, for instance, in Espley's paper cited above).

In the case of a non-linear characteristic the values C_p will depend on the working potential of the valve. If a sufficient number of current ordinates are available we are then enabled to calculate a whole series of values of C_p by assuming the working potential to be shifted so as to coincide with one or the other of the given ordinates of the characteristic. The values of C_p obtained in this way are then most suitably labelled $C_p(-n) \ldots C_p(-1), C_p(0) \ldots C_p(+n)$ the argument in brackets denoting the working potential of the valve to which they refer.

Now, quite generally, if the working potential of the valve is varied in a sinusoidal fashion, say, by an amount $B\cos\omega_b t$, then C_p will itself become a function of time of the form

$$C_p = C_{p0} + C_{p1}\cos\omega_b t + \ldots$$
$$= \sum_{q=0}^{q=Q} C_{pq}\cos q\omega_b t \quad \ldots \quad \ldots \quad (3)$$

The values of C_{pq} can obviously be calculated from equidistant values of C_p by a formula of the same type as (2), i.e.

$$C_{pq} = \sum_{n=-N}^{n=+N} b_{qn} \,.\, C_p(n) \quad \ldots \quad \ldots \quad (4)$$

From (3) it follows that the valve output has the form

$$i_a = \sum_p C_p \cos p\omega_a t$$
$$= \sum_p \Big(\sum_q C_{pq}\cos q\omega_b t\Big) \,.\, \cos p\omega_a t$$

$$= \sum_p \sum_q C_{pq} \cos p\omega_a t \, . \cos q\omega_b t$$

$$= \tfrac{1}{2} \sum_p \sum_q C_{pq}(p\omega_a + q\omega_b)t \qquad .. \quad .. \quad (5)$$

so that the coefficients C_{pq} equal just twice the wanted intermodulation products.

From (2) it follows that

$$C_p(n) = \sum_{m=-M}^{m=+M} a_{pm} \, . \, I_{m+n} \quad .. \quad .. \quad (2a)$$

hence from (4)

$$C_{pq} = \sum_{n=-N}^{n=+N} b_{qn} \, . \sum_{m=-M}^{m=+M} a_{pm} \, . \, I_{m+n} \quad .. \quad (6)$$

$$= \sum_n \sum_m b_{qn} . a_{pm} . I_{m+n} = \sum_{k=-M-N}^{k=+M+N} r_k \, . \, I_k$$

where $k = m + n$ and where r_k denotes all possible products $b_{qn} \, . \, a_{pm}$ in which the values m and n add up to k. These products are easily formed if we write down on paper the line of coefficients a_{pm}, and then on a strip of paper in reverse order the line of coefficients b_{qn} ; we need then only multiply each coefficient of B by that of A standing underneath ; k equals the distance between the central term of the a's and the central term of the b's. Thus, for instance, in the case where $p = 1$, $q = 1$, $A = 2$ and $B = 1$ the calculation of the coefficient $r_k = r_{-1}$ looks as follows :

$$\tfrac{1}{2} \times \begin{vmatrix} +1 & 0 & -1 \end{vmatrix}$$

$$\tfrac{1}{3} \times \begin{vmatrix} -1 & -1 & 0 & +1 & + \end{vmatrix}$$

$$r_{-1} = \tfrac{1}{2} \times \tfrac{1}{3} \times (-1 + 0 + 0) = -\tfrac{1}{6}$$

The " mechanism " by means of which the coefficients r_k are created becomes perhaps clearer still if we follow the course of the calculation in matrix notation. It will be noted that formula (2) can be interpreted as the multiplication of a " line " vector $|a_{pm}|$ by a " column " vector $\{I_m\}$. In the case just mentioned ($A = 2$, $p = 1$) the line vector has the form

$$\begin{vmatrix} -1 & -1 & 0 & +1 & +1 \end{vmatrix}$$

It is then easily seen that

$$\begin{vmatrix} C_1(-1) \\ C_1(0) \\ C_1(+1) \end{vmatrix} = \tfrac{1}{3} \begin{vmatrix} -1 & -1 & 0 & +1 & +1 & 0 & 0 \\ 0 & -1 & -1 & 0 & +1 & +1 & 0 \\ 0 & 0 & -1 & -1 & 0 & +1 & +1 \end{vmatrix} \times \begin{vmatrix} I_{-4} \\ I_{-3} \\ \vdots \\ I_0 \\ \vdots \\ I_{+4} \end{vmatrix}$$

We need only pre-multiply both sides of the last equation by the line vector of the b_{qn}s required in order to get the desired result C_{11}. Hence the line vector which generates directly this result from the column vector of the I's is obtained if we form the product

$$\tfrac{1}{2} \begin{vmatrix} -1 & 0 & +1 \end{vmatrix} \times \tfrac{1}{3} \begin{vmatrix} -1 & -1 & 0 & +1 & +1 & 0 & 0 \\ 0 & -1 & -1 & 0 & +1 & +1 & 0 \\ 0 & 0 & -1 & -1 & 0 & +1 & +1 \end{vmatrix} \quad .. \quad (8)$$

$$= \tfrac{1}{6} \times \begin{vmatrix} +1 & +1 & -1 & -2 & -1 & +1 & +1 \end{vmatrix}$$

This line of reasoning can be easily generalized so as to cover the case of more than two input frequencies. Suppose the input e.m.f. contains a third frequency of amplitude s. We need then only provide a current (column) vector comprising $2s$ more values than we had before and extend the first matrix by which we multiplied it (the a — matrix) by $2s$ of those staggered lines ; we proceed similarly with the b-matrix. The result of the multiplication will be a column vector of values $C_{11}(-s)$, $C_{11}(-s+1)$ . . . $C_{11}(+s)$ and we need only pre-multiply this by the line-vector corresponding to the third modulation component in order to get again a matrix consisting of a single line, giving us the desired series of coefficients r_k for this case.

It is perhaps of interest to discuss shortly the relation between the formulae developed here and those which were derived recently by the author in another paper.* The most obvious difference is, of course, that the present formulae save the work involved in the formation of the difference table. On the other hand the formulae given here deal only with the case of integral amplitudes of the grid swing, while the difference method is not limited in this way. It is easily seen, however, that this restriction is purely accidental and only due to the fact that the known formulae for the calculation of harmonic output of the type (2) deal only with the case of integral amplitudes. If formulae of this type are available dealing with non-integral amplitudes (such formulae have recently been derived by the author) the same line of reasoning allows the derivation of the corresponding formulae for intermodulation products.

A difference of a more subtle nature, however, still exists: it has to do with the way in which the analysis underlying the formulae "draws" a smooth curve through the given current ordinates. In the present method we always take groups of m given current ordinates and—using the known formulae of the type (2)—we assume them to be linked by a parabola of the $(m - 1)$th order. There are n sets of m points, and n parabolae of the kind mentioned. These parabolae may all be parts of one and the same parabola of the $(m - 1)$th order in the case where such a parabola can be passed through all the ordinates given. In general a parabola of higher order is required to fulfil this condition. The difference method uses such a parabola and thus possesses the advantage of (theoretically) higher accuracy. The difference in practice is slight and the question which of these methods gives a closer approach to the actual valve characteristic is a debatable one: the higher order terms which we have to include in the expression for the parabola in order to make it pass exactly through all the given points may impart to this curve a "waviness" which is not present in the actual characteristic. We may, of course, have on occasion to deal with data which do not justify any further smoothing; i.e., which demand the use of the higher order parabola. For this reason it may be of interest to mention that it is possible to derive from the difference method formulae of the type (6), so that even in this case the actual amount of arithmetical work can be cut down to a minimum.*

* "Calculation of Intermodulation Products by Means of a Difference Table," *Journal Inst. El. Eng.*, Vol. 93, Part III, No. 23, p. 211.

* "Lagrangean Formulae for the Direct Calculation of Harmonic Output and of Intermodulation Products." Accepted for publication in the *Philosophical Magazine*. These formulae cover also the case of non-integral amplitudes.

APPENDIX

COEFFICIENTS a_{pm} FOR OUTPUT $p\omega_a$

To facilitate the derivation of formulae for other combination frequencies we reproduce here the coefficients derived in Espley's paper for the calculation of harmonic output (see reference footnote ‡) They are arranged in Table form subject to the same conventions as used above in Tables I and II.

Amplitude	p	Common Factor	− 5	− 4	− 3	− 2	− 1	0	+ 1	+ 2	+ 3	+ 4	+ 5
1	0	1/4					+ 1	+ 2	+ 1				
	1	1/2					− 1	0	+ 1				
	2	1/4					+ 1	− 2	+ 1				
2	0	1/6				+ 1	+ 2	0	+ 2	+ 1			
	1	1/3				− 1	− 1	0	+ 1	+ 1			
	2	1/4				+ 1	0	− 2	0	+ 1			
	3	1/6				− 1	+ 2	0	− 2	+ 1			
	4	1/12				+ 1	− 4	+ 6	− 4	+ 1			
3	0	1/1280			+ 167	+ 378	− 135	+ 460	− 135	+ 378	+ 167		
	1	1/640			− 167	− 252	+ 45	0	− 45	+ 252	+ 167		
	2	1/2560			+ 559	+ 486	− 1215	+ 340	− 1215	+ 486	+ 559		
	3	1/256			− 45	+ 36	+ 63	0	− 63	− 36	+ 45		
	4	9/1280			+ 17	− 42	+ 15	+ 20	+ 15	− 42	+ 17		
	5	81/1280			− 1	+ 4	− 5	0	+ 5	− 4	+ 1		
	6	81/2560			+ 1	− 6	+ 15	− 20	+ 15	− 6	+ 1		

CORRESPONDENCE

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

Iron-Dust Cores

To the Editor, "Wireless Engineer."

SIR,—I was rather surprised to discover, on reading your note on p. 156 of the June issue, that it is still apparently not generally recognized that the permeability formula quoted by Mr. Burgess, from certain of the papers referred to in the Radio Research Board Report of 1934 (with which your result of 1933 is, as you remark, sensibly identical), is probably about a century old. The problem is identical with that covered by Poisson's Theory of Magnetisation, and the formula is given in Maxwell's "Treatise," Vol. 2, ¶ 430, and Vol. 1, ¶ 314 (pp. 57 and 440, respectively, 3rd edition).

In view of the historical interest of this formula, ınd in order to avoid confusion in the future, it seems desirable to have some means of indicating ts classical origin. The related result in electro-statics is usually associated, in one form or another, with the names of Clausius and Mosotti, so there would be a precedent for adopting this description n magnetostatics. Since, however, the result for he electrostatic problem was originally derived rom that for the magnetostatic one, such a pro-edure would be, perhaps, undesirable. I would uggest, as an alternative, that the result be referred o as the "Poisson-Maxwell" formula.

I noticed the identity of these various formulæ –3 years ago, but as the result itself is not of great ractical value, I did not, at the time, think the oint worthy of mention.

Incidentally, it is possible to derive the result for he simple cubic model by methods other than that iven in your note of 1933.

ALAN FAIRWEATHER.

Physics Group,
P.O. Research Station,
Dollis Hill, N.W.2.

Pulse Modulation

To the Editor, Wireless Engineer.

SIR,—We have read with interest the article by Roberts and Simmonds in the November issue of *Wireless Engineer* (Vol. 22, p. 538), and the criticisms f Section 1.4 put forward by Mr. R. B. Shepherd in ie April issue (Vol. 23, p. 114). We agree with r. Shepherd that the derivations in the article are seudo-static so that they should be treated only s approximations.

There are some inconsistencies in the article etween the definitions of types of pulse modulation the technical description and those implied in ie analysis.

In the case of pulse-amplitude modulation the rmula derived for flat-topped pulses (Fig. 4) ctually applies to a form of amplitude modulation, hich may be called "top-modulation," in which ie top of a pulse is modulated at each instant by ie modulating voltage present at that instant. ıch pulses may be regarded as vertical slices of e modulating waveform. Incidentally, the ethods of producing amplitude modulation described in 1.3.1. would give this form of pulse amplitude modulation and not the rectangular pulses shown in Fig. 4.

The spectrum implied in (6) does not correspond to length-modulated pulses whose centres occur at fixed time intervals, as suggested in 1.4.2. It does correspond, however, to the method of modulation described in 1.3.2. When using this method, the centre of the pulse (which we take to be midway between the two edges) does not recur at equal intervals of time.

The waveform of phase-modulated pulses given in (7), obtained as in 1.4.3., certainly contains no term at the modulating frequency, but it does not conform with the commonly accepted definition given in 1.3.3. which specifies that the phase-modulated pulses retain constant length. It can be shown that the pulses described by (7) suffer length, as well as phase, modulation such that the component at the modulating frequency vanishes.

Turning to Mr. Shepherd's suggestions for a more exact study, it appears that his treatment of pulse-amplitude modulation, though quite different from that developed by us, gave an identical result. He bases his method on the assertion that, in all three types of pulse modulation, amplitude, length and phase, "the property of the pulse chain which is being varied is determined by the modulating signal at a number of instants equally spaced along the time-axis." While this is true for flat-topped amplitude modulation, it is not true for length or phase modulation where the modulation process depends on the slicing of a sawtooth voltage at a variable level. If such a process is examined, it will be seen that each edge subjected to independent modulation is shifted in time by an amount which is proportional to the modulating voltage at the instant when the edge occurs. Clearly, these instants are not uniformly spaced, and so Mr. Shepherd's assertion cannot be true. This renders his treatment of length and phase modulation approximate also.

An exact investigation of the modulation, made at S.R.D.E., leads to a formula for length-modulated pulses identical with (6); the formula for phase-modulated pulses of constant length is

$$i = i_{\max} S + i_{\max} \frac{Sp}{\omega} \phi_{\max} \left\{ \frac{\sin \pi Sp/\omega}{\pi\, Sp/\omega} \right\} \cos pt$$

$$+ i_{\max} S \sum_{k=1}^{\infty} \sum_{n=-\infty}^{\infty} J_n(k\psi_{\max}) \frac{\sin \pi S(k + n\omega/p)}{\pi S(k + n\omega/p)} \cos (k\omega + np)t$$

in the notation of Roberts and Simmonds. The term at the modulating frequency, $p/2\pi$, differs from that given by Mr. Shepherd by the factor in curly brackets. In most applications S will be small; this factor is then nearly unity and Mr. Shepherd's formula gives a good approximation.

A theoretical study of the spectrum of modulated pulses for a number of typical modulation systems has been made at S.R.D.E. Results were obtained without approximation, and a report with limited circulation was issued in September, 1945; it is hoped that it will be published shortly.

EDGAR FITCH.

Signals Research and Development Establishment, Christchurch.

To the Editor, "Wireless Engineer"

SIR,—Some conclusions which have been reached pertaining to Section 1.4 of the article by F. F. Roberts and J. C. Simmonds[1] and to R. B. Shepherd's criticism,[2] recently published in your journal are submitted below.

Let us consider the spectrum analysis of width-modulated pulses. Although I am not in disagreement with Mr. Shepherd's criticism of Messrs. Roberts' and Simmonds' method of analysis, I should like to point out that their method is entirely correct under certain conditions. The exact law governing the modulation must be taken into account and it should be noted that many such laws are possible. In the above-mentioned articles the instants at which pulses start and stop are determined by the signal amplitude at fixed time intervals. If the instants of the voltage jumps are determined by the signal amplitudes at the times when those jumps occur, the mathematical expression turns out to be simpler and the analysis indicated by Messrs. Roberts and Simmonds applies exactly. A proof follows at the end of this communication.

The law of modulation just defined is easily realized physically by adding to the signal voltage a saw-tooth voltage of larger amplitude, clipping, and then limiting the resultant.[3] The methods of W. A. Beatty[4] also yield pulses whose width modulation is governed by this law. The mathematical expression, placing in evidence the individual components of the spectrum, is

$$(1)\quad e = S_0\,(1 - A\cos pt) + 2/\pi \sum_{\nu=1}^{\infty}\sum_{n=-\infty}^{\infty} 1/\nu \left\{ J_{(n)}\left[\frac{Ad_0}{2}(\nu\omega)\right] \sin\left[\frac{d_0}{2}(\nu\omega) - \frac{n\pi}{2}\right]\right\} \cos(\nu\omega + np)t$$

where ω = pulse-repetition frequency in angular measure.

p = modulating-signal frequency in angular measure.

d_0 = average pulse duration.

$S_0 = \dfrac{\omega d_0}{2\pi}$ = average duty cycle.

A = modulation index.

This expression is for "symmetrical" width modulation by a sinusoidal signal, although the pulses do not generally widen and narrow symmetrically with this modulation law, when the modulating frequency is near the pulse repetition frequency. For symmetrical pulse-width modulation in accordance with the law specified by the above-named authors, the corresponding spectrum is[5].

$$(2)\quad e = \sum_{\nu=0}^{\infty}\sum_{n=-\infty}^{\infty} \frac{1}{\nu + n/p\omega}\left\{ J_{(n)}\left[\frac{Ad_0}{2}(\nu\omega + np)\right] \sin\left[\frac{d_0}{2}(\nu\omega + np) - \frac{n\pi}{2}\right]\right\} \cos(\nu\omega + np)t$$

Similar analyses exist, of course, for asymmetrically width-modulated pulses, in which one pulse edge remains fixed and the other edge moves in accordance with the law specified.

There are several noticeable differences between the two spectra given by (1) and (2) which are of interest from the point of view of audio fidelity. It should be noted that these considerations also apply to pulse-time or delay modulation systems in which width-modulated pulses are produced in the receiver for detection purposes.

The proof that the instants of voltage jumps are determined by the signal amplitudes at those instants is as follows :—

By ordinary Fourier analysis it is found that the series

$$e = S + 2/\pi \sum_{\nu=1}^{\infty} [1/\nu \sin(\pi S)] \cos \nu\omega t.$$

represents the pulse train shown in Fig. 1.

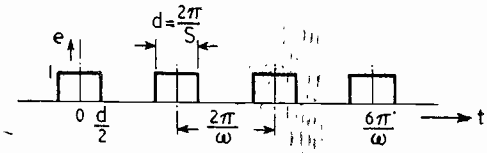

Fig. 1.

If one lets $\theta = \omega t$, the function becomes

$$e(S, \theta) = S + 2/\pi \sum_{\nu=1}^{\infty} [1/\nu \sin(\pi S)] \cos \nu\theta$$

This function equals either one or zero for any value of θ provided $0 \leq S \leq 1$. It is a simple matter to map the regions of the $S - \theta$ plane in which the function has the value one. This is shown in Fig. 2, which is correct regardless of the

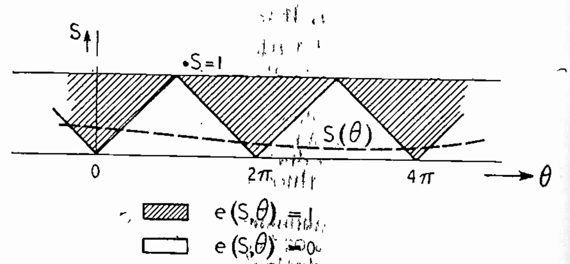

Fig. 2.

manner in which S and θ may vary. In particular, S may be a function of θ, as indicated by the broken line. When the line lies in the shaded regions, the

[1] Roberts, F. F., and Simmonds, J. C., "Multichannel Communications Systems, Preliminary Investigation based upon Modulated Pulses," *Wireless Engineer*, Vol. 22, No. 266, p. 538, November 1945.

