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WIRELESS ENGINEER

The Journal of Radio Research & Progress

DECEMBER 1946
Vol. XXIII. No. 279

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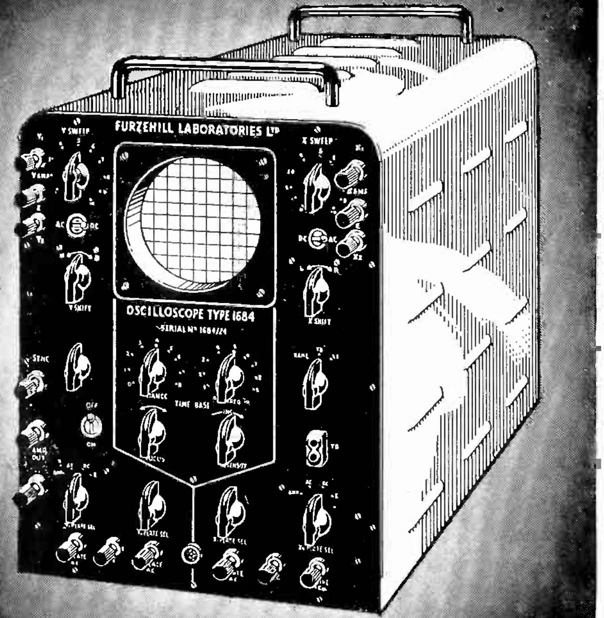

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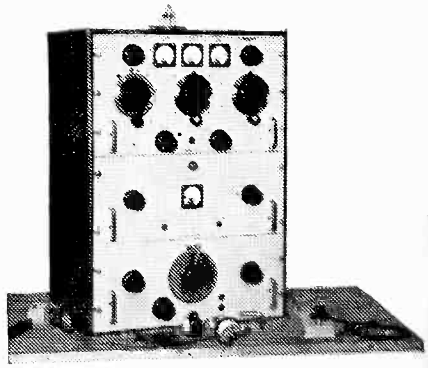

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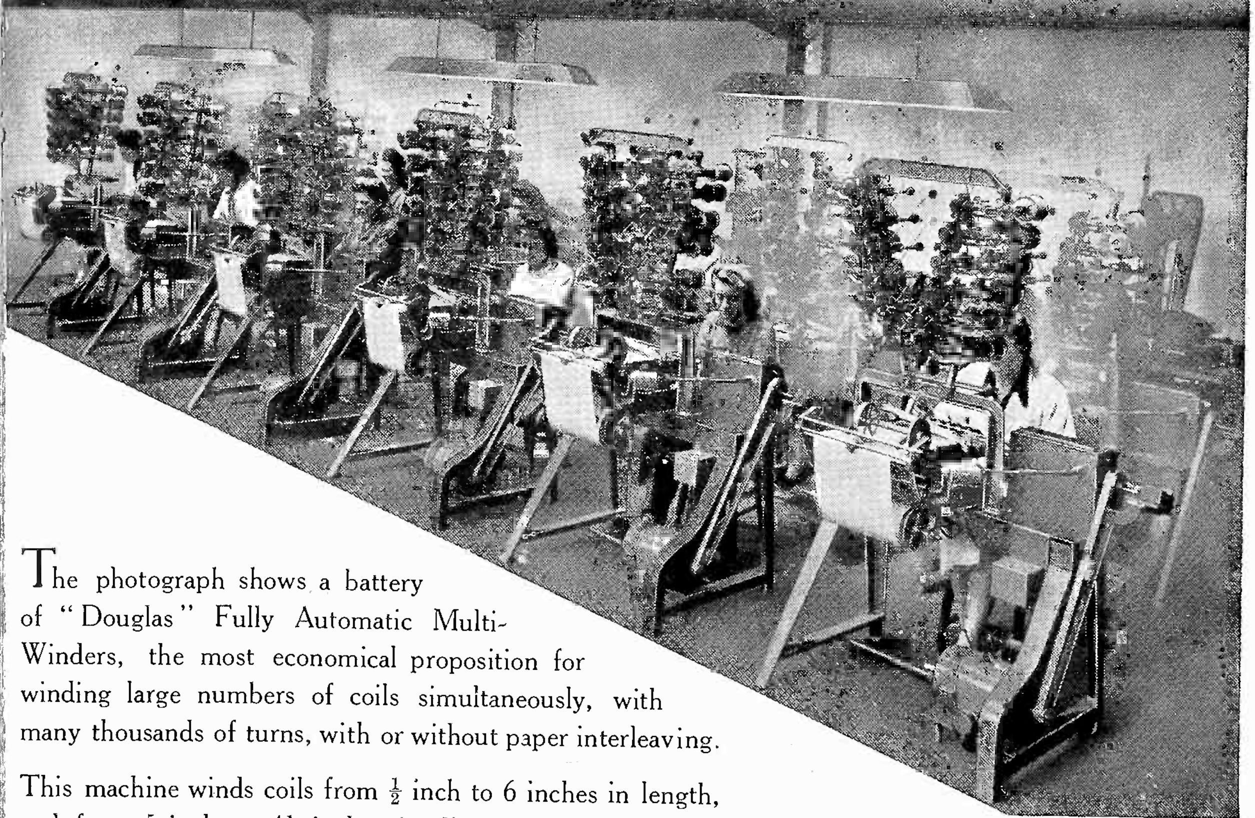

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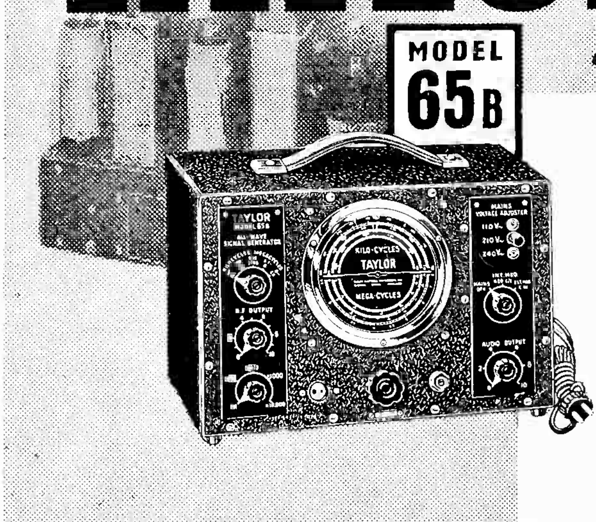

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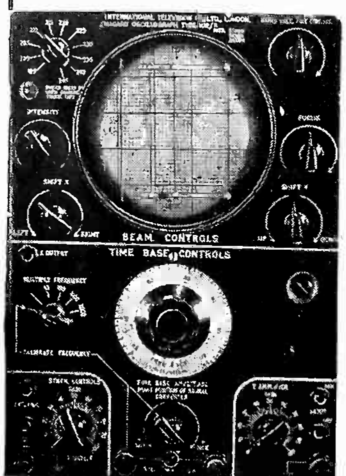

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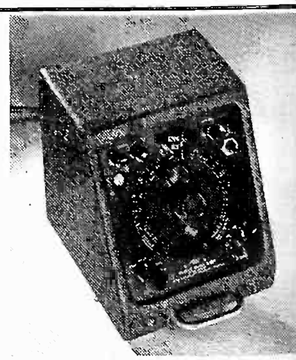

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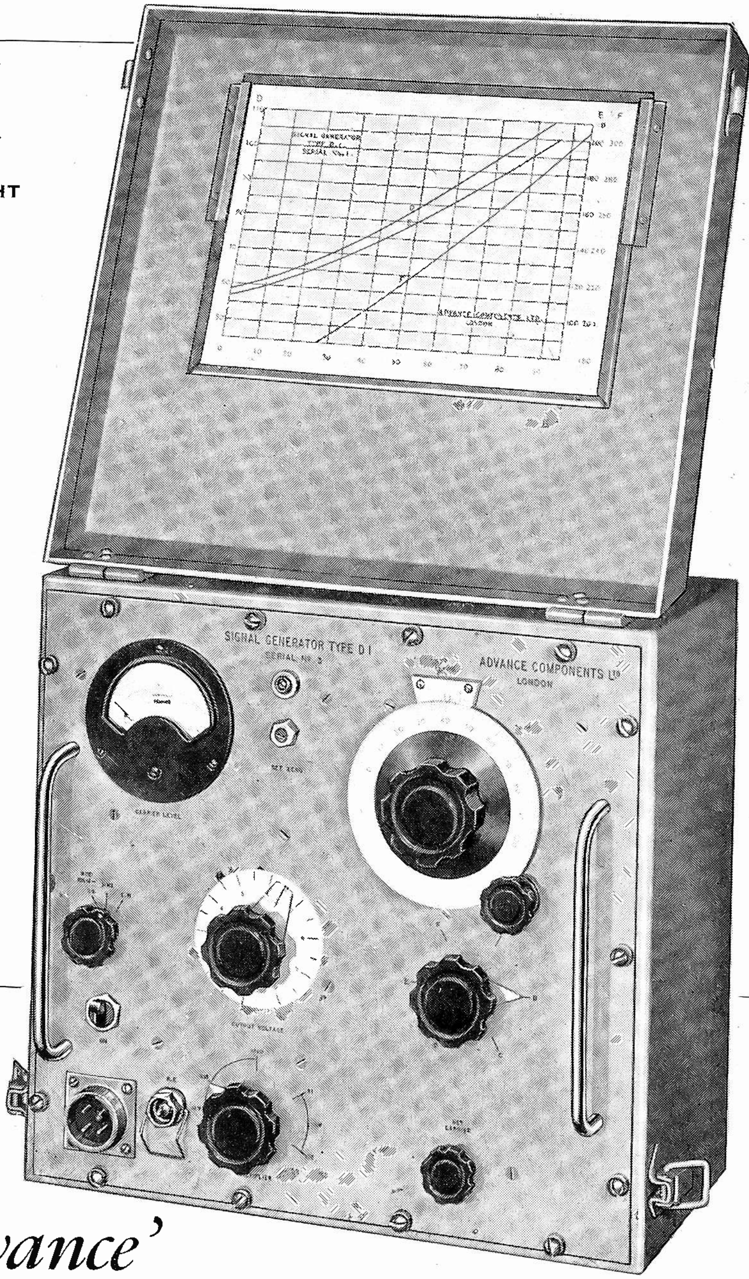

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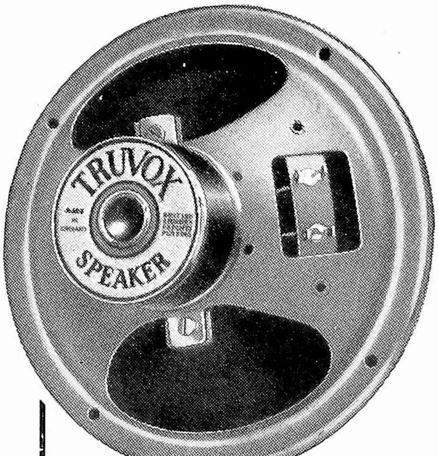

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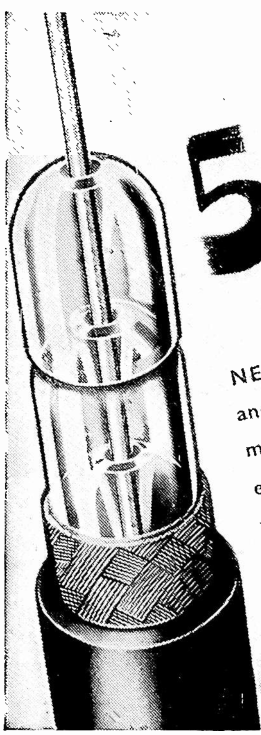

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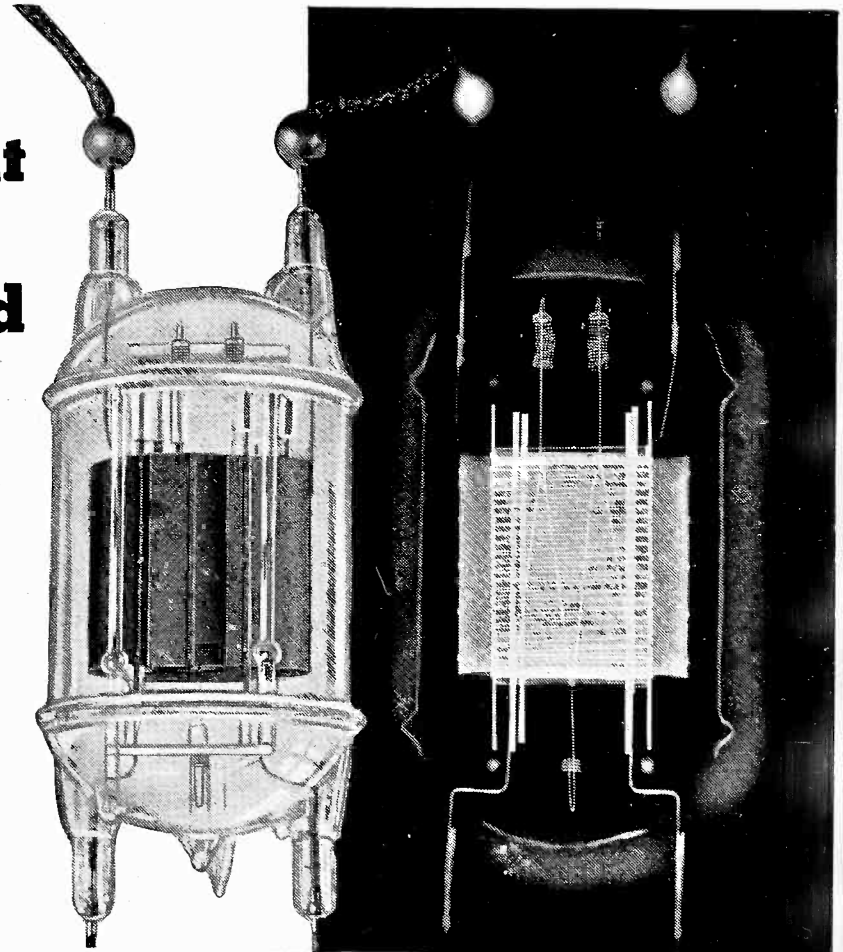

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EDITORIAL

Stresses in Magnetic and Electric Fields

THIS is a subject on which there has been since the days of Maxwell, and on which there still is, a surprising lack of agreement.

When the magnetic field crosses the air-gap between an electromagnet and the piece of iron which is being attracted, it is known that the tension in the field is equal to $B^2/8\pi$ dynes per square centimetre. The greater part of this acts on the surface of the iron, but not all of it, for the magnetic field passes into the iron with the same value of B but a greatly reduced H and a greatly reduced tension. There appear to be considerable differences of opinion as to the magnitude of this tension within the iron. In section 642 of Vol. II of "Electricity and Magnetism," Clerk Maxwell considers this question and comes to the conclusion that the resulting force, in the simple case which we are considering, may be regarded as made up of two components; viz., a uniform pressure of $H^2/8\pi$ in all directions, and a tension in the direction of the field of $BH/4\pi$. This gives a resultant tension of

$$BH/4\pi - H^2/8\pi \text{ or } \left(B^2/8\pi\right)\left(\frac{2}{\mu} - \frac{1}{\mu^2}\right) \text{ dynes}$$

per cm² in the iron, so that if $\mu = 1000$, all but 1/500 of the air-gap force acts on the surface polarity.

The tension within the iron is not lost so far as the lifting power of the magnet is concerned, but it acts in a different way. If one pictures the flux passing through the iron from pole to pole as stretched elastic threads it is seen at once that there must be a "catapult" force on the iron.

On p. 180 of his "Principles of Electromagnetism" Moullin considers this problem and comes to a different conclusion. He says that if the intensity of surface polarity is I', then "at a point of space between the two surfaces the force on a unit pole would be $B = H + 2\pi I' + 2\pi I'$ (H is, of course, the magnetizing force inside the iron). But the force on a unit pole in one of the surfaces is less than B by the contribution from one surface. There is polarity I' per unit area, and therefore the pull on the face is

$$P = (H + 2\pi I')\, I'A$$
$$= \left\{H + 2\pi\frac{(B-H)}{4\pi}\right\}\frac{(B-H)}{4\pi}A$$
$$= \frac{B^2 - H^2}{8\pi}A = \frac{B^2}{8\pi}\left(1 - \frac{1}{\mu^2}\right)A."$$

Moullin attributes the fact that this is less than $B^2/8\pi$ per cm² to the neglect of leakage flux, but, as a matter of fact, the result is bigger than it should be, for it is only supposed to give the force on the surface polarity, which according to Maxwell should be

$$\left(B^2/8\pi\right)\left(1 - \frac{2}{\mu} + \frac{1}{\mu^2}\right).$$

This discrepancy is apparently due to the assumption that the force on each square centimetre of the pole-face is $I'(H + 2\pi I')$; if Maxwell is correct it is really only $2\pi I'^2$. In the gap where the unit pole is placed in a uniform field of strength equal to B the force on it will be equal to B, but as the flux enters the pole-face we must picture B splitting up into two components H and $4\pi I'$, of which the former passes through the surface into the iron and takes no part in the polar force. Hence, the force on the polar surface per cm² is not $\frac{B-H}{4\pi}\left(H+\frac{B-H}{2}\right)$ but only $\left(\frac{B-H}{4\pi}\right)\left(\frac{B-H}{2}\right)$ which is equal to $\frac{B^2}{8\pi}-\frac{BH}{4\pi}+\frac{H^2}{8\pi}$ and since the total tension per cm² is $B^2/8\pi$, the tension inside the iron is equal to the difference, viz

$$\frac{BH}{4\pi}-\frac{H^2}{8\pi}=\frac{B^2}{8\pi}\left(\frac{2}{\mu}-\frac{1}{\mu^2}\right)=\frac{BH}{8\pi}\left(2-\frac{1}{\mu}\right)$$

which is in accordance with Maxwell. On a subsequent page Moullin gives the Maxwell formula and refers to it as the correct answer.

Larmor in the analogous electric case obtained the same result as Moullin in a different manner. In the air-gap the force on unit pole would be B, whereas in the iron it would be H; if the unit pole is situated on the boundary between them, the most obvious value to take is the mean $(B+H)/2$, and since the pole strength per cm² is $(B-H)4\pi$, this gives a force per cm² of $(B^2-H^2)/8\pi$, which is the value obtained by Moullin. We should add that Larmor did not support this, but merely gave it as one of what he called the "discrepant" values.*

The problem can be approached in a different manner, which also has its pitfalls—very subtle ones—into which we have fallen in the past. If a uniformly wound toroid of permeability μ is split across a diameter and immersed in a medium also of permeability μ, then on separating the two halves, the gap is not filled with air but with the medium of the same permeability as the toroid. If we assume that the current is increased as the gap is opened so that the flux Φ is maintained constant, there will be no induced e.m.f. and no interchange of energy with the electric circuit; hence, B, H, and Φ are unchanged but the volume has been increased by $2Ag$, if A is the cross-sectional area of the ring and g the length of the gap. Since the energy per cm³ is $HB/8\pi$ we have for the pull required

$$P\times g=\frac{HB}{8\pi}\times 2Ag \text{ and } P=\frac{HB}{8\pi}\times 2A.$$

Proc. Roy. Soc. LII (1892) p. 55.

The pull per cm² is therefore

$$HB/8\pi=\frac{B^2}{8\pi}\cdot\frac{1}{\mu}$$

and, since there are no poles, this should be the tension inside the material of permeability μ. This is only half the value given by the Maxwell formula, but if $\mu=1000$, it is a thousand times the value given by Moullin's formula. In the analogous electric case Larmor also gave this as one of the "discrepant" values.

Assuming that Maxwell's formula gives the correct value we have to explain why the above way of looking at the problem gives only half the correct result. If the voltage applied to a capacitor is gradually increased from 0 to V, the energy supplied to it is $0.5QV$ or $0.5CV^2$, but if the voltage V is suddenly applied to it, so that the whole charge enters it under the full voltage V then the energy supplied to it must be QV or CV^2, that is, twice the previous value. Similarly if, instead of gradually increasing the load on a spring-balance, one applies the whole weight suddenly, twice the energy is given to the spring. In both cases the extra energy is dissipated as heat due to oscillations before the steady state is reached. Similarly if, instead of gradually building up a magnetic field by increasing the m.m.f., one applies the full value to the unmagnetized material, the energy supplied is not the $HB/8\pi$ per cm³ or the $0.5LI^2$ which is finally stored, but twice this value, the other half being dissipated. When the gap was made between the two half-rings and filled with a medium of the same permeability, we assumed that the current was increased so that the flux Φ was maintained constant; this means that the value of B in the medium in the gap was not gradually increased but instantly raised to its full value. The energy supplied to the gap was therefore twice that ultimately stored in it and the work done in separating the two half-rings was double that calculated above. This gives for the tension or pull per cm² $\frac{B^2}{8\pi}\cdot\frac{2}{\mu}$ which agrees with the Maxwell formula, except for the usually negligible term involving $1/\mu^2$.

We now proceed, however, to remove even this small discrepancy. In the case of an air capacitor suddenly connected across a battery of negligible resistance by means of wires also of negligible resistance, the initial rush of current would be limited by the inductance of the circuit, since $di/dt = V/L$ when $t = 0$; an oscillatory current would be set up, which in the absence of losses would continue indefinitely, charging and discharging the capacitor. Owing to the unavoidable losses in the battery and leads, however, the oscillation would be damped out, leaving the capacitor charged with an amount of energy $0.5CV^2$ and this is the total energy supplied to the capacitor. If the air capacitor were replaced by one with a dielectric in which losses occur then the oscillation would be damped out, even although the battery and leads were free from loss, but the energy supplied to the capacitor would then include both the stored energy and that dissipated in the dielectric. The total electrical displacement within the dielectric is made up of two components in accordance with the formula $D = \kappa_0\mathcal{E} + 4\pi P$ in which the first term represents the component which would be present even in a vacuum and the second the component due to the molecular polarization, or displacement of electrons within the dielectric molecules. We may regard the capacitor as made up of two capacitors in parallel, in the first of which the energy supplied is only that ultimately stored in it, whereas in the other the energy supplied is double that ultimately stored, the excess being dissipated as dielectric hysteresis. From this point of view the doubling of the energy would not apply to the whole capacitance but only to the polarized portion, which forms $1 - \kappa_0/\kappa$ of the whole.

Exactly similar considerations can be applied to the magnetic case of a uniformly wound toroid which is connected in series with a constant current source but which is normally short-circuited. On opening the short-circuit switch, the coil is suddenly called on to carry the constant current. Just as the unavoidable inductance fixed the rate at which the capacitor was charged, so here the unavoidable capacitance between the leads and turns fixes the rate at which the current through the coil, and with it the magnetic flux, increases. The initial rate of voltage rise across the coil will be given by the formula $dv/dt = I/C$. Oscillations occur as in the capacitor, and by analogous considerations it is easily seen that in the formula $B = \mu_0 H + 4\pi J$ it would only be the latter term that would involve a doubling of the stored energy to cover the losses incurred in the oscillations set up by what may be called shock excitation. Hence instead of the energy supplied to the gap in the above experiment being

$$\frac{HB}{8\pi} \times 2$$

it is

$$\frac{H^2}{8\pi} + \frac{H(B-H)}{8\pi} \times 2$$

$$= \frac{BH}{4\pi} - \frac{H^2}{8\pi} = \frac{B^2}{8\pi}\left(\frac{2}{\mu} - \frac{1}{\mu^2}\right)$$

Our experiment with the two half-rings is, of course, purely fictitious; we imagine the two half-rings made, say, of iron, and when they are separated we picture the gap being immediately filled with some imaginary medium of the same permeability magnetized instantly to the full value, since we assume a constant flux in the ring.

Analogous reasoning can be applied to the electric case. Instead of an iron ring we assume a ring of some dielectric material split across a diameter and immersed in a medium of the same dielectric constant. Instead of maintaining a magnetic flux by means of a current through the ring, we imagine an electric flux to be maintained by a changing magnetic field through the ring. If we replace H by $\mathcal{E}$ and B by $4\pi D$ we obtain for the electric tension per cm² along the field

$$D\mathcal{E} - \frac{\mathcal{E}^2}{8\pi} = 2\pi D^2\left(\frac{2}{\kappa} - \frac{1}{\kappa^2}\right)$$

This formula for the electric field is not given by Maxwell, but if the formula gives the correct stress in the magnetic field the parallelism is such that it must also give the correct stress in the electric field.

We would emphasize that we have not proved the correctness of Maxwell's formula, but rather, assuming its correctness, we have shown how it can be obtained from simple energy considerations if certain assumptions are made. A number of eminent physicists, including Helmholtz, have disagreed with the Maxwell formula, and maintained that the tension is simply $BH/8\pi$ and not $\frac{BH}{8\pi}\left(2 - 1/\mu\right)$. In support of this it might be pointed out that in the above imaginary experiment, although the flux density in the gap is maintained constant, the medium can only get into the gap by passing through the fringe of the field in which the flux density increases gradually from zero to the full value, thus avoiding any shock excitation.

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uniform field of strength equal to B the force on it will be equal to B, but as the flux enters the pole-face we must picture B splitting up into two components H and $4\pi I'$, of which the former passes through the surface into the iron and takes no part in the polar force. Hence, the force on the polar surface per cm² is not $\frac{B-H}{4\pi}\left(H+\frac{B-H}{2}\right)$ but only $\left(\frac{B-H}{4\pi}\right)\left(\frac{B-H}{2}\right)$ which is equal to $\frac{B^2}{8\pi}-\frac{BH}{4\pi}+\frac{H^2}{8\pi}$ and since the total tension per cm² is $B^2/8\pi$, the tension inside the iron is equal to the difference, viz

$$\frac{BH}{4\pi}-\frac{H^2}{8\pi}=\frac{B^2}{8\pi}\left(\frac{2}{\mu}-\frac{1}{\mu^2}\right)=\frac{BH}{8\pi}\left(2-\frac{1}{\mu}\right)$$

which is in accordance with Maxwell. On a subsequent page Moullin gives the Maxwell formula and refers to it as the correct answer.

Larmor in the analogous electric case obtained the same result as Moullin in a different manner. In the air-gap the force on unit pole would be B, whereas in the iron it would be H; if the unit pole is situated on the boundary between them, the most obvious value to take is the mean $(B+H)/2$, and since the pole strength per cm² is $(B-H)4\pi$, this gives a force per cm² of $(B^2-H^2)/8\pi$, which is the value obtained by Moullin. We should add that Larmor did not support this, but merely gave it as one of what he called the "discrepant" values.*

The problem can be approached in a different manner, which also has its pitfalls—very subtle ones—into which we have fallen in the past. If a uniformly wound toroid of permeability μ is split across a diameter and immersed in a medium also of permeability μ, then on separating the two halves, the gap is not filled with air but with the medium of the same permeability as the toroid. If we assume that the current is increased as the gap is opened so that the flux Φ is maintained constant, there will be no induced e.m.f. and no interchange of energy with the electric circuit; hence, B, H, and Φ are unchanged but the volume has been increased by $2Ag$, if A is the cross-sectional area of the ring and g the length of the gap. Since the energy per cm³ is $HB/8\pi$ we have for the pull required

$$P\times g=\frac{HB}{8\pi}\times 2Ag \text{ and } P=\frac{HB}{8\pi}\times 2A.$$

The pull per cm² is therefore

$$HB/8\pi=\frac{B^2}{8\pi}\cdot\frac{1}{\mu}$$

and, since there are no poles, this should be the tension inside the material of permeability μ. This is only half the value given by the Maxwell formula, but if $\mu = 1000$, it is a thousand times the value given by Moullin's formula. In the analogous electric case Larmor also gave this as one of the "discrepant" values.

Assuming that Maxwell's formula gives the correct value we have to explain why the above way of looking at the problem gives only half the correct result. If the voltage applied to a capacitor is gradually increased from 0 to V, the energy supplied to it is $0.5QV$ or $0.5CV^2$, but if the voltage V is suddenly applied to it, so that the whole charge enters it under the full voltage V then the energy supplied to it must be QV or CV^2, that is, twice the previous value. Similarly if, instead of gradually increasing the load on a spring-balance, one applies the whole weight suddenly, twice the energy is given to the spring. In both cases the extra energy is dissipated as heat due to oscillations before the steady state is reached. Similarly if, instead of gradually building up a magnetic field by increasing the m.m.f., one applies the full value to the unmagnetized material, the energy supplied is not the $HB/8\pi$ per cm³ or the $0.5LI^2$ which is finally stored, but twice this value, the other half being dissipated. When the gap was made between the two half-rings and filled with a medium of the same permeability, we assumed that the current was increased so that the flux Φ was maintained constant; this means that the value of B in the medium in the gap was not gradually increased but instantly raised to its full value. The energy supplied to the gap was therefore twice that ultimately stored in it and the work done in separating the two half-rings was double that calculated above. This gives for the tension or pull per cm² $\frac{B^2}{8\pi}\cdot\frac{2}{\mu}$ which agrees with the Maxwell formula, except for the usually negligible term involving $1/\mu^2$.

We now proceed, however, to remove even this small discrepancy. In the case of an air capacitor suddenly connected across a battery of negligible resistance by means of wires also of negligible resistance, the initial rush of current would be limited by the

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inductance of the circuit, since $di/dt = V/L$ when $t = 0$; an oscillatory current would be set up, which in the absence of losses would continue indefinitely, charging and discharging the capacitor. Owing to the unavoidable losses in the battery and leads, however, the oscillation would be damped out, leaving the capacitor charged with an amount of energy $0.5CV^2$ and this is the total energy supplied to the capacitor. If the air capacitor were replaced by one with a dielectric in which losses occur then the oscillation would be damped out, even although the battery and leads were free from loss, but the energy supplied to the capacitor would then include both the stored energy and that dissipated in the dielectric. The total electrical displacement within the dielectric is made up of two components in accordance with the formula $D = \mathcal{E}/4\pi + P$ in which the first term represents the component which would be present even in a vacuum and the second the component due to the molecular polarization or displacement of electrons within the dielectric molecules. We may regard the capacitor as made up of two capacitors in parallel, in the first of which the energy supplied is only that ultimately stored in it, whereas in the other the energy supplied is double that ultimately stored, the excess being dissipated as dielectric hysteresis. From this point of view the doubling of the energy would not apply to the whole capacitance but only to the polarized portion, which forms $(\kappa - 1)/\kappa$ of the whole.

Exactly similar considerations can be applied to the magnetic case of a uniformly wound toroid which is connected in series with a constant current source but which is normally short-circuited. On opening the short-circuit switch, the coil is suddenly called on to carry the constant current. Just as the unavoidable inductance fixed the rate at which the capacitor was charged, so here the unavoidable capacitance between the leads and turns fixes the rate at which the current through the coil, and with it the magnetic flux, increases. The initial rate of voltage rise across the coil will be given by the formula $dv/dt = I/C$. Oscillations occur as in the capacitor, and by analogous considerations it is easily seen that in the formula $B = \mu_0 H + 4\pi J$ it would only be the latter term that would involve a doubling of the stored energy to cover the losses incurred in the oscillations set up by what may be called shock excitation. Hence instead of the energy supplied to the gap in the above experiment being

$$\frac{HB}{8\pi} \times 2$$

it is

$$\frac{H^2}{8\pi} + \frac{H(B-H)}{8\pi} \times 2$$
$$= \frac{BH}{4\pi} - \frac{H^2}{8\pi} = \frac{B^2}{8\pi}\left(\frac{2}{\mu} - \frac{1}{\mu^2}\right)$$

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G. W. O. H.

EFFECTIVE IMPEDANCE OF A SPHERE IN A MAGNETIC FIELD*

By T. S. E. Thomas, B.Sc., Ph.D.

SUMMARY.—A conducting sphere in a uniform magnetic field may be regarded as being equivalent to a single-turn coil of the same diameter. Formulae are given for (a) the equivalent resistance and inductance of the coil, (b) the change in inductance and resistance of a solenoid when a sphere is placed at its centre, (c) the heat dissipated in a sphere in a uniform alternating magnetic field.