[2] Shepherd, R. B., Letter to the Editor, *Wireless Engineer*, Vol. 23, No. 271, p. 114, April, 1946.

[3] Kell, R. D., U.S. Patent 2,061,734.

Beatty, W. A., British Patent 523,575.

[5] Fredendall, G. L.; Schlesinger, K.; and Schroeder, A. C., "Transmission of Sound on the Picture Carrier," *Proc. I.R.E.*, Vol. 34, pp. 49–61, February, 1946.

value of $e(S, \theta)$ is unity, otherwise, it is zero. Since θ is the time angle and S the relative pulse which is to be varied in accordance with a signal, the instant at which the transition occurs depends upon the signal amplitude at that instant.

It is of interest to notice that the saw-tooth boundary and the dotted line are directly related to the corresponding quantities in the physical modulation process.

E. R. Kretzmer.

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NEW BOOKS

Alternating Current Measurements at Audio and Radio Frequencies (2nd Edition).

By David Owen, B.A., D.Sc., F.Inst.P. Pp. 120 + vii, with 80 diagrams. Methuen and Co., Ltd., 36, Essex Street, London, W.C.2. Price 5s.

The author succeeded so well, by his selection and presentation of material in the first edition of this little book, in providing in compact form most of the really useful information that one would expect to find in a far larger volume, that one can understand any reluctance to make any very drastic changes in preparing the second edition, now published. Revision has been confined for the most part to such slight improvements in the text as there was any need to make. As regards symbols, replacement of "p" by "ω" is in line with present-day standards.

The author's deliberate departure from the standard notation for vector quantities is more questionable, however. It will be granted that the prescribed **I**, **V** and **Z** in Clarendon type, corresponding to the scalar I, V and Z, are badly suited to purely manuscript work. But they were never intended for it; the standard MS. notation—a bar over the letter—is convenient to use and less likely to be misread than Dr. Owen's *z* for the impedance operator. If the MS. is intended for printing, the standard means of indicating bold type—$\underset{\sim}{Z}$, etc.—is quite practicable and unambiguous. Dr. Owen's $\mathcal{I}$, $\mathcal{V}$, and $\mathcal{E}$ are little if any easier to write than $\bar{I}$, $\bar{V}$, and $\bar{E}$, and are more likely to be confused in typesetting; in any case $\mathcal{E}$ is already the standard symbol for electric field strength. The reviewer does not agree that in printed work there is any justification for abandoning **I**, **V** and **Z**, least of all on the ground of difficulty in distinguishing them from the corresponding scalar symbols. In a printed page they are the most easily picked out of any.

The chapter on r.f. measurements, occupying about one-third of the book, seemed even in 1937 to be rather less well abreast of current practice than the a.f. chapters, and as in spite of relatively rapid advances in practice this chapter is substantially unchanged in the second edition, it contains features that are now decidedly outmoded. Among them is Fig. 55, a circuit diagram of a wavemeter showing terminals for an external coupling coil directly in the calibrated tuned circuit, a variable capacitor across phones and H.T., and sliding short-circuit contacts on reaction coil and main tuning coil, but no grid bias or capacitor.

The author's sound, clear and concise presentation and his avoidance of anything like padding, make his work so helpful to the busy reader that it is to be hoped that in a future edition he will bring the r.f. chapter more completely up to date. The reviewer suggests, too, that the Twin-T method of reactance and resistance measurement, which combines the advantages of null methods with that of having a common earthy point for source, detector and unknown, deserves admission.

M. G. S.

Theorie des Oscillateurs

By Yves Rocard. Pp. 223 + viii and 75 Figs.

This book is a wartime product, written in 1940 and published in 1941, and the author states this as a reason for the absence of a bibliography, but refers readers to the papers by van der Pol in the Philosophical Magazine between 1922 and 1928, and to one by Liénard in the Revue générale d'Electricité of May 26 and June 2, 1928. The author deals with many different types of oscillations and goes into them very thoroughly. Chapter I is entitled the pendulum, but before coming to the real pendulum, electric circuits and vibrating cantilevers are considered; the pendulum is analysed very thoroughly, including the electrically maintained pendulum. Chapter II deals with relaxation oscillations, synchronization, production of submultiples of the frequency, *Ziehen*, and allied phenomena. In the following chapter oscillators without self-inductance or inertia are considered. Chapter IV deals with a complicated type of oscillation called "non-holonomes" and three-wheeled chariots with spring-controlled steering. Chapter V leaves engineering and deals with economic oscillations; this method of considering economic crises was introduced by Kalecki in 1933. The following chapter is concerned with electromagnetic and acoustic propagation in so far as they are involved in oscillatory systems such as resonant lines and pipes. The singing arc and allied phenomena are considered in Chapter VII, and the hunting of rotating machines in Chapter VIII. The final chapter deals with the important subject of the vibration of the wings of aeroplanes.

This book can be heartily recommended to anyone seriously interested in the subject of oscillations.

G. W. O. H.

Whittaker's Electrical Engineers' Pocket Book (7th Edition).

Edited by R. E. Neale, B.Sc., A.C.G.I., A.M.I.E.E. Pp. 938 + ix. Published by Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 30s.

Cours de Radioéléctricité Génerale. Tome II, Les Lampes Amplificatrices.

By P. David. Pp. 206. Published by Librairie de l'Enseignement Technique, 61, Boulevard Saint-Germain, Paris. Price 370 francs.

BACK ISSUES

Copies of *Wireless Engineer* for March, 1946, are required by Public and University Libraries in the U.S.A. Readers who have copies for disposal are asked to communicate with the Publisher.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

574 726.—Generating and utilizing short pulses of sound, for calibrating loudspeakers and microphones, and for measuring the acoustic properties of studios and concert halls.

Western Electric Co., Inc. Convention date (U.S.A. 25th July, 1942.

574 749.—Microphone-loudspeaker installation for measuring the acoustic properties of a room by increasing the relative effect or "weight" of the fading echoes of "testing" sounds.

Western Electric Co., Inc. Convention date (U.S.A.) 17th November, 1942.

574 808.—Back-coupled valve equipment for detecting and locating land-mines, booby-traps, and other metallic objects.

Cinema-Television, Ltd., and S. S. West. Application dates 21st May and 10th September, 1943.

574 941.—Oscillator and feed-back circuit for indicating the amount of unbalance in an impedance network and, more particularly, for locating buried conductors.

Hazeltine Corporation (assignees of L. F. Curtis) Convention date (U.S.A. 31st December, 1941.

574 955.—Balanced inductor system, associated with an oscillation generator and a receiver, for detecting the presence of buried conductors.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 31st December, 1942.

DIRECTIONAL WIRELESS

574 710.—Cathode-ray indicator for a radio-compass in which the pick-up voltages from directional and "sense" aerials are periodically switched across each pair of deflecting-plates.

Marconi's W.T. Co., Ltd., and N. H. Clough. Application date 16th October, 1940.

574 933.—Blind-landing system in which the glide-path is continuously indicated by a radio-altimeter which compares the normal ground-signals with those received from a reflector on the landing field.

Standard Telephones and Cables, Ltd., C. W Earp, and C. E. Strong. Application date 2nd April, 1940.

574 950.—Radiolocation or other amplifier utilizing a number of narrow band-width stages, in which provision is made for the rapid damping of undesired oscillations during periodical switching operations.

W. L. Watton. Application date 23rd November, 1943.

574 964.—Frequency meter designed also to interpret the effect of sudden changes in phase, particularly in radiolocation equipment of the frequency-modulated type.

D. Weighton and Pye, Ltd. Application date 9th September, 1940.

574 965.—Radio-altimeter of the frequency-modulated type in which the reflected signal is converted into an amplitude-modulated equivalent in order to give low-altitude indications.

D. I. Lawson and Pye, Ltd. Application date 9th September, 1940.

RECEIVING CIRCUITS AND APPARATUS

574 626.—Resistance-capacitance coupling designed to offset the stray capacitances at the grid of the second valve in a two-stage amplifier.

Standard Telephones and Cables, Ltd., C. T. Scully and A. Waters. Application date 11th February, 1944.

574 811.—Capacitance controlled switch for correcting the "overshoot" due to inertia, say in the tuning control of a radio receiver which is constantly swept through a band of frequencies and is required to stop on receipt of a given signal.

E. L. C. White, M. G. Harker and J. P. W. Houchin. Application date 10th June, 1943.

574 823.—Amplifier with a double feed-back circuit for increasing the signal-to-noise ratio, particularly in the frequency-band covered by the A.C. mains-supply and its harmonics.

Standard Telephones and Cables, Ltd. (assignees of J. O. Weldon). Convention date (U.S.A.) 25th November, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

574 838.—Blocking-oscillator circuit which generates a pulsed output rich in harmonic frequencies, suitable for calibration purposes or for multi-channel signalling.

Hazeltine Corporation (assignees of R. E. Sturm). Convention date (U.S.A.) 20th September, 1941.

574 932.—Combined short-wave transmitting and receiving set designed to be concealed about the person of the operator.

The British Thomson-Houston Co., Ltd. and T. H. Kinman. Application date 30th January, 1940.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

574 769.—Time-constant circuit for reducing the effect of "backlash" voltage in a multivibrator which generates timed pulses in response to a triggering signal.

E. L. C. White and F. C. Williams. Application date 29th July, 1942.

574 844.—Generating pulses, suitable for echo-ranging, by periodically applying intense light-flashes to the photo-sensitive cathode of a magnetron or other type of oscillator.

The British Thomson-Houston Co., Ltd. (communicated by General Electric Co.). Application date 27th May, 1943.

ABSTRACTS AND REFERENCES

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

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. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to the World List practice.

ACOUSTICS AND AUDIO FREQUENCIES

7.947.44 : 534.25 **2111**

The Wave Equation in a Medium with a Variable **dex of Refraction.**—Bergmann. (*See* 2170.)

4.2 **2112**

Absorption and Scattering by Sound Absorbent **linders.**—R. K. Cook & P. Chrzanowski. (*J.* *oust. Soc. Amer.*, April 1946, Vol. 17, No. 4, . 315–325.) Theoretical and experimental studies, h fairly good agreement between them.

4.213.4 **2113**

Attenuation of Sound in Circular Ducts.—E. her. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, . 4, p. 338.) Correction to 257 of February.

.231.3 **2114**

The Driving-Point Impedance of an Infinite **d Plate.**—R. Clark Jones. (*J. acoust. Soc.* *er.*, April 1946, Vol. 17, No. 4, pp. 334–336.) the design of mechanical filters for preventing the nsmission of vibration from one structure to ther it is necessary to know the impedances of structures between which the filter is to be nected. Expressions for these impedances are derived, and the results applied to the case of a steel plate. Full paper, of which abstract was noted in 4089 of 1945.

534.43 : 621.395.61 **2115**

Phonograph Reproducer Design.—W. S. Bachman. (*Trans. Amer. Inst. elect. Engrs*, March 1946, Vol. 65, No. 3, pp. 159–162.) Description of the design and performance of two devices depending on the principle of the resistance-wire strain gauge. A variable-reluctance magnetic reproducer is also described.

534.771 **2116**

Monitored Live-Voice as a Test of Auditory Acuity.—R. Carhart. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, No. 4, pp. 339–349.) A statistical comparison between two methods of measuring deafness.

534.833 : 534.61 **2117**

A Small Acoustical Tube for Measuring Absorption of Acoustical Materials in Auditoriums.—D. P. Love & R. L. Morgan. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, No. 4, pp. 326–328.) Useful over a frequency range 200–1 000 c/s.

534.833.1 **2118**

Demountable Soundproof Rooms.—W. S. Gorton. (*Bell Lab. Rec.*, April 1946, Vol. 24, No. 4, pp. 150–154.) See also 1753 of July and 825 of April.

534.861.1 **2119**

Acoustical Treatment of Broadcast Studios.—J. B. Ledbetter. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 17..62.) A review of the requirements for studios of various sizes and the methods used to obtain the optimum reverberation time.

621.395.613.32 **2120**

Microphones: Part 3—Pressure-Operated Microphones.—S. W. Amos & F. C. Brooker. (*Electronic Engng*, June 1946, Vol. 18, No. 220, pp. 190–192.) Early examples of carbon granule microphones of both telephone and Reisz transverse current types are compared with the modern telephone inset and the double-button microphone. Frequency response curves are given, and the disadvantages of carbon types are listed. An early form of moving coil microphone, the Magnetophone, is mentioned. For previous parts see 1755 of July.

621.395.613.38 + 621.395.623.6] : 621.317.79 2121
Laboratory Method for Objective Testing of Bone Receivers and Throat Microphones.—E. H. Greibach. (*Trans. Amer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, pp. 184–187.) An account of the production and the performance of an artificial throat for test purposes.

621.395.613.38 2122
Inertia Throat Microphones.—E. H. Greibach & L. G. Pacent. (*Trans. Amer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, pp. 187–191.) The theory and design of a magnetic microphone, with a frequency response 100 — 5 000 c/s, with a sharp h.f. cut-off.

621.395.623.34 2123
Conical Sound Source.—P. G. Bordoni. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, No. 4, p. 338.) Correction to 266 of February.

621.395.623.7 2124
New Permanent Magnet Public Address Loudspeaker.—J. B. Lansing. (*J. Soc. Mot. Pict. Engrs*, March 1946, Vol. 46, No. 3, pp. 212–219.) A Duplex loudspeaker, with high efficiency, wide frequency range, large distribution angle, and small physical size. The use of special types of baffle with the speaker for public address systems is discussed. Improved response is obtained by ribbon coil construction, increased magnetic flux, and a large voice coil.

621.395.625 2125
A Report on the Sixth Annual Conference of Broadcast Engineers.—L. Winner. (*Communications*, April 1946, Vol. 26, No. 4, pp. 30..74.) Long illustrated summaries of the following papers:—Magnetic Recording, by S. J. Begun. Tools for the Study of Disk Recording Performance, by H. E. Roys. For other papers see 2143, 2319 and 2365.

621.395.625.2 : 621.396.933.4 2126
Recording C.A.A. Traffic Control Instruction.—K. M. MacIlvain. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 116–119.) Automatic equipment records two-way communications between control centre and aircraft pilots on a flexible plastic belt, giving 30 minutes of continuous recording, which can be stored for reference. There are separate recording and reproducing heads and amplifiers which can be operated simultaneously, the reproduction can be within one second of the recording.

621.395.625.3 2127
A New Wire Recorder Head Design.—T. H. Long. (*Trans. Amer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, pp. 216–220.) Description of a design that distributes wear, and results in a head that is virtually self-cleaning.

621.395.625.6 2128
Stereophon Sound Recording System.—C. Becker : H. B. Lee. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, No. 4, pp. 356–357.) A brief description of a system developed in Germany since 1938 for high-quality sound recording on film. "The system employs well known means in some respects, but has the important advantage of giving excellent 3-channel reproduction of great dynamic range and low noise level using a sound track of total width only 2.65 mm."

621.395.8 : 621.317.79 2129
The Measurement of Audio Distortion.—Scott. (See 2253.)

AERIALS AND TRANSMISSION LINES

621.315.21.029.5/.6 2130
Report of Conference on Radio-Frequency Cables.—(*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 911–941.) A symposium of 17 short papers as follows:—1. The Development of Radio-Frequency Cables in the United States, by J. H. Neher. 2. General Characteristics of Polyethylene, by J. W. Shackleton. 3. Polyethylene as Cable Insulation, by C. S. Myers & A. E. Maibauer. 4. Dielectric Strength of Polyethylene, by W. A. Del Mar. 5. Properties of Different Polyethylenes, by W. J. Clarke. 6. Radio-Frequency-Cable Manufacturing Methods, by T. M. Odarenko. 7. General Considerations in Radio-Frequency-Cable Design, by J. F. Wentz. 8. Losses in Radio-Frequency-Cable Components, by G. L. Ragan. 9. Radio-Frequency-Cable Power Ratings and Stability, by M. C. Biskeborn. 10. Shielding Characteristics of Radio-Frequency Cables, by R. G. Fluharty. 11. Types of Radio-Frequency Cables and Specifications, by E. E. Sheldon. 12. Design Considerations of High-Frequency Twin-Conductor Cable, by E. W. Greenfield. 13. Methods of Electrical and Mechanical Testing of Radio-Frequency Cables at the Naval Research Laboratory, by J. M. Miller. 14. Electrical Tests Over a Range of Frequencies, by C. C. Fleming. 15. The S-Function Method of Measuring Attenuation of Coaxial Radio-Frequency Cable, by C. Stewart, Jr. 16. Corona-Initiation Measurements on Polyethylene and Rubber Cables, by D. Depackh. 17. A Corona Voltmeter, by A. E. Widmer. Discussions of the papers grouped by subject are summarized.

621.315.212.1 : 621.39] (091) 2131
Historic Firsts : The Coaxial System.—(*Bell Lab. Rec.*, April 1946, Vol. 24, No. 4, pp. 148–149.)

621.315.212.1 : 621.392.2 2132
Design Data for Beaded Coaxial Lines.—C. R. Cox. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 130–135.) Equations and curves are given for the determination of the characteristic impedance, optimum insulator spacing, attenuation, and maximum power rating. The choice of insulator materials and bead shapes is discussed. Standard attenuation curves are given for 70-ohm broadcast cables, and for 51.5-ohm cables used in f.m. and television equipment.

621.392 2133
The Experimental Behaviour of the Coaxial Line Stub.—J. Lamb. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 188–190.) An experimental counterpart of the theoretical paper by Allanson, Cooper and Cowling (see 2134 below) at wavelengths of about 8 and 11 cm. A standing-wave detector with a very small probe energizing a thermocouple gives the impedance, using Bruckmann's method (2904 of 1938), from which a circle diagram is constructed. The stub susceptance is expressible in the form $[A \cot 2\pi (y - p_2)/\lambda] + B$ where y is the stub length and p_2 the distance of the first characteristic point from the stub entry.

621.392 2134

The Theory and Experimental Behaviour of Right-Angled Junctions in Rectangular-Section $[H_{01}]$ Wave Guides.—J. T. Allanson, R. Cooper & T. G. Cowling. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 177–187.) A theoretical analysis of a waveguide junction of *n* members made in terms of an equivalent transmission-line system is applied to the problem. "The behaviour is expressed in terms of six parameters, the values of which have been calculated over a range of wavelengths around 10 cm and determined experimentally at four points within this range. A description of the experimental technique employed is given, and an assessment made of the order of accuracy attained in the measurements."

621.392 2135

Normal Modes in the Theory of Wave Guides.—G. M. Roe. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 255.) When the boundaries are not perfectly conducting there is only a finite number of non-orthogonal modes satisfying the continuity conditions and the conditions at infinity. Abstract of an Amer. Phys. Soc. paper.