Introduction

EDDY currents have an analogous position in electrical engineering to frictional losses in other branches of engineering since their effects are sometimes undesirable, sometimes useful and are always difficult to estimate. The mathematical theory of eddy-current distributions has been almost entirely concerned with problems involving either infinite cylinders or unbounded planes. In recent years the developments in induction heating and in eddy-current methods of detecting concealed metal objects have shown the need for methods of predicting the effect of eddy-currents in objects of finite size. So far the only case which has been really amenable to mathematical calculation is that of the conducting sphere in a varying magnetic field. Although numerous papers have dealt with various aspects of this problem, formulae of practical importance are only given in two papers and as some are inaccurate, it has been thought desirable to revise and extend the theory.

General Theory

The field disturbance caused by placing a conducting sphere in a uniform alternating magnetic field can be described physically in two ways :—

1. It can be regarded as being equivalent to that due to a magnetic dipole the moment of which varies harmonically and has a phase lag behind the field.

2. It can be regarded as being equivalent to that due to a single-turn coil with the same diameter as the sphere. This coil has an equivalent resistance and inductance of such magnitude that the induced current in the coil has the same magnetic field as the dipole described above. The resistance and inductance will in general be functions of the frequency.

A formula for the moment of the equivalent dipole has been given by Smythe[1] and also by Divi lkovski[2]. It is possible, starting from this result, to deduce the equivalent resistance and inductance of the sphere. The magnetic moment P of the dipole in a field $H = H_0 \cos \omega t$ is

$$P=\frac{2(\mu-1)\, I_{1/2}(v)-(2\mu+1)I_{5/2}(v)}{(\mu+2)I_{1/2}(v)-(\mu-1)I_{5/2}(v)}\cdot\frac{a^3 H}{2} \qquad (1)$$

where a is the radius of the sphere, μ the permeability, ρ the specific resistance and $I_{1/2}(v)$ and $I_{5/2}(v)$ are modified Bessel functions of order 1/2 and 5/2 with $v = \left(\frac{4\pi\mu\omega}{\rho}j\right)^{1/2}$

It is known[1] that $I_{\frac{1}{2}}(v) = \left(\frac{2}{\pi v}\right)^{1/2} \sinh v$ (2)

and $I_{5/2}(v)$

$$= \left(\frac{2}{\pi v}\right)^{1/2}\left[\left(1+\frac{3}{v^2}\right)\sinh v - \frac{3}{v}\cosh v\right] \qquad (3)$$

so on substituting in (1) we get

$$P = \frac{\frac{2\mu+1}{v}\cosh v - \left(1+\frac{2\mu+1}{v^2}\right)\sinh v}{\left(1-\frac{\mu-1}{v^2}\right)\sinh v + \frac{\mu-1}{v}\cosh v}\cdot\frac{a^3 H}{2} \qquad (4)$$

When this expression is rationalized and reduced to its real and imaginary components it will be in the form

$$P = -\frac{H a^3}{2}(U + jV) \qquad (5)$$

If $I\,e^{j\omega t}$ is the equivalent current in the coil the magnetic moment of the dipole will be $P = \pi a^2 I e^{j\omega t}$. I is given by

$$[R + L\omega j]\, I = -\pi a^2 H_0 \omega j \qquad (6)$$

* MS. accepted by the Editor, April 1946.

where R and L are the equivalent resistance and inductance. Consequently

$$P = -\frac{\pi^2 a^4 H\,\omega\,(R - L\omega j)}{R^2 + L^2\omega^2}\,j \quad .. \quad (7)$$

By equating the real and imaginary components of (5) and (7) we get two equations and on solving them the following expressions are obtained for the equivalent resistance and inductance of the sphere :—

$$R = 2\pi^2 a\omega\left(\frac{V}{U^2 + V^2}\right) \text{ (abs. e.m.u.)} \quad (8)$$

$$L = 2\pi^2 a\left(\frac{U}{U^2 + V^2}\right) \text{ (abs. e.m.u.)} \quad (9)$$

It is useful to have formulae for the change in resistance and inductance of a solenoid when a sphere is placed at its centre as this approximates to the actual conditions in an induction furnace. They can be found by using the well-known equations for coupled circuits

$$\Delta R_1 = \frac{M^2\omega^2 R_2}{R_2{}^2 + (L_2\omega)^2}\;;$$

$$\Delta L_1 = -\frac{M^2\omega^2 L_2}{R_2{}^2 + (L_2\omega)^2} \quad .. \quad .. \quad (10)$$

It is clear that $M = \alpha \,.\, 4\pi n \times \pi a^2 = 4\alpha\pi^2 n a^2$ where n = turns per unit length, l and D = solenoid length and diameter and $\alpha^2 = l^2/(l^2 + D^2)$ so substituting in (10).

$$\Delta R_1 = 8\alpha^2\pi^2 n^2 a^3 \omega V \text{ (abs. e.m.u.)} \quad (11)$$

$$\Delta L_1 = -\,8\alpha^2\pi^2 n^2 a^3 U \text{ (abs. e.m.u.)} \quad (12)$$

Divil kovski[2] gives formulae for the above special case involving the solenoid inductance but on examination it will be found that they only give the correct result when the solenoid length is much greater than the diameter.

The mean rate of heat generation in the sphere W is clearly $\frac{1}{2}\Delta R_1 . I_1{}^2$, where $I_1 \cos \omega t$ is the solenoid current. Since the field at the centre of the sphere $H_0 \cos \omega t = \alpha . 4\pi n I_1 \cos \omega t$ by eliminating I_1 we can get a formula for the rate of heat generation involving the field strength. It is

$$W = \frac{1}{4} a^3 \omega H^2{}_0 V \text{ erg/sec.} \quad .. \quad .. \quad (13)$$

Non-magnetic Sphere

In this case the dipole moment Eqn. (4) is simplified to

$$P = -\frac{Ha^3}{2}\left[1 + \frac{3}{v^2} - \frac{3}{v}\cdot\frac{\cosh v}{\sinh v}\right] \quad (14)$$

On putting $m = a\left(\frac{2\pi\mu\omega}{\rho}\right)^{1/2}$ we have $v = m(1 + j)$ so

$$P = -\frac{Ha^3}{2}\left[1 + \frac{3}{2m^2 j} - \frac{3}{m(1+j)}\cdot\frac{\cosh m \cos m + j \sinh m \sin m}{\sinh m \cos m + j \cosh m \sin m}\right]$$

After simplifying this expression it will be found that

$$U = 1 - \frac{3}{2m}\,\frac{\sinh 2m - \sin 2m}{\cosh 2m - \cos 2m} \quad (15)$$

$$V = \frac{3}{2m}\left[\frac{\sinh 2m + \sin 2m}{\cosh 2m - \cos 2m} - \frac{1}{m}\right] \quad (16)$$

When $m > 3$ the above equations reduce to $U = 1 - 3/2\,m$ and $V = \frac{3}{2m}\left(1 - \frac{1}{m}\right)$. The equivalent inductance and resistance are obtained by substituting the above values of U and V in (8) and (9). In Fig. 1 the variation with frequency of the resistance and reactance are shown for the particular case of a copper sphere of 10-cm diameter.

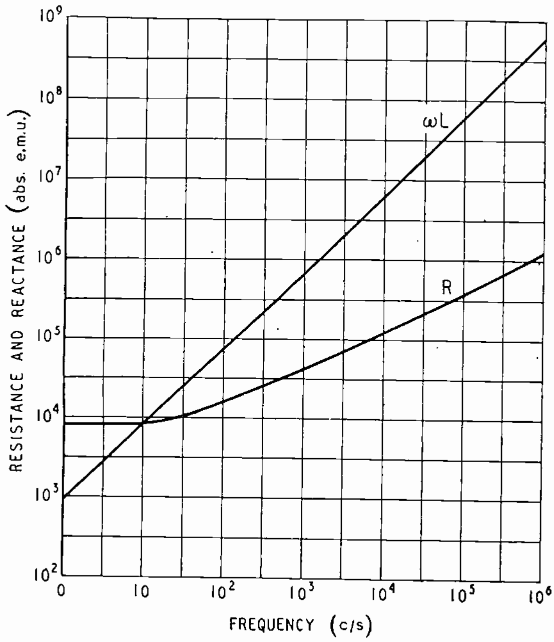

Fig. 1. *Equivalent resistance and reactance o copper sphere (abs. e.m.u.)*

The increase in resistance is, of course, due to the "skin effect" which causes the current to be confined to a thin surface layer when the frequency is high enough. Some inaccurate formulæ for the case of the sphere in the solenoid are given without proof by Jouguet[3].

It should be noted that the dipole field due to eddy currents is opposed to the inducing field and so, when in a non-uniform field, the sphere will behave as a diamagnetic substance and will tend to move from the stronger to the weaker parts of the field.

Magnetic Sphere

When $\mu > 1$ the rationalization of (4) leads to a complicated expression which will not be given here. If $v > 6$ it is simplified somewhat and the dipole moment can then be put in the form

$$P = -\frac{Ha^3}{2}(U + jV) \quad \ldots \quad \ldots \quad (5)$$

where

$$U = \frac{1 - \frac{\mu - 1}{2m} - \frac{(\mu - 1)(2\mu + 1)}{2m^2}\left(1 - \frac{1}{m} + \frac{2}{m^2}\right)}{1 + \frac{\mu - 1}{m} + \frac{(\mu - 1)^2}{2m^2}\left(1 - \frac{1}{m} + \frac{1}{2m^2}\right)} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

and $$V = \frac{m - 1}{1 + \frac{\mu - 1}{m} + \frac{(\mu - 1)^2}{2m^2}\left(1 - \frac{1}{m} + \frac{1}{2m^2}\right)} \frac{3\mu}{2m^2} \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

The equivalent resistance and inductance can again be found by substitution in (8) and (9). It will be seen that as $m \to \infty$, $R \to 0$ and $L \to 2\pi^2 a$

When $m \ll 1$ it can be shown that

$$P = \frac{2(\mu - 1)}{\mu + 2} \cdot \frac{Ha^3}{2} \quad \ldots \quad \ldots \quad (19)$$

The expression for U, and consequently the inductance, is negative at low frequencies and changes sign when $m = 1.28\ \mu$ (approx.). The explanation of this is that at low frequencies the moment is mainly due to the induced magnetization while at high frequencies the moment of the induced eddy currents is the larger component and the two components are opposed. To look at it from another aspect, it is an elementary fact that the presence of magnetic material in the field of an inductance increases the l.f. inductance and so in (12) ΔL_1 must be positive. It thus follows that L_2 must be negative at low frequencies.

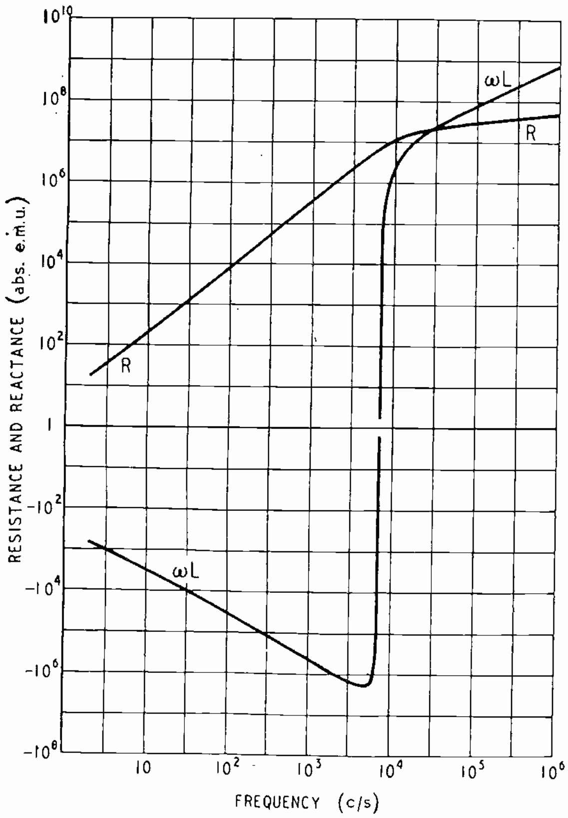

Fig. 2. *Equivalent resistance and reactance of steel sphere* ($\mu = 300$, $\rho = 15 \times 10^3$) *abs. e.m.u.*

In Fig. 2 the resistance and reactance of a steel sphere $\mu = 300$, $\rho = 15 \times 10^3$ abs. u. are shown.

It should be remembered that the effect of hysteresis has been ignored in the above analysis.

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1 W. R. Smythe, "Static and Dynamic Electricity," N.Y., 1939
2 M. Divilkovski, *J. Phys., U.S.S.R.*, Vol. 1, Nos. 5 and 6, 1939
3 M. Jouguet, *C. R. Acad. Sci., Paris*, May 10, 1943.

Indexes

As is our custom the Index to the Articles and Authors for the current volume is included in this issue.

The Index to the Abstracts and References published throughout the year is in course of preparation and will, it is hoped, be available in February, priced 2s. 8d. (including postage). As supplies will be limited our Publishers ask us to stress the need for early application for copies.

DIPOLE REFLECTOR INSULATION*

Effect on Performance at 6 Metres

By J. A. Saxton, B.Sc., Ph.D., A.M.I.E.E., and L. H. Ford, M.Sc.(Eng.), A.M.I.E.E.

(Communication from the National Physical Laboratory)

SUMMARY.—The effects of various insulators, used to support the ends of the parasitic aerial, were determined by measurements of the front-to-back signal ratio of a receiving-aerial system consisting of a half-wavelength dipole and a single parasitic reflector, at a wavelength of six metres. The particular insulators used in this investigation resulted in the effective length of the reflector being increased by about 20 per cent.

1. Introduction

THE simplest form of reflector which can be used to improve the performance of an aerial is a single conductor, about half a wavelength long. Such reflectors are commonly supported by strain insulators at the ends; when this is done the presence of the insulators may considerably alter the characteristics of the reflector, and the optimum length of conductor may differ from that computed from theory. The paper describes some experiments undertaken to determine the effect of the insulators on a reflecting curtain which failed to give the expected performance when first erected. It is supplementary to a previous paper on dipole reflectors by one of the authors.[1]

2. Experimental Procedure

A horizontally-polarized electric field on a wavelength of six metres was set up at the receiving site by means of a small oscillator the aerial current of which was maintained constant. The oscillator was about 150 metres distant from the receiver. The receiving-aerial system was mounted on a platform about 20ft above ground level. The receiving aerial consisted of a horizontal half-wave dipole aerial mounted on a wooden

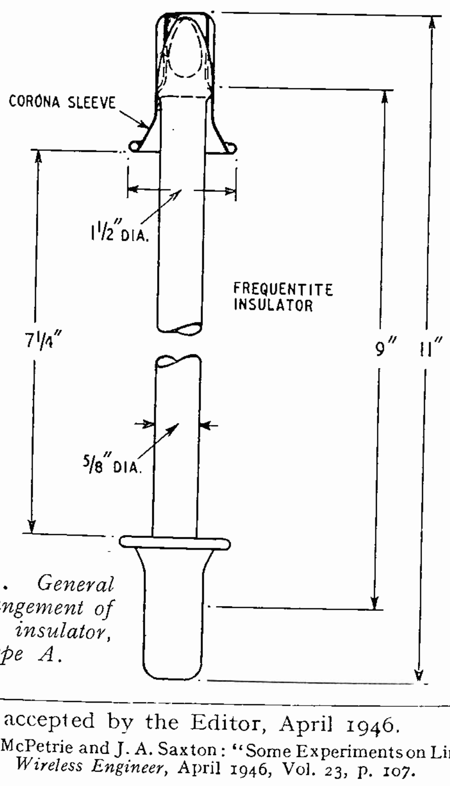

Fig. 1. *General arrangement of rod insulator, type A.*

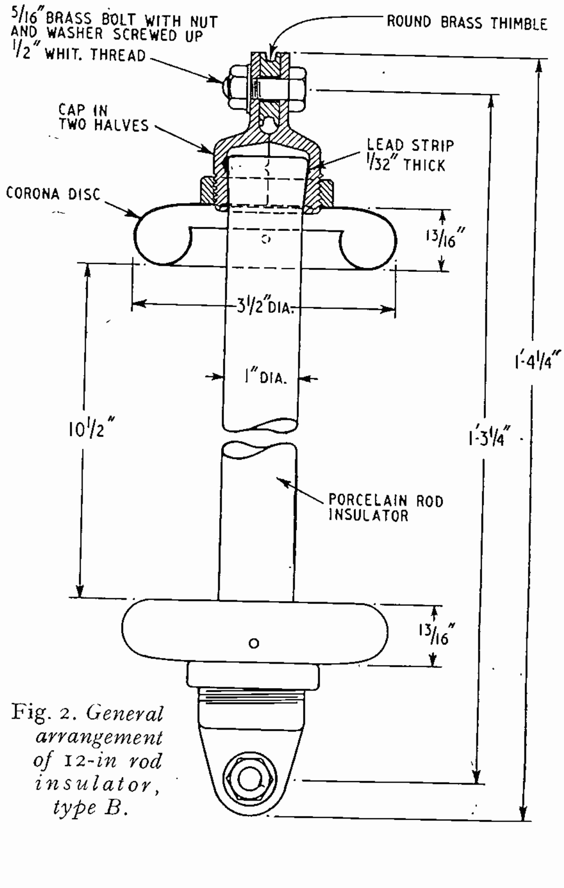

Fig. 2. *General arrangement of 12-in rod insulator, type B.*

* MS accepted by the Editor, April 1946.

[1] J. S. McPetrie and J. A. Saxton: "Some Experiments on Linear Aerials." *Wireless Engineer*, April 1946, Vol. 23, p. 107.

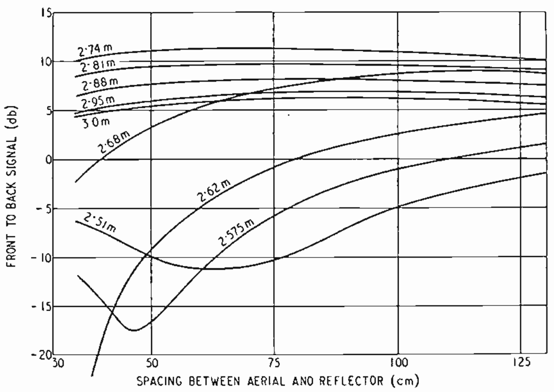

Fig. 3

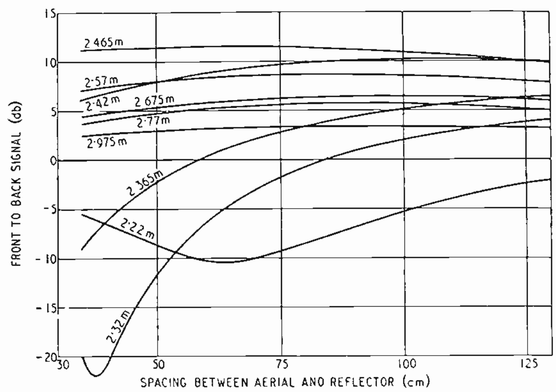

Fig. 4

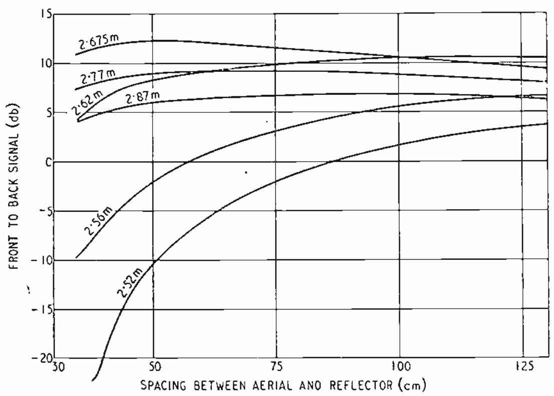

Fig. 5

Fig. 3. *Front-to-back signal with various reflector lengths at* $\lambda = 6.0$ *metres using insulators A, with corona rings. The reflector lengths measured include insulator corona rings.*

Fig. 4. *Front-to-back signal with various reflector lengths at* $\lambda = 6.0$ *metres using insulators B, with corona rings. The reflector lengths measured include insulator corona rings.*

Fig. 5. *Front-to-back signal with various reflector lengths at* $\lambda = 6.0$ *metres using insulators B, without corona rings. The reflector lengths measured include insulator caps.*

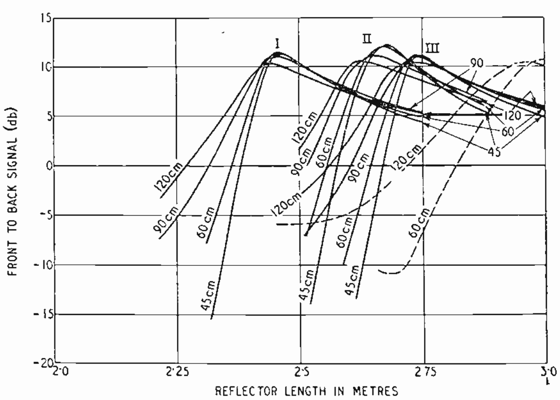

Fig. 6

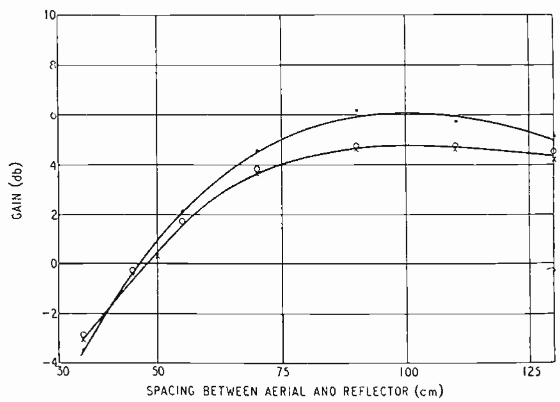

Fig. 7

Fig. 6. *Front-to-back signal with various reflector arrangements at* $\lambda = 6.0$ *metres. I. Insulators B, with corona rings; II. Insulators B, without corona rings; III. Insulators A, with corona rings.* — — — — — *computed curves neglecting insulators. The figures on the curves show the separation between aerial and reflector.*

Fig. 7. *Gain at* $\lambda = 6.0$ *metres with dipole aerial and reflector over simple dipole aerial, in direction of transmitter.* ● *Insulators A, reflector length 2.74 metres;* ×, *insulators B, with corona rings, reflector length 2.465 metres;* ○ *insulators B, without corona rings, reflector length 2.675 metres.*

frame, and connected to the input terminals of a field-strength measuring set by a vertical length of about one metre of twin flexible leads. The parasitic reflector consisted of a length of 200-lb copper wire (approximately 0.116-in diam.) strained between two insulators, which were mounted on the wooden frame supporting the receiving aerial in such a way that the separation of the two aerials, which were in the same horizontal plane, could be varied. The field strength was measured with various separations between the receiving and parasitic aerials, with the latter successively in front of and behind the former at each distance of separation. From these measurements the front-to-back signal ratio of the aerial system was obtained. The gain in signal in the direction of the transmitter over that received with a simple dipole aerial was also derived. Successive series of measurements were made using a number of lengths of parasitic aerial and a number of types of supporting insulator. The maximum error of any measurement was ±1 db.

3. Experimental Results

Three sets of observations were made, each with a different insulator arrangement.

(i) A series of experiments with various reflector lengths of between 3.0 metres and 2.51 metres, and aerial separations of between 35 cm and 130 cm, using insulators of type A. These were Frequentite insulators, with copper corona sleeves, shown in Fig. 1. The reflector lengths were measured, including the corona rings, which formed part of the conducting system. The values of front-to-back signal ratio, are shown plotted in Fig. 3.

(ii) A series of experiments with various reflector lengths of between 2.975 metres and 2.22 metres and aerial separations of between 35 cm and 130 cm, using insulators of type B. These were 12-in porcelain rod insulators 1-in diameter, with $\frac{3}{4}$-in roll, $3\frac{1}{2}$-in diameter corona discs, shown in Fig. 2. The reflector lengths were measured including the corona discs, which formed part of the conducting system. The values of front-to-back signal ratio are shown plotted in Fig. 4.

(iii) A series of experiments with various reflector lengths of between 2.87 metres and 2.52 metres, and aerial separations of between 35 cm and 130 cm, using insulators type B with the corona discs removed. The reflector lengths were measured including the metal caps on the ends of the insulators. The values of front-to-back signal ratio are shown plotted in Fig. 5.

From the curves of Figs. 3, 4 and 5, a further Fig. 6 was derived. This shows the result of varying the length of the reflector with fixed spacings between the receiving aerial and reflector of 45 cm, 60 cm, 90 cm, and 120 cm corresponding to 0.075 λ, 0.1 λ, 0.15 λ and 0.2 λ respectively. Computed curves are also shown for a simple reflector with no insulators at the ends.

Fig. 7 shows the variation of signal gain with a reflector over that without, plotted against the spacing between aerial and reflector. The length of reflector was that which gave maximum front-to-back signal ratio for each of the three insulator arrangements. The aerial system was normal to the direction of the transmitter throughout the experiments. The accuracy of these results is somewhat less than those plotted in the previous figures, since the field strength with the simple dipole receiving aerial, on which the results are based, was only measured at infrequent intervals during the experiments.

4. Conclusions

The results obtained in the series of experiments described above are in good general agreement with those described previously.[1] The effect of the metal caps and corona rings on the effective length of the reflector is clearly brought out by the experiments.

The metal corona sleeves on insulator A, for example, add 10 cm to the conductor length, but the effective length of the conductor is increased by about 35 cm. In the worst case the effective length of the reflector is about 20 per cent greater than the geometrical length; if the effect of the insulators is neglected with a reflector of this type a serious loss in performance will result.

5. Acknowledgments

The work described above was carried out as part of the programme of the Radio Research Board, to whom the paper was first circulated in October 1941. It is now published by permission of the Department of Scientific and Industrial Research.

ZERO TRACKING ERROR IN SUPERHETERODYNES*

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

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SUMMARY.—A pair of circuits is described which gives zero tracking error not only on three selected positions of the tuning range, but over the entire tuning range. Tuning is effected by a simultaneous variation of inductance and capacitance elements, such that the ratio L/C remains constant throughout the tuning range.

It is shown that small errors in this condition lead only to second-order tracking errors.

THE solutions of the tracking problem which have become known so far are all approximate ones—the usual one, for instance, giving zero tracking error at only three tuning positions; over the rest of the tuning range a small but finite tracking error has to be allowed.

For this reason the present note might be of interest as it describes a simple pair of circuits which gives correct tracking (zero tracking error) over the entire tuning range.† This circuit pair is of the type in which tuning is carried out by a simultaneous variation of the inductance and the capacitance elements. The special feature introduced here is the condition that the ratio L/C of these two elements remains constant throughout the tuning range.

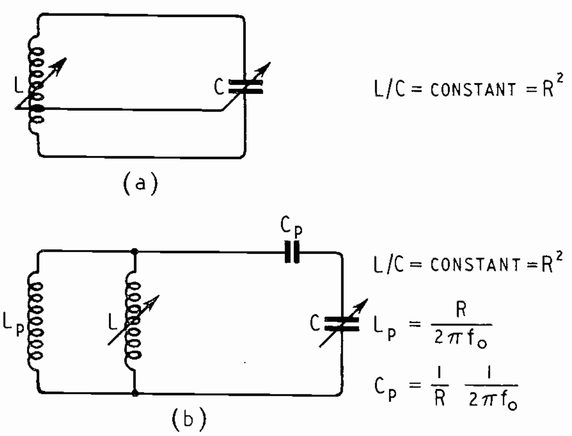


Fig. 1. *Signal (a) and oscillator (b) circuits resonant respectively at frequencies f and $f_1 = f + f_0$.*

If this condition is fulfilled, then the circuit pair illustrated in Figs. 1 (a) and 1 (b) gives ideal tracking with constant frequency difference (f_o) over the entire tuning range, while the circuit pair illustrated in Figs. 2 (a) and 2 (b) gives ideal tracking with constant difference (λ_0) of wavelength.

We shall first give the proof for the usual case of constant frequency difference.

Let

$$\omega = 2\pi f = 1/\sqrt{LC}$$

$$= \text{tuning frequency of circuit 1 (a)} \quad (1)$$

$$\omega_1 = 2\pi f_1 = 1/\sqrt{L_1 C_1}$$

$$= \text{tuning frequency of circuit 1 (b)} \quad (2)$$

where

$$L_1 = \frac{LL_p}{L + L_p} \quad \text{and} \quad C_1 = \frac{CC_p}{C + C_p} \quad (3)$$

Let δ be the mechanical position coordinate of the tuning mechanism such that

$$L = L_0 \, . \, \phi(\delta) \quad \ldots \quad \ldots \quad (4)$$

Then the constant L/C ratio, which we stipulated, requires $L/C = L_0/C_0 = R^2$, say; hence

$$C = C_0 \, . \, \phi(\delta) \quad \ldots \quad \ldots \quad (5)$$

and

$$\omega = \frac{1}{\phi(\delta) \, . \, \sqrt{L_0 C_0}} \quad \text{or} \quad \phi(\delta) = \frac{1}{\omega\sqrt{L_0 C_0}} \quad \ldots \quad \ldots \quad (6)$$

$$L = \sqrt{L_0/C_0}/\omega = R/\omega \quad \ldots \quad \ldots \quad (7)$$

$$C = \sqrt{C_0/L_0}/\omega = 1/\omega R \quad \ldots \quad \ldots \quad (8)$$

Together with the stipulated values

$$L_p = R/\omega_0 \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

$$C_p = 1/\omega_0 R \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

we get

$$L_1 = \frac{R/\omega \, . \, R/\omega_0}{R/\omega + R/\omega_0} = \frac{R}{\omega + \omega_0} \quad \ldots \quad (11)$$

$$C_1 = \frac{1/R\omega \, . \, 1/R\omega_0}{1/R\omega + 1/R\omega_0} = \frac{1}{R} \cdot \frac{1}{\omega + \omega_0} \quad (12)$$

$$\omega_1 = 1/\sqrt{L_1 C_1} = \omega + \omega_0 \quad (13) \text{ Q.E.D.}$$

The proof for the case illustrated in Figs. 2 (a) and 2 (b) follows either from the general theorem, given in "Notes on Tracking

* MS. accepted by the Editor, April 1946.

† British Patent Specification No. 578960 of 23rd October 1942.

Circuits"[1] or, in the present case, quicker still, by independent calculation.

If we denote $\frac{2\pi c}{\lambda'}$ by ω' and $\frac{2\pi c}{\lambda_0}$ by ω_0 (c = velocity of el. magn. waves), we have

$$L' = R/\omega' \qquad C' = 1/\omega' R \quad .. \quad (14)$$

and

$$L'_1 = L' + L_p = R\,(1/\omega' + 1/\omega_0) \quad (15)$$

$$C'_1 = C' + C_p = \frac{1}{R}\left(1/\omega' + 1/\omega_0\right) \quad (16)$$

$$\lambda'_1 = \frac{2\pi c}{\omega'_1} = 2\pi c\,\sqrt{L'_1 C'_1}$$

$$= 2\pi c\left(\frac{1}{\omega'} + \frac{1}{\omega_0}\right) = \lambda' + \lambda_0 \quad .. \quad (17)$$

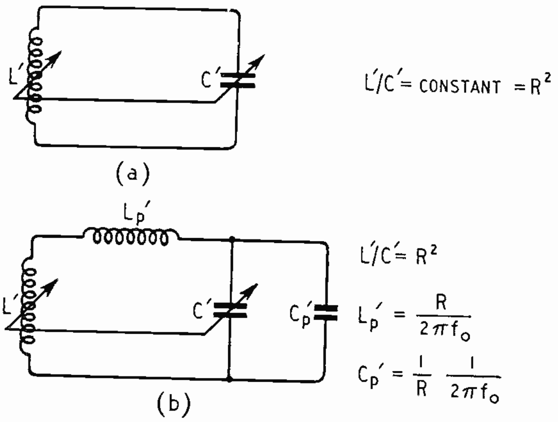


Fig. 2. *Signal (a) and oscillator (b) circuits resonant respectively at wavelengths* λ *and* $\lambda'_1 = \lambda' + \lambda_0$.