521.392 2136

Engineering Approach to Wave Guides.—T. Moreno. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 99–103.) The advantages of waveguides over oaxial air- and solid-dielectric cables in the requency range 2–30 kMc/s are described in relation to attenuation and power-carrying capacity. Design data and waveguide materials are discussed, nd a list of standard guide sizes for various frequency ranges is given.

21.392.012.2 2137

New Transmission-Line Diagrams.—A. C. chwager & P. Y. Wang. (*Trans. Amer. Inst. ect. Engrs*, December Supplement 1945, Vol. 64, . 955.) Discussion of 548 of March.

21.392 : 621.396.67 2138

Feeding Combined F.M. and A.M. Antenna rrays.—W. Pritchett. (*Electronic Industr.*, April 946, Vol. 5, No. 4, pp. 72–74.) Briefly describes vo previous methods (2118 of 1941—Taylor, & 34 of 1945—Alford), and a third method by which en-wire transmission lines are used with stub atching to separate the signals before applying em to their respective aerials.

1.392.21 : 621.315.1 + 621.396.664] : 621.396.712 2139

The Design and Use of Radio-Frequency Open-ire Transmission Lines and Switchgear for Broad-sting Systems.—F. C. McLean & F. D. Bolt. . *Instn elect. Engrs*, Part III, May 1946, Vol. 93, o. 23, pp. 191–210.) Main points discussed are :—e characteristic impedances, breakdown voltages, d attenuation of 2-, 4- and other multi-wire lines ; e method of construction and support as used in gh power transmitters ; the systems of manual d automatic switching between a number of lines, d the influence of open-air operation ; the match-g of balanced lines, and the relation between e standing-wave ratio and the power-handling pacity of the line ; the characteristics and costs typical line systems. The work described is that the B.B.C. high-power broadcast stations at quencies from 0.2 to 25 Mc/s.

621.396.67 + 621.396.11 2140

A Note on a Simple Transmission Formula.—Friis. (*See* 2282.)

621.396.67 2141

Concerning Hallén's Integral Equation for Cylindrical Antennas.—S. A. Schelkunoff : R. King. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 265–269.) Discussion by King of 851 of April. Comparative tables are given of experimental and theoretical values of the significant resonant parameters of aerials having $\Omega \equiv 2 \ln (2l/a) = 10$, 15 and 20. Schelkunoff, in replying, points out that Hallén's first approximation as used by King in his series of papers gives considerable errors and only the latest King and Middleton paper (1453 of June) gives results of the right order.

621.396.67 2142

"Cloverleaf" Antenna for F.M. Broadcasters.—(*Bell Lab. Rec.*, April 1946, Vol. 24, No. 4, pp. 163–164.) Note on an array giving a horizontal sheet of horizontally polarized rays, eliminating multiple transmission lines, phase-correcting networks, balancing lines etc. See also paper by P. H. Smith, referred to in 2143.

621.396.67 2143

A Report on the Sixth Annual Conference of Broadcast Engineers.—L. Winner. (*Communications*, April 1946, Vol. 26, No. 4, pp. 30..74.) Long illustrated summaries of the following papers :—Circular Antennas, by M. W. Scheldorf. F-M Broadcast Loops, by A. G. Kandoian. Super Turnstile Antenna, by R. F. Holtz. The Clover-Leaf F-M Antenna, by P. H. Smith. For other papers see 2125, 2319 and 2365.

621.396.677 2144

Vertical Rhombics.—T. J. White. (*Radio Craft*, April 1946, Vol. 17, No. 7, pp. 469, 509.) A side-length of 49 ft and vertical diagonal of 41 ft were found to be the best dimensions for use at 3–4.2 metres. Other constructional details, and the advantages of vertical rhombics over both horizontal rhombics and vertical dipole arrays are discussed.

621.396.677 2145

An Umbrella-Type Antenna.—A. K. Robinson. (*QST*, May 1946, Vol. 30, No. 5, pp. 70–73.) A number of radial wires slant downwards from a mast and are terminated by resistances to earth. A switching box at the top of the mast selects any pair of adjacent wires to give a sloping-Vee aerial for reception directive in elevation and azimuth. It is shown how the radiation lobes of a single wire of length 4λ combine with ground images and with the lobes of an adjacent wire. A variable-frequency oscillator is used for the adjustment of the terminating resistances, and practical results are given.

CIRCUITS

621.3.011.3 : 621.3.012.3 2146

Nomogram for Computing Inductance of Straight Cylindrical Wires.—J. I. Stephen. (*Communications*, April 1946, Vol. 26, No. 4, pp. 48–49.)

621.318.572 2147

Design of Counter Circuits.—E. R. Jacobson. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 25..59.) Description of a double-diode circuit for repetition-rate indication, giving a d.c. output proportional to the frequency of the applied impulses.

621.318.572 2148
Gate Circuit for Chronographs.—L. B. Tooley. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 144–145.) A simple circuit, including two thyratrons fired by successive pulses applied to the input, which can be used as a switch controlling the time of operation of a counter system.

621.385.3 : 621.396.615 2149
Circuits for Sub-Miniature Tube.—F.R. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 154–156.) Characteristics are given of the 6K4, a miniature triode suitable for a.f. and r.f. circuits; design data are given, and circuits suggested for its use in v.h.f. line-oscillators. The mechanical properties of the valve fit it for use in apparatus subject to vibration.

621.392 2150
Theorem on Equivalent Representations of an Arbitrary Linear Network.—E. J. Schremp. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 259–260.) Abstract of an Amer. Phys. Soc. paper.

621.392.4.012.3 2151
Phase-Shifter Nomograph.—R. E. Lafferty. (*Electronics*, May 1946, Vol. 19, No. 5, p. 158.) For calculating the component values of a bridge-type phase-shifting network with a range from 0° to 180°.

621.394/.397].645.2 : 621.392.5 2152
Theory and Design of Double-Tuned Circuits.—A. M. Stone & J. L. Lawson. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 62–68..128.) A detailed analysis giving the exact solution of shunt-fed, double-tuned, wide-band networks using inductive coupling, and of the equivalent T and π circuits. The results are shown graphically. Special applications considered are (*a*) video-frequency amplifier interstage coupling, (*b*) i.f. amplifier interstage coupling (15 Mc/s wide, 30 Mc/s mean), (*c*) coupling of i.f. amplifier to line, (*d*) coupling of frequency converter to i.f. amplifier.

621.395.645.2 : 621.395.813 2153
Radio Design Worksheet: No. 45—[Harmonic distortion in] **Non-Linear Resistances**; [and effect on gain of] **Amplifier Coupling.**—(*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 33–34.)

621.394/.397].645.3 2154
Balanced Output Amplifiers of Highly Stable and Accurate Balance.—E.M.I. Laboratories. (*Electronic Engng*, June 1946, Vol. 18, No. 220, p. 189.) A pair of amplifying valves have a common cathode circuit with the usual resistor replaced by a valve that is controlled from a potential divider connected between the anodes of the two amplifiers. The resulting stability and accurate balance is obtained without excessive potential drop in the cathode circuit.

621.395.645.3 2155
High-Fidelity All Purpose Amplifier.—R. T. Rogers & M. Putman. (*Radio News*, April 1946, Vol. 35, No. 4, pp. 32–34.) Details of the circuit and performance of a 30-W a.f. amplifier with negative feedback and bass and treble controls. The noise level is 50 db below maximum output and the distortion less than 4%.

621.396.611.21 2156
Forced Vibrations of Piezoelectric Crystals.—H. Ekstein. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 257.) Abstract of an Amer. Phys. Soc. paper.

621.396.615 2157
Two-Terminal Oscillator.—M. G. Crosby. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 136–137.) A twin triode is connected with one triode as a cathode follower driving the second triode through the common cathode resistance. The input-output transconductance is negative, so that an oscillator can be made by two-point connexion of a tuned circuit. Several applications are given, including the use of the circuit as a class-A limiter and as a true square-wave multivibrator.

621.396.615.11/.12 2158
A Wide-Range Test Oscillator.—C. F. Lober. (*QST*, May 1946, Vol. 30, No. 5, pp. 40–42.) Constructional details of an RC oscillator for 17–218 000 c/s sine- or square-wave, using a Wien-bridge circuit.

621.396.615.17 + 621.318.572 2159
Pulsing Circuits for Timing Applications.—R. L. Rod. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 27–30, 60.) Circuit details of the clipped-sine-wave pulse-generator, the self-running and triggered multivibrator, the blocking oscillator, the triggered-blocking-oscillator dividing-circuit, the triggered-transitron pulse-generator, a simple circuit for pulse-width discrimination, the pentode gating-circuit, and a triode coincidence-indicator.

621.396.615.17 2160
Controlled and Uncontrolled Multivibrators.—E. R. Shenk. (*Proc. Radio Cl. Amer.*, Feb. 1946, Vol. 23, No. 2, 18 pp.) An analysis, on the basis of capacitor-resistor time constants, gives an equation relating the natural frequency to the characteristics of the valves and to the circuit components. The conditions to be satisfied in a synchronized multivibrator to allow for variations in the circuit time constants are deduced, and the waveform and phase of the synchronizing voltage are considered. Percentage variations in the frequency of the synchronizing pulses over which a given order of division can be maintained and the application of either positive or negative pulses are discussed. Design curves are included, and worked examples are given.

621.396.615.17 2161
Waves and Pulses.—J. McQuay. (*Radio Craft*, April 1946, Vol. 17, No. 7, pp. 470..499.) The basic principles of pulse formation, followed by brief details of eight pulse-producing circuits.

621.396.615.17 : 621.317.755 2162
Single Sweep [timebase] **Generator.**—D. McMullan. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 4, 8.) Illustrated summary of 571 of March.

621.396[.619 + .621.53 2163
The Calculation of Intermodulation Products by Means of a Difference Table.—A. Bloch. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 211–216.) The method of central differences used by Espley (3872 of 1940) is applied to the intermodulation products in a nonlinear device fed with two voltages of different frequency. Sheppard's

difference and average operators δ and μ are applied, and the evaluation carried out in terms of the function $F_k^p(a)$ which is tabulated in the paper.

621.396.662.3 : 621.396.611.21 **2164**

The Crystal Filter : Parts 1 & 2.—R. W. Ehrlich. (*Radio Craft*, March & April 1946, Vol. 17, Nos. 6 & 7, pp. 398..442 & 476..507.) An elementary account of the principles and applications.

621.396.662.34 : 621.396.44 : 621.396.611.21 **2165**

A New Crystal Channel Filter for Broad Band Carrier Systems.—E. S. Willis. (*Trans. Amer. Inst. elect. Engrs*, March 1946, Vol. 65, No. 3, pp. 134–138.) Four crystal units are assembled in one lattice-type filter section, with substantial savings of weight and space. Attenuation of 50–60 db is obtained for frequencies more than 700 c/s from the edge of the pass band, which is about 3 kc/s wide. Temperature changes of 20° F alter the frequency by 0.03%.

621.396.69 **2166**

Printed Circuit Wiring.—(*See* 2229.)

621.396.82 : 621.317.79 **2167**

Cylindrical Shielding and Its Measurement at Radio Frequencies.—A. R. Anderson. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 312–322.) "The effectiveness of shields from the point of view of the wave theory of shielding is discussed. Specific consideration is given to cylindrical shielding against low-impedance fields and its measurement at radio frequencies. Various methods and concepts of measurement are discussed briefly; inadequacy of probe-type tests and the advantages of an integrating-type test are pointed out.

"Equipment of the integrating type suitable for production testing of specimens of cylindrical shielding from 3/16 to 2 inches diameter at 3 Mc/s is described and illustrated. With this equipment, shielding effectiveness of the unknown is determined in terms of the effectiveness of a specified rigid metal-tube standard. Sensitivity is sufficient to measure the leakage through 0.024 inch of copper at the test frequency. A shielded room is not required.

"Experimental results obtained with this and similar equipment from 200 kc/s to 10 Mc/s are given. Tests at various frequencies on thin-wall copper tubes of different thicknesses are shown to be in agreement with the results predicted by theory. Included are data on metal tubes, wire braids, coaxial cable, and flexible-shielding conduits.

"Test results are shown to be independent of current through the specimen, receiver gain or adjustment, and various other factors. Results are shown also, in general, to be independent of the length of specimen tested and its impedance. Various factors affecting test results are considered and formulas are given for correcting results obtained on exceptional specimens having abnormally high resistance."

621.396.822 **2168**

A Generalization of Nyquist's Thermal Noise Theorem.—Schremp. (*See* 2300.)

[621.394/.397].645.3 + 621.392.5 **2169**

Network Analysis and Feedback Amplifier Design. [Book Review]—H. W. Bode. Van Nostrand Co., New York, 1945, 529 pp., $7.50. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, p. 277.) "The communication engineer whose mathematical foundation has been well laid and well used, will find this advanced text to be an authoritative and up-to-date contribution to the field of network-theory application."

GENERAL PHYSICS

517.947.44 : 534.25 **2170**

The Wave Equation in a Medium with a Variable Index of Refraction.—P. G. Bergmann. (*J. acoust. Soc. Amer.*, April 1946, Vol. 17, No. 4, pp. 329–333.) In the usual derivation of the wave equation for the sound pressure in air or in water no account is taken of the occurrence of density gradients. In this paper preliminary consideration is given to the conditions under which these gradients should be considered in the derivation of the wave equation itself.

523.165 + 537.591.15 **2171**

The Origin of Large Cosmic-Ray Bursts.—R. E. Lapp. (*Phys. Rev.*, 1st/15th April 1946, Vol. 69, Nos. 7/8, pp. 321–337.)

530.12 + 531.51 + 538.3 **2172**

A Classical Theory of Electromagnetism and Gravitation : Part 1—Special Theory.—H. C. Corben. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 225–234.) A unified electromagnetic and gravitational field theory is obtained by introducing a fifth dimension ict' where t' is a second dimension of time symmetrical with t. The special theory (in which $\partial/\partial t' \equiv 0$) is presented here. The extended conservation laws for charge, mass, energy, momentum, and the fields of a point charge-mass are derived. An accelerated mass radiates longitudinal gravitational waves which are propagated with the velocity of light *in vacuo*, and the resultant energy loss may be observable in the case of large bodies. In matter, gravitational waves are slowed down, and are identified with sound waves.

531.4 + 539.62 **2173**

Studies in Friction : Part 1—"Solid" *versus* "Polar" Boundary Films.—M. E. Merchant. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 250–251.) The friction between iron surfaces and the durability of the boundary film are very different according to whether carbon tetrachloride or oleic acid is added to pure mineral oil lubricant. Abstract of an Amer. Phys. Soc. paper.

536.2 : 546.87–1 **2174**

The Thermal Conductivity of Bismuth at Low Temperatures.—S. Shalyt. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 5, pp. 315–316.) Short description of measurements made with a cylindrical specimen of high purity set up in a suitable magnetic field. At 65–80° K the thermal resistance was increased 15–20% by the application of the field, but no detectable change was observed at 2–4° K. In the absence of the field the thermal resistance reached a minimum value in the region of 4° K. It is concluded that the minimum ". . . is chiefly due to the lattice".

537.122 : 538.3 **2175**

Classical Theory of the Point Electron.—M. Schönberg. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 211–224.)

537.32 : 537.312.62 **2176**
On the Thermoelectric Phenomena in Superconductors.—V. L. Ginsburg. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 3, pp. 148–153.)

537.564 [illegible] **2177**
On the Energy Loss of Fast Particles by Ionization.—L. Landau. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 4, pp. 201–205.) A theoretical development of a formula for the energy loss distribution for a fast particle which traverses a layer of matter and loses a small part of its energy through ionization, *i.e.*, a formula for the probability that the energy loss shall lie between given limits.

538.114 **2178**
On the Theory of Ferromagnetism.—B. T. Geylikman. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 3, pp. 182–191.) " On the basis of a translation model of the metal the temperature dependence of the magnetic moment at high and low temperatures has been found. At high temperatures the dependence obtained differs slightly from Heisenberg's formula, the Curie temperature, however, appears to depend on the degree of filling of the zone. The dependence of the conductivity of ferromagnetics on the temperature, which agrees with experiment, is also determined." An appendix gives a brief theoretical treatment of the fine structure of emission and absorption spectra from metals.

621.314.632 : 537.221 **2179**
Erratum : A Method for Measuring Effective Contact E.M.F. between a Metal and a Semi-Conductor.—W. E. Stephens, B. Serin & W. E. Myerhof. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 244.) Graph omitted from 1519 of June.

621.385 : 538.312 **2180**
Energy Conversion in Electronic Devices.—Gabor. (*See* 2394.)

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.165 + 537.591.15 **2181**
The Origin of Large Cosmic-Ray Bursts.—R. E. Lapp. (*Phys. Rev.*, 1st/15th April 1946, Vol. 69, Nos. 7/8, pp. 321–337.)

523.72 : 621.396.822 **2182**
Microwave Radiation from the Sun.—G. C. Southworth. (*J. Franklin Inst.*, March 1946, Vol. 241, No. 3.) Correction to 3252 of 1945.

523.746 **2183**
Sunspots.—A. L. Narayan. (*Curr. Sci.*, April 1946, Vol. 15, No. 4, pp. 95–98.) A general description of the structure and characteristics. The complex motion of the associated matter is discussed.

550.37 **2184**
Magnitude of the Earth's Charge.—A. B. Arlick. (*Curr. Sci.*, Dec. 1945, Vol. 14, No. 12, pp. 318–319.) In the light of modern theory, the value of Q is modified to 2.5×10^{14} coulombs instead of 4.5×10^{5} coulombs as previously assumed.

550.37 **2185**
Structure of the Earth's Electric Field.—A. B. Arlick. (*Curr. Sci.*, April 1946, Vol. 15, No. 4, pp. 105–106.) Certain anomalies in terrestrial magnetism and electricity are thought to be a natural consequence of the internal core, and of the existence of positive and negative ionic layers in the atmosphere.

550.37 **2186**
A Theory of the Fundamental Phenomena of Atmospheric Electricity.—J. Frenkel. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 5, pp. 285–304.) Attention is drawn to the application of the concepts of colloidal suspensions to the case of the atmosphere in which charged water drops and ice crystals are suspended. Laboratory measurements are considered in which a model of the atmosphere may be built using a suitable colloidal suspension.

In the atmosphere the cloud of charged drops becomes polarized due to the drops' sinking under gravitational force. The steady downward field within the cloud is in the range 30–150V/cm. The field in the space surrounding a spherical cloud is also calculated, and the numerical values agree fairly well with those measured in practice. " The clouds can thus be treated as electrical generators using the potential energy of the forces of gravity with a very small efficiency (of the order of 10^{-4}). . . The special conditions which are characteristic of thunder-clouds are elucidated (large vertical thickness and high water content), as well as the role of the increase of the negative local fields (giving rise to lightning discharges)." The mechanism by which the initial negative charge on the rain drops is neutralized (and sometimes reversed) during their passage to the ground is discussed.