If the variation of L and C is such that their ratio does not remain exactly constant, a tracking error will of course arise. It is of interest, however, that this error will be of second order if the ratio error is of first order.

To calculate the error, we introduce $S = 1/C$ so that the constant L/C ratio is now transformed into a constant $L \cdot S$ product. If there are errors in the dimensioning of the tuning elements we can then always put

$$S = S_t + \Delta S \quad .. \quad .. \quad .. \quad (18)$$

where ΔS indicates the deviation from the ideal condition. The tracking error is then

$$\Delta f = \frac{f_0}{8} \cdot \frac{f}{f_1} \cdot \left(\frac{\Delta S}{S_t}\right)^2 \quad .. \quad .. \quad (19)$$

or, if we introduce with analogous meaning

$$C = C_t + \Delta C \left(C_t = \frac{1}{S_t},\; C = \frac{1}{S}\right) \quad (20)$$

$$\Delta f \approx \frac{f_0}{8} \cdot \frac{f}{f_1} \cdot \left(\frac{\Delta C}{C_t}\right)^2 \quad .. \quad .. \quad (21)$$

Proof of equation (19).

If we put

$$1/C_p = S_p \quad \text{and} \quad 1/C_1 = S_1 \quad .. \quad (22)$$

we have

$$S_1 = S_t + S_p + \Delta S = S_{1t} + \Delta S \quad (23)$$

If we take the values

$$\omega_t = \sqrt{\frac{S_t}{L_1}} \quad \text{and} \quad \omega_{1t} = \sqrt{\frac{S_{1t}}{L}} \quad .. \quad (24)$$

as reference values, and use a Taylor expansion to calculate the deviations $\delta\omega$ and $\delta\omega_1$ which are due to the increment ΔS, we get,

$$\delta\omega = \frac{1}{2\sqrt{LS_t}} \cdot \Delta S - \frac{1}{8\sqrt{LS_t^3}} \cdot \Delta S^2 + \ldots \quad .. \quad .. \quad (25)$$

$$\delta\omega_1 = \frac{1}{2\sqrt{L_1 S_{1t}}} \Delta S - \frac{1}{8\sqrt{L_1 S_{1t}^3}} \Delta S^2 + \ldots \quad .. \quad .. \quad (26)$$

The tracking error is then (in angular frequency)

$$\Delta\omega_0 = \delta\omega_1 - \delta\omega \quad .. \quad .. \quad (27)$$

Now, as we have

$$\frac{1}{\sqrt{L_1 S_{1t}}} = \sqrt{\frac{C_{1t}}{L_1}} = \frac{1}{R} = \sqrt{\frac{C}{L}} = \frac{1}{\sqrt{L \,.\, S_t}} \quad .. \quad .. \quad (28)$$

the two first order terms for $\delta\omega$ and $\delta\omega_1$ cancel and we are left with

$$\Delta\omega_0 = -\frac{1}{8}\,\frac{1}{R}\left[\frac{1}{S_{1t}} - \frac{1}{S_t}\right]\Delta S^2 \quad .. \quad (29)$$

$$= +\frac{1}{8} \cdot \frac{1}{\sqrt{L_p S_p}} \cdot \frac{S_p}{S_{1t} \,.\, S_t} \cdot \Delta S^2$$

$$= \frac{1}{8}\,\omega_0\,\frac{S_t^2}{S_{1t} \,.\, S_t}\left(\frac{\Delta S}{S_t}\right)^2$$

$$= \frac{1}{8}\,\omega_0 \cdot \frac{\omega}{\omega + \omega_0}\left(\frac{\Delta S}{S_t}\right)^2$$

or

$$\Delta f = \frac{1}{8} f_0 \cdot \frac{f}{f_1}\left(\frac{\Delta S}{S_t}\right)^2 \quad .. \quad .. \quad (30)$$

The question of physical realization of the components required in this scheme has not been dealt with in these notes. It may be mentioned, therefore, that the scheme has been applied without difficulty in a case in which the tuning frequency varied over a range of 1 : 6.

[1] *Wireless Engineer*, Nov. 1942, Vol. 19, p. 508.

PHASE DETECTORS*

Some Theoretical and Practical Aspects

By L. I. Farren, Whit. Schol., A.M.I.E.E., A.C.G.I., D.I.C.

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

SUMMARY.—The theory of operation of various forms of phase detector is developed, for the case when the applied voltages are sinusoidal and when they are rectangular.

A number of practical forms of circuit are considered and the results of measurements made on these circuits are given.

Introduction

The various fundamental methods of measuring the phase difference between two sinusoidal voltages of the same frequency are well known and have been described by M. Levy.[1] In practice it is often desirable that the phase detector employed should produce at its output terminals a steady potential, the polarity of which depends on whether the phase angle is lagging or leading, and the magnitude of which is as nearly as possible proportional to the phase difference.

In some other applications it is necessary for the output from the phase detector to operate control relays when the phase angle deviates from zero by more than a specified amount, one relay operating for leading angles and another for lagging.

In such applications the main requirement is for a high conversion factor from phase angle to output potential, while a subsidiary requirement is that this output potential should be substantially independent of the amplitudes of the voltages whose phase difference is to be measured.

In the phase detectors to be considered these requirements are taken into account.

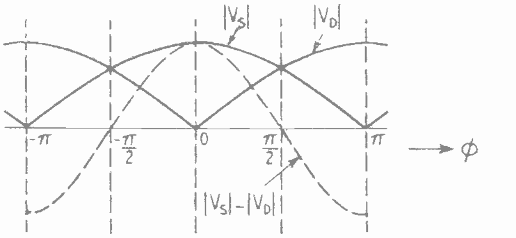


Fig. 1. The magnitudes $|V_D|$ and $|V_S|$ and their difference are shown here as functions of the phase angle ϕ.

Suppose we wish to measure the phase difference between two alternating voltages $V_1 \sin \omega t$ and $V_2 \sin (\omega t + \phi)$.

If separate amplifiers, with a.v.c. applied, are used to amplify V_1 and V_2, it is possible to obtain two output voltages of the same amplitude, say, $V_3 \sin \omega t$ and $V_3 \sin (\omega t + \phi)$. If these outputs are combined in such a way that their sum and difference are obtained separately we get,

$$\left.\begin{aligned} V_S &= V_3 \sin \omega t + V_3 \sin (\omega t + \phi) \\ &= 2V_3 \cos(-\phi/2)\ \sin(\omega t + \phi/2) \\ V_D &= V_3 \sin \omega t - V_3 \sin (\omega t + \phi) \\ &= 2V_3 \sin(-\phi/2) \cos(\omega t + \phi/2) \end{aligned}\right\} \quad \ldots (1)$$

In Fig. 1, the magnitudes $|V_S|$ and $|V_D|$ of V_S and V_D respectively are plotted against ϕ for values of ϕ from $-\pi$ to $+\pi$, and on the same base is plotted the curve of $|V_S| - |V_D|$.

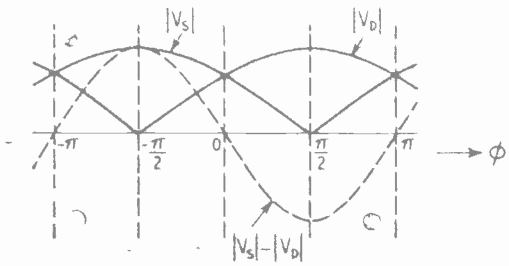


Fig. 2. Curves of $|V_D|$, $|V_S|$ and $|V_S| - |V_D|$ are shown here for the case when one voltage is $V_3 \sin (\omega t + \phi + \pi/2)$.

This latter curve is sinusoidal and has peak values at $\phi = 0$ and $\phi = \pm n\pi$. Hence the quantity $|V_S| - |V_D|$ possesses no characteristic to indicate whether ϕ is positive (lead) or negative (lag).

If now one of the voltages, say, $V_3 \sin (\omega t + \phi)$, is made to lead by an additional angle of $\pi/2$ on the other, we have

$$\left.\begin{aligned} V_S &= V_3 \sin \omega t + V_3 \sin (\omega t + \phi + \pi/2) \\ &= 2V_3 \cos(-\pi/4 - \phi/2) \sin(\omega t + \phi/2 + \pi/4) \\ V_D &= V_3 \sin \omega t - V_3 \sin (\omega t + \phi + \pi/2) \\ &= 2V_3 \sin(-\pi/4 - \phi/2) \cos(\omega t + \phi/2 + \pi/4) \end{aligned}\right\} \quad \ldots (2)$$

In Fig. 2, the magnitudes $|V_S|$ and $|V_D|$ of V_S and V_D respectively derived from

*MS. accepted by the Editor, April 1946.

equation (2), are plotted against ϕ together with the curve of $|V_S| - |V_D|$.

It will be seen that the quantity $|V_S|-|V_D|$ changes sign at $\phi = 0$, being positive when ϕ is negative (lag) and negative when ϕ is positive (lead).

If the added phase shift is made $-\pi/2$ instead of $+\pi/2$, the curve for $|V_S| - |V_D|$ will still change sign at $\phi = 0$, but it will have positive values when ϕ is positive and vice versa.

In phase detectors employing the sum and difference method it is usual therefore to shift the phase of one of the voltages by $\pm \pi/2$.

In order to keep the notation consistent, the additional phase shift of $\pi/2$ will be added to the voltage $V_3 \sin(\omega t + \phi)$.

From the foregoing discussion it will be seen that the formation of the voltages V_S and V_D is accomplished by the vectorial addition of two sinusoidal quantities. The formation of the quantity $|V_S| - |V_D|$ is based on the assumption that the magnitudes $|V_S|$ and $|V_D|$ may be subtracted one from the other, irrespective of the signs or relative phases of V_S and V_D.

In practice this may be accomplished by the use of a diode rectifier circuit which provides at its output terminals a unidirectional voltage proportional to the peak value of the alternating voltage at its input. Thus by applying V_S and V_D to separate rectifier circuits and by connecting the outputs in such a way that their output voltages oppose each other, a combination proportional to $|V_S| - |V_D|$ may be obtained.

Before dealing with the various forms of phase detector we shall first consider the simple diode rectifier and output circuit, as the method used in dealing with this case is of use when considering the more complicated circuits.

The Diode Rectifier and Load Circuit

The circuit is shown in Fig. 3. The resistance R_1 represents the combination of a physical resistance in series with the forward conducting resistance of the rectifier G. The load circuit consists of the resistance R_2 in parallel with the capacitance C. The input voltage applied to the circuit is $V_a \cos \omega t$ and the resultant output voltage is V_A.

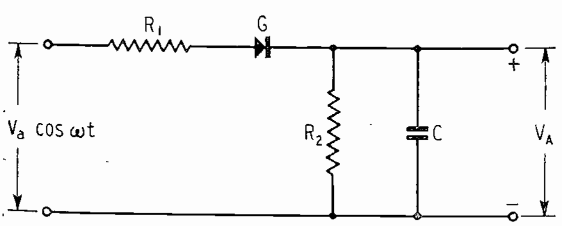


Fig. 3. The basic diode rectifier with its load circuit.

We wish to find V_A in terms of V_a, R_1, R_2 and C. The following assumptions are made :—

(*a*) The forward conducting resistance of G is small compared with R_1 and is constant for all positive values of applied voltage. In practice, when a phase detector is working over the range which is of interest, the voltage V_a is generally greater than 10 volts, so that this assumption is not unreasonable.

(*b*) The backward resistance of G is large compared with R_2.

(*c*) The time constant CR_2 is large compared with the period of one cycle of the applied signal, namely, $2\pi/\omega$. In such a case, the voltage V_A is independent of C.

If these assumptions are valid, then once the transient charging period of C has passed, the voltage V_A remains substantially constant over each a.c. cycle and acts as a steady bias on the rectifier.

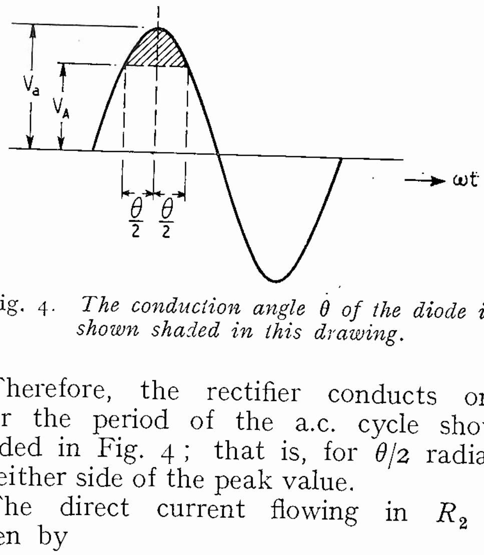


Fig. 4. *The conduction angle θ of the diode is shown shaded in this drawing.*

Therefore, the rectifier conducts only over the period of the a.c. cycle shown shaded in Fig. 4; that is, for $\theta/2$ radians on either side of the peak value.

The direct current flowing in R_2 is given by

$$I_A = V_A/R_2$$

The current necessary to keep C charged is provided by the rectifier over the periods shown shaded in Fig. 4. The average value of this current must obviously equal I_A.

$$\therefore \; I_A = V_A/R_2$$

$$= \frac{V_a}{2\pi R_1}\int_{-\theta/2}^{+\theta/2} (\cos \omega t - V_A/V_a)\, d(\omega t).$$

From Fig. 4 we see that

$$V_A/V_a = \cos \theta/2$$

$$\therefore V_A/R_2 = \frac{V_a}{2\pi R_1}\int_{-\theta/2}^{+\theta/2}(\cos \omega t - \cos \theta/2)\, d\,(\omega t)$$

$$= \frac{V_a}{2\pi R_1}(2 \sin \theta/2 - \theta \cos \theta/2)$$

and $$\frac{R_2}{R_1} = \frac{2\pi \cos \theta/2}{2 \sin \theta/2 - \theta \cos \theta/2} \quad .. \quad (3)$$

This equation may be expressed in a more useful form by plotting R_2/R_1 against $\cos \theta/2$.

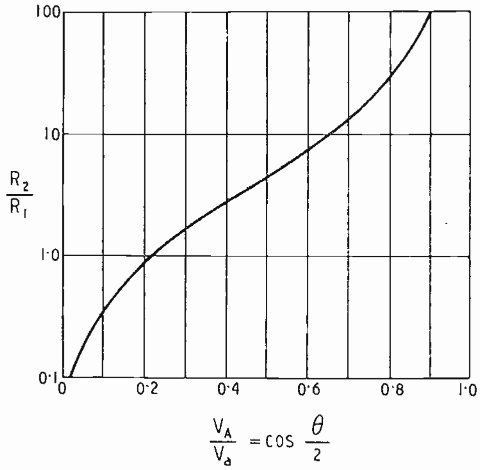


Fig. 5. *The relationship between V_A/V_a and R_2/R_1 for the circuit of Fig. 3.*

From the resulting curve shown in Fig. 5, for any chosen value of R_2/R_1, $\cos \theta/2$ and thence V_A/V_a may be found. It is seen quite clearly that the efficiency of the rectifier, in converting an alternating voltage of peak value V_a into a steady voltage V_A, can be kept high only by using a large value for the ratio R_2/R_1.

In the following analysis, except when otherwise necessary, this lack of efficiency will be expressed simply by the relationship

$$V_A = KV_a.$$

The Simple Push-Pull Phase Detector

(a) Sinusoidal Input.

The circuit is shown in Fig. 6. The alternating voltages, whose phase difference $\phi + \pi/2$ is to be indicated in terms of ϕ only, are $v_1\,(a)$ and $v_2\,(c)$, and by means of the transformers T_1 and T_2 the sum of $v_1\,(a)$ and $v_2\,(c)$ and the difference of $v_1\,(b)$ and $v_2\,(c)$ may be applied separately to the two rectifiers G_A and G_B respectively.

It has already been mentioned in the introduction that means are readily available for making the amplitudes of v_1 and v_2 the same. Thus if we take $v_1\,(a)$ as our datum voltage we have :

$$v_1\,(a) = V_1 \sin \omega t$$
$$v_2\,(c) = V_1 \sin (\omega t + \phi + \pi/2).$$

The alternating voltage applied to rectifier

$$G_A = V_a = v_1\,(a) + v_2\,(c)$$
$$G_B = Vb = v_2\,(c) - v_1\,(b)$$
$$\therefore V_a = 2V_1 \cos(-\pi/4 - \phi/2) \sin (\omega t + \phi/2 + \pi/4)$$
$$V_b = 2V_1 \sin(-\pi/4 - \phi 2) \cos (\omega t + \phi/2 + \pi/4)$$

If the efficiency of rectification, as determined from Equ. (3) is K, then we have for the rectified output voltages V_A and V_B,

$$\left.\begin{aligned} V_A &= 2KV_1\,|\cos - (\pi/4 + \phi/2)| \\ V_B &= 2KV_1\,|\sin - (\pi/4 + \phi/2)| \end{aligned}\right\} (4)$$

Since the rectifiers are unidirectional conductors, the output terminals A and B must both be at positive potentials with respect to the common point of the resistors R_2.

Hence the effective output voltage V_C expressed as the potential of A relative to B is,

$$V_C = V_A - V_B$$
$$= 2KV_1\,\big[|\cos - (\pi/4 + \phi/2)| - |\sin - (\pi/4 + \phi/2)|\big] \quad .. \quad (5)$$

The curve of V_C plotted against ϕ will be similar in shape to the curve for $|V_S| - |V_D|$ in Fig. 2, having zero values at $\phi = 0$ and $\pm n\pi$, and maximum positive and negative values at $\phi = -n\pi/2$ and $+n\pi/2$ respectively.

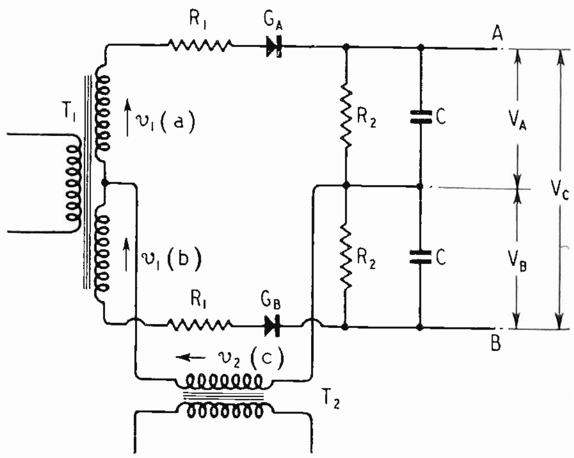


Fig. 6. *Simple push-pull phase detector.*

Summarizing we may say that this type of phase detector has a sine-law relation between V_C and ϕ and that the maximum sensitivity is obtained when the ratio R_2/R_1 is kept as high as possible. In a practical case the resistances R_1 would be formed by the internal impedances of the generators feeding the transformers T_1 and T_2.

Let us consider the application of this detector to a relay control circuit. We have seen that although the terminals A and B are themselves never negative with respect to their centre point, the voltage V_C varies sinusoidally when plotted against ϕ.

In order to operate one relay for positive values of ϕ and another for negative values, an arrangement as shown in Fig. 7 could be used.

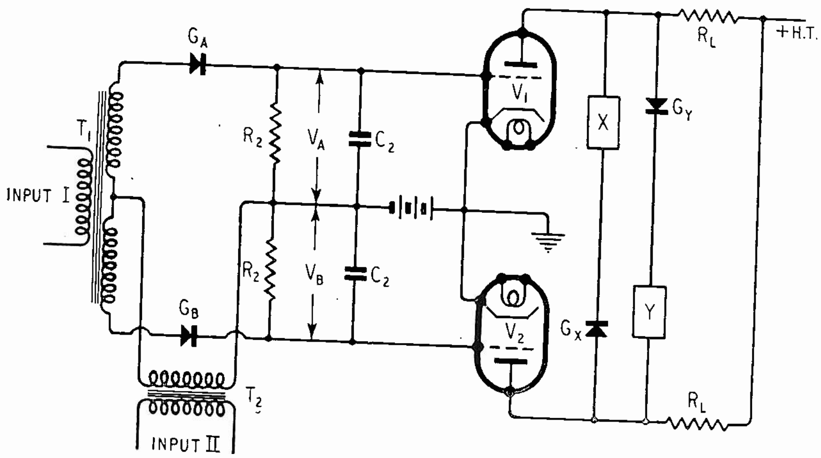


Fig. 7 (above). *Phase detector for operating relays X and Y.*

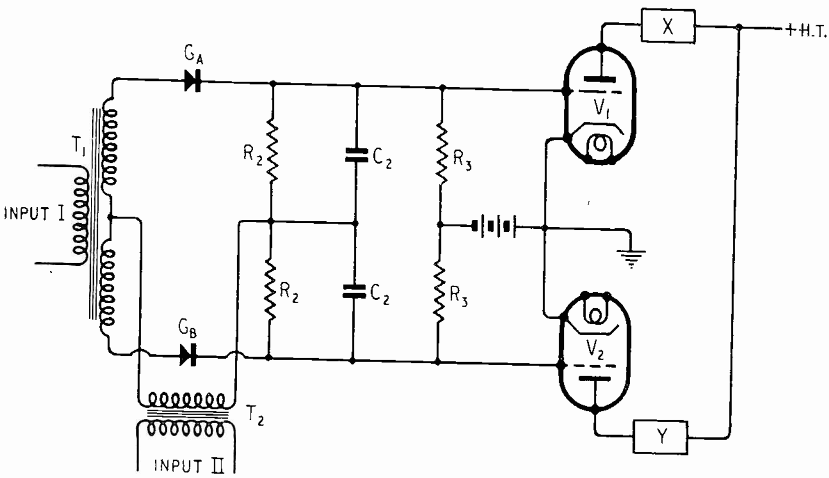


Fig. 8 (right). *An alternative circuit to Fig. 7 for use with relays.*

If the valves V_1 and V_2 are identical in their characteristics, then when $\phi = 0$, $V_A = V_B$ and their anode potentials will be equal. Hence no current will flow in either of the relays X and Y.

If ϕ is negative, V_A is greater than V_B and the anode potential of V_1 falls as that of V_2 rises. Current will flow through the rectifier G_x and relay X, which will operate if $V_A - V_B$ is large enough. If ϕ is positive, then by the same reasoning current will flow through G_y and relay Y.

The advantage of this system is that the valves may be operated on the linear part of their characteristics, thus ensuring maximum sensitivity. The disadvantage is the introduction of two additional rectifiers and the necessity for an initial balance of the anode potentials of the two valves.

An alternative circuit arrangement is shown in Fig. 8; it differs from that shown in Fig. 7 in that the common point of the resistors R_2 and capacitors C_2 is isolated from the cathodes of V_1 and V_2. Instead, two resistors R_3 are connected across the output terminals, and the cathodes are connected, through a negative grid bias supply, to the common point of these resistors.

The steady voltage across each resistor R_3 is equal to $\frac{V_A - V_B}{2}$ or $V_C/2$; thus if V_A is greater than V_B the grid of V_1 becomes more positive with respect to its cathode whilst the grid of V_2 becomes more negative. Hence the relays X and Y will operate for certain negative and positive values of ϕ respectively.

(b) Square Wave Input.

In order that the sensitivity of phase detection shall remain substantially constant for a wide range of values of input voltage to the receiver, it is necessary to keep the amplitudes substantially constant. This may be achieved by the use of delayed a.v.c. or by using a limiter stage with tuned output to preserve the sinusoidal form of the voltage V_1.

Practical difficulties arise with the latter method owing to possible variations in the tuned circuit; the phase shift introduced by the tuned circuit changes most rapidly at resonance, and small percentage changes in the resonant frequency produce relatively large changes in phase shift which would lead to errors in phase-shift indication. For this reason it is of interest to consider the result which would be obtained if the tuning of the limiter-stage output is dispensed with, so that the phase detector is supplied with voltage waves which are substantially rectangular in shape.

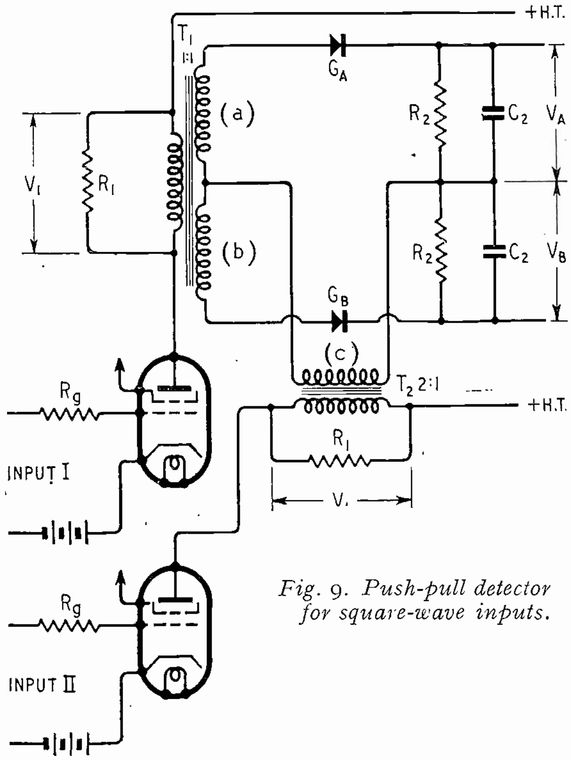


Fig. 9. Push-pull detector for square-wave inputs.

The type of circuit used is shown, in simple form, in Fig. 9. The two inputs, I and II, are the sinusoidal voltages having a phase difference of $(\pi/2 + \phi)$, each being applied through a resistor R_g to the grid of a tetrode.

Each valve has its control grid biased so that the anode current in the absence of a signal is approximately half the value of the anode current at zero grid voltage. The value of R_g is made sufficiently large to ensure that the grid potential of each valve is prevented, by the flow of grid current, from ever becoming more than, say, 1 volt positive to cathode, even in the presence of the positive peak of the largest applied signal.

For example, suppose that the grid current characteristics of the valve are such that a positive potential of 1 volt between grid and cathode corresponds to a grid current of 100 microamperes. Then if $R_g = 250{,}000$ ohms, and the normal grid bias is -3 volts, an input signal of 29 volts peak is needed to drive the grid positive by 1 volt.

This method of limiting is well known and has the effect of converting an input voltage signal of sinusoidal wave form into an anode current of substantially square waveform.

For successful operation, therefore, the input signals must be large compared with the normal grid bias voltage.

Since the anode resistance of a tetrode valve is very high, such a valve may be considered as a controlled-current generator. If the current waveform is square, as just described, then the waveform of the voltage developed across a load circuit will be square only if the load is resistive. For this reason resistors R_1 are connected across the primary windings of the transformers T_1 and T_2 as shown in Fig. 9. Fig. 10 shows the waveforms of the voltages (*a*), (*b*) and (*c*) which appear across the secondary windings of the transformers T_1 and T_2. The waveform of (*c*) is shown lagging by $(\pi/2 + \phi)$ behind (*a*).

The sum of (*a*) and (*c*) represents the voltage applied to rectifier G_A and the sum of (*b*) and (*c*) represents the voltage applied to G_B. The wave forms of (*a*) + (*c*) and (*b*) + (*c*) are shown in Fig. 11.

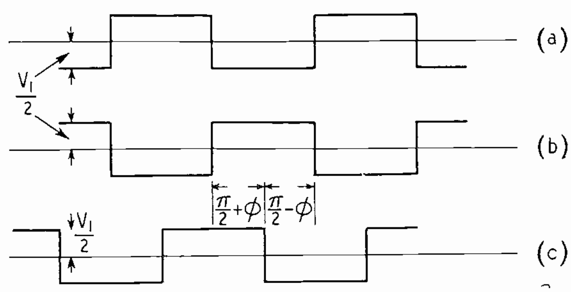


Fig. 10. The waveforms of the voltages on the transformer secondaries of Fig. 9 are shown here.

It is interesting to note the difference between these combined voltages and those obtained in the case of sinusoidal voltage waves. In the latter case, a change of ϕ produced a differential change in the amplitudes of the combined waves, and this change in amplitudes was used as a means of measuring ϕ. In the case of square-wave voltages the amplitudes of the combined waves are unaffected but the shapes of the waves are changed. Both (*a*) + (*c*) and (*b*) + (*c*) consist of a succession of alternate positive and negative rectangular pulses, the width of the pulses being dependent on ϕ.

From Fig. 11 we see that the width of the pulses of (*a*) + (*c*) is $(\pi/2 - \phi)$ and of (*b*) + (*c*) is $(\pi/2 + \phi)$.

We see also that when the positive pulse of (*a*) + (*c*) is being applied to the rectifier

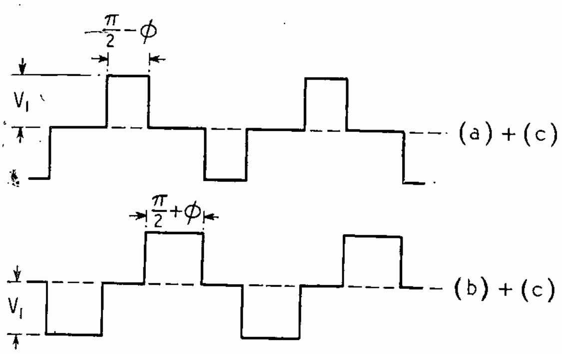


Fig. 11. The waveform of voltage (a) + (c) applied to G_A and of voltage (b) + (c) applied to G_B.

G_A, (*b*) + (*c*) is zero and when the positive pulse of (*b*) + (*c*) is being applied to the rectifier G_B, (*a*) + (*c*) is zero. Thus only one-half winding of the secondary of transformer T_1 is loaded at any time and this fact enables a simplification to be made in drawing the equivalent circuit for Fig. 9. This equivalent circuit is shown in Fig. 12, in which the transformers have been removed and the equivalent generators have been inserted. It should be mentioned here that the voltages V_1 shown across the primaries of T_1 and T_2 in Fig. 9 are the voltages which would appear across R_1 if the secondary windings of T_1 and T_2 were open circuited.

Referring again to Fig. 12; we have to find the steady potential acquired by the capacitors C_2 when the rectifiers G_A and G_B are supplied with the voltage waves shown in Fig. 11. If the time constant C_2R_2 is made large compared with the period of V_1 then V_A and V_B may be considered as steady voltages.

If R_2 is made very much greater than R_1, V_A will approximate to the peak value of the voltage (*a*) + (*c*), namely, V_1, independently of the value of ϕ, except for values of ϕ very close to $\pi/2$, when the voltage wave (*a*) + (*c*) becomes a series of positive and negative "spikes" of short duration. The same remarks apply to the voltage V_B except that the discontinuity occurs in that case for values of ϕ very close to $-\pi/2$.

In other words, if the rectification circuits are designed on the principle of the diode peak voltmeter (which is best for the case of sinusoidal inputs) then one loses the differential action of V_A and V_B which is essential for phase discrimination. An optimum value for the ratio R_2/R_1 can be found which gives the best differential action.

V_A will acquire a value such that the quantity of electricity which flows from C_2 through R_2 in the period of 1 cycle (2π radians) is exactly equal to the quantity of electricity supplied from the generators through the rectifier G_A for the period that the rectifier is conducting, namely $(\pi/2 - \phi)$ radians.

Hence:

$$\frac{V_1 - V_A}{R_{1}/2} \cdot (\pi/2 - \phi) = \frac{V_A}{R_2} \cdot 2\pi \quad \ldots (6)$$

and $$\frac{V_1 - V_B}{R_{1}/2} \cdot (\pi/2 + \phi) = \frac{V_B}{R_2} \cdot 2\pi \quad \ldots (7)$$

Equations (6) and (7) may be rewritten:

$$V_A = V_1\left[\frac{(\pi/2 - \phi)}{(\pi/2 - \phi) + \pi \cdot R_1/R_2}\right] \ldots (8)$$

and $$V_B = V_1\left[\frac{(\pi/2 + \phi)}{(\pi/2 + \phi) + \pi \cdot R_1/R_2}\right] \ldots (9)$$

From (8) and (9), we see that $V_A = V_B$ when $\phi = 0$, $V_A < V_B$ when ϕ is positive and $V_A > V_B$ when ϕ is negative. The most suitable value of R_1/R_2 is the one which gives the largest change in $V_A - V_B$ for a given small change in ϕ from $\phi = 0$.