551.51.053.5 : 523.78 **2187**
Ionosphere Observations [at Uppsala] **during the Solar Eclipse on September 10, 1942.**—W. Stoffregen. (*Ark. Mat. Astr. Fys.*, 20th Feb. 1946, Vol. 32, Part 4, Section B, No. 9, 6 pp. In English.) " The observations agree with earlier ones, and show a well marked ionization decrease of the F_2-region during the obscuration of the sun. The virtual height of the F_2-region increased parallel with the eclipse. No time difference of importance between the variation of the eclipse and the ionization was noted."

551.51.053.5 : 621.396.11 **2188**
On the Absorption of Radio Waves and the Number of Collisions in the Ionosphere.—Ginsburg. (*See* 2287.)

631.437 **2189**
On the Theory of Seismic and Seismoelectric Phenomena in a Moist Soil.—J. Frenkel. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 4, pp. 230–241.) The propagation of elastic waves in the surface layers of the soil is accompanied by the appearance of electric potential differences between points situated at different distances from the source. " According to the theory of Helmholtz and Smoluchovski, the difference of hydrostatic pressure Δp between two points of the soil must be connected with a difference of the electrical potential $\Delta V = \frac{\epsilon\zeta}{4\pi\mu\sigma}\Delta p$ where ζ is the electrokinetic potential, *i.e.* the potential drop in the surface double layer, μ — the viscosity of the water and σ — its electrical conductivity." The paper contains a very detailed theoretical analysis of the propagation of

transverse and longitudinal waves in dry and moist soil, from which the electrical effects are derived in accordance with the above formula.

LOCATION AND AIDS TO NAVIGATION

621.396.11 : 551.51.053.5 : 621.396.9 **2190**

2-Mc/s Sky-Wave Transmission.—J. A. Pierce. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 146–153.) A simplified review of present ionospheric knowledge, with particular reference to Loran operations and the effect upon the sky-wave delay times of reflections at the *E* and *F* layers. It is shown that the *E* layer is relatively stable, is little affected by ordinary disturbing phenomena, and can be used for Loran operations at medium and long ranges.

621.396.9 **2191**

An Introduction to Loran.—J. A. Pierce. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 216–234.) The history and principles of the system are described. Within the ground-wave service area (ranges up to 700 nautical miles over sea) errors vary from about 300 yards to 1 mile; at night, distances up to 1400 miles may be covered by sky waves, giving errors of 1½ to 8 miles. The ultimate potential accuracy and the possibility of automatic position indicators and course followers are discussed, and mention is made of a new "cycle matching" technique which may considerably enhance the present accuracy of measurement.

The transmitting and receiving apparatus is broadly described, with block diagrams.

21.396.9 **2192**

The Decca Navigator.—(*Electronic Engng*, June 946, Vol. 18, No. 220, pp. 166–171.) A detailed escription of the system with a functional account f the equipment. See also 1848 of July and back eference.

21.396.9 **2193**

Shoran Precision Radar.—S. W. Seeley. (*Trans. mer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, . 232–240.) The system has been used extenvely for air navigation, aerial mapping, and ind bombing. The aircraft transmits short lses, at about 250 Mc/s, to a pair of spaced ound stations fitted with repeaters that receive, shape, and retransmit the pulses. The time delay etween the original transmission and the reception the aircraft of the retransmitted pulses deterines the position of the craft relative to the reaters. There is no transmission between the ound stations. The history of the project, the ethod of use, and the main technical features the system are described. The equipment is signated AN/APN-3 and AN/CPN-2. Useful nge about 250 miles, accuracy about 50ft.

1.396.9 **2194**

Merchant Marine Radar.—I. F. Byrnes. (*RCA v.*, March 1946, Vol. 7, No. 1, pp. 54–66.) A rvey of the essential requirements, based on the S. Coast Guard "Minimum Recommended ecification Briefs" and on a similar British docunt. It deals particularly with the so-called ss-A type of radar, which operates in the 3-cm nd, and is intended for navigation in restricted ters, with a receiver having a noise factor not worse than 15 db, and using a p.p.i. The importance of adequate power for operation under adverse conditions is emphasized.

621.396.9 **2195**

Radar Systems Considerations.—D. A. Quarles. (*Trans. Amer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, pp. 209–215.) A technical background for the more detailed exposition of modern radar. A brief description is given of the nature and function of each major part of the system.

621.396.9 **2196**

Radar for Blind Bombing: Part 1.—J. V. Holdam, S. McGrath & A. D. Cole. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 138–143.) A description of the history and circuit details of H2X, the 3-cm radar system designed for use in aircraft as a navigational aid, and for the location and identification of ground targets obscured by cloud or smoke. The antenna, with a 29-inch modified paraboloid reflector, gives a beam width of 3°, can be rotated through 360° in azimuth, and tilted through ±20° in elevation. The echoes are displayed on an azimuth-stabilized p.p.i. presentation, with the aircraft heading shown as a radial line starting at the centre of the tube. An electronic bombing computer provides a range mark, the bombs being released when range mark and target coincide. For navigation, the system can be used in conjunction with radar responder beacons situated on the ground. When these beacons receive a pulse of the proper duration in the airborne search-radar frequency band, they respond with a coded series of pulses in the beacon frequency band. The subsequent display on the p.p.i. then gives the aircraft's position relative to a known point.

There are two versions of the equipment designated AN/APQ-13 and AN/APS-15.

621.396.9 : 523.3 **2197**

Radar Reaches the Moon.—T. Gootée. (*Radio News*, April 1946, Vol. 35, No. 4, pp. 25..88.) For a more detailed account see 1856 of July (Mofenson). For other brief accounts see J. DeWitt, *Radio Craft*, April 1946, Vol. 17, No. 7, pp. 464..502, and H. Kauffman, *QST*, May 1946, Vol. 30, No. 5, pp. 65–68.

621.396.9 : 621.385.832 **2198**

The Skiatron in Radar Displays.—King: Watson. (*See* 2404.)

621.396.933.2 **2199**

The Omnidirectional Range.—D. M. Stuart. (*Aero Digest*, 15th June 1945, Vol. 49, No. 6, pp. 76, 77, 150.) Outline description of the system. In the aircraft the azimuth of the ground station is determined from the phase of the received 60-c/s modulation, imposed at the ground by means of a continuously rotating goniometer on the carrier radiated from two pairs of cross-connected monopoles. Radiation from a central monopole is used for reference purposes.

621.396.933.2 **2200**

An Omnidirectional Radio-Range System: Part 3—Experimental Results and Methods of Use.—D. G. C. Luck. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 94–117.) For parts 1 & 2 see 458 and 2388 of 1942. Tests were made at about 6 and 125 Mc/s. Ground measurements showed overall instrumental errors averaging less than 1°, but "flight tests . . . showed considerably larger errors, apparently related to terrain or transmitter-site characteristics. Sky-wave operation at the lower frequency was found fairly satisfactory in the absence of violent fading. Standing-wave effects were sought but not found in the ultra-high-frequency field. Trouble was experienced in the higher-frequency flight tests with spurious modulation of received signals produced by spinning propellers and imperfect structural bonding of aircraft, as well as with ignition interference."

621.396.9 **2201**

Radar. [Book Review]—O. E. Dunlap, Jr. Harper & Bros., New York, 1946, 203 pp., $2.50. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, p. 277.) "The text is well written, easily read, and up to date. . . . It is a valuable nontechnical contribution to inform the general public. . . ."

621.396.9 **2202**

Radar — Radiolocation Simply Explained. [Book Review]—R. W. Hallows. Chapman & Hall, London, 140 pp., 7s. 6d. (*Elect. Rev., Lond.*, 31st May 1946, Vol. 138, No. 3575, p. 848.) ". . . not highly technical, but contains a clear exposition of the basic principles. . . ."

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788 **2203**

A Reliable High Vacuum Gauge and Control System.—R. G. Picard, P. C. Smith & S. M. Zollers. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4. pp. 125–129.) The instrument incorporates two gauges, a thermocouple, and a cold-cathode discharge gauge, neither of which is damaged by the admission of air to the vacuum system. The useful range is from atmospheric pressure to about 10^{-4} mm Hg. The gauges are described, and a circuit is given whereby the gauge current can be used to operate other devices.

531.788.7 **2204**

An Ionization Gauge of Simple Construction.—C. M. Fogel. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 302–305.) For pressure range 10^{-4}–10^{-8} mm Hg. Advantages claimed include easy outgassing, good sensitivity, linear scale, small leakage current, and the fact that the filament is not damaged by heating it in air.

533.5 **2205**

A High Temperature Sodium Chloride to Glass Vacuum Seal for Infra-Red Cells.—G. L. Simard & J. Steger. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, pp. 156–157.)

533.5 **2206**

A Rapidly Acting Vacuum Valve.—D. D'Eustachio. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 251.) Abstract of an Amer. Phys. Soc. paper.

535.37 : 661.1 : 546.791 **2207**

Polarization of Photoluminescence of Uranium Glasses.—A. N. Sevchenko. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 3, pp. 163–170.) An experimental investigation showing that the polarization depends markedly on the wavelength of the exciting radiation, and that the fine structure of the polarization spectra depends on the structure of the uranium molecules. The maximum polarization in the specimens examined was 25%. The polarization decreases with the decay of luminescence, showing that the ". . . energy of excitation is transmitted from the excited to the unexcited molecules. . . . It is proved that the nature of absorption and emission of radiation by uranium in glass and in solutions is due to electric dipoles."

537.228.1 + 539.32 + 621.3.011.5] : [546.32.85 + 546.39.85 **2208**

The Elastic, Piezoelectric, and Dielectric Constants of Potassium Dihydrogen Phosphate and Ammonium Dihydrogen Phosphate.—W. P. Mason. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 173–194.) The full paper of which an abstract was summarized in 1260 of May.

539.234 : 535.87 : 546.621 **2209**

Numerical Data on the Optical Properties of Aluminized Mirrors.—L. Dunoyer. (*C.R. Acad. Sci., Paris*, 7th May 1945, Vol. 220, No. 19, pp. 686–688.) Mirrors were prepared by condensation in a vacuum, and the transmission and reflection factors measured for the metallized and unmetallized sides. The same factors are derived for the metal layer alone in air and in glass. A table shows these data for metal thicknesses from 7.5 to 80.9 mμ. For other measurements on the mirrors see 2210/2212 below.

539.234 : 535.87 : 546.621 **2210**

On the Optical Density of Thin Films of Aluminium Deposited on Glass by Evaporation and the Thickness of the Protective Alumina Layer.—L. Dunoyer. (*C.R. Acad. Sci., Paris*, 4th June 1945, Vol. 220, No. 23, pp. 816–817.) The curve of optical density against film thickness (determined by weight) has a sharp bend for a thickness of 10.8 mμ which, together with previous evidence, suggests a change in layer structure for a thickness of about 11 mμ. Extrapolation indicates zero optical density for a film thickness of 5.4 mμ. This is explained as due to oxidation of an actual thickness of 2.9 mμ of metallic aluminium. Correction for the oxide layer converts the figure for the critical thickness from 11 mμ to 8.5 mμ.

The absorption and extinction coefficients are calculated.

539.234 : 546.621 **2211**

On the Diffusion of Atoms or Molecules by a Glass Wall.—L. Dunoyer. (*C.R. Acad. Sci., Paris*, 9th April 1945, Vol. 220, No. 15, pp. 520–522.) A film of aluminium deposited on glass by condensation at oblique incidence in a vacuum was found to vary in thickness with distance from the emitting source at a rate that changed abruptly at the place where the thickness was about 11 mμ. It is suggested that the crystallites in films of greater thickness are sufficiently close to ensure the capture of each incident atom by the field of the nearest crystal lattice, whereas for thinner films an appreciable fraction of the incident atoms do not adhere, but are diffused away from the glass. It is considered unlikely that the discontinuity in the rate of change of density of the film is associated with the difference in angle of incidence of the particles.

539.234 : 621.316.849.011.2 : 546.621 **2212**

Electrical Resistance of Thin Films of Aluminium Deposited on Glass by Thermal Evaporation.—L. Dunoyer. (*C.R. Acad. Sci., Paris*, 25th June

1945, Vol. 220, No. 26, pp. 907–909.) The resistivity of the metal film increases as the thickness is reduced. The ratio of film resistivity to bulk resistivity is about 2 for thicknesses near 100 mμ (corrected for the oxide layer), 9.4 for 7.2 mμ, 119 for 3.3 mμ, 860 for 1.9 mμ and ∞ for 0.9 mμ, corresponding to a layer about two atoms thick. Figures are given for 19 different thicknesses.

539.32.082 2213

Elastic Constants of Crystals.—S. Bhagavantam. (*Sci. Culture*, April 1946, Vol. 11, No. 10, Suppt. p. 3.) Abstract of an address delivered at the Indian Science Congress, describing a new method of measuring the elastic constants of materials in the form of small plates.

546.287 : 621.315.612 2214

The Use of Liquid Dimethylsilicones to produce Water-Repellent Surfaces on Glass-Insulator Bodies.—O. K. Johannson & J. J. Torok. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 296–302.) The article to be treated is thoroughly cleaned and dipped in a dilute solution of the silicone in an inert solvent. The solvent is allowed to evaporate, and the article is then baked to fix the film on the surface. The routine is described.

Numerical and graphical results given in terms of surface resistance and power factor show that this finish is superior both to the untreated surface and to wax-dipped surfaces. The overall power factor in the dry state is not affected by the finish. The silicone does not affect the resistance to fungus growth.

546.287 : 621.315.616.9 : 621.316.842 2215

Silicone Coating for [wire-wound] **Resistors.**—. E. Marbaker. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, p. 10.) Withstands repeated 275° C thermal shocks and repeated immersion in hot and cold salt water without cracking, crazing, or peeling, and has good dielectric strength. Summary of a paper . *J. Amer. Ceramic Soc.*, 1st Dec. 1945.

546.289 : [621.315.59 + 621.314.63 + 537.32 2216

Germanium Alloys.—(*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 258–259.) Abstracts are given of the following Amer. Phys. Soc. papers: Electrical Properties of Germanium Alloys: Part 1 Electrical Conductivity and Hall Effect, by K. Lark-Horovitz, A. E. Middleton, E. P. Miller & I. Walerstein. Electrical Properties of Germanium Alloys: Part 2—Thermoelectric Power, by K. Lark-Horovitz, A. E. Middleton, E. P. Miller, W. Scanlon & I. Walerstein. Theory of Impurity Scattering in Semiconductors, by E. Conwell & V. F. Weisskopf. Theory of Resistivity of Germanium Alloys, by K. Lark-Horovitz & V. A. Johnson. Theory of Thermoelectric Power in Germanium, by V. A. Johnson & K. Lark-Horovitz.

621.314.63 + 621.315.59 2217

Heat Treatment of Semi-Conductors and Contact Rectification.—B. Serin. (*Phys. Rev.*, 1st/15th April 1946, Vol. 69, Nos. 7/8, pp. 357–362.) The influence of heating silicon to about 1 000° C probably causes evaporation of the impurities, and an analysis of this process is given which suggests that a surface layer of at least 10^{-6} cm thickness is depleted. The characteristics of a rectifier so obtained are given following Bethe's theory, and it is concluded that heat treatment results in increased back resistance and decreased contact capacity, with improvement in rectification efficiency.

621.315.59 2218

On the Theory of Electric Properties of Good Conducting Semi-Conductors.—K. Shifrin. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 4, pp. 242–252.) A theoretical and experimental study of the properties of substances such as lead sulphide and lead selenide, which have relatively high conductivities (of the order of 100 or even 1 000 mhos/cm), and which differ from ordinary semiconductors in the sign of the temperature coefficients of conductivity and thermo-e.m.f. It appears that these distinctive properties are caused by the presence of atoms of impurity metals.

621.315.612.6 : 621.315.613.1 2219

Manufacture and Use of Glass Bonded Mica.—D. E. Replogle. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 94–96.) A general survey of its properties and of its advantages over other synthetic insulators. It may be machined or moulded with greater ease and accuracy than steatite, has good electrical properties, does not require sealing, and will not support fungus growth.

621.315.615 : 621.319.4 : 621.365.5 2220

Capacitors for High-Frequency Induction-Heating Circuits.—F. M. Clark & M. E. Scoville. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 995–996.) Discussion of 636 of March.

621.315.616.7 2221

Sulfur in Synthetic Rubbers.—F. S. Malm. (*Bell Lab. Rec.*, March 1946, Vol. 24, No. 3, pp. 106–110.) A short study of the solubility and diffusion rates of sulphur in the process of vulcanization.

621.315.616.9 2222

The Development of Polythene as a High-Frequency Dielectric.—W. Jackson & J. S. A. Forsyth. (*J. Instn elect. Engrs*, Part I, May 1945, Vol. 92, No. 53, p. 214.) Summary of 2768 of 1945.

621.318.32 : 621.318.42 2223

Ferroinductance as a Variable Electric-Circuit Element.—J. D. Ryder. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 962–963.) Discussion of 643 of March.

621.318.32.013 : 539.3 2224

Magnetization and Stress.—R. M. Bozorth. (*Bell Lab. Rec.*, March 1946, Vol. 24, No. 3, pp. 116–119.) A short account, illustrated by curves for iron, nickel, and 68 Permalloy, of the effect of mechanical stress on ferromagnetic properties.

621.318.322 : [621.314.2.029.4/.5 2225

Applications of Thin Permalloy Tape in Wide-Band Telephone and Pulse Transformers.—A. G. Ganz. (*Trans. Amer. Inst. elect. Engrs*, April 1946, Vol. 65, No. 4, pp. 177–183.) An account of construction and properties, illustrated by graphs, and of applications to both transformers and non-linear inductors.

621.357.9 2226

Remarks on the Mechanism of Electrolytic Polishing and on Its Unevenness in the Case where there exists a Viscous Anodic Layer.—C. Gutton. (*C.R. Acad. Sci., Paris*, 7th May 1945, Vol. 220, No. 19, pp. 684–686.)

621.396.611.21 2227
Plating Quartz Oscillator Crystals.—K. M. Laing. (*Communications*, April 1946, Vol. 26, No. 4, pp. 26–28, 56.) An analysis of plating methods.

621.396.611.21 : 537.531.9 2228
Quartz Oscillator Plates. Frequency Adjustment by X-Ray Irradiation.—L. A. Thomas. (*Beama J.*, April 1946, Vol. 53, No. 106, p. 144.) Describes changes in colour and in elastic properties when exposed to X-rays. Abstract of a paper in *Elect. Times*, 7th March 1946, Vol. 109, No. 2837, pp. 336–340.

621.396.69 2229
Printed Electric-Circuit Process.—(*Communications*, April 1946, Vol. 26, No. 4, pp. 78, 79.) See also 1887 of July (Brunetti & Khouri), and *Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 90..120.

621.791.3 : 621.315.351 2230
Destructive Effect of High Temperature Solders on Copper Wire.— R. H. Bailey. (*Wire & W. Prod.*, March 1945, Vol. 20, No. 3, pp. 197–199.) The influence of temperature, wire size, and tin content of the solder is discussed and illustrated by graphs, and the detrimental effect on wire life of high soldering temperatures and high tin content emphasized. It is recommended that fine wires should be soldered at temperatures below 600°F.

66.002.3 (03) 2231
Encyclopedia of Substitutes and Synthetics. [Book Review]—M. D. Schoengold (Ed.). Philosophical Library, New York, 1943, 360 pp., $10.00. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, p. 280.)

666.1/.2 2232
The Elements of Glass Technology for Scientific Glass Blowers (Lampworkers). [Book Review]—W. E. S. Turner. The Glass Delegacy of the Univ. of Sheffield, Sheffield, 1945, 29 pp. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, p. 147.) " . . . a very compact and concise summary of the fundamental properties of glass which are concerned in such working."

679.5 2233
Plastics : Scientific and Technological. [Book Review]—H. R. Fleck. English Univ. Press, London, 25s. (*Engineer, Lond.*, 29th March 1946, Vol. 181, No. 4707, p. 294.) " Instructive and comprehensive treatise which will be of considerable value to all connected with the application of plastics in industry." Contains a survey of literature.

MATHEMATICS

518.5 2234
A New Type of Differential Analyzer.—V. Bush & S. H. Caldwell. (*J. Franklin Inst.*, March 1946, Vol. 241, No. 3.) Correction to 361 of February.

621.396.67 2235
Concerning Hallén's Integral Equation for Cylindrical Antennas.—Schelkunoff : King. (*See* 2141.)

51 : 62 2236
Engineering Mathematics. [Book Review]—H. Sohon. D. Van Nostrand Co., New York, 1944, 278 pp., $3.50. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, pp. 142–143.)

518.2 2237
Tables of Functions with Formulae and Curves. [Book Review]—E. Jahnke & F. Emde. Dover Publications, New York, 306 pp., 22s. 6d. (*Beama J.*, April 1946, Vol. 53, No. 106, p. 138.) An enlarged and new edition (subsequent to the 1938 edition).

MEASUREMENTS AND TEST GEAR

621.3.083.7 : 629.13 2238
Electronic Recorder Aids Flight Research.—T. A. Dickinson. (*Aero Digest*, 15th April 1945, Vol. 49, No. 2, pp. 76..200.) General description of an 80-channel telemetering system for transmitting data from aircraft instruments to a pen-recorder assembly on the ground.

621.3.087.5 2239
Colored Trace Oscillograms.—L. S. Trimble & F. W. Bowden. (*J. Soc. Mot. Pict. Engrs*, March 1946, Vol. 46, No. 3, pp. 231–236.) A colour-sensitive photo-recording material has been used for the simultaneous recording of several electrical impulses. This allows the reproduction of interweaving traces in separate and distinct colours. A 5½-inch-wide film in combination with filtered light beams has given recording speeds up to 20 inches per sec.

621.317 : 621.396.61 2240
Resonant-Cavity Measurements.—R. L. Sproull & E. G. Linder. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 305–312.) Methods of measuring the resonant frequency, Q, and shunt resistance of resonant cavities in the wavelength range 2–12 cm are described. An f.m. oscillator is used with probe injection to the cavity under test. A similar probe is used with a crystal detector, of which the output is amplified and applied to the Y plates of a c.r.o. The 60-c/s timebase on the X plates controls the modulator of the oscillator so that a stationary " response " curve of the cavity is obtained. The procedure is described for using this apparatus for measuring the resonant frequency in terms of that of a cavity-resonator wavemeter, and for measuring the Q. The shunt impedance is derived from measurements of Q or resonant frequency before and after the insertion of a rod of lossy dielectric into the resonator.

621.317.1 : [621.315.21.029.5/.6 2241
Testing of R.F. Cables.—(*See* 2130.)

621.317.341.029.58/.62] : 621.315.212 2242
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[621.317.714+621.317.727] .087.64 2249
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53.08 2257
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66.002.3 (03) 2231
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518.5 2234
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621.396.67 2235
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51 : 62 2236
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MEASUREMENTS AND TEST GEAR

621.3.083.7 : 629.13 223[illegible]
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621.3.087.5 223[illegible]
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621.317 : 621.396.61 224[illegible]
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621.791.3 : 621.315.351 2230
Destructive Effect of High Temperature Solders on Copper Wire.—R. H. Bailey. (*Wire & W. Prod.*, March 1945, Vol. 20, No. 3, pp. 197–199.) The influence of temperature, wire size, and tin content of the solder is discussed and illustrated by graphs, and the detrimental effect on wire life of high soldering temperatures and high tin content emphasized. It is recommended that fine wires should be soldered at temperatures below 600°F.

66.002.3 (03) 2231
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666.1/.2 2232
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MATHEMATICS

518.5 2234
A New Type of Differential Analyzer.—V. Bush & S. H. Caldwell. (*J. Franklin Inst.*, March 1946, Vol. 241, No. 3.) Correction to 361 of February.

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MEASUREMENTS AND TEST GEAR

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621.317 : 621.396.61 2240
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621.317.1 : [621.315.21.029.5/.6 2241
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621.317.341.029.58/.62] : 621.315.212 2242
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21.317.714+621.317.727] .087.64 2249
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OTHER APPLICATIONS OF RADIO AND ELECTRONICS

621.3.078 : 621.791.76 **2258**

Electronic Controls for Resistance Welding.—H. L. Horton. (*Machinery, N.Y.*, Oct. 1944, Vol. 51, No. 2, pp. 153–159.) A survey of methods of controlling the heat generated and of timing control, and their application to various types of industrial equipment. Part 3 of a series. For other parts see 2273, 2259, 2269 and 2263.

621.3.078 : 621.9 **2259**

Electronic Control and Regulation of Motor Drives.—H. L. Horton. (*Machinery, N.Y.*, June 1944, Vol. 50, No. 10, pp. 165–172.) Control (*i.e.*, arbitrary adjustment by external influence) is distinguished from regulation (*i.e.*, self-correction by feedback of the deviation from a standard). An account of the principles and their application to typical practical problems of machine-tool practice. Part 2 of a series. For other parts see 2273, 2258, 2269 and 2263.

621.317.39 : 531.717 : 667.613 **2260**

Instrument for Measuring Thickness of Nonconducting Films Applied over Nonmagnetic Metals.—A. L. Alexander, P. King & J. E. Dinger. (*Industr. Engng Chem.* (*Analyt. Edit.*), June 1945, Vol 17, No. 6, pp. 389–393.) The inductance coil, 1 inch in diameter, of an oscillator with a frequency of 5 kc/s or more, is placed first on an uncoated metal surface, and then on a similar surface that has been coated; the difference in oscillator frequency in the two cases, determined by a heterodyne method, is a measure of the coating thickness. The tuning capacitor of the oscillator, adjusted to bring the frequency always to that of a constant reference oscillator, can be calibrated in film thickness for different film substances. The device is simple and suitable for routine measurements in the range 0–0.025 inch, with an accuracy better than 0.001 inch. Measurements must be made on a flat surface not less than 2 inches in diameter in order to obtain freedom from edge effect.

Complete circuit diagrams are given.

621.317.39 : 531.76 **2261**

Electronic Chronoscope for Measuring Velocities of Detonation of Explosives.—C. R. Nisewanger & F. W. Brown. (*U.S. Bureau of Mines Rept of Investigations*, March 1946, R.I. 3879, 18 pp.) An instrument for measuring the time of travel (of the order of microseconds) of an explosion in a short length of material. The novel method used employs the voltage-time characteristics of an RC circuit, with thyratrons to give the switching action at the beginning and end of the time interval measured. The explosion can either be used to bridge two separated wires by the ionization it produces ("make" system), or to fuse a continuous wire ("break" system). A d.c. valve-voltmeter is used to indicate the charge on the capacitor of the RC circuit, and a meter reading nearly proportional to the time interval is obtained; there are five ranges with full-scale times from 5 to 150 μs. The instrument is mains-operated, with voltage-regulator tubes to ensure stability of calibration. An internal test circuit generating a pulse about 2 μs in length is incorporated. The method of operation is described in detail, and further improvements are suggested. A table of typical velocity measurements is given.

621.317.39 : 620.172.222 **2262**

Resistance Wire Strain Gage Applications and Circuits.—E. G. Van Leeuwen & W. F. Gunning. (*Prod. Engng*, July 1945, Vol. 16, No. 7, pp. 443–449.) The construction, mounting operations, and associated electrical circuits are described, together with applications to the measurement of various types of strain.

621.317.39 : 621 **2263**

Electronic Measurement, Analysis, and Inspection: Parts 1 & 2.—H. L. Horton. (*Machinery, N.Y.*, June & Aug. 1945, Vol. 51, Nos. 10 & 12, pp. 157–161 & 168–173.) A review of photocell applications, temperature regulation, metallurgical analysis with a cathode-ray tube, X-ray examination of materials, devices for measuring small mechanical irregularities and displacements, and the electron microscope. Parts 5 and 6 of a series. For other parts see 2273, 2259, 2258 and 2269.

621.317.39.083.7 : 531.74 : 621.396.663 **2264**

Improvements in Devices for the Instantaneous Transmission of Angles.—R. Barthélemy. (*Génie civ.*, 15th Feb. 1946, Vol 123, No. 4, p. 52, *C. R. Acad. Sci., Paris*, 29th Oct. 1945, Vol. 221, No. 18, pp. 487–489.) Alternating current in the moving coil of a goniometer coil system induces currents in the stators proportional to the sine and cosine of the angle of the rotor. The currents from the stators are respectively passed through the rotor coils of two other goniometers of which the rotors are on a common spindle and bear the same angle to their respective stators. These four stators are connected in series in pairs, the X-coil of one with the Y-coil of the other. The outputs from the two pairs of stators are applied with or without amplification to the deflector plates of a c.r. tube, and set the trace at an angle that is the sum of the angle of setting of the first goniometer and the common angle of setting of the other two. Further pairs of coupled goniometers can be added so that the output of the system defines an angle that is the sum of the angles of setting of each spindle. The systems can also be used to operate servomechanisms instead of a c.r. display.

621.317.39.083.7 : 532.593.082 **2265**

Measurement of Ocean Waves Generated by Atomic Bombs.—N. J. Holter. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 94–98.) A general description of the following equipment: underwater recording echo-sounders, self-contained wave-pressure recorders, shore-connected wave-pressure recorders, radio-synchronized cameras, recording television, maximum-water-height recording transmitters, and water level recorders.

621.317.755 : 545.822 **2266**

Spectrochemical Analysis with the Oscillograph.—G. H. Dieke & H. M. Crosswhite. (*J. opt. Soc. Amer.*, April 1946, Vol. 36, No. 4, pp. 192–195.)

621.317.755 : 621.43 **2267**

Ignition Testing Unit.—(*Flight*, 12th July 1945, Vol. 48, No. 1907, pp. 47–48.) Description of a cathode-ray equipment that displays the ignition pulses derived from the p.d. at the magneto switch or ignition coil. Faults are detected by abnormalities in waveform. Circuit details are not given.

621.365.5 + 621.365.9 + 621.396 2268

Discussion on "The Place of Radiant, Dielectric and Eddy-Current Heating in the Process Heating Field".—L. J. C. Connell, O. W. Humphreys & J. L. Rycroft. (*J. Instn elect. Engrs*, Part II, Feb. 1946, Vol. 93, No. 31, pp. 48–50.) For original paper see 145 of January.

621.365.5 + 621.365.92 2269

Electronic Heating of Metals and Non-Metallic Materials.—H. L. Horton. (*Machinery, N.Y.*, March 1945, Vol. 51, No. 7, pp. 146–155.) A review of the principles and mechanical-engineering applications of induction and dielectric heating. Part 4 of a series. For other parts see 2273, 2259, 2258 and 2263.

621.365.52 2270

Measurement of the Form Factor in Induction Ovens without Magnetic Core.—G. Ribaud & M. Leblanc. (*C.R. Acad. Sci., Paris*, 23rd May 1945, Vol. 220, No. 21, pp. 732–733.) A table of values is given for a number of useful forms. See also 3821 of 1944.

621.365.52 2271

Design of Induction-Heating Coils for Cylindrical Non-Magnetic Loads.—J. T. Vaughan & J. W. Williamson. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 965–966.) Discussion of 148 of January.

621.365.92 : 674.23 2272

Electronic Heating in the Furniture Industry.—E. S. Winlund. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 108–113.) A review of the principles of generating the power for dielectric heating, transferring it to the load, and shaping the electrodes to concentrate the heat where it is required. Several examples are given of its application to the setting of the bonding-glues used in assembling joints, and in producing plywood and veneered furniture. The efficient use of dielectric heating can effect a considerable saving in production costs.

621.38 : 621 2273

Electronics for the Machine Designer.—G. A. Caldwell & C. Madsen. (*Machinery, N.Y.*, May 1944, Vol. 50, No. 9, pp. 135–150.) A review of the fundamentals of electronics and of the features which make electronic devices potentially useful for application in the mechanical field. The first of a -part series. For other parts see 2259, 2258, 2269 and 2263.

621.383 + 621.317.755] : 535.243 2274

Spectral Intensity Measurements with Phototubes and the Oscillograph.—G. H. Dieke, H. Y. Loh & H. M. Crosswhite. (*J. opt. Soc. Amer.*, April 1946, Vol. 36, No. 4, pp. 185–191.)

621.383 : 536.52 : 621.317.39 2275

Color Temperature Testing in Projector Lamp Production.—S. Pakswer & J. Kirk. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, pp. 157–158.) Phototubes measure the blue and red radiations from the lamp, and their ratio (giving the temperature of the lamp) is displayed on a c.r.t.

621.385.833 2276

On a Photographic Method for Investigating the Optical Properties of Magnetic Lenses and for Recording β-Ray Lines.—H. Slätis. (*Ark. Mat. Astr. Fys.*, 20th Feb. 1946, Vol. 32, Part 4, Section A, No. 20, 27 pp. In English.)

621.396.611 : 621.384 2277

On the Design of a Cavity of a Linear Electron Accelerator.—E. S. Akeley. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 255.) Abstract of an Amer. Phys. Soc. paper.

621.396.9 : 359 2278

Navy Radio and Electronics during World War II.—J. B. Dow. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 284–287.) A non-technical review of some of the electronic devices used by the U.S. Navy emphasizing their importance in naval tactics. Extracts from action reports illustrate the use of radar fire control and of sonar (see 1750 of July) against submarines.

621.396.9 : 623.454.25 2279

The Application of Radar to Ballistics: the Radar Shell-Fuse.—M.A. (*Génie civ.*, 1st March 1946, Vol. 123, No. 5, p. 63.) See also 1627 of June (Selvidge) and 624 of March (Huntoon & Miller).

621.396.91.083.7 2280

Radiosonde Telemetering Systems.—V. D. Hauck, J. R. Cosby & A. B. Dember. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 120–123.) A description of equipment used by the U.S. Army and Navy, designated AN/AMQ-1D, and by the Weather Bureau, designated 506-WB. It is essentially a development of the Diamond and Hinman apparatus (see 2682 of 1938 and 58 of 1939). A temperature-compensated aneroid unit operates a multi-contact switch connected to temperature- and humidity-sensitive resistors that control, in turn, the quench frequency of the transmitter. Batteries with lead and lead-dioxide plates are used, with perchloric acid as the electrolyte. Accuracy: pressure, 5 millibars in the range 10-1 060 mb and +60 to −90°C; temperature, 1°C.

621.38 : 62 2281

Electronic Equipment and Accessories. [Book Review]—R. C. Walker. Chemical Pub. Co., Brooklyn, N.Y., 1945, 239 pp., $6.00. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, p. 141.) "..can be recommended as a 'first course' in electronic instrumentation as well as a compendium of information on electronic and associated devices."

PROPAGATION OF WAVES.

621.396.11 + 621.396.67 2282

A Note on a Simple Transmission Formula.—H. T. Friis. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 254–256.) A formula relating the received and transmitted powers at the aerial terminals, P_r and P_t, in terms of the effective areas A_r and A_t of the aerials, their distance apart d, and the wavelength λ, is derived in the form

$$\frac{P_r}{P_t} = \frac{A_r A_t}{d^2 \lambda^2}$$

The meaning to be ascribed to the effective area is discussed, and its value given for certain special cases. The formula applies to free-space transmission only, and should not be used when d is small, because the assumption of a plane wavefront is then not justified.

621.396.11 **2283**
Propagation of Radiation in a Medium with Random Inhomogeneities.—P. G. Bergmann. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, pp. 255–256.) The use of ray optics shows that fluctuations of a radiative field are related to variations in refractive index, and increase with the 3/2-power of distance. Abstract of an Amer. Phys. Soc. paper.

621.396.11 : 523.746.5 **2284**
DX and the Present Sunspot Cycle — A Prophecy.—E. H. P. Young. (*R.S.G.B. Bull.*, May 1946, Vol. 21, No. 11, p. 170.) Discussion of 324 of February (Gleissberg).

621.396.11 : 551.51.053.5 **2285**
Radio Propagation Work at the National Bureau of Standards.—N. Smith & R. Silberstein. (*QST*, May 1946, Vol. 30, No. 5, pp. 45–50.) An account of the progress made in forecasting transmission conditions. Maximum usable frequencies and lowest useful high frequencies can now be predicted accurately from measurements of the properties of the ionosphere made at vertical incidence. A map shows the world-wide distribution of observing stations in January 1946.

621.396.11 : 551.51.053.5 **2286**
Irregularities in Radio Transmission.—O. P. Ferrell. (*Radio, N.Y.*, Feb. 1946, Vol 30, No. 2, pp. 23–24.) A survey of sporadic-*E* propagation at v.h.f., and of the effect on f.m. transmission. A bibliography with abstracts is included. For previous parts of this 3-part series see 1333 of May and 1640 of June.

621.396.11 : 551.51.053.5 **2287**
On the Absorption of Radio Waves and the Number of Collisions in the Ionosphere.—V. Ginsburg. (*J. Phys., U.S.S.R.*, 1944, Vol. 8, No. 4, pp. 253–256.) "The measurement of the absorption of radio waves in the ionosphere enables one to determine the effective number of collisions in some of its regions. On the other hand, it is possible with the help of the usual method of kinetic equation to evaluate the number of collisions effective for the process of absorption of radio waves. Both the electrons' collisions with the molecules and their collisions with the ions can be thus calculated. The cross section for the latter process under conditions prevailing in the ionosphere is about a million times larger than for collisions with the molecules. In this connexion the concentration of ions and molecules in the ionosphere, as derived from radio measurements, is discussed."

621.396.11 : 551.51.053.5 : 621.396.9 **2288**
2-Mc/s Sky-Wave Transmission.—Pierce. (*See* 2190.)

621.396.13 : 621.397 **2289**
Vertical *v.* Horizontal Polarisation.—H. P. Williams. (*J. Televis. Soc.*, Sept. 1945, Vol. 4, No. 7, pp. 171–177.) A consideration of the relative merits for television transmission, with particular reference to the effect of ground reflection and aerial height. It is concluded that there is no distinct advantage in either mode, but "such differences as do exist are mostly in favour of horizontal polarization".