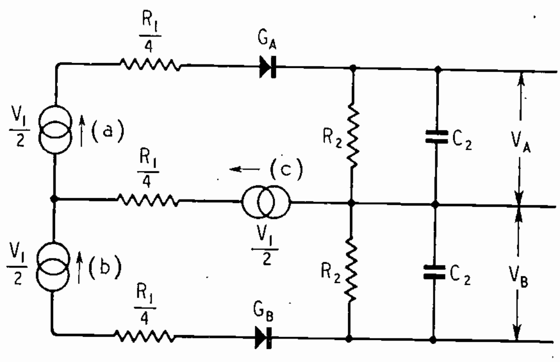


Fig. 12. The equivalent circuit of Fig. 9.

By differentiation this optimum is

$$\frac{dV_A}{d\phi} = V_1\left[\frac{-\pi \cdot \dfrac{R_1}{R_2}}{\left\{(\pi/2 - \phi) + \pi \cdot \dfrac{R_1}{R_2}\right\}^2}\right] \ldots (10)$$

$$\frac{dV_B}{d\phi} = V_1\left[\frac{\pi \cdot \dfrac{R_1}{R_2}}{\left\{(\pi/2 + \phi) + \pi \cdot \dfrac{R_1}{R_2}\right\}^2}\right] \ldots (11)$$

At $\phi = 0$

$$\left[\frac{d\,(V_A - V_B)}{d\phi}\right]_{\phi=0} = -\,2\pi V_1\left[\frac{4\cdot\dfrac{R_1}{R_2}}{\pi^2\left(1+\dfrac{2R_1}{R_2}\right)^2}\right] = -\,\frac{8V_1}{\pi}\left[\frac{R_1/R_2}{(1+2R_1/R_2)^2}\right] \quad \ldots \quad (12)$$

We see that at $\phi = 0$ the differential sensitivity is a function of R_1/R_2. The value of R_1/R_2 for which the sensitivity is a maximum is given by the solution of

$$\left[\frac{\partial^2\,(V_A - V_B)}{\partial\phi\,\partial\,R_1/R_2}\right]_{\phi=0} = 0$$

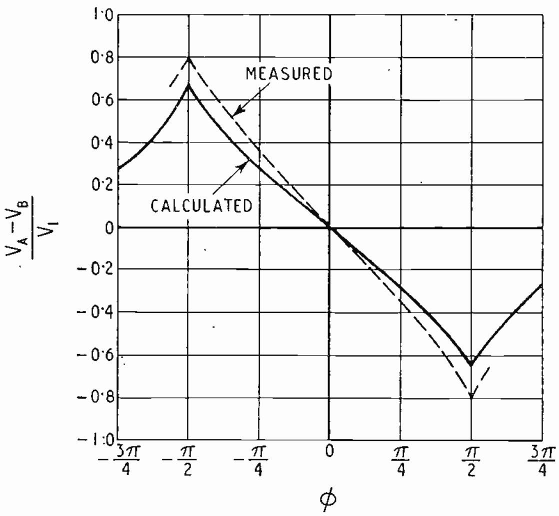


Fig. 13. Push-pull phase detector with square-wave input. Calculated and measured curves.

That is,

$$\frac{-8V_1}{\pi}\left[\frac{\left(1+2R_1/R_2\right)^2 - \dfrac{4R_1}{R_2}\left(1+\dfrac{2R_1}{R_2}\right)}{(1+2R_1/R_2)^4}\right] = 0$$

This is satisfied by $1 - 4\left(\frac{R_1}{R_2}\right)^2 = 0$

or $R_2 = 2R_1$ .. .. .. (13)

Substituting this condition in equations (8) and (9) we get :

$$\frac{V_A - V_B}{V_1} = \frac{\pi\phi}{\pi^2 - \phi^2} \quad \ldots \quad \ldots \quad (14)$$

This equation is plotted in Fig. 13 over the range of ϕ from $-\pi/2$ to $+\pi/2$ (equation (14) is strictly correct for this range only).

On the same base is plotted the result obtained from measurements on a circuit similar to that of Fig. 9, with the following component values :—

$R_1 = 22{,}000$ ohms.
$R_2 = 47{,}000$ ohms.

The Balanced Push-Pull Phase Detector

(*a*) *Theory for Sinusoidal Input.*

We have shown that the simple push-pull phase detector, as in Fig. 6, is capable of detecting a phase difference by a difference in the two steady voltages V_A and V_B. Owing to the configuration of the circuit, neither V_A nor V_B can ever be negative (that is, the points A and B are always positive in potential relative to the centre point). When $\phi = 0$, $V_A = V_B$ and $V_C = 0$. The practical difficulties arising from the fact that V_A and V_B are voltages of considerable magnitude when $\phi = 0$, could be obviated by the circuit arrangement of Fig. 8. The same result may be achieved by the use of a balanced push-pull phase detector as shown in Fig. 14.

This arrangement is similar to that of Fig. 6 with the addition of the cross-connected rectifiers and resistors G_3, G_4 and R_1. From the symmetry of the circuit it will be evident that the voltages from the transformers T_1 and T_2, taken singly, cannot produce steady voltages V_A and V_B.

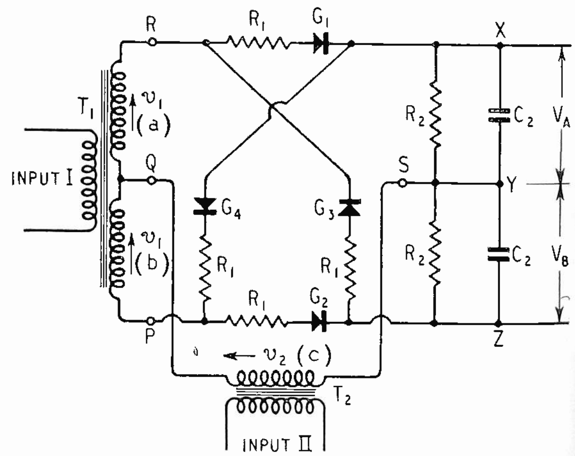


Fig. 14. Balanced push-pull phase detector.

The resultant charge on the capacitor C_2 between the points XY is provided by currents from the rectifiers G_1 and G_4 only, whilst the capacitor C_2 between YZ receives its charge from the rectifiers G_2 and G_3 only.

If we consider the capacitor between XY the relevant circuit may be re-drawn as in

Fig. 15; on the assumption that the generators driving the transformers T_1 and T_2 are of low internal impedance, the secondary windings RQ, QP and QS have been replaced in Fig. 15 by the equivalent generators of e.m.fs. v_1 (a), v_1 (b) and v_2 (c) respectively.

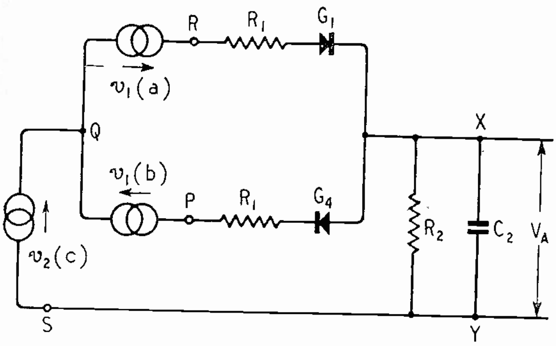


Fig. 15. Equivalent circuit of elements of Fig. 14 which produce V_A.

If we adopt the notation which has already been used we have

$$v_1(a) = v_1(b) = V_1 \sin \omega t.$$
$$v_2(c) = V_1 \sin(\omega t + \phi + \pi/2).$$

If the instantaneous voltage applied to rectifier G_1 is called V_{g1} and that applied to G_4 is V_{g4}, then

$$V_{g1} = v_2(c) + v_1(a)$$
$$V_{g4} = v_2(c) - v_1(b)$$

It is evident that current through G_1 makes X positive in potential relative to Y, and current through G_4 makes Y positive in potential relative to X.

From an inspection of Fig. 15 we may deduce the following:

(1) If $V_{g1} = V_{g4}$ the net charge accumulated by C_2 over each a.c. cycle is zero and hence $V_A = 0$.

(2) If V_{g1} is greater than V_{g4}, X becomes positive relative to Y.

(3) If V_{g4} is greater than V_{g1}, Y becomes positive relative to X.

Using our original notation we know that:

$V_{g1} = V_{g4}$ corresponds to $\phi = 0$.
$V_{g1} > V_{g4}$ corresponds to ϕ negative.
$V_{g1} < V_{g4}$ corresponds to ϕ positive.

Thus V_A changes sign as ϕ changes sign, and we see that the balanced push-pull circuit overcomes this limitation in the simple push-pull circuit, in which V_A and V_B are always positive and only the difference $(V_A - V_B)$ changes sign with ϕ.

In order to determine V_A we again make the assumption that V_A is substantially a constant unidirectional voltage over the period of one a.c. cycle.

In this case it implies that not only must the time constant C_2R_2 be large compared with the period $2\pi/\omega$, but that C_2R_1 must also be large, since C_2 effectively discharges through G_4 and R_1, or G_1 and R_1 depending on which of V_{g1} or V_{g4} respectively is the greater.

Let us consider the case when ϕ is negative. V_{g1} is greater than V_{g4} and V_A is positive. Thus G_1 will have a negative bias of V_A applied to its anode and G_4 will have a positive bias of V_A applied to its anode. Under these conditions G_1 will conduct for a period less than the positive half-cycle of the applied voltage V_{g1} and G_4 will conduct for a period greater than the positive half-cycle of V_{g4}. This is shown in Fig. 16 in which the phase equality between the waveforms of V_{g1} and V_{g4} is shown for convenience and has no significance.

From Fig. 16 we see that G_1 conducts for an angle $\theta_1/2$ on either side of the positive peak value of V_{g1} and G_4 conducts for an angle of $\theta_4/2$ on either side of the positive peak value of V_{g4}.

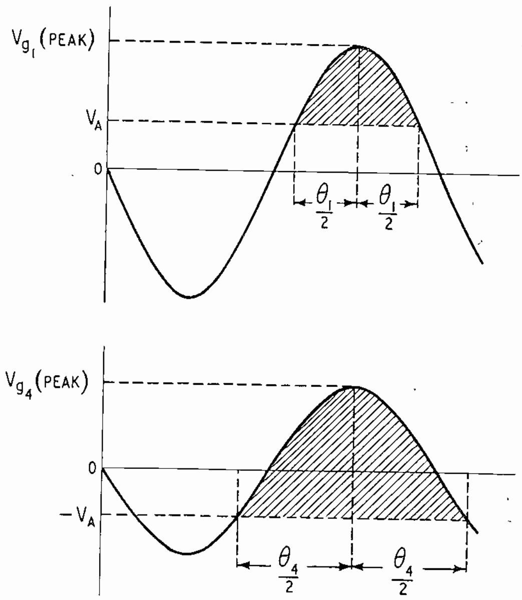


Fig. 16. Conduction angles of rectifiers G_1 and G_4.

Now,

$$\left.\begin{aligned} \frac{\theta_1}{2} &= \cos^{-1} \frac{V_A}{V_{g1}\ (\text{peak})} \\ \frac{\theta_4}{2} &= \left[\pi/2 + \sin^{-1} \frac{V_A}{V_{g4}\ (\text{peak})}\right] \end{aligned}\right\} \quad \ldots (15)$$

Inserting the peak values of V_{g1} and V_{g4} from equation (2) we get:

$$\left.\begin{aligned}\cos\frac{\theta_1}{2} &= \frac{V_A}{|2V_1\cos(\pi/4+\phi/2)|}\\ \cos\frac{\theta_4}{2} &= \frac{-V_A}{|2V_1\sin(\pi/4+\phi/2)|}\end{aligned}\right\} \quad .. \quad (16)$$

For a given value of ϕ, V_A will assume a steady value such that the quantity of electricity flowing through G_1 over the period θ_1 is equal to the quantity of electricity flowing through G_4 over the period θ_4 plus the quantity of electricity flowing through the resistance R_2 in one a.c. cycle (2π radians).

The plus sign applies to the case when V_{g1} is greater than V_{g4}. We may write therefore :—

Thus equation (18) may be rewritten in terms of $V_A/2V_1$, and ϕ only, from which it should be possible to find $V_A/2V_1$ in terms of ϕ.

However, $V_A/2V_1$ is not expressed as an explicit function of ϕ and hence graphical methods must be used to obtain the relationship.

Thus for each value of ϕ chosen, both sides of equation (18) may be plotted for a series of values of $V_A/2V_1$. Where the pairs of curves intersect gives the unique values of $V_A/2V_1$ for the particular values of ϕ chosen. At one point in this process a discontinuity occurs and this will now be discussed.

Referring to Fig. 16 it is clear that as V_{g1}

$$\frac{1}{R_1}\int_{-\frac{\theta_1}{2}}^{+\frac{\theta_1}{2}} (V_{g1}-V_A)\,d(\omega t) = \frac{1}{R_1}\int_{-\frac{\theta_4}{2}}^{+\frac{\theta_4}{2}} (V_{g4}+V_A)\,d(\omega t) + \frac{2\pi V_A}{R_2} \quad .. \quad .. \quad (17)$$

By making R_2 very much greater than R_1 we can ignore it in the following calculations.

$$\therefore \int_{-\frac{\theta_1}{2}}^{+\frac{\theta_1}{2}} \Big[2V_1\cos(\pi/4+\phi/2)\cos\omega t - V_A\Big]\,d(\omega t).$$

$$= \int_{-\frac{\theta_4}{2}}^{+\frac{\theta_4}{2}} \Big[2V_1\sin(\pi/4+\phi/2)\cos\omega t + V_A\Big]\,d(\omega t).$$

This expression reduces to,

(peak) increases and V_{g4} (peak) decreases, a value of ϕ may be found at which V_{g4} (peak) $= V_A$. At this particular value of ϕ, $\theta_4/2 = \pi$ and for all values of ϕ lying between this value and the value which gives V_{g4} (peak) $= 0$, namely $\phi = -\pi/2$, $\theta_4/2$ will remain constant at the value π.

Let us find this critical value of ϕ.

We have, for $\theta_4/2$ just equal to π.

$$V_A = V_{g4}\,\text{(peak)}$$

$$\therefore V_A = 2V_1\sin(\pi/4+\phi/2)$$

$$\text{or}\quad \frac{V_A}{2V_1} = \sin(\pi/4+\phi/2)$$

$$\frac{2V_1}{V_A}\left[\cos(\pi/4+\phi/2)\sin\frac{\theta_1}{2} - \sin(\pi/4+\phi/2)\sin\frac{\theta_4}{2}\right] = \frac{\theta_1}{2}+\frac{\theta_4}{2} \quad .. \quad .. \quad (18)$$

If we wish to express $\dfrac{V_A}{2V_1}$ in terms of ϕ only we must eliminate $\theta_1/2$ and $\theta_4/2$ in equation (18).

From equation (16) we have,

$$\left.\begin{aligned}\frac{\theta_1}{2} &= \cos^{-1}.\ \frac{V_A/2V_1}{\cos(\pi/4+\phi/2)}\\ \frac{\theta_4}{2} &= \pi/2+\sin^{-1}.\ \frac{V_A/2V_1}{\sin(\pi/4+\phi/2)}\end{aligned}\right\} .. \quad (19)$$

From equation (19)

$$\frac{\theta_1}{2} = \cos^{-1}\tan(\pi/4+\phi/2)$$

$$\text{or}\ \cos\frac{\theta_1}{2} = \tan(\pi/4+\phi/2)$$

$$\therefore \sin\frac{\theta_1}{2} = \sqrt{1-\tan^2(\pi/4+\phi/2)}$$

$$\left.\begin{aligned}\therefore\ \sin\frac{\theta_1}{2} &= \sqrt{1-\cos^2\frac{\theta_1}{2}} = \sqrt{1-\frac{(V_A/2V_1)^2}{\cos^2(\pi/4+\phi/2)}}\\ \text{and}\ \sin\frac{\theta_4}{2} &= \sqrt{1-\cos^2\frac{\theta_4}{2}} = \sqrt{1-\frac{(V_A/2V_1)^2}{\sin^2(\pi/4+\phi/2)}}\end{aligned}\right\} \quad .. \quad .. \quad (20)$$

Substituting this in equation (18) and remembering that $\frac{\theta_4}{2} = \pi$ we have

$$\cot\left(\pi/4 + \phi/2\right)\sqrt{1 - \tan^2\left(\pi/4 + \phi/2\right)} = \cos^{-1}\tan\left(\pi/4 + \phi/2\right) + \pi$$

or

$$\sqrt{\cot^2\left(\pi/4 + \phi/2\right) - 1} = \cos^{-1}\tan\left(\pi/4 + \phi/2\right) + \pi \quad \ldots (21)$$

This gives a solution $\phi = -65.5°$.

Thus we use equation (18) as it stands for all values of ϕ from 0 to $-65.5°$, and we use the same equation with π substituted for $\theta_4/2$ for all values of ϕ between $-65.5°$ and $-90°$.

Using this graphical method the curve relating $V_A/2V_1$ with ϕ is plotted in Fig. 17 for values of ϕ from 0 to $-180°$; the curve for values of ϕ from 0° to $+180°$ is identical in shape but with negative values for $V_A/2V_1$.

The flat top to the curve, over the region $-70° > \phi > -110°$ also appears in the results obtained from measurements on this circuit, which are also plotted in Fig. 17.

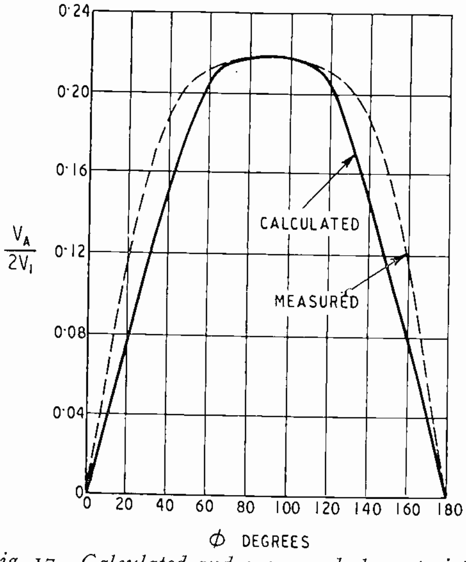


Fig. 17. Calculated and measured characteristics of balanced push-pull phase detector with sine-wave input.

If the other half of the circuit of Fig. 14 had been considered we should have found that the magnitude of the voltage V_B is always equal to V_A, the polarity being such that the potential of X is always equal and opposite to that of Z, relative to Y.

From Fig. 17 we see that the peak value of $V_A/2V_1$ is 0.218

$$\therefore \frac{V_A + V_B}{2V_1} = 0.436 \text{ (Maximum value).}$$

Comparing this value with that obtained from the simple push-pull circuit with sinusoidal input we see that the balanced push-pull circuit is less than 50 per cent as efficient as the former.

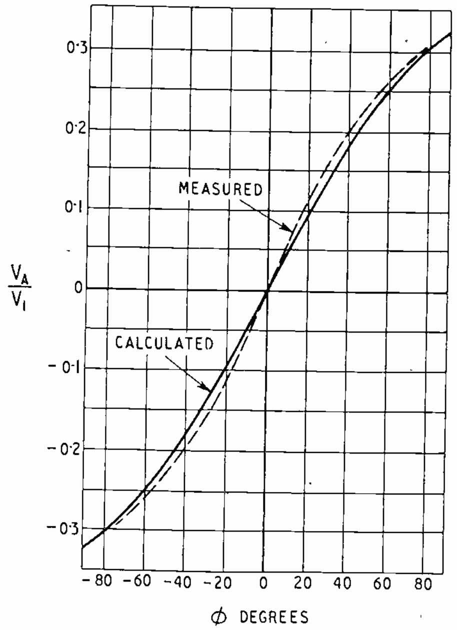


Fig. 18. Calculated and measured characteristics of balanced push-pull phase detector with square-wave input.

(b) *Theory for Square-Wave Input.*

By considering Figs. 11 and 15 we can find the result of applying rectangular waves to the circuit of Fig. 14.

If ϕ is negative, $\left(\frac{\pi}{2} - \phi\right)$ is greater than $(\pi/2 + \phi)$, and hence the time duration of the pulses applied to G_1 are greater than those applied to G_4. Hence the capacitor C_2 will acquire a steady voltage V_A such that X is positive in potential to Y.

If R_2 is very much greater than R_1, the voltage V_A must satisfy the following equation, taken over one complete cycle,

$$\frac{(V_1 - V_A)(\pi/2 - \phi)}{R_1} = \frac{V_A\left(2\pi - \frac{\pi}{2} - \phi\right) + V_1(\pi/2 + \phi)}{R_1} \quad (22)$$

Which reduces to,

$$\frac{V_A}{V_1} = \frac{-\phi}{\pi - \phi} \quad \ldots \quad \ldots \quad \ldots \quad (23)$$

This equation is exact for values of ϕ from 0 to $-\pi/2$.

For values of ϕ from 0 to $\pi/2$, Y becomes positive in potential to X and the equation should read,

$$\frac{V_A}{V_1} = \frac{\phi}{\pi + \phi} \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

The complete curve is shown in Fig. 18.

If the resistance R_2 is not so small that it may be neglected, equation (22) should be written,

$$\frac{(V_1 - V_A)(\pi/2 - \phi)}{R_1} = \frac{V_A(2\pi - \pi/2 - \phi) + V_1(\pi/2 + \phi)}{R_1} + \frac{2\pi V_A}{R_2} \quad \ldots (25)$$

which reduces to,

$$\frac{V_A}{V_1} = \frac{-\phi}{\pi(1 + R_1/R_2) - \phi} \quad \ldots \quad \ldots \quad (26)$$

The measured response on a circuit made up with the values $R_1 = 5{,}000$ ohms and $R_2 = 22{,}000$ ohms is also plotted in Fig. 18.

Conclusion

The simple push-pull and the balanced push-pull phase detectors with sinusoidal and square-wave input have been analysed. Reviewing the results it would appear that for the overall requirements of sensitivity and a reasonably linear relation between phase difference and output, the simple push-pull detector with square-wave input gives the best result. The simple push-pull detector with sinusoidal input is more sensitive but the relationship between ϕ and the output voltage is sinusoidal, which may be undesirable.

REFERENCE

1. "Methods and Apparatus for Measuring Phase Distortion." M. Levy. *Electrical Communications*, Jan. 1940.

World List of Scientific Periodicals

A third edition of this reference book is being prepared to include all scientific and technical periodicals that have appeared from 1900 to 1947. Librarians are asked to co-operate by sending particulars of all journals which do not appear in the second edition to the Secretary, World List of Scientific Periodicals, c/o The Zoological Society of London, Regents Park, London, N.W.8.

BOOKS

Uber Frequenzmodulatoren für Ultrahochfrequenz.

By Georg Weber. Pp. 95 with 35 Figs. Published by Verlag AG. Gebr. Leemann & Co., Zürich. Price 9 Francs (Swiss).

This represents the thesis presented by the author for the D.Sc. degree at the Zürich Technische Hochschule. The work was carried out in the Institut für Hochfrequenztechnik under the direction of Dr. F. Tank. It deals with the difficulties of applying frequency modulation to transmitters working at frequencies of 100 to 600 Mc/s. Of the five chapters the first three discuss the problem and the last two describe the construction of apparatus and the measurements made with it. The relative merits of amplitude and frequency modulation are discussed in the opening chapter. The second chapter deals with the variable impedance valve, and the use of a klystron for this purpose. Chapter 3 is divided into two parts dealing with two different types of mechanical modulators, viz., piezoelectric and electrostatic modulators The latter is then chosen and the remainder of the book describes in detail the construction and testing of an electrostatic frequency modulator. By means of the movement of a membrane the capacitance of a cavity resonator in the u.h.f. system is varied, thus causing the frequency to vary. The membrane is moved electrostatically by means of a metal plate parallel to it, the two forming an air capacitor, the voltage of which is varied by the modulating valve.

The results obtained are considered satisfactory. The question of distortion is discussed, and also the question as to the number of channels that can be utilized within a given frequency band in view of the large band of frequencies involved in a frequency-modulated transmission. The book is well worth careful study by anyone interested in this branch of the subject.

G. W. O. H.

The Magnetron

The object of this note is to draw attention to the April number of the *Bell System Technical Journal*, Vol. XXV, No. 2. Although published as a monthly issue of the Journal, it may well be regarded as a textbook on the magnetron, for it contains only one article, "The Magnetron as a Generator of Centimetre Waves." The authors are Fisk, Hagstrum, and Hartman, all of whom were engaged in the Electronics Research Department on magnetron development during the war. The article occupies 180 pages and has 80 figures, including many excellent photographs. Extra copies can be obtained at 1 dollar per copy from the American Telephone and Telegraph Co., 195 Broadway, New York. Although nominally the April number, circumstances delayed its publication until July. It is an outstanding publication, and it can be strongly recommended, notwithstanding the fact that the authors use the same abbreviation *m* for both milli- and mega-.

G. W. O. H.

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.

Response of Oscillator to External E.M.F.

To the Editor, "Wireless Engineer"

SIR,—In his article "Oscillator Power Relations" in the September 1946 issue of *Wireless Engineer*, Mr. R. E. Burgess includes a section discussing the response of an oscillator to an external e.m.f. injected into its circuit. The brevity of treatment of this section is such that I cannot myself fully follow it, and the section also seems irrelevant to the article; but these are personal matters. My present object is to point out what seems to me to be a fallacious argument; I suggest that it is not possible to consider the effective "half-power" bandwidth of the system, nor to express it in terms of a linear tuned circuit.

Mr. Burgess specifies the external (or injected) frequency to be different from the oscillation frequency. Yet he deduces the bandwidth between the points where the response is 3 db below that at midband, even though the response at midband (i.e., at the natural oscillation frequency) is specifically excluded from his analysis! Moreover, he specifies that the injected e.m.f. is small so that U (the voltage across the oscillator due to the injected frequency ω) is small compared with A (the voltage across the oscillator due to the free oscillation of frequency ω_0). This requirement appears to me to exclude consideration of any frequency near the "3-db pass-band," because at any frequency so close to the natural frequency, the injected e.m.f. would need to be almost infinitesimal to avoid making U comparable with A.

No mention is made by Mr. Burgess of synchronization, the well-known phenomenon of suppression of the free oscillation by the forced oscillation. This occurs when $\omega \sim \omega_0$ is sufficiently small in relation to the amplitudes in the circuit. Mr. Burgess gives Appleton's paper[1] of 1922 as one of his references in spite of ignoring the effect in his text. This paper discusses some aspects of synchronization, and a more comprehensive treatment will be found in my own more recent paper.[2] This matter is vital to Mr. Burgess's problem, as I hope to show below.

Using the methods, results and symbols of my paper, in which

$\hat{e}_i \sin \omega t$ is the fundamental component of the forced oscillation voltage across the input to the non-linear maintaining circuit,

$\hat{e}_s \sin \omega t$ is the injected voltage,

$\hat{e}_{io} \sin \omega_0 t$ is the natural oscillation voltage with no injected signal,

$G(e_i)$ is the non-linear amplification of the maintaining circuit to fundamental frequencies,

and putting $\hat{e}_{im}$ for the peak amplitude of the forced oscillation when $\omega = \omega_0$ and using the subscript p for values associated with the pull-out point, or point of failure of synchronization, we can proceed as follows:—

If the injected voltage is small, then just at the point where synchronization is about to fail, and a free oscillation about to start, we have the relation

$$\frac{\hat{e}_{ip}}{\hat{e}_s} = \frac{1}{2Q\left(1 - \dfrac{\omega_p}{\omega_o}\right)}$$

and under such conditions, $\hat{e}_{ip}$ is only slightly smaller than $\hat{e}_{io}$.

When $\omega = \omega_0$, then $\hat{e}_i$ has the value of $\hat{e}_{im}$ and $\hat{e}_{im} > \hat{e}_{io}$ always. We have now the relation

$$\frac{\hat{e}_{im}}{\hat{e}_s} = \frac{1}{1 - G_m(e_i)}$$

where $G_m(e_i)$ is the gain of the maintaining circuit for the amplitude $\hat{e}_{im}$.

When free oscillation occurs in the absence of an injected signal, $G_o(e_i) = 1$, and since $\hat{e}_{im} > \hat{e}_{io}$ and the non-linearity must be such as to reduce the gain for an increased amplitude, we have $G_m(e_i) < 1$. Thus, for a given injected voltage $\hat{e}_s$, the change in response between frequencies ω_o and ω_p is given by

$$\frac{\hat{e}_{im}}{\hat{e}_{ip}} = \frac{2Q\left(1 - \dfrac{\omega_p}{\omega_o}\right)}{1 - G_m(e_i)}$$

This may be greater or less than 3 db according to the actual values of Q, $\hat{e}_s$ (which determines ω_p/ω_o), and $G(_{ei})$. In an average case it will be greater than 3 db; e.g., Fig. 11 in my paper shows that for $G(_{ei}) = 1.03 - 0.12\hat{e}_i^2$ (which gives $\hat{e}_{io} = 0.5$), $\hat{e}_s = 0.05$ and $Q = 80$, the output of forced oscillation at pull-out is approximately 4 db below that at "midband."

We can thus conclude that the 3-db bandwidth (if it has any meaning at all) will generally occur within the synchronizing frequency range, which is not discussed by Mr. Burgess, and is implicitly excluded from his analysis by his requirement $U \ll A$. Evidently the response cannot be expressed in terms of a fixed effective Q, because for a constant value of injected voltage, the forced oscillation amplitude varies with frequency, so that the non-linear factor (considered by Mr. Burgess as a parallel negative conductance) varies with frequency.

It is clear, I think, that Mr. Burgess's discussion is, to say the least, somewhat misleading, There is no opportunity to give the matter a full analysis on my part here, but I would claim that it is more readily treated by the methods used in my paper[2] than by Mr. Burgess's method.

Amersham, Bucks. D. G. TUCKER.

REFERENCES

1 E. V. Appleton, "The Automatic Synchronization of Valve Oscillators," *Proc. Camb. Phil. Soc.*, 1922–3, Vol. 21, p. 231–248.

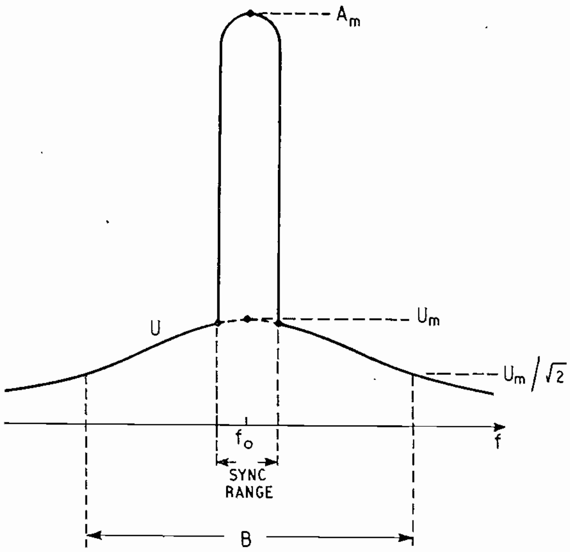
2 D. G. Tucker, "Forced Oscillations in Oscillator Circuits, and the Synchronization of Oscillators," *J.I.E.E.*, 1945, Vol. 92, Part III, p. 226–234.

To the Editor, "Wireless Engineer."

SIR,—Dr. Tucker's criticism springs from a misunderstanding which may well have arisen from the admitted brevity of section 6 of my paper.

The response curve defined by equation (19) relates the amplitude U of the forced oscillation to that of the injected e.m.f. E whose frequency is different from the oscillation frequency. It is specifically stated in my paper that E is sufficiently small for $U \ll A$ where A is the amplitude of the free oscillation and the synchronization range is correspondingly very small; ω is naturally assumed to lie *outside* the synchronization range in order that both the free and forced vibrations are present in the form given by equation (17).