621.396.812.3 : 551.51.053.5 **2290**
On Some Observations of Fading of Short-Wave Signals.—S. S. Banerjee & G. C. Mukerjee. (*Sci. Culture*, April 1946, Vol. 11, No. 10, pp. 571–575.) Quasi-regular variations in the intensity of short-wave radio signals reflected from the ionosphere are interpreted as due to interference between multiple reflections.

RECEPTION

621.396.619.018.41 : 621.396.82 **2291**
Larger F.M. Carrier Suppresses Smaller. — H. G. Shea. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 78–79.) A simple explanation with vector diagram illustrations.

621 396.621 **2292**
32-Volt [broadcast] **Receiver.**—L. Treakle. (*Radio Craft*, April 1946, Vol. 17, No. 7, pp. 466..516.) Constructional details.

621.396.621 **2293**
Radio Data Sheet 334.—(*Radio Craft*, April 1946, Vol 17, No. 7, p. 475.) Servicing data for Farnsworth broadcast receivers.

621.396.621(43) **2294**
Five New Circuits.—R. M. Cater. (*Radio Craft*, April 1946, Vol. 17, No. 7, pp. 467 . . 496.) Circuit details of German midget broadcast receivers.

621.396.621.029.62 **2295**
A Battery Operated V.H.F. Receiver.—E. L. Cameron. (*R.S.G.B. Bull.*, June 1946, Vol. 21, No. 12, pp. 185–186.) Design and construction of a simple two-unit portable receiver for the range 56–112 Mc/s.

621.396.621.54.029.62 **2296**
A Two-Meter Crystal-Controlled Converter.—C. F. Hadlock. (*QST*, May 1946, Vol. 30, No. 5, pp. 31–35.) For selective reception in the 112-Mc/s and 144-Mc/s amateur bands, a crystal-controlled beat oscillator converts the signal frequency to the 30–40-Mc/s region. Constructional details are given.

621.396.662.1 **2297**
New Tuning System for the Amateur Receiver.—W. J. Halligan & N. Foot. (*QST*, May 1946, Vol. 30, No. 5, pp. 18..124.) An application of split-stator capacitors giving improved v.h.f. performance with 3 to 1 tuning ranges up to 150 Mc/s. Basic circuits are given for an oscillator and mixer, with 6-band switching, to operate in the range 540 kc/s–110 Mc/s.

621.396.8 : 621.396.13 : 621.396.619.16 **2298**
Determination of Noise Power and Signal/Noise Ratio for the Case of Simplex or Multiplex Radio Transmission on Ultra-Short Waves by (A) Amplitude- or Duration-Modulated Pulses (B) Frequency-Modulated Pulses.—Chireix. (*See* 2307.)

621.396.8 : 621.396.619.018.41 **2299**
Nonlinearity in Frequency-Modulation Radio Systems Due to Multipath Propagation.—Meyers. (*See* 2321.)

621.396.822 **2300**
A Generalization of Nyquist's Thermal Noise Theorem.—E. J. Schremp. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 255.) Nyquist's theorem (1928 Abstracts p. 581) for the thermal current generator of a linear passive 2-terminal

network at temperature T is extended for an M-terminal network to

$$[i^2_{mn}(r, a; \nu)]_{Av} = 2kTg_{mn}(r, a; \nu)\, d\nu$$

for the incoherent nodal currents if the generating parameter a obeys

$$a(-\nu)\,[a(\nu) - 1]\,Y_{rr}(\nu) + a(\nu)\,[a(-\nu) - 1]\,Y_{rr}(-\nu) = 0$$

where $y = g + jb$ is the admittance. Abstract of an Amer. Phys. Soc. paper.

621.396.823 : 621.317.7.089.6 **2301**

A Study of Wave Shapes for Radio-Noise-Meter Calibrations.—Frick. (*See* 2248.)

621.396.828 **2302**

Noise Limiting in C.W. Reception.—G. Grammer. (*QST*, May 1946, Vol. 30, No. 5, pp. 13..122.) Explains the poor results obtained with the usual amplitude limiter when using a beat-frequency oscillator, and gives a detailed description of a satisfactory clipper circuit for headphone reception, using germanium crystal rectifiers.

621.397.82 **2303**

Local Oscillator Radiation and Its Effect on Television Picture Contrast.—E. W. Herold. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 32–53.) A study of the effect of c.w. interference arising from the local oscillators of nearby receivers. The chief annoying effect of such interference at the high end of the video band was a serious loss in contrast. "The observations and computations indicated that a 20-db signal-to-interference field strength ratio at the antenna is a minimum satisfactory value. To maintain this ratio in a 500-μV/m region of a desired transmitter, nearby receivers must have a radiation below 0.01 μW. Pre-war receivers, which used no radio frequency stage, radiated 100 000 times as much as this and were extremely unsatisfactory. A grounded-grid triode r.f. stage may give a reduction of about 30 db or more and a pentode r.f. stage may be made even better." It is concluded that an adequate television service will require suppression of local-oscillator radiation if the frequency assignments are such as to make interference possible.

STATIONS AND COMMUNICATION SYSTEMS

621.396.1 **2304**

Communications: Implement to Peace.—R. C. Wakefield. (*Elect. Engng, N.Y.*, March 1946, Vol. 65, No. 3, pp. 99–105.) Description of developments in U.S. Army communications during the war, and of their application and adaptation to peace-time conditions. The main new proposals put forward are the provision of sufficient radio-relay stations, with control by one international company, and the use of pulse modulation and other multiplex systems in place of the more expensive (in frequency and money) cable systems.

621.396.1 **2305**

We Have New Regulations.—K.B.W. (*QST*, May 1946, Vol. 30, No. 5, pp. 23–24.) Revised F.C.C. rules for U.S. amateur radio.

621.396.13 **2306**

Observations and Comparisons on Radio Telegraph Signalling by Frequency Shift and On-Off Keying.—H. O. Peterson, J. B. Atwood, H. E. Goldstine, G. E. Hansell & R. E. Schock. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 11–31.) A long and fully detailed account of a thorough comparison in respect of communication reliability between on-off keying (CWT) and frequency-shift keying (FST) of transmissions on 200 kc/s from Bolinas, California, to Riverhead, New York. The CWT signals were received with a standard RCA 3-receiver diversity group, and the FST through a frequency-shift adaptor, using two receivers of the same diversity group. The comparison was based on error-counts on a 5-unit start-stop printer using a recurring series of test words transmitted from a loop of perforated tape. The conclusions were mainly in favour of the FST system.

621.396.13 : 621.396.8 : 621.396.619.16 **2307**

Determination of Noise Power and Signal/Noise Ratio for the Case of Simplex or Multiplex Radio Transmission on Ultra-Short Waves by (A) Amplitude- or Duration-Modulated Pulses (B) Frequency-Modulated Pulses.—H. Chireix. (*Ann. Radioélect.*, July 1945, Vol. 1, No. 1, pp. 55–64.) A theoretical study. The signal/noise ratio depends in each case on the gain in the transmission system, as in the case of keyed c.w. The analysis shows the system of frequency-modulated pulses to be effectively equivalent to a carrier-current system with the same total frequency deviation. Pulse duration modulation compares favourably with multichannel frequency modulation, and with frequency-modulated pulses when an upper and lower amplitude limiter is used on the receiver with the two thresholds brought as close together as possible.

621.396.24 + 621.396.933 **2308**

Aircraft Microwave-Beam System.—(*Aero Digest*, 15th June 1945, Vol. 49, No. 6, pp. 82–84.) A note on the application by the Raytheon Manufacturing Co. to the F.C.C. for permission to erect a microwave relay system and television broadcasting chain along the west coast of U.S.A. The potentialities of the scheme are discussed. See also 186 of January.

621.396.41 : 621.396.619.16 **2309**

A Selective Pulse Communication System.—A. R. Knight & H. Storck. (*QST*, May 1946, Vol. 30, No. 5, pp. 74..144.) A proposal by which many stations might work on the same frequency without interference. A master station transmits synchronizing pulses which control pulses emitted in keyed transmission from subsidiary stations. The master pulses also control gates in the receiving circuits, which can be adjusted manually in time relative to the master pulses. The gate is just wide enough to admit one pulse from any subsidiary transmitter, and is adjusted until it is open at the instants when the pulses from the selected transmitter arrive at the receiver.

621.396.619.018.41 **2310**

The Fundamental Principles of Frequency Modulation.—B. van der Pol. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 153–158.) A theoretical survey of the nature, generation, and circuit response of f.m. waves. The voltage and current generated in a circuit with variable parameters are expressed in a form similar to the W.K.B. solution familiar in quantum mechanics. The response of a circuit to an f.m. wave is obtained in a form similar to that of Carson and Fry (464 of

1938) but it is shown that in general the resulting series is asymptotic.

621.396.619.018.41 : 001.4 **2311**

Defining Common F.M. Engineering Terms.—(*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 79..81.) Short definitions of 17 terms.

621.396.619.018.41 : 621.3.012.3 **2312**

Frequency and Phase Deviation.—(*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 69–70.) Two nomographs. The first relates modulating frequency, modulation index, and frequency deviation in the case of f.m., and modulating frequency, initial phase shift, and equivalent f.m. deviation in the case of ph.m. The second relates peak f.m. deviation and the modulating frequency to the condition required to give zero amplitude of the carrier frequency.

621.396.619.018.41 : 621.396.216 **2313**

F.M. Systems Engineering.—R. R. Batcher. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 75..132.) A general survey of the requirements and methods of f.m. transmitting systems. A loose-leaf supplement gives schematic diagrams of the various parts of the system.

621.396.619.16 **2314**

Microwave Pulse [-time] **Modulation for Ham Communications.**—R. Endall. (*Radio News*, April 1946, Vol. 35, No. 4, pp. 41..94.) A general account of the principles and features of the system, including the use of the cyclodos and cyclophone cathode-ray-beam modulator and demodulator tubes. See also 1352 of May, 1056 of April (Black), and back references.

621.396.65.029.62/.64] : 621.396.619.16 **2315**

Pulse-Modulated Radio Relay Equipment.—J. J. Kelleher. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 124–129.) An account of the development of the equipment used for military communications, with block diagrams and abridged specifications of the equipments AN/TRC-5 and AN/TRC-6. See also 1353 of May and back references.

621.396.664 **2316**

C.B.S. Studio Control-Console and Control-Room Design.—H. A. Chinn. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 287–295.) The chief design considerations for studio control equipment are location of controls and visual monitoring facilities, visibility into the studio, pleasing appearance, ease of maintenance, and flexibility.

The way in which the C.B.S. console fulfils these requirements is described, and its fitting into a complete studio layout to give maximum visibility is discussed. The circuit facilities of the console are outlined; space is available for additional equipment if required for special purposes.

621.396.664 **2317**

Two-Studio Console.—(*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 71..130.) A Raytheon 7-channel programme-mixing console with separate amplifiers for each channel, a programme-level indicator and amplifier for the main output, and monitoring loudspeakers.

621.396.7 + 621.397.26 **2318**

The Programme of Work of la Radiodiffusion française.—M.A. (*Génie civ.*, 15th Feb. 1946, Vol. 123, No. 4, p. 52.) A brief summary of the plans for building new transmitting stations, studios, and laboratories, and for the development of television, and of a North African network.

621.396.712 **2319**

A Report on the Sixth Annual Conference of Broadcast Engineers.—L. Winner. (*Communications*, April 1946, Vol. 26, No. 4, pp. 30..74.) Long illustrated summaries of the following papers:—Preventive Maintenance for Broadcast Stations, by C. Singer. Irregular Room Surfaces in Studios, by K. C. Morrical. F.M. Station Monitor, by H. R. Summerhayes, Jr. For other papers see 2125, 2143 and 2365.

621.396.712 : 621.317.36 **2320**

The Measurement of Broadcast Station Frequencies.—Hers. (*See* 2246.)

621.396.8 : 621.396.619.018.41 **2321**

Nonlinearity in Frequency-Modulation Radio Systems Due to Multipath Propagation.—S. T. Meyers. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 256–265.) "A theoretical study is made to determine the effects of multipath propagation on over-all transmission characteristics in frequency-modulation radio circuits. The analysis covers a simplified case where the transmitted carrier is frequency-modulated by a single modulating frequency and is propagated over two paths having relative delay and amplitude differences. Equations are derived for the receiver output in terms of the transmitter input for fundamental and harmonics of the modulating frequency. Curves are plotted and discussed for various values of relative carrier- and signal-frequency phase shift and relative amplitude difference of the received waves.

"The results show that a special kind of amplitude nonlinearity is produced in the input-output characteristics of an over-all frequency-modulation radio system. Under certain conditions, sudden changes in output-signal amplitude accompany the passage of the input-signal amplitude through certain critical values. Transmission irregularities of this type are proposed as a possible explanation of so-called "volume bursts" sometimes encountered in frequency-modulation radio circuits. In general, it appears that amplitude and frequency distortion are most severe where the relative delay between paths is large and the amplitude difference is small."

621.396.82 : 551.57 : 629.135 **2322**

[U.S.] **Army-Navy Precipitation-Static Project: Part 4—Investigations of Methods for Reducing Precipitation-Static Radio Interference.**—G. D. Kinzer & J. W. McGee. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 234–240.) 'Studies showed that interfering noise associated with the use of bare-wire antennas was roughly proportional to the amount of corona-current discharge. It was found that the use of antennas insulated with polyethylene provided comparatively static-free radio reception by preventing corona discharge from the antenna. Correlated ground and flight experiments showed that, unless the corona discharge occurs at areas adjacent to antennas, little noise is produced in the radio receiver. The characteristics of several types of electrostatic dischargers, intended to reduce the equilibrium potential of the airplane for a given charging condition, were examined. The dry-wick discharger recently adopted by the military services was found to give the best over-all electrical and mechanical performance." The technique of measurement is described, and diagrams are shown of the noise as a function of the electric field intensity at the aerial.

621.396.82 : 551.57 : 629.135 : 621.3.027.7 **2323**
[U.S.] **Army-Navy Precipitation Static Project : Part 5 — The High-Voltage Characteristics of Aircraft in Flight.**—R. Gunn & J. P. Parker. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 241–247.) "The important high-voltage electrical characteristics of aircraft in flight are determined from (*a*) flight operations in precipitation areas; (*b*) flight operations using a new artificial charger to electrify the airplane in flight; (*c*) high-voltage experiments on the airplane supported in a giant hangar; and (*d*) theoretical analysis.

"It is shown how the fundamental electrical constants of the airplane may be approximately determined and how these may be used to forecast the high-voltage behaviour of a flying aircraft. It is shown that, at a given altitude, the current I discharged by an airplane in flight is of the form

$$I = AE + B(E^2 - E_0^2)$$

where E is the magnitude of the electric field as measured on the belly and A, B and E_0 are constants.

"The electrical capacitance of an aircraft in flight is about 20% of the wing span expressed in centimetres." A theoretical analysis is given of the potential and space-charge distribution surrounding a sphere equivalent to an aircraft in a hangar, and close agreement is obtained between the observed and calculated currents.

621.396.931 **2324**
Mobile Radio Service.—(*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 84–85.) An experimental semi-automatic f.m. radio telephone for party-line service to a fleet of vehicles.

621.396.931 **2325**
F.M. Railroad Radio Satellite System.—W. S. Halstead. (*Electronic Industr.*, June 1946, Vol. 5, No. 6, pp. 62–65..128.) Local 152–162-Mc/s f.m. transmitter-receiver stations with restricted service zones are connected to a central station by a 150–250-kc/s f.m. induction link that uses overhead wires primarily used for another purpose. Mobile v.h.f. units in the zone of any local station can communicate with any part of the system, or with other mobile units in any v.h.f. zone.

621.396.931.029.62 **2326**
A Method of Increasing the Range of V.H.F. Communication Systems by Multi-Carrier Amplitude Modulation.—J. R. Brinkley. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 159–176.) "The initial development of a method of extending the range or improving the coverage of v.h.f. communication systems of the type used for police services is described. The method is based on the simultaneous amplitude modulation of a number of carriers closely spaced in frequency. The frequency spacing between the carriers is so chosen that they lie within the bandwidth of the v.h.f. receiver, without producing audible interaction components of importance.

"Two-carrier schemes employing separate transmitters at the same site have been found to give improved coverage, while two- and three-carrier schemes using separate sites have been found to give greatly increased range.

"An unsuccessful attempt to achieve the same object with . . . f.m. transmitters using the same nominal carrier frequency is described. The difficulties of employing frequency modulation with common modulation are discussed and considered to be fundamental.

"Single-station v.h.f. schemes upon which the development of the multi-carrier scheme is based are briefly described." A long discussion is included. For a less detailed account see 1357 of May.

SUBSIDIARY APPARATUS

621.314.2.029.4/.5] : 621.318.322 **2327**
Applications of Thin Permalloy Tape in Wide-Band Telephone and Pulse Transformers.—Ganz. (*See* 2225.)

621.314.22/.23 **2328**
The Impedances of Multiple-Winding Transformers : Part 3.—S. A. Stigant. (*Beama J.*, April 1946, Vol. 53, No. 106, pp. 139–141.) For previous parts see 1685 of June and 2017 of July.

621.315.612 : 546.287 **2329**
The Use of Liquid Dimethylsilicones to Produce Water-Repellent Surfaces on Glass-Insulator Bodies.—Johannson & Torok. (*See* 2214.)

621.316.721/.722].078.3 : 621.386 **2330**
The Stabilization of X-Ray Tube Current and Voltage.—A. F. LeMieux & W. W. Beeman. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, pp. 130–132.) Description of circuits for stabilizing the current (up to 50 mA) and voltage (35 kV) of the discharge to 0.1% by means of degenerative feedback of the amplified variations to the primary a.c. power line. The stabilizer operates at ground potential.

621.316.74 **2331**
Tapered - Thickness Bimetal. — W. B. Elmer. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, p. 962.) Discussion of 757 of March.

621.316.842 : 546.287 : 621.315.616.9 **2332**
Silicone Coating for [wire-wound] **Resistors.**—Marbaker. (*See* 2215.)

621.316.849.011.2 : 539.234 : 546.621 **2333**
Electrical Resistance of Thin Films of Aluminium Deposited on Glass by Thermal Evaporation.—Dunoyer. (*See* 2212.)

621.316.93 **2334**
Lightning Investigations on 33-kV Wood-Pole Lines.—F. E. Andrews & G. D. McCann. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 954–955.) Discussion of 760 of March.

621.316.98 **2335**
The Frequency of Occurrence and the Distribution of Lightning Flashes to Transmission Lines.—R. H. Golde. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 902–910.)

621.317.333.4 **2336**
Exploring Coils.—T. C. Henneberger. (*Bell Lab. Rec.*, April 1946, Vol. 24, No. 4, pp. 145–147.)

An a.f. source is used to produce a tracing current through the faulty cable, and an exploring coil detects the magnetic field so produced. Practical applications of the method are briefly discussed.

621.317.39.083.7 : 531.74 : 621.396.663 2337
Improvements in Devices for the Instantaneous Transmission of Angles.—Barthélemy. (*See* 2264.)