The "3-db bandwidth" derived from equation (19) is referred to the value U_m obtained at f_0 by extrapolating the U, f curve through the synchronization range and *not* to the value A_m of the oscillation at f_0. The figure (not to scale) illustrates this point: B is reckoned between the points where $U = U_m/\sqrt{2}$ and not $A_m/\sqrt{2}$.



R. E. BURGESS.

National Physical Laboratory,
Teddington, Middx.

Transient Response of Filters.

To the Editor, "Wireless Engineer."

SIR,—I have read with interest Mr. C. C. Eaglesfield's short article on this subject in the November 1946 issue of *Wireless Engineer*, and am duly impressed by the neat and elegant way in which he solves the filter build-up equation which I found so difficult in my article in the March 1946 issue. I would like to point out, however, that I did give values for the coefficient G, based on the analogous low-pass filter, and these values were determined from exactly the same formula as Mr. Eaglesfield derives; this is easily seen from the figures I gave. My difficulty at this stage was that the calculated values did not fit the measured responses; and I suggested the reason was probably the effect of dissipation, since the Q-value of the inductors was only 100, which gives Qn (the factor affecting response, corresponding to Q in a low-pass filter—see my earlier article in the February 1945 issue) of only 3.7. I think Mr. Eaglesfield has rather overlooked the fact that I had dealt with these points.

D. G. TUCKER.

Amersham, Bucks.

Is Rotation Relative or Absolute?

To the Editor, "Wireless Engineer"

SIR,—In your editorial of the October issue, I found many controversial statements. They seemed to contradict entirely many experiences of the physical world. Therefore may I submit a few ideas on the subject "Is rotation relative or absolute"?

In order that we may possess a framework on which to build the argument it is necessary to state those things which we can regard as axiomatic.

1. The medium of events is "free space," which does not restrict those events.

2. An observer, in space, is capable of making time measurements.

3. The observer regards himself as stationary, when not acted upon by any force. If acted upon by a force he regards himself as moving with an acceleration in the direction of that force.

4. Distance is to be measured in absolute space.

5. A line is uniquely determined by two points in space.

6. The angle between two lines is to be regarded as some measure of the variation in distance between pairs of points on the lines, which are members of ordered aggregates of points in one-one correspondence, on these lines.

Having made these preliminary remarks, let us now consider what is meant by motion. The motion of a body infers change of position with time. To establish position we can erect two different systems of coordinates, either the Cartesian system or the polar system. To simplify the argument let us limit the discussion to a plane. Both these coordinate systems require two lines to establish the position of a point in a plane and therefore, in general require three points, including the datum point of the observer. In the case of polar coordinates, the position itself is regarded as one of the three points. In this last case, position is defined by the distance between the point and the pole, and the angle between the initial line and the line through the pole and the given point. Variation of either or both of these quantities with time will be sufficient to establish motion.

Let us now attempt a definition of rotation as applied to a finite body of zero thickness, in the plane of the coordinate system.

Suppose the observer at the datum point, draws a line across the body. He will note that this line makes different angles with the mean direction of the body as time progresses. Eventually by a series of observations he will determine the axis of rotation, which will seem to be stationary to him.

Having fixed this axis, the rotation of the body can be defined as a change in the angle between the line joining the datum point with the axis and the line joining the axis to any other point on the body, with time. Note that if no such point can be observed, the rotation of the body will not be visible.

Suppose now, the observer is fixed at the end of some extended radius of the body, which rotates. The observer will note that the angle subtended at the centre by every point is invariant with respect to time. He therefore concludes that the body is not rotating, although he is experiencing a force directed along the radius and towards the axis of rotation. He will conclude an acceleration towards the axis.

Now consider the case where the observer is situated at the axis of rotation. He will not be subject to any radial force. Unless there exists a point, external to the body, which is not subject to a radial force, he will not be able to erect the two lines by which rotation can be detected, since every two lines within the body will intersect at angles invariant with time. If however such an external point exists, the observer will conclude that it is rotating about him, by erecting a datum line on the body and another from himself to the external point.

We may therefore make the following generalizations :

(i) To any observer anywhere on the plane with relation to the axis of rotation of the body, the rotation will be detectable, provided the observer is not subject to the same radial force as he would be if he were attached to a fixed infinite radius of the body.

(ii) To any observer anywhere on the plane of the body, and "attached" to the radius of the body passing through his datum point, rotation will *not* be visible.

Therefore it is concluded that rotation is relative to the observer.

B. A. Hunn, Capt. R.E.M.E.

London, S.W.1.

To the Editor, The Wireless Engineer

Sir,—Your Editorial slyly shifts the absolute quality from the rotation of the body to the non-rotation of the observer. It is necessary to regard an observer who is "on" or "at rest relative to" a body as one whose sole frame of reference is in completely fixed relationship to the body in question ; but you reject this definition in your footnote and adopt another definition which in fact makes the rotation of the cylinder become relative to the line joining the observer and the distant point on which he keeps his eye constantly fixed.

The fact which has some appearance of making the observer conscious of rotation is not the relative motion of certain points but the need for a constant force to maintain a central acceleration, just as with the revolving magnet the force on a neighbouring charge is the crucial issue. The trouble then is that a rotating body has an *acceleration*, and while we have become accustomed to the special theory of relativity, which applies to systems with constant relative velocity, transformations between systems having relative accelerations come under the general theory of relativity which is beyond the range of engineers' mathematics. However, it is concerned with this very problem of the invariance of forces when referred to different co-ordinate systems, and the general theory of relativity should not be ignored even if we do not understand its details.

D. A. Bell

London, N.21.

Class-B Amplifiers

To the Editor, The Wireless Engineer

Sir,—In your October correspondence columns Dr. Sturley has described an interesting method of calculating approximately the relation between the peak and mean currents in Class-B amplifier valves with sinusoidal grid excitation. The basic assumption in Dr. Sturley's analysis, namely, that the anode current becomes zero whenever the alternating component of the grid voltage becomes negative, may also be used to calculate approximately the peak and mean currents and the anode dissipation for grid voltages of arbitrary waveform, e.g. speech waves, if the crest factor, C (= peak/r.m.s.), and the form factor, F (= r.m.s./arithmetic mean), are known.

Let I_o = anode current in the absence of grid excitation

I_p = peak anode current with grid excitation

When the alternating grid voltage is positive the mean anode current is $I_o + (I_p - I_o)/CF$, and when the alternating grid voltage is negative the anode current is zero. It is further assumed that positive and negative values of grid voltage are equally probable. The mean anode current over both positive and negative values of grid voltage is then

$$I_a = I_o/2 + (I_p - I_o)/2CF$$

Suppose that two valves are used in a push-pull amplifier with an h.t. voltage V_a, and an anode-to-anode load which is a resistance R at all the frequencies concerned, and is zero for d.c. With grid excitation the peak current in the load is $I_p/2$, and the load-current waveform may be taken as a first approximation to be the same as the grid voltage waveform. Let V_{min} be the minimum value reached by the anode voltage, then $R = 4(V_a - V_{min})/I_p$, and the power absorbed by the load is $RI_p^2/4C^2$. The total power supplied by the h.t. source is $2V_aI_a$, whence the anode dissipation in each valve is

$$V_aI_a - RI_p^2/8C^2$$
$$= V_aI_o/2 + V_a(I_p - I_o)/2CF - I_p(V_a - V_{min})/2C^2.$$

For sine waves $C = \sqrt{2}$ and $F = \pi/2\sqrt{2}$. For speech waves $F = 2$. The value of C is somewhat indeterminate and may depend on the amount of peak limiting or permissible distortion, but a value of 5 may be taken as representative for most applications.

The formulae given above are approximate, and the accuracy decreases as the product CF increases, but they have been found useful in making the first attempt at a design.

A. S. G. Gladwin

University of London,
King's College.

BRITISH I.R.E.

The 21st birthday of the British Institution of Radio Engineers was celebrated by a dinner at the Savoy Hotel on 31st October, 1946. Admiral the Viscount Mountbatten of Burma replied to the toast of the President proposed by the immediate past President, Mr. Leslie McMichael.

The Institution has grown out of the Institution of Wireless Technology which was formed in 1925, its present title being taken on the fusion of the original institution with the Institute of Radio Engineers in 1942.

Precision Instruments

A new catalogue of precision apparatus for electrical standards for research and industry has been produced by H. W. Sullivan, Ltd., London, S.E.15. Of 200 pages, it contains detailed descriptions and characteristics of apparatus ranging from fixed and variable standard capacitors and inductors to bridge and frequency-standard oscillators.

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

577 333.—Spring guiding-member for clamping and controlling the vibration of a loudspeaker diaphragm.

D. Eklöv. Convention date (Sweden), 16th December, 1942.

577 358.—Loudspeaker in which the main diaphragm is coupled to an auxiliary system of elastically-mounted massive elements, to prevent resonance effects.

The British Thomson-Houston Co., Ltd. Convention date (U.S.A.), 7th January, 1943.

DIRECTIONAL AND NAVIGATIONAL SYSTEMS

577 242.—Radio installation for training operators on a grounded aeroplane in the art of radio-navigation and blind-landing.

Link Aviation Devices Inc. Convention date (U.S.A.) 29th April, 1942.

577 269.—Rotary-disc switching device for alternate transmission and reception, through waveguide couplings, say in radiolocation equipment

Marconi's W.T. Co. Ltd. (assignees of G. W. Leck). Convention date (U.S.A.) 25th May, 1943.

577 275.—Time-storage or integrating devices, used in combination with a c. r. tube, for reducing interference in the observation of "repetitive" signals, such as are used in radiolocation.

W. S. Percival. Application date 30th November, 1939.

577 276.—Blind-landing system in which a glide-path of constant field-strength approaches ground at a point remote from the transmitting aerials.

Standard Telephones and Cables Ltd., C. W. Earp and G. G. Samson. Application date 23rd February, 1940.

577 285.—Coupling network for transforming, without distortion, the output from the constantly-rotating search-coil of a radio goniometer to an amplifier feeding a c. r. indicator.

Standard Telephones and Cables Ltd. (assignees of H. G. Busignies). Convention date (U.S.A.) 6th March, 1941.

RECEIVING CIRCUITS AND APPARATUS

577 240.—Cathode-ray tube for monitoring, or indicating the beginning and end and operating-frequency, of one or more radio transmitters.

H. A. M. Clark. Application date 20th June, 1941.

577 247.—Diversity-reception system, for reducing the effect of selective fading, and applicable to frequency-modulation signals.

S. G. Dehn (communicated by Press Wireless Inc.). Application date, 13th April, 1944.

577 345.—Radio-operated switch for rendering a distant receiver active for predetermined periods, say for the remote control of firing apparatus.

D. Weighton and Pye Ltd. Application date 15th November, 1940.

577 443.—Radio set in which a rigid metal front panel is fitted with a pair of projecting rails, which can serve either as carrying-handles or as supporting-feet.

G. A. Laughton and H. N. Cox. Application date 27th April, 1944.

577 462.—Coupling network, say between two i.f. amplifiers, to provide a band-pass effect having an adjustable characteristic at frequencies near the middle of the band.

The General Electric Co. and D. C. Espley. Application date 21st May, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

577 278.—Electron-discharge device, for velocity-modulation, in which the bunched electrons are projected on to a secondary-emission electrode.

Standard Telephones and Cables Ltd., J. H. Fremlin, and R. N. Hall. Application date 24th May, 1940.

577 280.—Oscillator or frequency-changing device in which a beam of electrons is subjected to a wave-like deflection as it passes through a static magnetic-field.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 22nd December, 1939.

577 530.—Velocity-modulating tube in which the bunched stream is returned to the resonator along a potential gradient which is set up by a reflecting electrode-system.

A. F. Pearce, N. C. Barford, and B. J. Mayo. Application dates 16th December, 1941, and 13th January, 1943.

SUBSIDIARY APPARATUS AND MATERIALS

577 089.—Preparations of a fine-grain fluorescent material containing cadmium and manganese phosphate, and a mixture of chlorides and phosphates to serve as activators.

Siemens Electric Lamps and Supplies, Ltd. and H. Austin. Application date 24th April, 1944.

577 120.—Arrangement for time-marking, when making photographic records of oscillograph indications over a wide frequency-range.

A. C. Cossor, Ltd. and A. N. Melchior. Application date 19th April, 1944.

577 219.—Shrouded terminal, providing high insulation, particularly for feeding an element which is enclosed in an hermetically-sealed case.

Standard Telephones and Cables Ltd., P. K. Chatterjea, and S. J. Powers. Application date 11th February, 1944.

577 428.—Insulating coating, containing finely-divided anthracite coal, for reducing corona effects in high-voltage conductors.

Westinghouse Electric International Co. Convention date (U.S.A.) 3rd December, 1942.

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

[534 + 536] : 538.569.4.029.64 **3509**

Thermal and Acoustic Effects attending Absorption of Microwaves by Gases.—Hershberger. (*See* 3585.)

534.21 **3510**

The Propagation of Sound in the Atmosphere—Attenuation and Fluctuations.—V. O. Knudsen. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 90–96.)

534.21 **3511**

Propagation of Sound over Absorbent Surfaces.—L. K. Cook. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 252.) Summary of Amer. Acoust. Soc. paper.

534.212 : 534.321.9 **3512**

The Directional Characteristics of a Free-Edge Disk mounted in a Flat Baffle or in a Parabolic Horn.—F. H. Slaymaker, W. F. Meeker & L. L. Merrill. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 251.) When a parabolic horn is excited by a diaphragm at supersonic frequencies, the sharpest beams are obtained with the diaphragm radiating most of its energy towards the side walls. The differential equation for the vibration of a thin free-edge circular disk is solved, and the results tabulated so that the dynamic curve and directional radiation pattern can be calculated for any disk and frequency. Summary of Amer. Acoust. Soc. paper.

534.32 **3513**

A Hundred-Element Tone Synthesizer.—E. C. Wente, C. A. Lovell & J. F. Muller. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 253.) A complex electric current is generated by a combination of up to one hundred sine-wave currents derived from magnetic records, each of which is variable in amplitude and substantially free from harmonics. Summary of Amer. Acoust. Soc. paper.

534.321.9 : 534.241 **3514**

Echo Formation on Simple Surfaces.—C. E. Mongan, Jr. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 255.) A laboratory technique has been devised for the observation of supersonic echo formation at plane, cylindrical, and spherical discontinuities. Summary of Amer. Acoust. Soc. paper.

534.321.9 : 549.514.51 **3515**

Refinements in Supersonic Reflectoscopy. Polarized Sound.—F. A. Firestone & J. R. Frederick. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 200–211.) Supersonic waves of various types can be radiated by suitable excitation of quartz crystals and can be used, in a reflectoscope, for the detection of flaws in metals by the reflections they produce. The reflectoscope has also been used extensively for studying the laws of reflection and refraction of polarized sound in solids.

534.41 + 534.781 **3516**

The Portrayal of Visible Speech.—J. C. Steinberg & N. R. French. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 4–18.) The object is to produce a satisfactory time-intensity-frequency (three-dimensional) speech pattern. The best scales for such a diagram, and other possible developments suggested by the physiological characteristics of speech and reading, are discussed. Methods of evaluating pattern legibility are also suggested.

534.41 + 534.781 **3517**

The Sound Spectrograph.—W. Koenig, H. K. Dunn & L. Y. Lacy. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 19–49.) The mechanical arrangements and electrical circuits are described. Time-intensity-frequency records of a wide variety of sounds are shown and the problems arising in their analysis are discussed.

534.41 + 534.781 **3518**

Basic Phonetic Principles of Visible Speech.—G. A. Kopp & H. C. Green. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 74–89.) The visible characteristics of the various fundamental phonetic sounds, classified according to their method of production, are shown pictorially and discussed. Racial and individual differences of speech are also considered.

534.41 + 534.781] : 535.37 **3519**

Visible Speech Translators with External Phosphors.—H. Dudley & O. O. Gruenz, Jr. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 62–73.) Speech patterns, analysed on an intensity-frequency-time basis, are displayed on an endless moving phosphorescent belt. Any pattern is visible for about 1¼ sec after which it is erased by red lamps.

534.41 + 534.781] : 621.385.832 **3520**

Visible Speech Cathode-Ray Translator.—R. R. Riesz & L. Schott. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 50–61.) The special cathode-ray tube has a persistent screen in the form of a cylindrical band, and is rotated about a vertical axis. The electron beam always excites the screen in the same vertical plane, so the speech patterns, portrayed both as a spectrum and as a pitch analysis, appear along a horizontal time axis. The translator has been used to study patterns of speech sounds and their combinations. Trained observers can interpret the pictures of conversational speech at 90–120 words per minute.

534.417 : 534.88 **3521**

Echo Ranging Sonar [model QCS/T].—Evans. (*See* 3605.)

534.7 **3522**

Effects of Distortion on the Intelligibility of Speech at High Altitudes.—G. A. Miller & S. Mitchell. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 250.) "Sounds spoken into the closed cavity of an oxygen mask at high altitudes differ substantially in quality and intensity from normal speech at sea level." The most satisfactory method of correcting this appears to be sharp, symmetrical limiting ("peak clipping"). Summary of Amer. Acoust. Soc. paper.

534.7 **3523**

The Effects of High Altitude on Speech and Hearing.—H. W. Rudmose, K. C. Clark, F. D. Carlson, J. C. Eisenstein & R. A. Walker. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 250–251.) Measurements of speech energy, made at simulated altitudes from sea level to 40 000 ft show that the energy decrement of vowels and semi-vowels, expressed in decibels, varies uniformly with altitude but there is little change in unvoiced consonants, or in the threshold of hearing. Summary of Amer. Acoust. Soc. paper.

534.78 **3524**

Effects of Amplitude Distortion upon the Intelligibility of Speech.—J. C. R. Licklider. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 249.) Amplitude distortion of various forms was introduced into otherwise high-quality audio systems by the use of nonlinear circuits. Tests indicated that cutting of peaks resulting from overdriving the amplifiers had little detrimental effect on intelligibility whereas cutting of the low amplitude part of the speech had a serious effect. The reduction in intelligibility caused by distortion increases when noise is mixed with the speech, except when the noise consists of pulses and the distortion limits them. Summary of Amer. Acoust. Soc. paper.

534.78 **3525**

Effects of Frequency Distortion upon the Intelligibility of Speech.—J. P. Egan & F. M. Wiener. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 249–250.) Bandwidths used for frequency-distortion tests ranged from half an octave to the whole of the speech frequency range. Articulation increased with the intensity level of the received speech, but less rapidly the smaller the bandwidth. When the speech is mixed with a uniform spectrum of noise, and speech and noise are together passed through a filter, articulation differs very little from that obtained by filtering the speech only, before mixing with the noise. When, however, the noise level falls rapidly as a function of frequency, articulation can be improved by filtering both noise and speech. Summary of Amer. Acoust. Soc. paper.

534.78 **3526**

Correlation of the Audio Characteristics of Communication Systems with Measured Articulation Scores.—L. L. Beranek. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 250.) A method has been devised for determining the ability of a communication system to transmit speech intelligibly. "The results indicate that it is possible to estimate from physical data the performance of a system in an assumed ambient noise field." Summary of Amer. Acoust. Soc. paper.

534.78 **3527**

The Masking of Speech by Sine Waves, Square Waves, and Regular and Randomized Pulses.—S. S. Stevens, J. Miller & I. Truscott. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 250.) The most effective frequency for the masking of speech by sine waves is about 300 c/s for intense waves and 500 c/s for weak waves. Square waves are approximately equally effective between 80 c/s and 400 c/s. Regular pulses with a duration of 10 μs are most effective at about 200 pulses/sec but when the pulses occur at random time intervals the masking is greatly increased. Summary of Amer. Acoust. Soc. paper.

534.84 **3528**

Note on Normal Frequency Statistics for Rectangular Rooms.—R. H. Bolt. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 130–133.) A graphical method for determining the average number and spacings of normal frequencies, up to a given frequency, for a rectangular room of known dimensions.

534.84 **3529**

The Design and Construction of Anechoic Sound Chambers.—L. L. Beranek & H. P. Sleeper, Jr. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 140–150.)

534.844.1 **3530**

The Measurement of Reverberation.—W. Tak. (*Philips tech. Rev.*, March 1946, Vol. 8, No. 3, pp. 82–88.) In rooms and auditoria. Theoretical discussion of principles of measurement; apparatus used will be described in a subsequent article.

621.394/.396].645 3531
The Multiamp.—Jackson. (*See* 3559.)

621.395.61 : 534.64 3532
Motional Impedance Analysis applied to a Dynamic Microphone.—J. E. White. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, pp. 155–160.) A method whereby the pressure sensitivity at low audio frequencies, the microphone mechanical impedance, and other characteristics may be calculated.

621.395.613.38 3533
Magnetic Throat Microphones of High Sensitivity.—D. W. Martin. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 253.) Summary of Amer. Acoust. Soc. paper.

621.395.623.6 3534
Development of Midget Earphones for Military Use.—H. A. Pearson, A. B. Mundel, R. W. Carlisle, W. Knauert & M. Zaret. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 253.) Summary of Amer. Acoust. Soc. paper.

621.395.623.7 3535
The Output Stage.—Stanley. (*See* 3727.)

621.395.623.8 : 621.396.932 3536
Marine Loudspeaking Gear.—P. Hickson. (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 254–255.) Description of Ardente "Loud Hailer" type 431, which was designed for inter-ship communication to work off a 12-V accumulator, high voltage being supplied by a small motor generator. The audio amplifier gives an output of 15 W which was found sufficient for the purpose and enabled the apparatus to be kept small; it weighed 23 lb. The frequency response curve of the amplifier is flat from 300 to 10 000 c/s, attenuation being introduced at the lower end to match the characteristics of the loudspeaker unit.

621.395.667 3537
Fundamental Tone Control Circuits — A Reference Sheet.—(*See* 3728.)

621.395.92 3538
Desirable Frequency Characteristics for Hearing Aids.—H. Davis, C. V. Hudgins, G. E. Peterson & D. A. Ross. (*J. acoust. Soc. Amer.*, July 1946, Vol. 18, No. 1, p. 247.) Characteristics investigated included one with uniform acoustic gain from 100 to 7 000 c/s, and others with a slope of either 6 db or 12 db per octave towards either the high or the low frequencies. Tests on hard-of-hearing subjects showed that the best articulation was achieved with the flat characteristic or one with a 6 db per octave slope increasing towards the high frequencies. This was also true in the presence of static noise. Summary of Amer. Acoust. Soc. paper.

AERIALS AND TRANSMISSION LINES

621.392 3539
A Fractional Termination for Ladder Networks.—W. R. LePage. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 530–536.) A theoretical survey of the possibilities of using a new termination for a uniform ladder network, which renders it more nearly like its corresponding circuit of distributed constants than either the mid-shunt or mid-series terminated types, is given. The improvement, which holds only over a limited frequency range, is small, becoming less as the number of sections is increased.

621.392 3540
Anomalous Attenuation in Waveguides.—D. A. Bell. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 287–288.) A note on a pictorial and qualitative method of showing the variation with frequency of attenuation in waveguides, prompted by a paper by Kemp. A correction to this paper appears at the bottom of p. 289; the original paper was abstracted in 2818 of October.

621.392 3541
A Theory of the Narrow Resonant Slit in a Wave Guide Partition.—E. S. Akeley. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 697.) "The ratio r of the amplitude of the transmitted radiation at infinity to the incident amplitude is determined. Resonance occurs at $k = \pi/2L$ for infinitely narrow slit and $r = 1$ at resonance. These results are independent of the position of slit in partition. Formulas are given for the determination of the shape of the resonance maximum and shift of same from $k = \pi/2L$." Summary of Amer. Phys. Soc. paper.

621.392 : 538.566 3542
The Scattering of Electromagnetic Radiation by a Thin Circular Ring in a Circular Wave Guide.—P. Feuer & E. S. Akeley. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 697.) "The ratio of the scattered field to the incident field at a great distance from the obstacle is computed and also the position and shape of the resonance maximum." Summary of Amer. Phys. Soc. paper.

621.392 : 621.315.1 3543
Flexible Wave Guides.—A. R. Anderson & A. M. Winchell. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 104–109.) Three types of flexible waveguides are described, the first consisting of a metal strip wound spirally about a rectangular former; the second, a series of circular sections held by an internally ribbed synthetic rubber jacket; and the third, a thin-walled, seamless corrugated rectangular tube. The construction of each is given in detail and their characteristics tabulated. Their possible uses are discussed and the mechanical limitations of each type are considered. There is appreciable leakage of energy from the second type which also suffers from the disadvantage of restricted frequency coverage.

621.396.67 3544
More about Aerials — Polarization : Gain : Reflectors.—"Cathode Ray". (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 251–253.) An elementary discussion of electromagnetic fields and the above-mentioned properties of aerials. For part 1 see 2821 of October.

621.396.67.013 3545
The Magnetic Antenna.—L. Page. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 645–648.) The antenna investigated is an infinitely long cylindrical rod (radius a, permeability μ, permittivity κ) with a few turns wound around the centre. The increase of flux is given by equation (14) and is shown graphically as a function of λ/a in Figs. 1 and 2. For constant κ there is a critical wavelength λ_m, approximately proportional to $\sqrt{\mu}$,

at which the flux ratio exhibits a sharp maximum, while for constant μ the flux ratio increases strongly with increase of κ. If $\kappa = 25$, $\mu = 100$, and $a = 2$ cm, then $\lambda_m = 3$ m, and the value of the flux ratio is 7.2. This effect has a possible practical application.

621.396.67.08.011.2 **3546**
Antenna Impedance Measurement.—King. (*See* 3684.)

621.396.671 **3547**
The Cylindrical Antenna : Current and Impedance.—R. King & D. Middleton. (*Quart. appl. Math.*, July 1946, Vol. 4, No. 2, pp. 199–200.) Correction to 1453 of June.

621.396.677 **3548**
A Comparison of the Efficiencies of Rhombic Type Aerials.—I. M. Ruschuk. (*Vestnik Elektropromyshlennosti*, 1946, No. 2, pp. 13–18. In Russian.) Mathematical discussion showing that the gain of a variation of the broadside rhombic aerial, as proposed by Eisenberg, is 1.8 times higher on short waves and 1.53 times higher on long waves than in the case of an ordinary rhombic aerial.

621.396.679.4.012.2 **3549**
Solving Feeder Problems Graphically.—R. E. Kelley. (*QST*, Sept. 1946, Vol. 30, No. 9, pp. 25–27..140.) Explains the use of a circle diagram to calculate the impedance of a line for given loads and for given lengths.

CIRCUITS

621.3.014/.015].33 : 517.942.82 **3550**
Switching Problems and Instantaneous Impulses.—J. C. Jaeger. (*Phil. Mag.*, Sept. 1945, Vol. 36, No. 260, pp. 644–651.) Discussion of the application of the Laplace transform to circuits or linear systems in which an instantaneous change of conditions is imposed; the work of Ghizzetti (*R.C. Circ. Math. Palermo*, 1937, Vol. 61, p. 339) is critically considered. The paper includes a treatment of the case of an impulsive current or e.m.f. having a very large magnitude and very small duration, but finite time-integral.

621.314.015.33 **3551**
Pulse Transformer Ratings based on Energy Considerations, and Methods of Design based on Thermodynamical Considerations.—W. H. Bostick. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 697.) Summary of Amer. Phys. Soc. paper.

621.315.14.011.3/.4 **3552**
Geometric Mean Distances for Rectangular Conductors.—H. B. Dwight. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 536–538.) Values of geometric mean distances are given in graphical form for the calculation of reactance of parallel conductors of rectangular cross-section, for a wide range of dimensions and spacings. The formulae used and method of application to practical cases are illustrated by examples.

621.392 **3553**
A Fractional Termination for Ladder Networks.—LePage. (*See* 3539.)

621.392 : 621.315.59 **3554**
Nonlinear Circuit Element Applications.—H. E. Kallmann. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 130–136.) Applications considered comprise bridge circuits in which nonlinear elements are combined with ordinary resistors to improve power supply regulation; use as limiters to facilitate pulse squaring; and logarithmic scaling. The application of the latter in electrical computing operations is briefly described.

621.392.012.2.029.64 **3555**
A Circle Diagram for Resonant Microwave Systems.—W. Altar. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 697.) "The diagram permits the mapping, in the complex plane, of load impedances or reflection coefficients, of such contour lines as loaded resonator Q, frequency pulling, and the circuit efficiency." Summary of Amer. Phys. Soc. paper.

621.394/.397].645 **3556**
Minimal Noise Amplifiers.—E. J. Schremp. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 695–696.) "The present unified method, employing a simple principle valid at all frequencies, consists of two successive steps: (1) for each independent internodal tube noise generator, apply the constraint that the ratio vanish between its output response and that of the signal source; and (2) introduce small variations from the resulting constraints, to secure a compromise in gain, bandwidth, stability, and noise figure." Summary of Amer. Phys. Soc. paper.

621.394/.397].645 **3557**
Cathode Follower Coupling in D.C. Amplifiers.—Y. P. Yu. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 99–103.) The use of phase inverter circuits employing a high-value common cathode resistor is discussed, and the reduction of circuit noise considered. A high-gain (60 db) amplifier was designed for a single 250-V power supply, using a cathode follower as an inter-stage coupling element, and with injection on to the screen grid: the circuit noise level was "almost unmeasurably low".

621.394/.397].645.34 **3558**
Termination Effects in Feedback Amplifier Chains.—A. J. Ferguson. (*Canad. J. Res.*, July 1946, Vol. 24, Sec. A, No. 4, pp. 56–78.) An analysis is carried out of a typical i.f. or video feedback amplifier chain to investigate the influence of the input and output circuits on the overall frequency response. The analysis is similar to that of a four-terminal passive network and the solution to the network equations can be resolved into a wave advancing from the input to the output and another reflected back through the amplifier to the input. Performance can thus be expressed in terms of the reflection coefficients of the source and terminal impedances. Reflection coefficients are calculated for typical simple circuits used with amplifiers of three, four and five stages, and many of the derived frequency response curves are unsatisfactory. Considerably better curves may be obtained by using rather more complex terminations, and the best curves result from matching the amplifier chain to both the source and the load. Matching, however, limits the overall gain to half the value which could otherwise be achieved.

621.394.396].645 **3559**
The Multiamp.—C. E. Jackson. (*Radio News*, Sept. 1946, Vol. 36, No. 3, pp. 58..155.) An

amplifier giving 30 W high-fidelity output over the entire audio range, with a total harmonic distortion of less than 2%, and noise level 60 db below 30 W on the microphone channels. Higher outputs, up to 90 W, can be obtained by adding compact booster units using 6V6 valves; the power gain of the valves is increased by applying abnormally high anode and screen voltages and controlling the anode current by a simple network. The output transformer is provided with tappings giving fifteen possible impedance values for matching purposes. The input channels include two 125-db gain microphone stages and two 85-db gain programme stages.

621.395.667 3560
Design of Attenuation Equalizers.—H. N. Wroe. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 272–280.) From theoretical considerations a method of accurately calculating the performance of an equalizer is deduced. Its application in particular to telephone cables is illustrated. Equalizer performance is found to depend on two quantities which can be calculated without making conventional assumptions concerning its internal structure. A general method of equalizer design is deduced.

621.396.611 3561
The Tapped Inductor Circuit.—J. E. Haworth. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 284–286.) The tapped inductor, in conjunction with a suitable capacitor, is considered as a two-terminal network possessing both resonant and anti-resonant properties. Expressions for impedance are derived and the results illustrated graphically. The application of the theory in the design of valve oscillators is discussed.

621.396.621.53.018.41.012.7 3562
Mixer Frequency Charts.—Badessa. (*See* 3737.)

621.396.645.014.332 3563
Peak Pulse Currents in Class B Amplifiers.—K. R. Sturley. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, p. 286.) A simpler method than that involving Fourier analysis of the waveform, and only slightly less accurate, for estimating the peak pulse anode current taken by a valve in class-B operation, including the effect of the "standing feed".