621.317.755 2338
The Precision High-Tension Oscillograph with Four Cathode Rays.—G. Induni. (*Brown Boveri Rev.*, Sept./Oct. 1943, Vol. 30, pp. 222–223.) Four separate deviation systems for voltages up to 3 kV, and two for voltages up to 50 kV. Continuously pumped. Abstract in *Rev. gén. Élect.*, Jan. 1946, Vol. 55, No. 1, p. 2D.

621.317.755.087.5 2339
An Automatic Oscillograph With a Memory.—A. M. Zarem. (*Trans. Amer. Inst. elect. Engrs*, March 1946, Vol. 65, No. 3, pp. 150–154.) The instrument has a flat response up to 30 Mc/s, and can be used for problems concerning randomly occurring transients. Three cathode-ray tubes allow simultaneous indications of inter-related quantities. The screens, which have a long afterglow, are continuously excited, and the occurrence of a transient pulse releases a camera shutter and interrupts the beams, so that events prior to the photographic exposure are recorded. Illustrations of sporadic disturbances in mercury arc rectifiers are given. The system is completely automatic, and 40 photographs can be taken without the aid of an operator. See also 3117 of 1937 and 666 of 1938 (Kuehni & Ramo), and 723 of 1939 (Pakala).

621.318.42 2340
Optimum Air Gap for Various Magnetic Materials in Cores of Coils Subject to Superposed Direct Current.—V. E. Legg. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, p. 969.) Discussion of 763 of March.

621.318.423 2341
The Self-Inductance of a Toroidal Coil Without Iron.—H. B. Dwight. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, p. 999.) Discussion of 765 of March.

621.319.4.011.4 2342
Resistance and Capacitance Relations Between Short Cylindrical Conductors.—F. L. ReQua. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, p. 962.) Discussion of 766 of March.

621.319.42 : 621.315.616.9 2343
Polystyrene Capacitors.—J. R. Weeks. (*Bell Lab. Rec.*, March 1946, Vol. 24, No. 3, pp. 111–115.) Short description of the construction and performance. They are superior to mica capacitors in power factor, but are slightly bigger for the same capacitance, and have a greater temperature coefficient of capacitance.

621.319.5 : 621.317.2 2344
[U.S.] **Army-Navy Precipitation Static Project : Part 6—High-Voltage Installation of the Precipitation-Static Project.**—M. Newman & A. O. Kemppainen. (*Proc. Inst. Radio Engrs, W. & E.*, May 1946, Vol. 34, No. 5, pp. 247–254.) Description of the artificial lightning generator which gives any of (*a*) 1.5 MV at 1.5 mA d.c., (*b*) impulse voltages up to 5 MV, (*c*) impulse currents up to 200 000 A. The Cockcroft-Walton method of cascade rectifier connexion is used to build up the high voltage. "Conditions of electrical-field stress before the lightning discharge are produced by an automatically controlled transition of a generator of high-voltage direct current into a surge generator, resulting in a doubled field stress and a surge breakdown with lightning current characteristics. The combination is thus very suitable for studying certain phases of aircraft operation, particularly communications, under controlled laboratory conditions, corresponding to flight under electrical-storm conditions."

621.38 : 612.84 2345
The Electric Eye *v.* the Human Eye.—Sommer. (*See* 2361.)

621.389 : 623.555.2 2346
Invisible Light Aids Marksman.—(*Radio News*, June 1946, Vol. 35, No. 6, pp. 35..129.) General description of a device incorporating an infra-red spotlight and image converter for use with a rifle sight in the dark. The image converter has a photoelectric screen on which the i.r. image is formed, and the photoelectrons are focused by an electron lens on to a fluorescent screen to form a visible image.

621.396.614 2347
High-Frequency Alternators.—J. H. Walker. (*J. Instn elect. Engrs*, Part II, Feb. 1946, Vol. 93, No. 31, pp. 67–80.) A review of homopolar and heteropolar induction alternators for frequencies up to 50 kc/s, with an appendix giving the mathematics of novel features of the heteropolar type.

621.396.662 2348
A Visual Tuning Indicator Employing a Thyratron.—L. S. Joyce. (*Electronic Engng*, June 1946, Vol. 18, No. 220, pp. 183–186.) A thyratron with a.c. anode supply is controlled by a grid bias combining an a.c. supply of the same frequency but different phase, and a d.c. component obtained by rectification of the tuned signal. Change of the d.c. bias by tuning alters the striking point of the anode-voltage cycle and the mean anode current. The current is used to operate a meter or lamp indicator.

621.396.68 : 621.397.6 2349
Television Voltage [power supply] **Circuits : Part 13.**—E. M. Noll. (*Radio News*, June 1946, Vol. 35, No. 6, pp. 50..82.) For previous parts of this series on television circuits, see 1710 of June.

621.396.68.027.226 2350
Constant 6 Volt D.C. Supply for the Service Lab.—C. C. Springer. (*Radio News*, June 1946, Vol. 35, No. 6, pp. 44..146.) Constructional details of a battery charger, with automatic regulation to prevent overcharge, that can be used with a battery across its terminals as a constant 6-V source.

621.396.682 : 621.397 2351
Power Frequency Changers for Color Television.—D. L. Jaffe. (*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 15–16.) A method for btaining power at 120 c/s from 60-c/s mains using an induction motor driven in reverse by a synchronous motor. The output is in synchronism with the mains

621.396.689 2352
Recent Developments in Heavy Duty Vibrator Type Power Supplies.—M. R. Williams. (*Radio News*, June 1946, Vol. 35, No. 6, pp. 46..151.) Operates from 32 V d.c., and gives a power supply of 350 W, 110–120 V a.c., at 60 c/s. A multiple-contact vibrator is used with a circuit that makes it unnecessary for all contacts to close in exact synchronism.

621.398 : 621.396.61 2353
All Purpose [amateur] **Transmitter Remote Control System.**—P. Johnson. (*Radio News*, June 1946, Vol. 35, No. 6, pp. 68..70.)

778.53 : 621.3 2354
A Wide-Angle Fastax.—J. H. Waddell. (*Bell Lab. Rec.*, April 1946, Vol. 24, No. 4, pp. 139–144.) A camera with a horizontal field of 40° using 35-mm film "for studying the action of relays, switches and other fast moving electrical apparatus."

621.317.755 + 621.385.832 2355
The Cathode-Ray Tube Handbook. [Book Review] —S. K. Lewer. Isaac Pitman & Sons, London, 100 pp., 6s. (*R.S.G.B. Bull.*, May 1946, Vol. 21, No. 11, p. 177.) ". . . very useful introduction to c.r.o. work."

621.318.5 2356
Relay Engineering [Book Review]—C. A. Packard. Struthers-Dunn, Philadelphia, Pa., 1945, 640 pp., $3.00. (*Electronic Industr.*, June 1946, Vol. 5, No. 6, p. 130.) ". . . covers the selection of relays, applications and circuits, auxiliary equipment, standards, and much material relating to the specific problems of designing the coil and contact structures . . ."

621.384 2357
Le Cyclotron. [Book Review]—M. E. Nahmias. Éditions de la Revue d'Optique Théorique et Instrumentale, Paris, 1945, 254 pp., 200 fr. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, p. 135.) "The book is well written, concise and to the point", and particularly helpful in its treatment of theory and mathematical development.

621.385.833 2358
Electron Optics and the Electron Microscope. [Book Review]—V. K. Zworykin, G. A. Morton, E. G. Ramberg, J. Hillier & A. W. Vance. John Wiley & Sons, New York, 1945, 766 pp., $10.00. (*Rev. sci. Instrum.*, April 1946, Vol. 17, No. 4, pp. 138–139.) "In the opinion of the reviewer it is the best English language book yet published not only for electron microscopy but for general electron optics as well." See also 1960 of July.

TELEVISION AND PHOTOTELEGRAPHY

621.3.018.7 + 621.317.35 2359
Television Waveforms.—(*J. Televis. Soc.*, Sept. 1945, Vol. 4, No. 7, p. 178.) Reproduction of chart from *Electronic Engineering* giving equations for 16 common waveforms.

621.317.79 : 621.397.62 2360
A Television Signal Generator : Part 1—General Features.—Hibberd. (*See* 2255.)

621.38 : 612.84 2361
The Electric Eye *v.* the Human Eye.—W. Sommer. (*J. Televis. Soc.*, Sept. 1945, Vol. 4, No. 7, pp. 150–170.) An account of the characteristics and functions of the human eye, and of photoelectric cells. Data for these (sensitivity, etc.), and for photographic emulsions and for c.r.t. fluorescent screens are presented in tabular form. Long bibliography.

621.396.13 : 621.397 2362
Vertical *v.* Horizontal Polarisation.—Williams. (*See* 2289.)

621.397 2363
Where Color Television Stands.—D. G. Fink. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 104–107.) The similarities and differences between the black-and-white and the colour systems are discussed. It is shown that the colour system is likely to be more costly, and that there are still uncertainties in its performance requiring further research. Whether to continue with the present system, or to introduce the colour system immediately, depends upon the time required to assess the additional costs and to resolve the uncertainties. Whatever the decision there should be no delay in the research on the colour system.

621.397 2364
Color Television—Is it Ready to Adopt ?—(*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 88..120.) A critical discussion of the C.B.S. colour television demonstration, which, using films as a source of programmes, avoided the colour fringe effect. "Quite a different result is expected by engineer critics when the live colour-pickup camera goes into action." A list of the advantages and drawbacks of colour and black-and-white television is given.

621.397 2365
A Report on the Sixth Annual Conference of Broadcast Engineers.—L. Winner. (*Communications*, April 1946, Vol. 26, No. 4, pp. 30..74.) Summary of the paper Televising Motion Picture Films, by S. Helt. For other papers see 2125, 2143 and 2319.

621.397 : 621.396.619.16 2366
Pulse-Width Modulation [for television sound channels].—(*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, p. 4.) Illustrated summary of 459 of February.

621.397.2 2367
Discussion on "A Survey of the Problem of Post-War Television".—B. J. Edwards. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 216–220.) For original paper see 1109 of 1945.

621.397.26 2368
The B.B.C. Television Waveform.—(*Electronic Engng*, June 1946, Vol. 18, No. 220, pp. 176–178.) A revised specification of the radiated waveform of the B.B.C. transmissions, with diagrams, and with an appendix explaining the method of interlacing. Reprinted from 637 of 1939.

621.397.26 2369
Facsimile Methods for Broadcast Work.—(*Electronic Industr.*, June 1946, Vol. 5, No. 6, pp. 74..119.) A general account of the "Faximile" and "Telefax" systems.

621.397.26 2370
A New Television System : "Stratovision".—M. Adam. (*Génie civ.*, 15th March 1946, Vol. 123, No. 6, pp. 76–77.) See also 3970 of 1945.

621.397.5 **2371**
Field Television.—R. E. Shelby & H. P. See. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 77–93.) A résumé of the history of N.B.C. operations, with special reference to the greatly widened scope made possible by use of the image orthicon camera. The article concludes that there are now virtually no technical limitations on the televising of indoor programmes with normal illumination, and that the image orthicon camera " represents the greatest single advancement so far made in field television". See also 2374 below.

621.397.6 : 621.396.68 **2372**
Television Voltage [power supply] **Circuits: Part 13.**—Noll. (*See* 2349.)

621.397.61 **2373**
C.B.S. Color or Fine Line Television Transmitter.—(*See* 2386.)

621.397.611 **2374**
Image Orthicon Camera.—R. D. Kell & G. C. Sziklai. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 67–76.) A description of one of a series of developmental television cameras using the image orthicon. It is self contained, and weighs less than 40 lb. The power required is 300 W, and may be taken from a non-regulated supply. As an illustration of the sensitivity, there are three half-tone reproductions of a television picture of the head and shoulders of a subject illuminated with a 3-kW light, a 25-W desk lamp, and one candle respectively. For a brief description of the image orthicon itself see 1376 of May.

621.397.62 **2375**
Tele Color Reception.—R.R.B. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 82..118.) A description of the C.B.S. colour television apparatus to guide experimenters in building receiving sets. Various designs for colour-wheel filter segments are discussed. For a fuller account see 2051 of July (D.G.F.).

621.397.82 **2376**
Local Oscillator Radiation and Its Effect on Television Picture Contrast.—Herold. (*See* 2303.)

TRANSMISSION

621.396.61.029.58 **2377**
100 Watt—28 Mc Transmitter.—N. Lefor. (*Radio News*, April 1946, Vol. 35, No. 4, pp. 50–51.) Constructional details of a crystal-controlled 6L6 oscillator with 829B (beam double tetrode) frequency doubler and anode-modulated output stages.

621.396.61.029.62 **2378**
Transmitter for 2 Meters.—E. F. Crowell & R. L. Parmenter. (*Radio News*, June 1946, Vol. 35, No. 6, pp. 28..144.) Constructional details of an amateur a.m. or i.c.w. equipment that can be received consistently over 15–25 miles.

621.396.619 **2379**
Class " C " Grid Bias Modulation: Part 1.—W. W. Smith. (*Radio News*, April 1946, Vol. 35, No. 4, pp. 55..111.) An account of methods of reducing distortion by stabilization and by maintenance of correct operating conditions, including a comparison with class-B and anode modulation.

621.396.619.018.41 **2380**
A New Exciter Unit for Frequency Modulated Transmitters.—N. J. Oman. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 118–130.) A detailed account of the development and final design of a unit based on a reactance-tube modulator, as distinct from the Armstrong phase-shift system. A special feature is the stabilization of the carrier frequency by reference to a crystal-controlled oscillator by means of a capacitor mounted on the shaft of an induction motor which rotates in sense according to the sense of the frequency displacement. It is stated that the accuracy of this frequency control is limited by the heat cycle of the crystal oven. The distortion in the f.m. output of the exciter is of the order of 0.5% for modulating frequencies from 30 to 15 000 c/s. The noise level is 74 db below 100% modulation.

621.396.619.018.41 **2381**
Frequency Modulation by Non-Linear Coils.—L. R. Wrathall. (*Bell Lab. Rec.*, March 1946, Vol. 24, No. 3, pp. 102–105.) The current/magnetic-flux relationship in a coil wound on a permalloy core is nonlinear, and results in the occurrence of voltage pulses at each reversal of sign of the current. Addition of relatively low frequency signal current to the carrier current causes shifting of the position in time of current zeros, and therefore of voltage pulses, in opposite directions for positive and negative pulses. The pulses are thus phase-modulated. Pulses of one polarity are separated by a rectifier, and one of the harmonics selected by a band-pass filter.

621.396.619.018.41 **2382**
WHFM's F.M. Converter.—K. J. Gardner. (*Electronic Industr.*, April 1946, Vol. 5, No. 4, pp. 80–81.) The adaptation of a 45.1-Mc/s transmitter for simultaneous operation on 98.9 Mc/s. A circuit diagram is given. The r.f. output is 1 kW.

621.396.619.018.41 **2383**
Direct Frequency-Modulation Modulators.—N. Marchand. (*Communications*, April 1946, Vol. 26, No. 4, pp. 42..59.) An analysis of miscellaneous types of modulators not using the reactance tube. Input capacitance, transmission line, RC f.m. oscillator, and inductively coupled types are discussed, and design equations given. These systems employ a two-terminal impedance with a reactive component that varies with modulating voltage. For previous parts in this series see 1994 & 2068 of July.

621.396.662.078.3 : 621.396.619.018.41 **2384**
New Transmitter Circuits.—(*Radio*, N.Y., Feb. 1946, Vol. 30, No. 2, p. 35.) A block diagram of the Federal f.m. stabilization system in which an f.m. oscillator is controlled by a crystal oscillator. The resulting output of the modulated oscillator is phase modulated with respect to the fixed oscillator.

621.396.662.078.3 : 621.396.619.018.41 **2385**
F.M. Frequency Control System.—J. R. Boykin. (*Radio*, N.Y., Feb. 1946, Vol. 30, No. 2, pp. 20..63.) Each cycle of the beat between the modulated frequency and a fixed reference frequency is used to produce a pulse, the polarity of which depends on whether the reference frequency is greater or less than the other. The pulses are sorted according to polarity, integrated, and used to produce a voltage for correcting the mean frequency of the

modulated oscillator. The system regulates the oscillator frequency so that the areas of the frequency/time curve above and below the reference frequency are kept equal.

621.397.61 **2386**
C.B.S. Color or Fine Line Television Transmitter.—(*Radio, N.Y.*, Feb. 1946, Vol. 30, No. 2, pp. 31..58.) Description of a 600-W transmitter for 490 Mc/s, that can be amplitude-modulated from 0 to 10 Mc/s. A 6.8-Mc/s crystal-controlled oscillator feeds a chain of frequency-multipliers and amplifiers, the final stage being modulated by the output of a video-frequency amplifier having d.c. coupling between stages.

VALVES AND THERMIONICS

621.385 **2387**
Mechanism of the Operation of Kenotrons with Cold Emission.—V. Sorokina. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 1, p. 61.) Abstract of a paper of the Acad. Sci., U.S.S.R.

621.385 **2388**
The Role of Surface Charges in Electron Devices.—P. Timofeev. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 1, p. 61.) When an insulator is placed near the cathode a large potential gradient can be created due to secondary emission. Cold emission from the cathode can then occur. Kenotrons with cold cathodes have been devised with a potential drop below 100 V. Abstract of a paper of the Acad. Sci., U.S.S.R.

621.385 **2389**
The Passage of High-Frequency Currents through Electronic Devices.—G. Gvosdover. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 1, p. 63.) The successive approximations for the potential drop in a plane capacitor, carrying a variable electron beam, are established by expanding a power series of a small parameter. Cases considered include electron currents in the klystron and diode, and in the former the dependence of amplitude and wavelength of oscillation on current strength. Abstract of a paper of the Acad. Sci., U.S.S.R.

621.385 **2390**
Electronic Devices with Effective Emitters of Secondary Electrons.—P. Aranovich. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 1, p. 61.) Various metallic oxides with large secondary-emission coefficients have been investigated. The emission varied considerably with field gradient, and was reduced greatly by depositing fine metallic films on the oxide surface. Strong emission is accompanied by luminescence of the surface. Abstract of a paper of the Acad. Sci., U.S.S.R.

621.385 **2391**
Velocity Modulation.—J. E. Kauke. (*Radio News*, Feb. 1946, Vol. 35, No. 2, pp. 44..74.) An elementary description of the principle, and its application to twin-cavity and reflex klystrons.

621.385 **2392**
Contribution to the Physics and Technique of Velocity-Modulated Electronic Transmitting Tubes.—R. Warnecke. (*Onde élect.*, Sept. & Oct. 1945, Vol. 20, Nos. 222 & 223, pp. 47–60 & 72–100.) Reprint of 3879 of 1945.

621.385 **2393**
Some Electrical Characteristics of Reflex [velocity-modulated] **Tubes.**—H. V. Neher. (*Phys. Rev.*, 1st/15th Feb. 1946, Vol. 69, Nos. 3/4, p. 134.) "... expressions are derived for the efficiency and electronic tuning when the transit angle across the gap in the cavity has its optimum value and the tube is delivering maximum power to the load." Abstract of an Amer. Phys. Soc. paper.

621.385 : 538.312 **2394**
Energy Conversion in Electronic Devices.—D. Gabor. (*J. Instn elect. Engrs*, Part I, May 1945, Vol. 92, No. 53, pp. 208–209.) Summary of 1071 of 1945. For discussion, see same journal Part III, Vol. 93, No. 22, pp. 126–127.

621.385.012.6 **2395**
Oscillograms of Valve Characteristics.—B. D. Chhabra, H. R. Sarna & M. Parkash. (*Curr. Sci.*, Dec. 1945, Vol. 14, No. 12, pp. 319–320.) The dynamic characteristics traced with sine-wave excitation become looped or closed curves, even if the anode and grid resistances are non-inductive, provided the grid resistance is greater than a certain maximum value.

621.385.032.21 **2396**
A Note on the Protection of Heaters for Cathodes.—E.M.I. Laboratories. (*Electronic Engng*, April 1946, Vol. 18, No. 218, p. 112.) Protection of the brittle cathode-heater insulation during cathode assembly is obtained by coating it with a skin, *e.g.* by applying a solution of nitro-cellulose in amyl acetate, which vaporizes during the heat-processing of the valve.

621.385.032.24 **2397**
Some Electrostatic Properties of Grid Electrodes.—V. Lukoshkov. (*J. Phys., U.S.S.R.*, 1945, Vol. 9, No. 1, p. 61.) An analysis using the conception of an infinitely fine ideal grid which can be replaced by a complete electrode of the same shape having an effective variable potential distribution. Abstract of a paper of the Acad. Sci., U.S.S.R.

621.385.16 **2398**
Separate Cavity Tunable Magnetron.—G. D. O'Neill. (*Electronic Industr.*, June 1946, Vol. 5, No. 6, pp. 48..123.) A disk-sealed tube is clamped in a single external annular-cavity resonator that is tuned by screwed plugs. The particular magnetron described generates 4-μs 80-W pulses of about 6-cm wavelength at about 10% efficiency.

621.385.16(52) **2399**
Japanese Magnetrons.—M. Hobbs. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 114–115.) Japanese war-time valve research in the microwave region was concentrated on centimetre-wave magnetrons. Magnetrons were used as local oscillators, for practically no progress had been made with small klystrons.

621.385.16.029.64 **2400**
The Multi-Cavity Magnetron.—(*Bell. Lab. Rec.*, June 1946, Vol. 24, No. 6, pp. 219–223.) An illustrated descriptive account.

621.385.3 : 621.396.615 **2401**
Circuits for Sub-Miniature Tube.—F. R. (*See* 2149.)

621.385.832 **2402**

Improved Cathode-Ray Tubes with Metal-Backed Luminescent Screens.—D. W. Epstein & L. Pensak. (*RCA Rev.*, March 1946, Vol. 7, No. 1, pp. 5–10.) The application of a light-reflecting electron-pervious, thin metallic layer on the beam side of the luminescent screen is claimed to have the following advantages:—1. Improved efficiency of conversion of electron beam energy into useful light. 2. Elimination of ion spot—thus making other, generally less direct, means for eliminating the ion spot unnecessary. 3. Improved contrast. 4. Elimination of secondary emission restrictions—thus permitting the use of high voltages and screen materials with poor secondary emission. The chief effect of such a film is to throw forward the light that would otherwise be radiated back towards the gun. The idea is not new, but recent improvements in technique, which are detailed in the article, have now made it possible and practical. The metal now used is aluminium, the range of thickness being 500–5 000Å. An important innovation has been the covering of the fluorescent material, before the deposition of the aluminium, with a thin film of organic material. This makes it possible to get the necessary smooth and mirror-like surface on the aluminium.

621.385.832 **2403**

Origin of Ion Burn in Cathode-Ray Tubes.—G. Liebmann. (*Nature, Lond.*, 23rd Feb. 1946, Vol. 157, No. 3982, p. 228.) This effect is thought to be due to negative ions issuing from the thermionic cathode. Ion burns showing distinctive patterns corresponding to the electron emission patterns of the cathodes were observed. Details are given of an experiment demonstrating this effect using a tube with magnetic deflexion and focusing.

621.385.832 : 621.396.9 **2404**

The Skiatron in Radar Displays.—P. G. R. King: D. S. Watson. (*Electronic Engng*, June 1946, Vol. 18, No. 220, pp. 172–173.) A description of the dark-trace tube used as a light valve to obtain large-screen radar displays by projection methods. Electron bombardment of a c.r.t. screen composed of alkali-halide crystals produces a dark coloration on an otherwise white background, and episcopic projection using intense external illumination produces a magnified image. The coloration produced decays at a slow rate dependent on the conditions of electron bombardment, illumination, and temperature, the latter being regulated by forced air circulation in the equipment described. Extract from a lecture by King at the I.E.E. Radiolocation Convention, with additions from a paper by Watson.

621.385.832 : 621.397.62 **2405**

Some Novel Projection Type Television Tubes.—(*Electronic Engng*, June 1946, Vol. 18, No. 220, p. 186.) A short note from the E.M.I. Laboratories.

621.396.694 **2406**

The Calculation of Amplifier Valve Characteristics.—G. Liebmann. (*J. Instn elect. Engrs*, Part III, May 1946, Vol. 93, No. 23, pp. 138–152.) "The anode-current/grid-voltage characteristics of valves are determined with the help of diagrams and design charts based on Langmuir's data on the current flow in plane diodes with consideration of initial electron velocities, and on Oertel's and Herne's equations for the amplification factor. The theory is extended to multi-grid valves and to valves possessing a more complicated shape. Special attention is given to the "variable-mu effect", which represents one of the limiting factors in practical valve construction. A simple expression describing this effect is derived, and a chart of the "variable-mu constant", α, is presented, in which space charge is taken into account. Measurements on specially made experimental valves and on several types of modern mass-produced valves confirm the treatment of the variable-mu effect and show that the methods outlined in the paper, forming a complete design system, allow the prediction of the static valve characteristic with good accuracy even in closely spaced modern valves. Finally, the influences of a change in control-grid wire diameter, of a statistical variation of control-grid pitch, and of cathode misalignment, are discussed." See also 1812 of 1937 (Benjamin *et al.*) & 3395 of 1943 (Thompson).

MISCELLANEOUS

001.891 : 08 **2407**

A Neglected Aspect of Research.—T. Coulson. (*J. Franklin Inst.*, March 1946, Vol. 241, No. 3, pp. 187–193.) A more thorough exploration of available literature and patent specifications by extensive library research at the outset of a research programme would save effort and money.

026 : 621.396 **2408**

A Reference Library for Radio Engineers.—G. J. Hunt. (*Electronic Engng*, June 1946, Vol. 18, No. 220, pp. 187–188.) Suggested list of 10 journals and 75 textbooks for a radio reference library. Headings for an alphabetic subject index are suggested.

029 **2409**

Documentary Reproduction.—L. Moholy. (*Nature, Lond.*, 12th Jan. 1946, Vol. 157, No. 3976, pp. 38–40.) Mainly an account of the present and possible uses of microfilm. The subject is also discussed editorially on pp. 29–30.

061.22 : 621.396(054) **2410**

Waves and Electrons.—The designation of this publication as "Proc. Inst. Radio Engrs, Section II", with separate paging, stopped after April 1946. "Proc. Inst. Radio Engrs and Waves and Electrons" is now paged as one journal, and will be referred to as *Proc. Inst. Radio Engrs, W. & E.* See 1740 of June and 1122 of April.

061.231 : 62 **2411**

[A.I.E.E.] **Planning Subcommittee Issues Progress Report on Study of Organization of Engineering Profession.** — American Institute of Electrical Engineers. (*Elect. Engng, N.Y.*, April 1946, Vol. 65, No. 4, pp. 169–173.) Full text of report.

061.5 : 621.3(054–2) **2412**

Philips Research Reports.—A new bi-monthly journal describing the results of research at the Philips Laboratories. Abstracts of papers in the first number were given in July.

061.5 : [621.38 + 621.396 **2413**

The [wartime] **Work of the B.T.-H. Research Laboratory.**—(*Beama J.*, March 1946, Vol. 53, No. 105, pp. 102–107.)

061.6 : 621.3 2414
The British Electrical and Allied Industries Research Association.—(*Engineer, Lond.*, 15th Feb. 1946, Vol. 181, No. 4701, pp. 155–156.) A summary of the report for 1945. Items discussed include work on dielectric materials; gas-blast circuit breakers for heavy duty; radio interference at frequencies below 25 Mc/s; magnetic material research; the "capacitor transformer"; surge phenomena and effects of lightning on overhead lines. See also *Electrician*, 8th Feb. 1946, Vol. 136, No. 3532, pp. 341–342.

061.6 : 621.3.027.3 2415
High-Voltage Research at the National Physical Laboratory.—R. Davis. (*Engineer, Lond.*, 23rd & 30th Nov. 1945, Vol. 180, Nos. 4689 & 4690, pp. 412–413 & 435–436.) Very long summary of the I.E.E. Parsons Memorial Lecture.

061.6 : [621.38 + 621.3.029.6 2416
Research Laboratory of Electronics at the Massachusetts Institute of Technology.—J. A. Stratton. (*Rev. sci. Instrum.*, Feb. 1946, Vol. 17, No. 2, pp. 81–83.) Announcement of the organization of a new laboratory to undertake research on microwaves, electronic techniques, and electronic aids to computation.

061.6 : 621.39 2417
Telecommunications Research. — (*Elect. Rev., Lond.*, 24th May 1946, Vol. 138, No. 3574, pp. 811–812.) Description of work at the (British) Post Office research station at Dollis Hill. Lines of investigation include the submarine repeater, the vocoder system, for converting speech to a telegraph-like code for transmission and reconstructing it at the receiver, coaxial-cable telephony, the production of crystal resonators, and methods of countering the effects of fading in radio reception.

347.771(73) 2418
Final Report of the National Patent Planning Commission.—A. W. Graf. (*Proc. Inst. Radio Engrs, N.Y.*, Part II, April 1946, Vol. 34, No. 4, p. 198.) Suggestions for improving the American system.

[...+6] : 623 2419
Impact of the War on Science.—L. J. Briggs. (*Elect. Engng, N.Y.*, Jan. 1946, Vol. 65, No. 1, pp. 8–10.) An account of the resulting acceleration in scientific research.

[...+6] "1939/1945" 2420
The Scientist in Wartime.—E. V. Appleton. (*Engineer, Lond.*, 23rd & 30th Nov. & 7th Dec. 1945, Vol. 180, Nos. 4689–4691, pp. 417–419, 432–433 & 454–455.) Very long summary of the Thomas Hawksley Lecture at the Instn Mech. Engrs.

519.283 2421
Quality Control through Product Testing.—P. L. Alger. (*Elect. Engng, N.Y.*, Jan. 1946, Vol. 65, No. 1, pp. 11–12.) The procedure required for statistical quality control is defined, and methods of sample testing to maintain an assigned level of quality are given.

519.283 2422
Statistical Methods in Quality Control: Part 8.—A.I.E.E. Subcommittee on Educational Activities. (*Elect. Engng, N.Y.*, Jan. 1946, Vol. 65, No. 1, pp. 23–24.) "The use of control charts for action when inspection is by the method of variables and the factors for control are averages and ranges . . The method is illustrated by a typical application; the cutting of small sleeves from a tubing material where weight is one of the critical characteristics to be controlled." For parts 7 and 9 see 1411/1412 of May; for previous parts see 805 of March.

519.283 2423
Statistical Methods in Quality Control: Part 10—Classification of Defects and Quality Rating.—A.I.E.E. Subcommittee on Educational Activities. (*Elect. Engng, N.Y.*, March 1946, Vol. 65, No. 3, pp. 117–119.) A measure of quality as the ratio of defective units to total units is usually adequate for simple products. It is suggested that for more complex products, classification of defects according to seriousness is needed, and quality rating by number of demerits per unit is explained.

519.283 2424
Quality Control of Production.—Statistician. (*Beama J.*, Feb. 1946, Vol. 53, No. 104, pp. 42–44.)

519.283 2425
Statistical Tools for Controlling Quality. — J. Manuele & C. Goffman. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 949–951.) Discussion of 503 of February.

519.283 2426
Statistical Methods in the Development of Apparatus Life Quality.—E. B. Ferrell. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, pp. 998–999.) Discussion of 804 of March.

519.283 : 519.24 2427
A Simple Test of Significance.—(*Engineering, Lond.*, 30th Nov. 1945, Vol. 160, No. 4168, p. 452.) Letter proposing a method of determining whether there is a significant difference between the results of two comparative series of measurements.

519.283 : 621.315.62 2428
Statistical Methods Applied to Insulator Development and Manufacture.—J. J. Taylor. (*Trans. Amer. Inst. elect. Engrs*, December Supplement 1945, Vol. 64, p. 952.) Discussion of 255 of January.

536.2 : 621.3.012.8 2429
The Accuracy of Lumping in an Electric Circuit representing Heat Flow in Cylindrical and Spherical Bodies.—V. Paschkis & M. P. Heisler. (*J. appl. Phys.*, April 1946, Vol. 17, No. 4, pp. 246–254.) "In using lumped resistance-capacitance circuits for studying heat conduction problems the influence of number and size of lumps is important. Several methods of lumping are conceivable for representation of cylindrical or spherical bodies and results of comparative tests show that equal geometrical size of lumps is most accurate. In the various lumps resistance and capacitance have to be in certain definite relationships, which are established in the paper. The influence of number of lumps is also investigated."

538.323 2430
An [alternating-current] **Electromagnet for Non-Magnetic Substances.**—W. V. Lovell. (*Phys. Rev.*, 1st/15th March 1946, Vol. 69, Nos. 5/6, p. 251.) The device depends on the interaction between currents in the "magnet" coil and induced currents in nearby conductors. Abstract of an Amer. Phys. Soc. paper.

551.575 2431
A Method of Determining the Size of [fog] Droplets Dispersed in a Gas.—R. L. Stoker. (*J. appl. Phys.*, April 1946, Vol. 17, No. 4, pp. 243–245.) "A method applicable to determining droplet sizes in the interior of an already existing atmosphere of fog or mist is developed and described. The method makes use of the fact that if droplets strike a suitably [soot-] coated surface without wetting the surface, a track of the contact area is formed. A criterion is derived and experimentally evaluated for relating the droplet diameter and the track diameter."

614.825 : 621.396.61 2432
Safety in the Shack.—(*R.S.G.B. Bull.*, June 1946, Vol. 21, No. 12, pp. 181, 184.) Recommendations for safe operation of amateur transmitters.

620.197+621.314.634 2433
Cathodic Protection and Applications of Selenium Rectifiers.—W. F. Bonner. (*Elect. Comm.*, 1945, Vol. 22, No. 4, p. 338.) Correction to 1944 of 1945.

621–752 2434
Modern Vibration Control Installations for Aircraft Radio and Instruments.— (*Aero Digest*, 1st June 1945, Vol. 49, No. 5, pp. 89–91, 144.) Description and performance of the "Vibrashock" suspension mount. " . . . any attempt to design a so-called 'standard' mount will necessarily prove unsatisfactory."

621.3 (07) 2435
Post-Graduate Engineering.—(*Elect. Rev., Lond.*, 15th Feb. 1946, Vol. 138, No. 3560, p. 257.) Summary of I.E.E. discussion on "Post-Graduate Courses in Electrical Engineering including Radio" led by W. Jackson and J. Greig.

621.3.081.4 2436
Absolute Bels.—F. S. G. Scott. (*Wireless Engr*, May 1946, Vol. 23, No. 272, pp. 132–139.) Author's definition :—"When any power (P_x) is compared (in bels) with one watt, the resultant answer is expressed in absolute bels." The symbol B is proposed for the absolute bel, with dB for the absolute decibel. It is also proposed that factors (forces, lengths, resistances, etc.) which are not themselves power, but which determine power in certain circumstances, may be expressed in bels. The application of these proposals is illustrated by reference to electrical and acoustical systems.

621.316.93 : 629.13 2437
Method of Removing Static Charges from Moving Bodies.—R. C. Ayres. (*Radio, N.Y.*, March 1946, Vol. 30, No. 3, p. 49.) Essentially for dissipating precipitation static charges on aircraft. Summary of U.S. Patent 2 386 084.

621.38/.39](43) 2438
German Electronic Equipment. — (*Elect. Rev., Lond.*, 15th March 1946, Vol. 138, No. 3564, p. 429.) A short account of the S.I.G.E.S.O. exhibition of German service equipment including radar, infrared technique, and guided missiles.

621.38 : 778 2439
Electronic Flash Tubes.—D. A. Senior. (*Electronic Engng*, May 1946, Vol. 18, No. 219, pp. 133–135, 141.) Application of high-speed photography to the study of under-water explosions. Exposure may be controlled by a high-speed shutter or by using intense flashes of short duration for illumination.

621.396 2440
Radio at the Paris Fair (8–24 Sept. 1945).—M. Adam. (*Génie civ.*, 1st Nov. 1945, Vol. 122, No. 21, pp. 168–169.) A review of the exhibits under the headings French broadcasting, broadcast receivers, television receivers, components, miscellaneous equipment, and test gear.

621.396.828 : [621.365.5+621.365.92 2441
Radiation from R.F. Heating Generators.—A. G. Swan. (*Electronics*, May 1946, Vol. 19, No. 5, pp. 162 . . 170.) Sufficient attenuation of the radiation is obtained by the use of a double-shielded room, constructed of copper or steel net up to ½-inch mesh. A filter at the mains input prevents radiation from the power lines.

621.396.933 2442
The Aircraft Radio Serviceman.—T. Wayne. *Radio News*, April 1946, Vol. 35, No. 4, pp. 28 . . 116.) Hints on the installation and maintenance of radio equipment in small private aircraft. The causes of precipitation static and means of reducing it are considered.

658 : 621.396.621 2443
Mass Production.—H. G. Shea. (*Electronic Industr.*, June 1946, Vol. 5, No. 6, pp. 51–55, 123.) Description of organization and methods employed in a typical receiver manufacturing plant. Emphasis is placed on cutting the number of departments to a minimum, thereby reducing the administrative staff required, and on keeping rigidly to time schedules for every operation.

519.283 2444
Sequential Analysis of Statistical Data : Applications. [Book Review]—Statistical Research Group, Columbia Univ. Columbia Univ. Press, New York, $6.50. (*Science*, 19th April 1946, Vol. 103, No. 2677, pp. 490–492.)

621.3 2445
Basic Electrical Engineering. [Book Review]—A. E. Fitzgerald. McGraw-Hill Book Co., New York, 1945, 441 pp., $ 3.75. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, p. 128). "A text book for students majoring in engineering, covering circuits, machines and electronics."

621.396 2446
Principles of Radio. [Book Review]—K. Henney. John Wiley & Sons, New York, 5th edn. 1945, $3.50, 21s. (*Engineering, Lond.*, 21st Dec. 1945, Vol. 160, No. 4171, p. 511.) "Can be recommended as a comprehensive course, suitable for those beginning the study of radio."