GENERAL PHYSICS

531.18 : 531.15 3564
Is Rotation Relative or Absolute?—G.W.O.H. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 263–264.)

534.2 : 550.34 3565
Studies on Seismic Waves: Part 1—Reflection and Refraction of Plane Waves. Part 2—Rayleigh Waves in a Superficial Layer.—C. Y. Fu. (*Geophys.*, Jan. 1946, Vol. 11, No. 1, pp. 1–23.)

535.215.1 + 621.383.2 3566
Complex Photocathodes.—Khlebnikoff. (*See* ...0.)

535.247.4 3567
The Specification of a Spectral Correction Filter for Photometry with Emission Photocells.—J. S. Preston. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, pp. 211–216.)

535.312.2 3568
Reflection [of light] **in a Corner formed by Three Plane Mirrors.**—J. L. Synge. (*Quart. appl. Math.*, July 1946, Vol. 4, No. 2, pp. 166–176.) Consideration of the case where the three planes are not mutually perpendicular.

536 : 621.3.012.8 3569
Electrical Solution of Thermal Problems.—F. G. Willey. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 190..198.) By setting up an analogous electrical circuit, difficult thermal problems can sometimes be rapidly solved. Typical examples are given.

536.21 : 517.942.9 3570
Heat Conduction in Elliptical Cylinder and an Analogous Electromagnetic Problem.—N. W. McLachlan. (*Phil. Mag.*, Sept. 1945, Vol. 36, No. 260, pp. 600–609.) The electromagnetic problem is that of a long uniform solenoid with a core of elliptical cross-section in which a constant current I_0 is applied at $t = 0$. The magnetizing force at any point in the core and the (variable) inductance of the solenoid due to the core flux are calculated.

537.13 3571
Production and Annihilation of Negative Protons.—(*Nature, Lond.*, 24th Aug. 1946, Vol. 158, No. 4008, pp. 280–281.) A short account of a theoretical paper by J. McConnell published in *Proc. roy. Irish Acad.*, discussing the possibility of observing negative protons which may be produced by collisions of mesons in cosmic rays.

537.2 : 621.317.72 3572
The Investigation of Electrostatic Fields by means of a Valve Voltmeter.—R. Street. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, pp. 203–204.) "The electrostatic field between two overlapping parallel planes has been investigated by means of a radioactive source and a valve electrometer. The equipotentials so obtained are in satisfactory agreement with the theoretical curves calculated from a Schwarz-Christoffel transformation. The experiment can be adapted as a laboratory exercise."

537.52 : 621.3.015.5.029.64 3573
Electrical Breakdown in Air at Microwave Frequencies.—D. Q. Posin. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 696.) "The Paschen Law was found to be approximately valid in this range, as in d.c., though dependent upon the length of time that the microwave field is applied." Summary of Amer. Phys. Soc. paper.

537.52 : 621.3.029.64 3574
Complex Conductivity of Electrical Discharge in Gas at Microwave Frequencies.—M. A. Herlin & S. C. Brown. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 696.) "The complex conductivity as a function of power gives the voltage and current characteristic of the discharge. Voltage and complex current characteristics have been studied as a function of cavity dimensions, tube dimensions, and pressure." Summary of Amer. Phys. Soc. paper.

537.521.6 : 533.5 3575
The Insulation of High Voltages in Vacuum.—J. G. Trump. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 692.) Field emission theory

is inadequate to account for insulation breakdown. Other mechanisms investigated include emission of particles by impact, and photoelectric emission. Summary of Amer. Phys. Soc. paper.

537.525 3576
A Generalization of the Conception of Electron Plasma.—A. A. Vlasoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 248–266. In Russian.) The importance of the interaction between electrons over distances exceeding their average spacing ("distant forces") is emphasized. If this interaction is taken into account, new dynamic properties of polyatomic systems become apparent, and the conceptions of "gas", "liquid" and "solid body" are modified towards greater unification with the conception of plasma. The problem of the transition from "micro" to "macro" is also understood in a different light. The main result is the proof that if the fundamental kinetic equation (1) is used, in which the distant interaction is taken into account, the spontaneous appearance of the crystalline structure from the gas (under suitable conditions with regard to density and temperature) becomes evident without the use of any additional hypotheses. The same applies to the appearance of peculiar "vibrational" properties in polyatomic systems. Conditions necessary for the appearance of the crystalline structure are discussed in detail.

537.525 3577
The Behaviour of Electron-Ion Plasma in Magnetic Fields.—G. V. Spivak & O. N. Repkova. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 275–279. In Russian.) The following effects of magnetic fields on the electron-ion plasma were investigated experimentally: (*a*) The variation in the concentration of charged particles in a magnetic field symmetrical with respect to the axis. Curves are plotted in Fig. 1 for various discharge currents (from 0.1 to 1.2 A) through mercury vapour in a "quasi-uniform" magnetic field, and in Fig. 2 for discharge currents of 100 and 400 mA through mercury vapour in the field of a magnetic lens. (*b*) The variation in the average electron energy. A curve is plotted in Fig. 3. (*c*) The variation in the electron distribution. The curve plotted in Fig. 4 refers to discharges through neon between two coaxial cylinders.

537.525 : 621.3.015.532 3578
The Variation of the Mobility of Negative Ions in Strong Electric Fields and the Role of This Phenomenon in Corona Discharges.—N. A. Kaptsoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 280–285. In Russian.) Experiments were conducted to explain the contradiction existing between the accepted values of K for the mobility of negative ions in humid air, and experimental values derived from volt-ampere characteristics of the corona discharge between two coaxial cylinders. The circuit used in these experiments is a simplified version of those proposed by Tyndall (1929 Abstracts, p. 146) and Van de Graaf (1928 Abstracts, p. 525) and the results obtained are plotted in Fig. 4. The contradiction is ascribed to the fact that the table values of K are given for values of E lower than those normally met in the case of corona discharges, and that complex ions are formed in humid air with these lower values of E.
An abstract in English was noted in 1814 of July.

537.525.3 : 621.316.722.078.3 3579
Characteristics of the Pre-Corona Discharge and Its Use as a Reference Potential in Voltage Stabilizers.—Brown. (*See* 3758.)

537.53 3580
Spontaneous Emission Probabilities at Radio Frequencies.—E. M. Purcell. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 681.) Summary of Amer. Phys. Soc. paper.

537.533 : 621.385.833 3581
Extraction of Electrons by an Electric Field.—P. I. Lukirski. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 226–231. In Russian.) A survey of literature on the Fowler-Nordheim theory of the electron emission from metals under the action of a strong electric field. Some of the experimental results obtained in Russia are also discussed.
An abstract in English was noted in 1952 of July.

537.591.8 3582
Production of Mesons by Electrons.—H. Feshbach. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 690.) Summary of Amer. Phys. Soc. paper.

538.569.4 + 621.396.11].029.64 : 551.57 3583
Absorption of Microwaves by Water Vapor.—Autler, Becker & Kellogg. (*See* 3719.)

538.569.4.029.64 3584
Absorption of Microwaves by Gases: Part 2.—J. E. Walter & W. D. Hershberger. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 694.) "The absorption coefficients and dielectric constants of sixteen gases have been measured at the two wavelengths $\lambda = 1.24$ cm and $\lambda = 3.18$ cm. The gases are H_2S, SO_2, COS, $(CH_3)_2O$, C_2H_4O, NH_3, six halogenated methanes, and three amines." For part 1 see 3234 of November. Summary of Amer. Phys. Soc. paper.

538.569.4.029.64 : [534 + 536 3585
Thermal and Acoustic Effects attending Absorption of Microwaves by Gases.—W. D. Hershberger. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 695.) "The conversion of microwave energy into thermal and acoustic energy by the use of any of the gases which absorb microwaves is described... A gas-filled resonator capable of detecting 10 milliwatts of microwave power is described which consists of a cavity which resonates electrically to the microwave frequency and acoustically to the modulating frequency." Summary of Amer. Phys. Soc. paper.

539.16.081 3586
New Units for the Measurement of Radioactivity.—E. U. Condon & L. F. Curtiss. (*Rev. sci. Instrum.*, June 1946, Vol. 17, No. 6, p. 249.)

539.389.3 : 536.7 3587
Thermodynamics of Relaxation Processes.—G. E. Kimball. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 688.) Summary of Amer. Phys. Soc. paper.

541.13 3588
Physical Interaction of Electrons with Liquid Dielectric Media. The Properties of Metal-Ammonia Solutions.—R. A. Ogg, Jr. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 668–669.) A

discussion in terms of quantum mechanics. The electrical and magnetic properties of such solutions are explained.

621.3.011.2 + 621.3.011.5] : 546.3[-13 + -14 **3589**

On the Relationship between the Liquid and Gaseous States in Metals.—Ya. Zel'dovich & L. Landau. (*Zh. eksp. teor. Fiz.*, 1944, Vol. 14, Nos. 1/2, pp. 32–34. In Russian.) It is pointed out that even at absolute zero there is a definite difference between a metal and a dielectric, and that a transition from one state into another can only be effected with emission or absorption of latent heat and an abrupt change in the properties of the material. A similar question of the transition from a metallic liquid state into a dielectric gaseous state is then examined, and the conclusion reached is that there should exist a non-metallic liquid phase which changes abruptly into a metal, when pressure increases, or into a gas, when pressure decreases.

621.314.63 : 539.233 **3590**

Contact Potential Difference as a Tool in the Study of Adsorption.—R. C. L. Bosworth. (*J. roy. Soc. N.S.W.* of 1945, 19th June 1946, Vol. 79, Part 2, pp. 53–62.) A description of apparatus for using the contact potential difference method to measure the work function of a surface and an account of its application to the study of the properties of electro-positive and electro-negative films and to the measurement of vapour pressures.

621.314.632 **3591**

Theory of Crystal Rectifiers.—Sachs. (*See* 3629.)

621.314.632.029.6 **3592**

High Frequency Rectification Efficiency of Radar Crystal Detectors.—Lawson, Goodman & Schiff. (*See* 3636.)

621.317.332 : 537.312.62 **3593**

High-Frequency Resistance of Superconductors.—A. B. Pippard. (*Nature, Lond.*, 17th Aug. 1946, Vol. 158, No. 4007, pp. 234–235.) Measurements have been made in the temperature range 2–4.2°K on mercury and polycrystalline tin using the specimen to form a twin, separately shielded, quarter-wave transmission line. The measured specific conductivity for tin at 3.8°K in the region of 1 200 Mc/s is about one seventh the d.c. value. These results, together with some obtained in the presence of a superposed constant magnetic field, are related to those of previous observers (See especially 208 of 1941).

621.384.2 **3594**

The Technique of Gamma Radiography.—R. Halmshaw. (*Engineering, Lond.*, 23rd Aug. 1946, Vol. 162, No. 4206, pp. 169–170.)

621.386.77 **3595**

Secondary Radiation from X-Ray Filters.—N. M. Morrow. (*Canad. J. Res.*, July 1946, Vol. 24, Sec. A, No. 4, pp. 46–55.)

537(075) **3596**

Principles of Electricity Illustrated. [Book Review]—R. C. Norris. Odhams Press, London, 380 pp., 8s. 6d. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, p. 293.)

538.1 **3597**

Le Magnétisme. Vol. 1 : Généralités et Magnéto-Optique ; Vol. 2 : Ferromagnétisme ; Vol. 3 : Paramagnétisme. [Book Notice] — Collection Scientifique, Institut International de Coopération Intellectuelle, Paris ; Columbia Univ. Press, U.S.A., 1940, 184 + 280 + 348 pp., $2.00 + $2.50 + $2.50. (*Science*, 26th July 1946, Vol. 104, No. 2691, pp. 70–73.) Report by S. J. Barnett on the proceedings of an international conference on magnetism held in Strasbourg in 1939 under the presidency of Prof. Weiss, the volumes constituting a wide survey of current magnetic research and summaries of earlier work.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 : 621.396.822 **3598**

Interpretation of Cosmic Noise — Radio Waves from Extraterrestrial Sources.—C. H. Townes. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 695.) Assuming cosmic noise is due to radiation from interstellar ions of density n and at temperature T, the effective temperature of the Milky Way is found to depend on frequency ν as

$$Ta = T\left[1 - \exp\left(-8 \times 10^{-8}\frac{n^2S}{\nu^2}\right)\right]$$

where S is the distance from the observer to the Milky Way boundary in the direction of observation. This gives qualitative agreement with some of the observational data. Summary of Amer. Phys. Soc. paper.

523.165 : 621.396.822 **3599**

Fluctuations in Cosmic Radiation at Radio-Frequencies.—J. S. Hey, S. J. Parsons & J. W. Phillips. (*Nature, Lond.*, 17th Aug. 1946, Vol. 158, No. 4007, p. 234.) Continuation of experiments referred to in 3270 of November. " Short period [order of several seconds] irregular fluctuations have been found to be associated with the direction of Cygnus. . . . The average amplitude of the fluctuations is 15% of the mean power received." The source appears to subtend an angle not exceeding 2°. A brief discussion of the significance of the results is given.

537.591.5 **3600**

Production of Mesotrons in the Stratosphere.—I. Bloch. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 575–585.) Theoretical derivation of the intensity of the penetrating cosmic-ray particles as a function of altitude, magnetic latitude and energy, assuming mesotrons to be produced in multiples by primary protons in fields of atomic nuclei.

537.591.8 **3601**

The Ionization Spectrum of Cosmic-Ray Electrons and Mesotrons.—P. B. Weisz & W. F. G. Swann. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 690.) The average ionization produced by mesotrons was found experimentally to be about 68% of that produced by electrons, but the experimental spread in values is unexpectedly large. Summary of Amer. Phys. Soc. paper.

538.71 : 629.123.011.22 **3602**

Measurement of Magnetic Fields beneath Ships.—H. A. Miller. (*J. R. Soc. Arts*, 12th April 1946, Vol. 94, No. 4715, pp. 327–329.) A comparison of the magnetic field existing beneath a ship in England and at a measurement range constructed off Colombo Harbour in the region of the magnetic equator.

550.34 : 534.2 3603
Studies on Seismic Waves: Part 1—Reflection and Refraction of Plane Waves. Part 2—Rayleigh Waves in a Superficial Layer.—Fu. (*See* 3565.)

551.51.053.5 : 621.396.11 3604
Short-Wave [ionospheric] **Forecasting.**—Bennington. (*See* 3721.)

LOCATION AND AIDS TO NAVIGATION

534.417 : 534.88 3605
Echo Ranging Sonar [model QCS/T].—R. J. Evans. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 88–93.) A device for accurate location of underwater targets. A principle analogous to radar is employed, with pulses of sound energy: echoes are received from obstacles. Frequencies employed are in the range 10 kc/s to 30 kc/s. A 600-W pulse of 0.1 to 0.2 seconds duration is transmitted at intervals of several seconds by a self-excited oscillator and amplifier feeding a magnetostriction projector-receiver, housed in a dome under the ship. Receiving equipment comprises a superheterodyne receiver, a range indicator and a loudspeaker for providing an audible signal. Each of these units is described in detail with block and circuit diagrams.

621.396.7 : 621.396.9 3606
Decca Navigator Stations.—M. G. Scroggie. (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 260–262.) The essential requirement of the service is the maintenance over the whole of its area of a phase pattern that is stationary and permanent. In order that the two interfering wave trains may be separately received, for purposes of phase checking, the transmissions are on two exact submultiples of the phase comparison frequency; one of a pair (or more) of transmitting stations provides the master drive for the others, thus ensuring relative frequency constancy, while a receiver automatically corrects the phase of one of each pair of transmissions. See also 1242 of May and back reference.

621.396.9 3607
Factors affecting the Range of Radar Sets.—L. R. Quarles & W. M. Breazeale. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 546–548.) The relation between received and transmitted powers is derived for the case of transmitting and receiving aerials fitted with parabolic reflectors, in terms of the wavelength, power gain of the aerials, and the range and effective area of the target. By considering the magnitude of the thermal agitation noise in the receiver, an expression is obtained for the maximum range at which an echo is detectable. The formula is discussed and illustrated by a numerical example. A brief discussion is given of the nature of the polar diagram of aerials using parabolic reflectors.

621.396.9 3608
Navigating by Loran.—C. J. Pannill. (*Telegr. Teleph. Age*, Sept. 1946, Vol. 64, No. 9, pp. 17–18.) A brief account of experiences on the liner Drottningholm during a voyage from New York to Shanghai. Dependable ranges of 700 miles by day and 1 400 miles by night were obtained.

621.396.9 3609
Successor to the Sextant.—H. Manchester. (*Sci. Amer.*, June 1946, Vol. 174, No. 6, pp. 264–267.) An elementary account of Loran.

621.396.9 3610
Radar.—E. Aisberg. (*Cah. toute la Radio*, Sept. 1945, No. 3, pp. 5–12.)

621.396.9 : 621.396.932 3611
Metrovick Marine Radar Set.—Metropolitan-Vickers Electrical Co. (*Engineering, Lond.*, 26th July 1946, Vol. 162, No. 4202, pp. 79–80; *Wireless World*, Aug. 1946, Vol. 52, No. 8, p. 269.) A production model, type MR1, which consists of three units: (1) a console containing the receiver, p.p.i., timebase strobe unit, control panel, power unit, and modulator; (2) the transmitter proper, signal mixer, head amplifier and mixer, i.f. amplifier, and discriminator circuit for a.f.c.; (3) the aerial unit of parabolic "cheese" type, normally driven at 20 r.p.m. and mounted in a perspex dome.

The frequency is 9 500 Mc/s with a peak power of 50 kW, $\frac{1}{4}$-μs pulses are used with a repetition rate of 1 000 per sec. Three ranges are provided: 3 000 yd, 10 000 yd, and 60 000 yd; the p.p.i. displays obstructions as near as 50 yd, and an audible warning signal is incorporated.

621.396.9 : 621.396.932 3612
Navigational Radar in Merchant Ships.—E. D. Hart. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 265–267.) A detailed description of modified naval radar equipment, demonstrated on H.M.S. Fleetwood. See also 1246 and 1247 of May.

621.396.9 : 621.397 3613
Has Radar influenced Television Development?—(*See* 3799.)

621.396.9 : 623.454.25 3614
Radio Proximity Fuze Design.—Hinman & Brunetti. (*See* 3713.)

621.396.932.25 3615
Auxiliary Pilot guides Ships.—J. H. Jupe. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 154..160.) A buoyant tank containing radar receiving and transmitting equipment is placed in position by a skilled navigator. The circuit consists basically of a supersonically quenched r.f. amplifier (made to oscillate for transmitting) with a demodulator and pulse amplifier. A pulse signal from a ship-borne interrogator is received and returned greatly amplified. On immersion, power supplies are connected automatically and the buoy is armed for self-destruction.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 3616
A Sensitive Vacuum Gauge with Linear Response.—J. R. Downing & G. Mellen. (*Rev. sci. Instrum.*, June 1946, Vol. 17, No. 6, pp. 218–223.) Ionization gauge for measuring pressures in the range between zero and 10 mm Hg, with linear response.

531.788.7 3617
A Radium Source Ion Gauge.—G. L. Mellen. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 691.) For measurement of pressures between 1 μ and 10 mm. Summary of Amer. Phys. Soc. paper.

533.5 : 621.3.032.53 3618
Glass-to-Metal Seal Design.—W. J. Scott. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, pp. 193–202.) The physics and chemistry of "oxide" and other seals are discussed from a theoretical and practical standpoint. Particular attention is paid to the formation of cracks and a nomogram correlates stress, strain and glass thickness. The relevant physical properties of various glasses and metals are tabulated. Excerpts from this paper were noted in 97 of January.

549.514.51 : 534.321.9 3619
Refinements in Supersonic Reflectoscopy. Polarized Sound.—Firestone & Frederick. (*See* 3515.)

535.215.1 : 546.28 3620
The Velocity of Propagation of the Transmitted Photo-Effect in Silicon Crystals.—F. C. Brown. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 686.) The relative magnitude of the transmitted effect is a function of the velocity, coefficient of recapture and distance travelled. The velocity, measured directly for distances of travel from 0.4 cm to 1 cm is 400 m/sec ± 5%. Summary of Amer. Phys. Soc. paper.

535.37 3621
Corpuscular *vs.* Undulatory Excitation of Phosphors.—H. W. Leverenz. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 686.) Summary of Amer. Phys. Soc. paper.

535.37 : 535.61–15 3622
Some Properties of Infra-Red Sensitive Phosphors.—R. T. Ellickson. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 685–686.) Alkaline earth sulphides and selenide phosphors activated with rare earths show a marked increase in phosphorescence under infra-red stimulation. Summary of Amer. Phys. Soc. paper.

537.226.8 : 621.319.4 3623
Temperature Coefficients of Interfacial Polarization in Dielectrics.—R. F. Field. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p 688.) Summary of Amer. Phys. Soc. paper.

541.147.4 : 546.683.22 3624
The Photoelectric Mechanism of the Thallous Sulfide Photo-Conductive Cell.—A. von Hippel, F. G. Chesley, H. S. Denmark, P. B. Ulin & E. S. Rittner. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 685.) Thermoelectric measurements show that pure thallous sulphide is "an 'excess' semiconductor changing to a 'defect' conductor on oxidation". The photo-sensitization of thallous sulphide is due to the presence of oxygen. Summary of Amer. Phys. Soc. paper.

546.431.826 : 621.3.011.5 3625
Oscillographic Study of the Dielectric Properties of Barium Titanate.—A. de Bretteville, Jr. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 687.) Barium titanate and solid solutions of barium and strontium titanates exhibit saturation of the dielectric flux density with increasing field strength. These properties have been studied by an oscillograph method throughout the charging and discharging cycle. Summary of Amer. Phys. Soc. paper.

546.45 : 669.018 3626
Beryllium : Workaday Metal.—F. P. Peters. (*Sci. Amer.*, June 1946, Vol. 174, No. 6, pp. 249–251.) A non-technical account of its principal properties and uses as an alloying metal.

549.514.51 3627
Recrystallization of Quartz as a Result of Flexure.—D. D'Eustachio. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 687.) Quartz crystals change from single crystals to a "poly-crystalline" structure when they are thinner than 25 μ but after cold working appear to recrystallize. See also 3310 and 3311 of November. Summary of Amer. Phys. Soc. paper.

621.314.632 3628
Rectification Series.—W. H. Brattain. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682.) Rectification takes place between one crystal and another on which a point has been made. Using the pointed crystal as reference, a series may be made such that any crystal in it will rectify in one direction with those above it and in the other direction with those below it. Summary of Amer. Phys. Soc. paper.

621.314.632 3629
Theory of Crystal Rectifiers.—R. G. Sachs. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682.) The observed d.c. characteristics of Ge and Si rectifiers agree approximately with those calculated on the multi-contact theory which assumes that (1) the contact potential ϕ varies continuously over the surface of contact, (2) the total current is the sum of the partial currents flowing through regions of varying ϕ, (3) the area of a region with a contact potential ϕ may be a function of ϕ, and (4) the number of spots having contact potential between ϕ and $\phi + d\phi$ is a function of ϕ. Summary of Amer. Phys. Soc. paper. See also 3630 and 3633.

621.314.632 3630
Semi-Quantitative Explanation of D.C. Characteristics of Crystal Rectifiers.—V. A. Johnson, R. N. Smith & H. J. Yearian. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682–683.) "The multi-contact theory is employed to explain the observed d.c. current-voltage characteristics between metal and semi-conductor (Ge and Si) . . . The proper slopes are obtained for the forward current." A graphical method is developed for the rapid synthesis of any characteristic. Summary of Amer. Phys. Soc. paper. See also 3629 and 3633.

621.314.632 3631
Contact Capacity of Crystal Rectifiers.—R. N. Smith. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 683.) The capacitance is measured indirectly from the decrease of rectification efficiency at microwave frequencies assuming that the crystal can be represented by a "spreading" resistance in series with a parallel combination of capacitance and the nonlinear contact resistance, these elements being independent of frequency. The dependence of capacitance on d.c. bias is in agreement with theory for silicon crystals but not for germanium units. Summary of Amer. Phys. Soc. paper.

621.314.632 **3632**
Image Force and Tunnel Effect in Crystal Rectifiers.—E. D. Courant. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 684.) The divergence of the experimental *i-V* curve from the theoretical (equation given) is explained by assuming that the height of the potential barrier is reduced by the image force, and that some electrons tunnel through the barrier. Summary of Amer. Phys. Soc. paper.

621.314.632 : 546[.28 + .289 **3633**
D.C. Characteristics of Ge and Si Crystal Rectifiers.—H. J. Yearian. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682.) The slope of the *i-V* characteristic is less than that predicted. A consideration of the difficulties in explaining the discrepancy. Summary of Amer. Phys. Soc. paper. See also 3629 and 3630.

621.314.632 : 546.289 **3634**
High Voltage and Photo-Sensitive Characteristics in Germanium.—S. Benzer. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 683.) Photo-effects of two types are observed in the visible and near infra-red range: (1) a saturated *i-V* characteristic in which the saturation current varies with illumination and temperature, and (2) a triple-valued characteristic with a voltage peak and negative resistance region. Some Ge rectifiers can withstand high inverse voltages. Summary of Amer. Phys. Soc. paper.

621.314.632 : 546.289 **3635**
Effect of Various Atmospheres on Germanium Crystal Rectifiers.—R. M. Whaley & K. Lark-Horovitz. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 683–684.) Relatively high-purity germanium which provided poor rectification in a vacuum was unchanged by admission of gas. Samples of relatively high conductivity, due to impurity content, which gave good rectification in vacuum, showed irreversible increases in back resistance upon admitting air. The changes can be accounted for by multi-contact theory. Summary of Amer. Phys. Soc. paper.

621.314.632.029.6 **3636**
High Frequency Rectification Efficiency of Radar Crystal Detectors.—A. W. Lawson, B. Goodman & L. I. Schiff. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682.) If a finite time is required to ionize the semiconductor donator levels in the blocking layer, the rate of decrease of efficiency with frequency may be explained. Summary of Amer. Phys. Soc. paper.

621.314.632.029.6 **3637**
Noise in Radar Crystal Detectors.—Schiff. (*See* 3725.)

621.315.59 **3638**
The Effect of Grain Structure on the Electrical Conductivity of Semiconductors.—B. Goodman. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 687.) Only the effect due to the discontinuities introduced into the periodic lattice potential is considered. The added resistivity may sometimes be comparable with that part of the room temperature resistance due to lattice vibrations, but it is small compared with the total resistivity which is mostly caused by the impurity ions. Summary of Amer. Phys. Soc. paper.

621.315.61 : 546.4 **3639**
Materials with High and Super-High Permittivities.—B. M. Vul. (*Elektrichestvo*, 1946, No. 3, pp. 12-17. In Russian.) Experimental investigation of titanates of metals in the second group of Mendeleeff's table. It is shown that a barium titanate can be used as an electrical insulating material with a permittivity exceeding 1 000.

621.315.612 : 621.319.4.029.5 **3640**
High Frequency Ceramic Capacitors.—Vul & Skanavi. (*See* 3779.)

621.315.616 **3641**
Synthetic Rubbers and Plastics : XI. (Part 3) Water and the High Polymer.—F. T. White. (*Distrib. Elect.*, Oct. 1946, Vol. 19, No. 164, pp. 170–173.) A discussion on moisture permeability, and the effect of including plasticisers, resins, or waxes in the basic materials. For part 2 (Section XI) see 2936 of October.

621.315.616 : 621.38/.39 **3642**
Plastics in the Electronic and High Frequency Industries.—W. S. Penn. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 280–281.) Improvements and future possibilities. Tables give properties of dielectrics of various types.

621.315.616.9 : 621.3 **3643**
Plastics and the Electrical Industry : Parts 1-4.—P. R. S. Gibson. (*Electrician*, 16th Aug.–6th Sept. 1946, Vol. 137, Nos. 3559–3562, pp. 443–445, 517–520, 582–585 & 649–652.) In part 1 the conductivity, dielectric strength, permittivity and power factor of plastic insulating materials in general are defined and discussed ; in subsequent parts the properties and uses of specific materials are described.

621.318.22 : 620.179.14 **3644**
Magnetic Testing of [ferromagnetic] **Metals.**—P. E. Cavanagh, E. R. Mann & R. T. Cavanagh. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 114–121.) The examination of the metallurgical properties of metals by testing their magnetic qualities. An extensive description of the technique with practical details and applications is given.

621.383.4 + 535.215.1 : 546.28 **3645**
A New Bridge Photo-Cell employing a Photo-conductive Effect in Silicon. Some Properties of High Purity Silicon.—Teal, Fisher & Treptow. (*See* 3784.)

621.396.611.21.032.2 : 546.59 **3646**
Gold Film Electrodes for High Frequency Quartz Plates.—Spears. (*See* 3794.)

669.45.778 : 621.315.22 **3647**
F-3 Lead Alloy — an Improved Cable Sheathing.—L. F. Hickernell & C. J. Snyder. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 563–569.) Details of a new arsenical lead alloy for cable sheathing, including chemical composition and physical properties. It is superior to materials hitherto used for power cables, notably in respect of its increased resistance to bending fatigue, creep resistance, and bursting strength.

621.315.614.72 **3648**
Varnished Cloths for Electrical Insulation. [Book Review]—H. W. Chatfield & J. H. Wreddon.

J. & A. Churchill, London, 1946, 255 pp., 21s. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, p. 292.) A "clear and orderly exposition of the technical features of varnished fabrics . . . The properties of the finished products . . . are very fully dealt with."

621.315.616 **3649**
Collection "Matériaux de Synthèse". Aminoplastes. [Book Review]—P. Talet. **Résines Vinyliques.** [Book Review]—H. Gibello. Dunod, Paris, 280 fr. & 260 fr. (*Engineering, Lond.*, 23rd Aug. 1946, Vol. 162, No. 4206, p. 171.)

MATHEMATICS

517.432.1 **3650**
Some Notes on the Operational Calculus.—L. Jofeh. (*J. Brit. Instn Radio Engrs*, March/May 1946, Vol. 6, No. 2, pp. 73–77. Discussion, pp. 77–79.) A short review is given of the various systems of operational calculus and the Heaviside system is discussed in greater detail. The basis of the operational form of a differential equation is explained and the interpretation of the operational equation illustrated by an example. A bibliography of 14 items is given.

517.512.2 **3651**
Fourier Series.—M. M. Levy. (*J. Brit. Instn Radio Engrs*, March/May 1946, Vol. 6, No. 2, pp. 54–73.) An outline of Fourier analysis and its application to the study of periodic and non-periodic functions. Fourier series are given in trigonometrical and exponential form, and simplified forms derived which are applicable to periodic curves having various types of symmetry. Expressions are given for obtaining the coefficients of the series from the discontinuities in a periodic curve. The theory is extended to the treatment of non-periodic functions such as the unit pulse and unit impulse functions, and the response of a low-pass filter to a pulse of given width is determined. Brief mention is made of the harmonic analysis of periodic functions with special reference to methods of determining very high harmonic components.

517.942.82 : 621.3.014/.015].33 **3652**
Switching Problems and Instantaneous Impulses.—Jaeger. (*See* 3550.)

518.2 **3653**
Mathematical Tables.—(*Bur. Stand. J. Res.*, July 1946, Vol. 37, No. 1, p. 73.) A list of mathematical tables made available through the National Bureau of Standards, including powers of integers, exponentials, circular functions and associated integrals, logarithms, and probability functions.

518.4 : 676.31 **3654**
Utility of Log-Log *vs* Arithmetic Co-Ordinate Grids.—A. A. Merrill. (*Gen. elect. Rev.*, July 1946, Vol. 49, No. 7, pp. 20–22.)

518.5 : 621.385.001.8 **3655**
Electronic Computers.—W. Shannon. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 110–113.) The fundamental circuits for performing elementary mathematical calculations electrically are described, with brief remarks on the military and industrial use of electrical computers.

[… + 537].014.2 : 518.61 **3656**
On the Numerical Treatment of Forced Oscillations.—A. C. Sugar. (*Quart. appl. Math.*, July 1946, Vol. 4, No. 2, pp. 193–196.) An approximation to the Duhamel integral is used as the solution of the differential equation of a harmonic oscillator. Vector methods are used to deduce the maximum displacement and acceleration.

536.21 : 517.942.9 **3657**
Heat Conduction in Elliptical Cylinder and an Analogous Electromagnetic Problem.—McLachlan. (*See* 3570.)

621.396.679.4.012.2 **3658**
Solving Feeder Problems Graphically.—Kelley. (*See* 3549.)

516 + 517 **3659**
Analytical Geometry and Calculus. [Book Review]—H. B. Phillips. J. Wiley, New York: Chapman & Hall, London, 2nd edn, 504 pp., 27s. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 218.) For courses in science and engineering.

518.2 **3660**
An Index of Mathematical Tables. [Book Review]—A. Fletcher, J. C. P. Miller & L. Rosenhead. Sci. Computing Service, London, 1946, 451 pp., 75s. (*Nature, Lond.*, 24th Aug. 1946, Vol. 158, No. 4008, pp. 252–253.) See also 3339 of November.

MEASUREMENTS AND TEST GEAR

531.71 + .76] : 621.383 **3661**
A Photoelectric Method of Indicating Small Displacements and of Timing a Moving Body.—D. S. Perfect & R. M. J. Withers. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, pp. 204–207.)

531.76 **3662**
The Measurement of Ultra-Short Time Differences.—S. H. Neddermeyer. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 702.) A device ("chronotron") which uses a bent coaxial line to produce superposition of pulses whose time interval is being measured. Accuracy to $\pm 3.10^{-11}$ sec is claimed. Summary of Amer. Phys. Soc. paper.

531.76 : 621.317.755 **3663**
A Note on the Measurement of Pulse Duration by Anode-Current Form-Factor.—L. H. Ford. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 216.) Pulse shape is intermediate between a rectangle and a triangle. In the former case pulse duration t is given by $t = T/F^2$ and in the latter by $t = 1.33T/F^2$, where T is the pulse-recurrence time and F the ratio of r.m.s. (measured thermally) to mean value of oscillator-anode current supply. The assumption of a perfect rectangle will give durations too small by not more than 10%.

In an experimental verification the results were compared with those obtained using a c.r.o. over a range of pulse width 2–1 000 μs and pulse recurrence 50–5 000 μs. Agreement was within 5%.

538.214 : 621.317.44 **3664**
An Electrodynamic Balance for the Measurement of Magnetic Susceptibilities.—T. S. Hutchison & J. Reekie. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, pp. 209–211.) The magnetic forces are compensated by passing known currents through a coil system. The balance is directly calibrated and can measure forces as low as a few hundredths of a dyne to an accuracy of about ¼%.

539.16.08 : 537.591.8 3665
Fluctuations in Measurements of Ionization per Centimeter of Path in Proportional Counters.—W. F. G. Swann. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 690.) Summary of Amer. Phys. Soc. paper.

621.317.33 3666
Measuring Mutual Inductance and Capacitance.—A. W. Simon. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 142 . . 154.) The method used "is based on the Campbell modification of the Felici circuit. . . It is particularly suitable for the accurate measurement of mutual inductance between coils with small coefficients of coupling such as are frequently encountered in radio work . . ." Measurements of intercoil capacitances can also be made.

621.317.333 3667
Measuring Insulation Resistance.—J. Piggott. (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 263–264.) The model 40 and model 7 "Avometers" are fitted with an automatic cut-out which requires the use of a protective rectifier. The circuit thus formed with the inductance of the moving coil of the instrument resonates at about 450 kc/s. If this frequency is picked up it may be rectified and produce false readings.

621.317.333.027.3 3668
High Voltage D.C. Testing of Rubber-Insulated Wire.—W. N. Eddy & W. D. Fenn. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 576–578.) The results of experiments on the limits suitable for the high voltage d.c. testing of plain insulated wire immersed in water.

621.317.7.017.5 3669
Instrument Bearing Friction.—A. L. Nylander. (*Gen. elect. Rev.*, July 1946, Vol. 49, No. 7, pp. 12–17.) Formulae are given for computing the bearing-system frictional torque in instruments requiring high sensitivity (e.g. microammeters). To reduce this torque, minimum pivot radius, maximum jewel-radius and minimum end-play consistent with small side-play error are required.

621.317.715.085.39 3670
A Simple Galvanometer Amplifier with Negative Feedback.—J. S. Preston. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, pp. 173–176.) An intense beam of light reflected from the mirror of an ordinary d'Arsonval galvanometer is focused on a pair of selenium rectifier photocells connected in series opposition, the net current from which is measured by a secondary galvanometer. Negative feedback is introduced by interconnexion of the two galvanometer circuits to give a more linear overall response, and a sensitivity less influenced by changes in individual elements. A red-absorbing filter is used in the light beam to eliminate photocell fatigue. Sufficient gain is obtained without valve amplification to give an overall sensitivity of 15–20 metres/μA with zero repetition to 10^{-10}A.

537.2 : 621.317.72 3671
The Investigation of Electrostatic Fields by means of a Valve Voltmeter.—Street. (*See* 3572.)

621.317.72 : 621.384.6 3672
A Megavoltmeter for Induction Electron Accelerators.—W. F. Westendorp. (*Rev. sci. Instrum.*, June 1946, Vol. 17, No. 6, pp. 215–217.)

621.317.725 : 621.385 3673
Inverse Vacuum-Tube Voltmeter.—S. H. Dike. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 140, 142.) Specially designed for measuring high voltages and maintaining a high input impedance. Calibration curves and a circuit diagram are given.

621.317.725 : 621.385 3674
Valve Voltmeters.—F. Haas. (*Cah. toute la Radio*, Sept. 1945, No. 3, pp. 18–20.)

621.317.726 3675
Fighting Vehicle Exhibition.—(*Engineer, Lond.*, 16th Aug. 1946, Vol. 182, No. 4727, pp. 148–149.) Includes description of a battery-operated peak voltmeter designed for the measurement of sparking-plug voltages. It is basically a resistance potential divider followed by a triode rectifier with a milliammeter in the anode, calibrated directly in kilovolts.

621.317.738 3676
Increasing the Sensitivity of the Schering Bridge for the Measurement of Small Loss Angles at Low Voltage.—G. Sella. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 15–27. With English, French and German summaries.) A push-pull preamplifier is inserted between the bridge and the output transformer in such a way as to preserve symmetry to earth; balance adjustments are provided on one of the values by a variable cathode resistor and a variable capacitance from anode to earth. The effective amplification at 50 c/s is roughly unity and the asymmetry is about 5.10^{-5}. The preamplifier is followed by a two-stage amplifier feeding a bridge-type copper-oxide rectifier connected to a d.c. amplifier. Tests show that at 50 c/s loss angles of 10^{-5} can be measured to 5% even with a test capacitance of 50 $\mu\mu$F.

621.317.755 3677
Elements of a New Oscilloscope Design.—E. C. Simmons. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 96–97 . . 118.) Design features of a commercial oscillograph for general laboratory use. A variety of timebases and synchronizing arrangements are considered. A calibration circuit for the determination of input signal amplitude is also included, together with a pulse generator for triggering external circuits.

621.317.761.029.62/.64 3678
The Determination of Very High Frequencies.—F. Dickson. (*Proc. Instn Radio Engrs, Aust.*, July 1946, Vol. 7, No. 7, p. 20.) "Fundamentally, the method is to determine two or more relatively low frequencies, the harmonics of which are related to the frequency to be checked in such a way that the latter is the l.c.m. of the observed frequencies", *i.e.* $F = nf_1 = (n - 1)f_2$ etc. For a suitable instrument see 679 of March.

621.317.763.029.62/.63 3679
Frequency Measurements at U.H.F.—R. Endall. (*Radio News*, Sept. 1946, Vol. 36, No. 3, pp. 50–52 . . 100.) Description of types of wavemeter available for amateur use in the range 100–3 000 Mc/s, including absorption wavemeters, butterfly types,

Lecher wire systems, and heterodyne frequency meters.

621.317.763.029.62 3680

A Wavemeter for the Ultra-Short Band.—J. Banner. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 268–269.) A compact, robust instrument, with frequency coverage 155–255 Mc/s and accurate to within ±0.25 Mc/s. Provision is made for use as a signal generator.

621.317.784.029.4 3681

Hypso-Wattmeter [variable-impedance output meter].—C. M. Laurent. (*Cah. toute la Radio*, Oct. 1945, No. 4, pp. 9–11.) Compares the power outputs of amplifiers or receivers up to 20 W with a reference power of 1 mW, at frequencies between 30 and 20 000 c/s. Design details are given.

621.317.79 : 621.396.619 3682

The Time-Delay [amplitude] **Modulation Meter, TH 3077.**—M. Sollima. (*Rev. tech. Comp. franç. Thomson-Houston*, Jan. 1944, No. 1, pp. 45–58.) A brief discussion of various types of meter for measuring modulation depth; the advantages of incorporating a time delay (described in French Patent 858 680) to give a suitable measure of peak values with small error are stated. A description of the TH 3077 includes details of circuit design. The l.f. amplifier is provided with negative feedback which does not function until the input level exceeds a certain value. The peak voltmeter is followed by a logarithmic d.c. network using three biased diodes enabling a nearly linear decibel scale to be obtained over range of 50 db. The error of measurement is less than 1 db for frequencies of 30–15 000 c/s.

621.385.832.088 3683

C.R. Tube Quality Measuring Apparatus.—A. M. Spooner. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 273–276; *J. Televis. Soc.*, June 1946, Vol. 4, No. 10, pp. 251–254.) Circuits are described for the determination of distortion in either magnetically or electrostatically deflected television tubes, and in their associated timebases. Pulses, synchronized to the line and frame frequencies, are fed to the picture grid to produce on the screen an array of dots. The defocusing and asymmetrical spacing of the dots give an indication of faulty circuits. Variation of spot size with peak beam-current may also be determined.

621.396.67.08.011.2 3684

Antenna Impedance Measurement.—D. D. King. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 696.) Summary of Amer. Phys. Soc. paper.

621.317.029.3/.6 3685

Alternating Current Measurements at Audio and Radio Frequencies. [Book Review]—D. Owen. Methuen, London, 2nd edn, 120 pp., 5s. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 218.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.714.7 : 621.317.39 3686

Electronic Gaging.—P. H. Hunter. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 68–71.) Describes two micrometers, one using a valve circuit for indicating the moment of contact (between the micrometer screw and the material measured) and the other using a photoelectric technique for continuous gauging of soft materials without physical contact.

535.61–15 : 536.51.072.2 3687

Thermal Detectors.—(*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 87..118.) Survey of the various principles used, especially superconductivity, and description of two bolometers, one of which can detect a temperature change as small as 10^{-6} °C, and has a time constant of the order of 1 ms. Sensitive apparatus of this type can be used for measurements of stellar radiation, atmospheric humidity, small r.f. currents, for physiological studies and in navigation.

535.61–15 : 621.383 3688

Investigations of Near Infra-Red Radiations by means of Image Converters.—A. Vasko. (*Nature, Lond.*, 17th Aug. 1946, Vol. 158, No. 4007, p. 235.) "The spectrum under test is projected on to a photo-electric cathode of the type (Ag)–Cs_2O, Cs, Ag–Cs. . . [The photo-electrons] are focused by an electronic lens and form a picture on the fluorescent screen . . ."

539.16.08 3689

Various Papers on Geiger-Müller and Other Particle Counters.—(*See* 3759/3762.)

621.316.7 3690

Industry studies New Circuit Technics.—R.R.B. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 66–67..130.) A general article comparing electronic control with pneumatic, hydraulic and mechanical systems.

621.317.39 : 620.172.222 3691

Electrical Resistance Wire Strain Gauges.—(*Engineering, Lond.*, 9th Aug. 1946, Vol. 162, No. 4204, pp. 121–123.)

621.317.49 3692

Magnetism and the Testing of Materials.—R. V. Baud. (*Engineering, Lond.*, 12th July 1946, Vol. 162, No. 4200, pp. 41–42.) The theory is given of (*a*) the X-ray absorption method, (*b*) the magnetic method, used in flaw detection, and the merits of each discussed. An abridged translation from *Schweiz. tech. Z.*, 11th Oct. 1945, p. 515.

621.365.5 : 669.14 : 621.785.6 3693

The Surface Treatment of Metals and in Particular the Surface Hardening of Steel by High-Frequency Currents.—R. Casti. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 306–308.) A discussion on the main factors which determine the thickness of the hardened zone, with brief notes on the design of a suitable heating coil. The results of tests on surface hardening of a chromium-steel disk, and of a carbon-steel shaft are given. These prove that variation of heating time provides a means of fixing the thickness of the hardened layer without affecting the degree of hardness.

621.365.92 : 674 3694

Joints in a Jiffy [by means of electronic heating of wood].—J. Markus. (*Sci. Amer.*, June 1946, Vol. 174, No. 6, pp. 245–248.)

621.365.92 : 678 3695

Capacity-Current Heating in the Rubber Industry.—T. H. Messenger. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 270–272..276.)

621.365.92 : 679.5 3696

Hardening of Plastics by High-Frequency Power.—H. Stäger & F. Held. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 298–305.) The changes in a plastic when subject to hardening by hot plate presses and by high-frequency power are outlined.

A series of tests carried out on pure resins and on laminated wood is described. The 23-Mc/s generator provided 1.5 kW for heating small cylindrical specimens of resin and 3-cm wooden cubes. The temperature of the specimen was measured by thermocouples inserted at the centre and 0.5 cm from the surface. The relations between applied voltage, heating time, and temperature are shown graphically. A comparison was made of the hardening produced by hot-plate and high-frequency power methods, and the results are given.

621.38 : 655.324.5 3697

Electronic Register Control for Multicolor Printing.—W. D. Cockrell. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 617–622.)

621.38.001.8 3698

Tubes on the Job.—(*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 98–99.) Describes briefly the use of electronic apparatus in (*a*) mobile radio for trucks, (*b*) rubber weighing, (*c*) a wheel balancer, (*d*) a coin rejector, (*e*) a wind-up reel regulator, and (*f*) stress measurements on steel trusses.

621.38.078 : 6 3699

What Industry seeks in Electronic Control.—P. Ewald : L. C. Roess : H. K. Steele. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 85–86..116.)

Chemists need reliable and corrosion-proof electronic measuring instruments.

In the oil industry, mass spectrometers, absorption spectrometers, electronic computers, knock meters, and devices for measuring electrical conditions causing corrosion could usefully be developed.

The food industry needs improved devices for colour determination, rapid heating, and determination of moisture.

621.383.001.8 3700

Reading Aid for the Blind.—V. K. Zworykin & L. E. Flory. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 84–87.) A light synchronized with a f.m. audio-oscillator moves over a line. Reflected light actuates an amplifier by means of a photoelectric cell when the scanning spot is over the black portion of a character. A distinctive sound thus corresponds to each letter.

621.384 3701

Various Papers on Electron Accelerators.—(*See* 3786/3789.)

621.385 : 6 3702

Electronic Inspection.—V. Zeluff. (*Sci. Amer.*, Feb. 1946, Vol. 174, No. 2, pp. 59–61.) Use of cathode-ray tubes and other electronic devices for production testing where speed and accuracy are needed.

621.385.001.8 : 518.5 3703

Electronic Computers.—Shannon. (*See* 3655.)

621.385.833 + 5353.17.6 3704

A Magnetic Lens with Minimum Spherical Aberration.—A. G. Vlasoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 235–239. In Russian.) The spherical aberration of a magnetic lens is considered, and a formula (1) for calculating it is given. Methods are indicated for deriving conditions under which spherical aberration would be a minimum. The case of a "short" magnetic lens is discussed in greater detail, and the shape of the pole shoes satisfying the required conditions is determined.

An abstract in English was noted in 1946 of July.

621.385.833 3705

Calculation of the Fields of Simple Electrostatic Lenses.—A. G. Vlasoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 240–242. In Russian.) Lenses are considered which represent systems of (*a*) a number of plane metallic electrodes perpendicular to the optical axis, and having circular apertures with their centres on the optical axis, and (*b*) a number of cylindrical surfaces with their axes coinciding with the optical axis. A function is found satisfying Laplace's equation within the space bounded by the electrodes, and passing through given values at the electrodes. It is shown that the problem can be reduced to that of Dirichlet for the case of a cylinder, and, starting from Laplace's equation, a solution (10) is found which satisfies all conditions of Dirichlet's problem.

An abstract in English was noted in 1945 of July.

621.385.833 3706

The Electrostatic Electron Microscope.—H. Bruck & P. Grivet. (*Onde élect.*, June 1946, Vol. 26, No. 231, pp. 175–227.) From the Electron Optics Laboratory of the Compagnie Générale de Télégraphie Sans Fil. Details of the theory and design, illustrated by examples of photomicrographs. It is claimed that the electrostatic type, though slightly inferior to the magnetic type in resolving power, gives images richer in contrast, and is less exacting in its power-stabilization requirements.

621.385.833 : 537.533 3707

Extraction of Electrons by an Electric Field.—Lukirski. (*See* 3581.)

621.389 : 535.61–15 3708

Sight at Night.—V. Zeluff. (*Sci. Amer.*, July 1946, Vol. 175, No. 1, pp. 21–23.) Possible uses of infra-red beams for travel at night or in fog.

621.39.083.7 : 539.89 3709

Telemetering for Project Crossroads.—J. W. Colton. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 76–79..135.) Engineering details of the equipment for recording the air and water pressures in the Bikini atomic bomb tests.

622.19 : 621.396 3710

The Impedance Method of Radio Prospecting. Practical Applications : Parts 1 & 2.—V. Fritsch. (*Arch. tech. Messen*, July & Aug. 1940, Nos. 109 & 110, pp. T75–76 & T90.) The measurement of resistance and capacitance between electrodes provides geological data which are of particular use in tectonic regions. Fissures, faults, cavities and water pockets can be detected from the capacitance variations observed as the electrodes are moved over the region. In interpreting measurements on glaciers the dependence of resistivity and dielectric constant of ice on temperature, frequency and impurities must be taken into account. The detection of coal, salt and ores is discussed. A table of the resistivities of various geological materials in the dry state is given. Other parts have been referred to in 1942 and 1943 abstracts.

622.19 : 623.26 : 621.396.9 **3711**

Treasure Finding Modernized.—W. E. Osborne. (*Radio News*, Sept. 1946, Vol. 36, No. 3, pp. 30..94.) General article on the adaptation of mine detectors to the location of metals and other materials, with mention of the various types of equipment used.

623.26 : 621.396.9 **3712**

The Problem of Land-Mine Detection. Detection of Metallic Masses of Small Dimensions.—H. Grumel & P. Morel. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 160–167.) A review of the problems of mine detection and of the electrical, military, and practical requirements for a detector. The S.F.R. model 451 is described in detail. It contains an exploring head consisting of two tuned iron-cored coils having mutually perpendicular axes to give zero coupling. One coil is part of the resonant circuit of a push-pull oscillator (at about 280 c/s) and the other is followed by a 2-valve tuned amplifier (gain about 70 db) feeding headphones. Two magnetic zero adjustments are provided to cater for in-phase and quadrature effects. With this detector the German " Schuhmine " could be detected easily at a depth of 10 cm, and an anti-tank mine at 55 cm.

623.454.25 : 621.396.9 **3713**

Radio Proximity Fuze Design.—W. S. Hinman, Jr., & C. Brunetti. (*Bur. Stand. J. Res.*, July 1946, Vol. 37, No. 1, pp. 1–13.) Particularly for bombs, rockets and mortars. The fuses operate on the principle that the Döppler beat between the e.m. radiation from an antenna on the projectile and the reflected radiation from a target is received by the same apparatus, amplified and used to control the detonator.

A description is given of the aerials, oscillating detectors, amplifiers and power supplies used, with a short account of the production, laboratory testing, and field testing processes.

621.317.755 : 6 **3714**

The Cathode-Ray Oscillograph in Industry. [Book Review]—Wilson. (*See* 3797.)

621.385.833 **3715**

Introduction to the Electron Microscope. [Book Review]—F. E. J. Ockenden. Williams & Northgate (Norgate), London, 1946, 24 pp., 27 figs., 2s. 6d. (*Elect. Rev., Lond.*, 13th Sept. 1946, Vol. 139, No. 3590, p. 430.) " . . . [this monograph, the second of a series] can be recommended to those who need a clear explanation . . . of the three principles on which electron microscopy is based."

621.386.1 **3716**

X-Rays in Practice. [Book Review]—W. T. Sproull. McGraw-Hill, London, 615 pp., 30s. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 218.)

PROPAGATION OF WAVES

538.566.029.63 : 535.42 **3717**

Diffraction Pattern of a Circular Aperture at Short Distances.—C. L. Andrews. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 684.) Measurements were made for λ 12.8 cm with aperture of 1 to 6λ. Fresnel zone theory could be used as an approximate guide. Checks were made against Kirchhoff's theorem. Summary of Amer. Phys. Soc. paper.

538.566.029.64 : 535.43 : 551.48 **3718**

The Frequency Dependence of Radar Echoes from the Surface of the Sea.—H. Goldstein. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 695.) The scattering cross-section σ per unit area of sea surface has been measured on λ 9.2, 3.2, and 1.25 cm. Although the $1/\lambda^4$ Rayleigh law, which would indicate scattering by spray droplets, is not observed, the changes of σ with polarization and with frequency are difficult to explain on the basis of scattering from large sea surfaces. Summary of Amer. Phys. Soc. paper.

621.396.11 + 538.569.4].029.64 : 551.57 **3719**

Absorption of Microwaves by Water Vapor.—S. H. Autler, G. E. Becker & J. M. B. Kellogg. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 694.) A new method, using a cubical copper cavity of 8½-ft side, within which thermocouples are placed at random, enables the loss of water vapour at various humidities to be measured. Over the range λ 0.7–1.69 cm there is an absorption peak at λ 1.33 cm where the attenuation is 0.024 db/km for 1 gm/m³ of water vapour. Summary of Amer. Phys. Soc. paper.

621.396.11 : 551.51.053.5 **3720**

Wave-Treatment of Propagation of Electromagnetic Waves in the Ionosphere.—M. N. Saha & B. K. Banerjea. (*Indian J. Phys.*, Oct. 1945, Vol. 19, No. 5, pp. 159–166.) " Wave-equations for the propagation of e.m. waves through the ionosphere have been obtained by the use of a new mathematical method involving the use of dyadic analysis introduced by Gibbs. Expressions for steady-current conductivity of the ionosphere have been obtained by this method and the results agree with those of Chapman ; an extra term for the conductivity, which is more prominent in the F_2-layer, has been obtained.

" It has been shown that the wave is split up into three waves, as in Zeeman effect, one of which is ordinary, the other two extraordinary, in accordance with observations by Toshniwal, and Harang."

621.396.11 : 551.51.053.5 **3721**

Short-Wave [ionospheric] **Forecasting.**—T. W. Bennington. (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 246–250.) As a result of wartime needs, ionospheric stations were set up all over the world. By means of their observations, world contour charts both of existing ionospheric conditions and of predicted conditions for any month of the year were constructed. The charts are customarily drawn in terms of the maximum usable frequency for 2 500 miles (the maximum distance of travel of a radio wave with only one reflection by the ionospheric layers). It was found that the ionization of the layers causing reflection depended on both the geographic and the geomagnetic latitude and longitude of the observing station. To take account of this the world is divided into three zones, bounded by certain geomagnetic meridians, and separate charts are issued for each zone. To be continued.

RECEPTION

534.78 3722
Effects of Amplitude Distortion upon the Intelligibility of Speech.—Licklider. (*See* 3524.)

534.78 3723
Effects of Frequency Distortion upon the Intelligibility of Speech.—Egan & Wiener. (*See* 3525.)

534.78 3724
Correlation of the Audio Characteristics of Communication Systems with Measured Articulation Scores.—Beranek. (*See* 3526.)

621.314.632.029.6 3725
Noise in Radar Crystal Detectors.—L. I. Schiff. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 682.) A calculation of noise due to shot effect of electrons crossing the blocking layer. A frequency-independent spectrum is deduced. Summary of Amer. Phys. Soc. paper.

621.395.623.6 3726
Development of Midget Earphones for Military Use.—Pearson, Mundel, Carlisle, Knauert & Zarat. (*See* 3534.)

621.395.623.7 3727
The Output Stage.—A. W. Stanley. (*Wireless World,* Aug. 1946, Vol. 52, No. 8, pp. 256–259.) Curves are given of the variation with frequency of resistance and reactance of a typical moving-coil loudspeaker. By considering these and the equivalent circuit of the output stage of an audio amplifier, the theoretical effects of correct matching are deduced. Frequency response curves taken under practical conditions are reproduced, showing that a knowledge of the response curve of a loudspeaker is useless unless the impedance of the driving source is known.

621.395.667 3728
Fundamental Tone Control Circuits—a Reference Sheet.—(*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 278–279.) Full circuit details of resistance and capacity networks, for obtaining the four chief types of tone control.

621.395.92 3729
Desirable Frequency Characteristics for Hearing Aids.—Davis, Hudgins, Peterson & Ross. (*See* 3538.)

621.396.619 3730
Comparison of Frequency Modulation and Amplitude Modulation.—T. J. Weijers. (*Philips tech. Rev.*, March 1946, Vol. 8, No. 3, pp. 89–96.) The relative merits of amplitude and frequency modulation in relation to noise and interference, and the advantages of frequency modulation with wide frequency-sweep and adequate receiver-limiting for high-fidelity broadcasting, are discussed.

621.396.619.018.41 : 621.396.621 3731
Linear Frequency Discriminator.—J. R. Tillman. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 281–286.) The disadvantages of discriminators which include inductances (*e.g.* variability with temperature) are described, and the design of a resistance-capacitance discriminator is discussed. This design is based on the output *versus* frequency characteristic of the Wien bridge near the balance frequency, and consists of two twin-T networks having suitably staggered balance frequencies. The linearity is good over the whole required range of frequency. This is true even for wide-band circuits if additional networks are used. The performance can probably be made substantially independent of temperature.

621.396.62.029.62 3732
Mobile Receiving Equipment for Two, Six and Ten Meters.—E. P. Tilton. (*QST*, Sept. 1946, Vol. 30, No. 9, pp. 28–35.) The system described uses three units: (*a*) an i.f. amplifier using a frequency of 11 Mc/s, superregenerative detector and audio stage; (*b*) a converter to cover two frequency ranges, 27–30 Mc/s and 50–54 Mc/s; (*c*) a converter for the 144–150 Mc/s band.

621.396.621+621.396.61] : 621.396.932 3733
Transmitting Equipment for the Merchant Navy.—Grumel. (*See* 3805.)

621.396.621 3734
An Amateur-Built Eight-Valve Communications Superhet.—E. W. Nield. (*R.S.G.B. Bull.*, Oct. 1946, Vol. 22, No. 4, pp. 50–54, 57.) A circuit design incorporating what are considered to be the most desirable features of various existing designs. The performance claimed is well up to commercial standards; 1 W is delivered by the loudspeaker for an input voltage to the receiver of less than 1 μV (30 per cent sine wave modulation). The a.v.c. is substantially flat above an input of about 5 μV.

621.396.621 3735
Modern Home Receiver Design.—Z. Benin. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 94–98.) The design of a commercial receiver suitable for f.m. operation in the 88–108 Mc/s portion of the spectrum as well as in the usual broadcast bands is considered in some detail. Necessary compromises in stage design to ensure satisfactory performance in the two roles are discussed. Particular attention is paid to the aerial circuits, i.f. transformer design and frequency stability of the conversion oscillator.

621.396.621.5 3736
Frequency Deviation Reception.—D. A. Griffin. (*Proc. Radio Cl. Amer.*, April 1946, Vol. 23, No. 4, pp. 3–7.) A description of a method of achieving increased selectivity and signal/noise ratio in the reception of keyed c.w. telegraphy signals. It is based upon the frequency modulation of the signals in the receiver itself in such a way that the desired signal is brought periodically within a narrow pass band while nearby unwanted signals remain just outside this pass band. An additional possibility is that by the suitable location of the mean frequency of the wanted signal relative to a narrow pass band, its frequency modulation can be converted into an amplitude modulation with a major component of twice the modulation frequency, whereas that of nearby unwanted signals remains at the fundamental. Thus audio-frequency discrimination can be used to gain additional selectivity.

Means of realizing these possibilities by the use of a double frequency-change process, with frequency modulation of the first conversion oscillator, are described.

621.396.621.53.018.41.012.7 **3737**

Mixer Frequency Charts.—R. S. Badessa. (*Electronics*, Aug. 1946, Vol. 19, No. 8, p. 138.) The charts deal with either sum or difference frequency mixers, and show the combinations of high order frequency components which are capable of beating together to give a resultant frequency coinciding with the desired output value.

621.396.645 : 629.135 **3738**

Isolation Amplifiers for Aircraft.—G. F. Rogers. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 122–123.) A device enabling members of an aircraft crew to listen as required to the various aircraft receivers without mutual interference. Each member is provided with his own single valve amplifier, to the control grid of which the receiver outputs are connected through decoupling resistors and selector switches. The grid circuit constant and gain of the amplifier are chosen so that satisfactory operation is achieved with up to five input channels.

621.396.82 **3739**

BCI [broadcast interference].—G.G. (*QST*, Sept. 1946, Vol. 30, No. 9, pp. 54–55.) Interference caused by amateur transmitters in the vicinity of broadcast receivers has been found due in certain cases to r.f. voltages being rectified at the grid of the first audio amplifier in receivers having poor shielding such as the midget a.c.–d.c. types. The trouble may be reduced or entirely overcome by inserting a suitable resistance in the grid circuit so that the grid capacitance and this resistance form a low-pass filter to the r.f. voltages. Alternative methods are mentioned using suitable by-pass capacitors in the grid circuit.

621.396.822.029.6 **3740**

Signal-Noise Ratio at V.H.F.—M. J. O. Strutt & A. van der Ziel. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, pp. 241–249.) Analyses are given of the signal/noise ratios of the grounded-cathode and grounded-grid triode amplifiers, assuming the use of equivalent noise current generators. The partial coherence of the induced grid noise and the anode or cathode noise determines the optimum values of the grid circuit detuning and aerial coupling; experimental confirmation is given (*cf.* Strutt & van der Ziel, 749 of 1945). Similar results are obtained for the velocity-modulation amplifier (Müller, 48 of 1943). The paper concludes with a discussion of valve and circuit design for maximum sensitivity. The authors' noise ratio w is compared with other definitions of noise factor.

621.396.823 : 621.43.04 **3741**

Motor-Car Ignition Interference.—C. C. Eaglesfield. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 265–272.) A simple theory is given in which the spark gap is replaced by a switch, and the radiating part of the ignition system by a small loop close to the plane earth. The initial current in the loop and hence the radiated field and the duration of the pulse are obtained. Comparison of the field strength calculated by this means with values measured by other observers shows agreement. The waveforms of the radiated field from a spark plug and from cars were investigated on a television receiver connected to a second c.r.t. from which photographs of the pulse trains were taken. From these photographs the number of pulses per train and its average duration for several makes of car were tabulated.

STATIONS AND COMMUNICATION SYSTEMS

621.391.1 **3742**

Multichannel Communication Systems.—F. F. Roberts & J. C. Simmonds. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 236–238.) Long summary in Italian of 183 of January and 416 of February.

621.395.332.029.64 (44) **3743**

First Microwave Telephone System operating on Busy Paris Route.—(*Telegr. Teleph. Age*, Sept. 1946, Vol. 64, No. 9, pp. 5, 6.) An announcement of the introduction into regular service by the French Ministry of Posts, Telegraphs and Telephones of a 12-channel, 3 000 Mc/s, frequency-modulated radio link between Paris and Montmorency.

621.395.44 **3744**

The Unit Bay 1B Coaxial Cable Transmission System : Part 4.—R. A. Brockbank & C. F. Floyd. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 64–65.) Continuation of 2000 of July, dealing with the installation and operation.

621.396 : 061.5 **3745**

High-Frequency and Communications Engineering.—K. Sachs & W. G. Noack. (*Brown Boveri Rev.*, Jan./April 1943, Vol. 30, Nos. 1/4, pp. 59–64.) Review of the Brown Boveri Company's work in 1942 including notes on (*a*) development of micro-wave oscillators, and applications of microwaves to distance-measurement and communication problems; (*b*) secrecy equipment on telephone and telegraphic systems; (*c*) medium and short-wave transmitters using remote control; (*d*) broadcast studio equipment; (*e*) supervisory remote-control systems applied to power-stations, railways, and industrial problems.

621.396 : 061.5 **3746**

High-Frequency and Communications Engineering.—K. Sachs & W. G. Noack. (*Brown Boveri Rev.*, Jan./Feb. 1944, Vol. 31, Nos. 1/2, pp. 86–93.) A review of research and development work undertaken in 1943 by the Brown Boveri Company, including notes on filters using artificially cultivated crystals, f.m. and unidirectional aerials applied to the design of sets for multichannel operation; magnetron developments, and an impedance-measuring device for u.h.f. work; medium-wave broadcast transmitters, and equipment used in police wireless communication; a telemetering system for supervisory control, and a low-voltage network telecontrol system.

621.396.029.56/.62 **3747**

Amateur Bands.—(*Wireless World*, Aug. 1946, Vol. 52, No. 8, p. 271.) The frequency bands now available to British amateur transmitters are 1.8–2.0, 7.15–7.30, 14.1–14.3, 28.0–30.0, and 58.5–60.0 Mc/s. These may be used for c.w., m.c.w., and R/T. The power limitations are given.

621.396.13 **3748**

A Preview of the Western Union System of Radio Beam Telegraphy : Part 2.—J. Z. Millar. (*J. Franklin Inst.*, July 1946, Vol. 242, No. 1, pp. 23–40.)

A description of the centimetre-wavelength beam system developed by R.C.A. for inter-city communications. Thirty-two voice-frequency bands in the range 500 c/s–150 kc/s modulate the frequency of a 1-Mc/s sub-carrier with a peak deviation of 400 kc/s. This signal in turn modulates the frequency of the r.f. transmitter, which has a peak deviation of 2 Mc/s. The transmitter has a power output of 50 mW. With a parabolic reflector to the antenna, the range is 55 miles. The effects of atmospheric conditions on the choice of operating frequency are considered, and vertical diversity reception is proposed to overcome interference fading. The repeater stations, which are mounted on steel towers, demodulate the signal to the 1-Mc/s sub-carrier, which then modulates a transmitter on a nearby frequency. The proposed relay networks are shown with examples of the terrain profile. For part 1 see 3048 of October.

621.396.13 **3749**

Reuters' Wireless Services.—W. West. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 48–52.) An account of the development of Reuters' service of news distribution from British Post Office transmitters, including the long-wave "European", and the short-wave "World" services, together with a description of the German Hellschreiber telegraph system.

621.396.24.029.64 **3750**

Radiotelephone Links on Ultra-Short Waves.—F. Vecchiacchi. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 3–14. With English, French and German summaries.) U.h.f. links can be used advantageously in multichannel long-distance telephony in Italy where the mountains provide natural intermediate relay points. The choice of wavelength, station spacing, modulation system, repeating system, and multiplexing system is discussed. Profile curves illustrate three possibilities for the Milan-Turin link. The Milan-Rome link which is nearly 500 km direct requires only two intermediate stations.

621.396.619.018.41 **3751**

Frequency Modulation: B.B.C. Field Trials.—H. L. Kirke. (*B.B.C. Quart.*, July 1946, Vol. 1, No. 2, pp. 62–80.) A detailed description of results obtained from the following tests: "1. Propagation tests on 45 and 90 Mc/s (field strength *versus* distance, for both horizontal and vertical polarization). 2. Fading measurements at various distances. 3. Comparative tests on f.m. and a.m. 4. Signal/noise ratio tests. 5. Practical listening tests with different types of receivers at various distances and in the homes of ordinary listeners." It is thought that the optimum conditions for a British u.s.w. f.m. broadcasting service are: maximum deviation 75 kc/s; pre-emphasis 50 μs; carrier-channel spacing 200 kc/s, but 400 kc/s between transmitters serving the same area. See also *Wireless World*, Oct. 1946, Vol. 52, No. 10, pp. 316–320.

621.396.619.16 **3752**

Pulse Modulation.—A. S. Gladwin. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 288–289.) A further contribution to the discussion given in various letters to *Wireless Engineer* since the article by Roberts & Simmonds (see 3054 of October and back references). A single general formula is here derived, in terms of which all types of modulated pulse trains with constant amplitude pulses can be represented.

621.396.82 **3753**

Adjacent Channel Interference.—A. G. Dunn. (*R.S.G.B. Bull.*, Oct. 1946, Vol. 22, No. 4, pp. 55–57.) To relieve congestion on amateur frequencies, it is essential (*a*) to improve apparatus, *e.g.* by using beam aerials and the least possible power, (*b*) to improve operating procedure: operators should be able to read morse well, choose frequency correctly, and use variable frequency oscillators where feasible; unnecessary "netting" should be avoided, (*c*) to share time and frequency more drastically.

621.396.9.015.33 **3754**

Pulse Technique and Its Applications [to radar].—A. de Gouvenain. (*Cah. toute la Radio*, Sept. 1945, No. 3, pp. 2–4.) An elementary description.

SUBSIDIARY APPARATUS

534.41 + 534.781 **3755**

The Sound Spectrograph.—Koenig, Dunn & Lacy. (*See* 3517.)

534.41 + 534.781] : 535.37 **3756**

Visible Speech Translators with External Phosphors.—Dudley & Gruenz. (*See* 3519.)

534.41 + 534.781] : 621.385.832 **3757**

Visible Speech Cathode-Ray Translator.—Riesz & Schott. (*See* 3520.)

537.525.3 : 621.316.722.078.3 **3758**

Characteristics of the Pre-Corona Discharge and Its Use as a Reference Potential in Voltage Stabilizers.—S. C. Brown. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, pp. 696–697.) Summary of Amer. Phys. Soc. paper.

539.16.08 **3759**

Radioactivity Meter for Nuclear Research.—A. G. Bousquet. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 88–89.) A commercial Geiger-Müller counter and associated amplifier for rate counting with valve quenching and meter indication.

539.16.08 **3760**

Small Mica Window Geiger-Müller Counter for Measurements of Radioactive Isotopes in Vivo.—E. Strajman. (*Rev. sci. Instrum.*, June 1946, Vol. 17, No. 6, pp. 232–234.)

539.16.08 **3761**

System for High Speed Counting of Nuclear Particles.—H. L. Schultz. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 689.) Summary of Amer. Phys. Soc. paper.

539.16.08 : 547.2 **3762**

Organic Vapors for Self-Quenched G.M. Counters.—E. der Mateosian & H. Friedman. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 689.) Summary of Amer. Phys. Soc. paper.

621–526 **3763**

Parallel Circuits in Servomechanisms—H. T. Marcy. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 521–529.). A general mathematical technique for the analysis of servomechanisms in which the inclusion of a component in the feedback circuit modifies the controlled quantity before comparison with the desired quantity. A bibliography of 8 items is given.

621–526 **3764**

The Frequency Response of Automatic Control Systems.—H. Harris, Jr. (*Trans. Amer. Inst. elect. Engrs*, Aug./Sept. 1946, Vol. 65, Nos. 8/9, pp. 539–546.) The accepted method of transient-response analysis of servomechanisms becomes unwieldy with complex systems. A frequency-response method based on Fourier analysis is advocated which gives equivalent results more simply. A numerical example is given of a torque amplifier with motor generator control.

621.314.12 : 621.394/.396].66 **3765**

The Amplidyne Electrical Control System.—British Thomson-Houston Company. (*Engineering, Lond.*, 2nd Aug. 1946, Vol. 162, No. 4203, pp. 103–105.) The machine is essentially a d.c. generator with an unusually low field-power, which can be used for automatic control of voltage, current, or power factor with good transient response. A description of several applications is given.

621.314.2 : 621.396.619 **3766**

Modulation Transformers for Broadcasting Transmitters.—M. G. Favre. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 323–326.) For 100% modulation, the highest quality is obtained with anode modulation of the final radio-frequency amplifier. The requirements for a class-B modulator and the design of the modulation transformer are given. The response curve of an 8.5-kW modulator indicates a loss of 0.5 db at 30 and 10 000 c/s when the transformer has an efficiency of 95%.

621.314.53 **3767**

Rotary Converter for Portable Power Supplies.—(*Electronics*, Aug. 1946, Vol. 19, No. 8, p. 142.) Coils rotating in a magnetic field carry with them an evacuated glass sphere containing mercury, which makes contact successively with tungsten electrodes. "The complete cased unit resembles a conventional vibrator in appearance."

621.314.6 + 621.319.4 + 621.383] : 669.018 **3768**

Light Alloys in Metal Rectifiers, Photocells and Condensers.—A series of anonymous articles under this or similar title has appeared in various issues of *Light Metals* since April 1944.

(i) April 1944, Vol. 7, No. 75, pp. 162–172. ". . . the theory and practice of the use of aluminium and magnesium [in metal rectifiers] are examined."

(ii) June 1944, Vol. 7, No. 77, pp. 276–298. "Particular attention is [here] paid to the selenium rectifier, and the use made of light metals in its construction."

(iii) Sept. 1944, Vol. 7, No. 80, pp. 437–458. "Concluding . . . a study of the selenium rectifier, and introducing a comprehensive discussion on photocells and the role of light metals in their construction."

(iv) Oct. 1944, Vol. 7, No. 81, pp. 505–512. "Continuing . . .a discussion on photocells. The copper-oxide and caesium types are here dealt with."

(v) Nov. 1944, Vol. 7, No. 82, pp. 525–529. "Apparatus, auxiliary materials and technique employed in preparing and handling alkali metals for photocells are described. Physical and chemical properties of these metals and methods for their extraction are then briefly discussed."

To be continued.

621.317.755 **3769**

Modification to Cossor Oscilloscope Model 339 to enable Modulation Measurements to be made at Carrier Frequencies above 20 Mc/s.—A. J. Muir & J. W. Whitehead. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, p. 189.)

621.317.755 **3770**

Fast Sweep Synchroscope.—D. F. Winter. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 695.) The basic problems involved in building a sealed tube cathode-ray oscillograph for measuring time intervals of 10^{-9} sec to within 10% are listed. Summary of Amer. Phys. Soc. paper.

621.317.755 **3771**

Elements of a New Oscilloscope Design.—Simmons. (*See* 3677.)

621.317.755.027.3 **3772**

The Precision-Type Quadruple-Beam High-Voltage Oscillograph.—G. Induni. (*Brown Boveri Rev.*, Sept./Oct. 1943, Vol. 30, Nos. 9/10, pp. 222–223.) One cathode is used and there are four independent deflexion assemblies for voltages up to 3 kV, and two deflexion assemblies for voltages up to 50 kV. The high voltage is supplied to the cathode through a screened lead from an oil-immersed 50-kV d.c. rectifier plant. The cast-iron body of the oscillograph is highly vacuum-tight and provides excellent screening, rubber packing helps to maintain the vacuum, and one molecular pump suffices. The beams are independently adjusted for intensity and shift, and a common focusing coil is used.

621.318.24 **3773**

Condenser-Discharge Magnetiser for Permanent Magnets.—F. Brailsford. (*Engineering, Lond.*, 16th Aug. 1946, Vol. 162, No. 4205, pp. 145–146.) Permanent magnets may be magnetized conveniently by passing "a high unidirectional current for a short time through a single conductor threading the magnet". This has been done by discharging a capacitor through the primary winding of a transformer with the secondary connected to the single magnetizing conductor. The circuit must be critically damped to obtain maximum peak current without oscillation. See also 2719 of September.

621.318.42 + 621.396.662.21 **3774**

Properties and Application of Standard-Q Coils at High Frequency.—G. Opitz. (*Arch. tech. Messen*, Sept. 1940, No. 111, pp. T106–107.) The self-capacitance C_s of a coil of standard Q $(=\omega L/r)$ can introduce errors according to the method of measurement. The construction of a series of iron-cored standards from 1 μH to 1 H (Q = 50–250) is described, and the influence of the iron on the loss and inductance of the coil (as a function of magnetization) is discussed. A 20% change of Q is possible for a $\pm$ 10°C temperature change or a variation of 0–80% of relative humidity.

621.318.5 **3775**

Electric Relays : a General Survey.—J. Sorge. (*Arch. tech. Messen*, April 1940, No. 106, pp. T40–41.)

621.318.572 **3776**

Electronic True Decade Counters.—H. G. Shea. (*Electronic Industr.*, Sept. 1946, Vol. 5, No. 9, pp. 82–84 . . 136.) Four double triode multivibrators have neon lamps in each anode circuit. By means of feedback to the third and fifth triode sections it is possible to count up to ten input pulses directly thus avoiding conversion to and from the binary scale. Another counter, described in 2496 and 2497 of September, uses ten directly-coupled twin pentodes arranged in a ring and variations of this circuit may be triggered by a.c.

621.319.3.027.3 **3777**

A Compact High Voltage Electrostatic Generator using Sulphur Hexafluoride Insulation.—W. W. Buechner, R. J. Van de Graaff, A. Sperduto, E. A. Burrill, L. R. McIntosh & R. C. Urquhart. **Preparation and Physical Properties of Sulfur Hexafluoride** [for use in generator].—W. C. Schumb. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 692.) The generator can produce over 5 MV, and has been used for investigating the dielectric properties of various gases including air. Summary of Amer. Phys. Soc. papers.

621.319.4 : 620.193.91 **3778**

Capacitor Life Testing.—J. R. Weeks. (*Bell Lab. Rec.*, Aug. 1946, Vol. 24, No. 8, pp. 296–299.) Relationships discovered in the last fifteen years between voltage, temperature, and life form the basis of accelerated tests in which the probable life can be determined in two weeks. The testing apparatus is described.

621.319.4.029.5 : 621.315.612 **3779**

High Frequency Ceramic Capacitors.—B. M. Vul & G. I. Skanavi. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 4, pp. 194–199. In Russian.) For practical purposes the following two types are required : (*a*) compensating, and (*b*) of high stability. The temperature coefficient of permittivity should be negative in the first, and as near as possible to zero in the second. As a result of the present investigation, materials were developed with positive and negative temperature coefficients by combining TiO_2 with MgO ("timag") and $MgCa(CO_3)_2$ ("tidol") respectively. A predetermined value of the coefficient can be obtained by using these materials in various proportions. Experimental curves are plotted showing permittivity ϵ, and its temperature coefficient, as measured in completed capacitors (Fig. 1), the effect of temperature on capacitance (Fig. 2), and the effect of frequency (Figs. 3 and 4) and temperature (Fig. 5) on the loss angle. Formulae are also quoted for calculating the heating of flat and cylindrical capacitors.

A summary in English was noted in 2761 of 1945.

621.383.2 + 535.215.1 **3780**

Complex Photocathodes.—N. S. Khlebnikoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 286–289. In Russian.) According to de Boer the external photoeffect of complex cathodes is determined by two elementary processes, the photo-ionization of adsorbed atoms, and the movement of the replenishing electrons through the intermediate layer. Investigations of the Sb-Cs type of cathode and later of the Cs-O-Ag type have led the author, however, to the conclusion that complex photocathodes should be regarded as semiconductors with a relatively low value of the work function, operating by the photo-emission of electrons from the depth of the intermediate layer. The advantages of the new theory are discussed, and further possible developments indicated.

An abstract in English was noted in 1819 of July.

621.383.2 **3781**

Certain Physical Properties of Caesium Oxide Photocathodes.—P. M. Morozoff & M. M. Butsloff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 291–303. In Russian.) A preliminary report on a detailed experimental investigation carried out to determine the spectral distribution of sensitivity, the energy distribution of photo-electrons, and the work function of caesium oxide photocathodes. Curves are plotted in Figs. 2 and 3 showing the spectral sensitivity when the photocathode is illuminated from the rear and the front respectively. The spectral distribution of sensitivity is closely connected with the thickness of the silver layer, and therefore with the thickness of the photocathode. Photocathodes of a given thickness, and therefore of a predetermined spectral sensitivity, can be obtained by varying the depth of the oxidation of the silver layer, and Fig. 4 gives sensitivity curves for photocathodes of different thickness. The difficulties of ensuring the required depth of oxidation are pointed out, and the structure of the photocathodes is discussed in detail. The electrical and optical properties of the silver layer are greatly affected by the temperature of the glass envelope during the deposition of the silver. The volt-ampere characteristics of the photocathodes illuminated from the front (thick lines) and from the rear (dotted lines) are shown in Fig. 9. It appears from these curves that the energy distribution of photo-electrons in this type of cathode is similar to that in the case of pure metals. An irregularity in the energy distribution is apparent, however, on wavelengths of 750 mμ and more. The reasons for this irregularity are discussed.

Measurements of the work function are described. The value was found to be of the order of 0.78–0.90 V, but may vary with time by as much as $\pm$ 1 V over a period of 10–500 hours.

An abstract in English as noted in 2033 of July.

621.383.2 **3782**

The Energy Distribution of Electrons and the Relationship between Photocurrent and the Angle of Incidence of Light in the case of Caesium Oxide Photocathodes.—A. M. Pyatnitski. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 304–308. In Russian.) Results of an experimental investigation are shown in the following curves : Fig. 1 (left)—the photocurrent against the angle of incidence of light ; Fig. 1 (right)—reflection, transmission and absorption of light against the angle of incidence ; Fig. 2 (upper curves)—the photocurrent for an angle of incidence of 70° against the wavelength of light ; Fig. 2 (lower curves)—reflection transmission and spectral characteristics against the wavelength ; Fig. 3 (left)—reflection, transmission and absorption, and Fig. 3 (right)—the photocurrent for different structures of the cathode and different angles of incidence ; Fig. 4—volt-ampere characteristics for infra-red light falling at different angles from the front and the rear of the cathode.

Conclusions : (*a*) The photocurrent depends on the angle of incidence of light. The relationship is determined by the structure of the cathode and the wavelength of the light. (*b*) The spectral characteristic also depends on the angle of incidence. (*c*) The maximum of energy distribution, independently of the wavelength, is shifted towards a greater energy value when the cathode is illuminated from the rear.

An abstract in English was noted in 2032 of July.

621.383.2 **3783**

New Photocells with Antimony-Caesium Cathodes.—N. S. Khlebnikoff & A. E. Melamid. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 309–312. In Russian.) Two types of photocell were developed, one for use with ultra-violet radiation, and the other possessing constant sensitivity and capable of operating under both weak and intense illumination. For the first type it is difficult to manufacture an envelope transparent to ultra-violet rays, and methods adopted to overcome this are described. The spectral characteristics of the photocells so produced are shown in Fig. 3. The cells are almost free from fatigue, and possess a very high resistance (of the order of $10^{13}\ \Omega$) between the anode and the cathode.

The production of the second type is based on the fact that the spectral sensitivity of the Sb–Cs cathodes decreases as a result of fatigue down to 50% of the original value, and is not restored after rest. A photocell can therefore be artificially fatigued by exposing it to the illumination of the sky. Photocells with a constant sensitivity (with no greater deviation than $\pm$ 10%) and capable of operating under such an intense illumination as 10^4 lux were produced in this way.

An abstract in English was noted in 2031 of July.

621.383.4 + 535.215.1 : 546.28 **3784**

A New Bridge Photo-Cell employing a Photo-Conductive Effect in Silicon. Some Properties of High Purity Silicon.—G. K. Teal, J. R. Fisher & A. W. Treptow. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 686.) An apparatus is described for making bridge-type photocells by reaction of silicon tetrachloride and hydrogen gases at ceramic or quartz surfaces at high temperatures. The variation of the conductivity of pyrolitic silicon films on porcelain with temperature is described and explained. Summary of Amer. Phys. Soc. paper.

621.383.5 **3785**

Blocking-Layer Photocells.—W. C. van Geel. (*Philips tech. Rev.*, March 1946, Vol. 8, No. 3, pp. 65–71.) An account of the structure and functioning of photocells formed from a layer of a semiconductor such as cuprous oxide or selenium separated from a metal electrode by a very thin insulating layer, the blocking layer. The internal and external photo-effects are explained as the action of light quanta in enabling the electrons to pass from one energy band to another. Examples of the characteristics of typical cells are given.

621.384 **3786**

The Synchro-Betatron, Electron Accelerator Guide Fields.—H. F. Kaiser & E. C. Greanias. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 536–537.) Discussion of the possibility of modifying the Kerst betatron for operation as a synchrotron, by the synchronized application of an intense guide field which increases in strength with the energy of the particle. A few calculations show the practicability of the scheme, and possible conductor guide systems are considered.

621.384 : 537.291 **3787**

Electron Orbits in the Synchrotron.—D. S. Saxon & J. Schwinger. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 702.) Equations for the orbital motion are derived on the assumption that the localized accelerating field can be replaced by an equivalent rotating electric field. Summary of Amer. Phys. Soc. paper.

621.384 : 621.385.16 **3788**

Preliminary Studies on the Design of a Microwave Linear Accelerator.—J. Halpern, E. Everhart, R. A. Rapuano & J. C. Slater. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 688.) Pulsed magnetrons operating at about 3 000 Mc/s and feeding into high-*Q* cavities have been used to obtain electron accelerating voltages of the order of 2 MV. Summary of Amer. Phys. Soc. paper.

621.384 : 621.392 **3789**

Wave Guide Acceleration of Particles.—E. L. Hudspeth. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 671.) The disadvantages of a linear accelerator may be overcome by using the transverse field inside a waveguide to accelerate the particles. The guide is bent into a spiral and holes in the walls allow the particles to move along a diameter. Phasing is obtained by adjusting the position of the holes and the spacing of the turns. The guide is short-circuited and operated as a cavity resonator.

621.385.18.029.64 **3790**

Various Papers on TR Switches.—(*See* 3814/3819.)

621.385.832.088 **3791**

C.R. Tube Quality Measuring Apparatus.—Spooner. (*See* 3683.)

621.394.624 **3792**

An Electronic Code Translator.—H. W. Babcock. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 282–283.) Slightly abbreviated reprint of 2730 of September.

621.395.636 **3793**

Dialling Selection Signals at Voice Frequency.—F. Lucantonio. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 195–217. With English, French and German summaries.) General discussion of systems of dialling signals with particular reference to Italian long-distance underground cables. Schematic and detailed circuits of the relay chains are given.

621.396.611.21.032.2 : 546.59 **3794**

Gold Film Electrodes for High Frequency Quartz Plates.—R. A. Spears. (*J. Brit. Instn Radio Engrs*, March/May 1946, Vol. 6, No. 2, pp. 50–59. Discussion, pp. 59–62.) A theoretical and practical discussion of the design of gold film electrodes and their effect on the natural frequency. The behaviour of electrodes is analysed to explain the advantages of adherent films. Factors in the design of film electrodes are the surface displacement of the crystal and the optimum area and location of the electrodes. A short account of a practical method of gold sputtering includes details of the preparation of surface and methods of varying quality, colour, durability, adherence, thickness, and weight of the film. An analysis is given of the effect of the gold deposit on frequency and activity and usual methods of mounting the crystals are described.

621.396.662 **3795**

A Device for [periodic] **Variation of Reactance.**—J. Bernhardt. (*Cah. toute la Radio*, Sept. 1945, No. 3, pp. 21–23.) A flexible vibrating blade has one end fixed, a soft iron armature at the centre and, at the free end, the element for varying reactance, which can be either (*a*) a closed wire loop in the field of a coil, (*b*) a capacitor plate, or (*c*) a piece of soft iron in the air gap of a magnet. The most convenient frequency of oscillation is 50 to 100 c/s. Various possible applications are mentioned.

621.396.682 : 621.316.722 **3796**

Multi-Voltage Regulated Power Supplies.—J. R. Mentzer. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 132–133.) A description of circuits for obtaining outputs at two regulated voltages by the use of standard gas-filled tubes. Any voltage that is a multiple of 15 V, up to the maximum voltage of the unregulated source, can be obtained by suitable additive or subtractive combinations of the tubes. A procedure is given for computing circuit values in relation to voltage and current requirements.

621.317.755 : 6 **3797**

The Cathode-Ray Oscillograph in Industry. [Book Review]—W. Wilson. Chapman & Hall, London, 2nd edn 1946, 18s. (*Engineering, Lond.*, 9th Aug. 1946, Vol. 162, No. 4204, p. 124; *J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 218.)

TELEVISION AND PHOTOTELEGRAPHY

621.385.832.088 **3798**

C.R. Tube Quality Measuring Apparatus.—Spooner. (*See* 3683.)

621.397 : 621.396.9 **3799**

Has Radar influenced Television Development?—(*J. Televis. Soc.*, March 1946, Vol. 4, No. 9, pp. 220–222.) A discussion before the Television Society led by F. R. W. Strafford. It was generally agreed that radar owed a great deal to television, but had so far had little influence on television development. It may have more in the future if higher frequency systems are introduced. Improved feeders and smaller and lighter components produced for radar could be adapted for television, but would not result in great reduction of cost to the user.

621.397 : 778.53 **3800**

Film—the Backbone of Television Planning.—R. B. Austrian. (*J. Televis. Soc.*, March 1946, Vol. 4, No. 9, p. 226.) Summary of an address given before the Society of Motion Picture Engineers. The high cost of programmes employing individual artists makes it probable that films will eventually be the major source of television transmissions.

621.397.26 **3801**

Stratosphere Television.—(*J. Televis. Soc.*, March 1946, Vol. 4, No. 9, p. 227.) Usable signals have been transmitted over a distance of 240 airline-miles from an altitude of 25 000 ft using only 250 W of power. These results agree almost exactly with pre-flight calculations. Transmissions to date have been on three frequencies between 100 and 550 Mc/s, with one channel devoted to studies of television "ghosting"; another to f.m. transmission; and the third for communications incident to test operation.

A suitable plane for the purpose is a low-wing all-metal monoplane about the size of the B-29, but weighing only one third as much. "Each plane would weigh 20 tons fully loaded." The original proposals were noted in 3970 of 1945.

621.397.611 **3802**

Portable Video Pickup Equipment.—W. A. Howard. (*Electronics*, Aug. 1946, Vol. 19, No. 8, pp. 124–129.) A portable lightweight television camera and associated control, monitoring and synchronizing equipment, designed to give an output of video and standard synchronizing signals. A detailed description of the camera and each auxiliary unit is given with performance specifications and method of operation.

621.397.645 **3803**

Television V.F. Stage.—W. T. Cocking. (*Wireless World*, Aug. 1946, Vol. 52, No. 8, pp. 265–268.) The advantages of feeding the vision signal on to the cathode of the display tube rather than to the grid are pointed out. A basic circuit, and a suitable synchronization pulse separator stage, are described.

621.397.645 **3804**

Television V.F. Stage.—H. Wood. (*Wireless World*, Oct. 1946, Vol. 52, No. 10, p. 346.) Comments on 3803 above.

TRANSMISSION

621.396.61 + 621.396.621] : 621.396.932 **3805**

Transmitting Equipment for the Merchant Navy.—H. Grumel. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 264–273.) Describes a telephony transmitter for use by unskilled persons giving an aerial power of 30 W on λ 80–220 m. Circuits and details of construction of the transmitter and the associated receiver (mounted in the same unit) are given. Mention is also made of three transmitters for use by skilled persons: (*a*) 300 W (A_1 communication) or 400 W (A_2) on λ 580–820 m, (*b*) 150–200 W (A_1) on λ 18, 24, 36 and 48 m, (*c*) 75 W (A_2) on λ 600 m—distress. Details of these equipments will be published later.

621.396.61.029.54 **3806**

The "Monobloc" 10-kW Broadcast Transmitters Type TH 1308.—C. Beurtheret. (*Rev. tech. Comp. franç. Thomson-Houston*, Oct. 1945, No. 4, pp. 45–52.) Description of a medium-wave transmitter suitable for rapid serial production to replace those of the French broadcasting system destroyed during the war. The anode efficiency of the power stage is 40% for carrier or 80% at peak, and the overall efficiency of the transmitter is 23% on carrier. The harmonic distortion is less than 2% at frequencies of 50–4 000 c/s for 80% modulation and less than 3% at 95% modulation. The noise modulation is 55 db below the level corresponding to 80% modulation. The advantages of the assembly of the transmitter in the form of a single rectangular block are stated.

621.396.611.21.029.62 : 621.396.662.078.3 **3807**

Crystal Control on 144 Mc/s.—W. W. King. (*QST*, Sept. 1946, Vol. 30, No. 9, pp. 46–50.) Three transmitters are described having output powers of 5, 20 and 60 W. The frequency is controlled by a 12 Mc/s A.T.-cut crystal operating on an overtone, frequency multiplication being carried out in stages which drive the output valves. All the transmitters described are plate-modulated.

621.396.615.12.029.5 **3808**

A Simple V.F.O. Crystal Substitute.—D. Mix. (*QST*, Sept. 1946, Vol. 30, No. 9, pp. 13–16.) Practical details of a variable frequency oscillator covering a frequency range from 3 500–4 000 kc/s. In order to obtain high frequency-stability an electron coupled oscillator having a large capacitance in its frequency-determining circuit is followed by two untuned amplifier stages. The oscillator valve is 6SK7 as this is well screened. The amplifier uses two 6F6's, which give little trouble from parasitic oscillations. The high-voltage supply to the oscillator and the first amplifier is stabilized from a regulator tube. The oscillator screen may be keyed without causing serious defects.

621.396.619 : 621.314.2 **3809**

Modulation Transformers for Broadcasting Transmitters.—Favre. (*See* 3766.)

VALVES AND THERMIONICS

621.385.1.032.216 **3810**

The Measurement of Differences of Contact Potential and of Saturation Current in Vacuum Tubes using Oxide Cathodes.—R. Champeix. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 208–235.) The characteristic log $I = f(V)$ (the 'residual current') is used, and is obtained when the electrode considered has a retarding potential relative to the cathode. This measurement of contact p.d. requires a knowledge of the saturation current, and a method for measuring it has been studied and evolved for oxide cathodes by using the discharge of a capacitor controlled by thyratrons. The method of interpreting Schottky's law to deduce the true saturation current is indicated. Evidence is given of the new phenomenon of the modification of the slope of the line log $I = f(V)$ when the condition of the receiving electrode is changed. Methods are proposed for stabilizing the contact p.d. during the industrial production of radio valves.

621.385.1.032.216 : 621.386.1 **3811**

A Study of Oxide Cathodes by X-Ray Diffraction Methods : Part 1 — Methods, Conversion Studies, and Thermal Expansion Coefficients.—A. Eisenstein. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 434–443.) Two methods are described, one for studying the conversion process in forming the cathode, the other for measuring the thermal expansion coefficients of barium, strontium, and thorium oxides. "The conversion of an equal molar barium-strontium carbonate solid solution, $(BaSr)CO_3$, involves (1) crystal growth in the carbonate, (2) decomposition to the mixed oxides, BaO and SrO, (3) formation of the oxide solid solution, (BaSr)O, and (4) crystal growth in the oxide. A similar sequence of events is observed in the conversion of a mixed carbonate, $BaCO_3 + SrCO_3$. Crystal and particle size, growth of carbonates, and crystal growth of oxides are investigated, and possible relationships are discussed."

621.385.16 + 621.396.9 **3812**

Radar and the Magnetron.—J. T. Randall. (*J. R. Soc. Arts*, 12th April 1946, Vol. 94, No. 4715, pp. 303–312. Discussion, pp. 312..323.) A paper read before the Royal Society of Arts giving a brief account of the basic principles and history of radar, and, in greater detail, of the development of the cavity magnetron.

The development of high powers at centimetre wavelengths began with the klystron (Varian & Varian, 1939) and was followed by the cavity magnetron (Randall & Boot, 1939–40) to which the improvement of strapping was added in 1941 by Sayers.

621.385.16 : 621.384 **3813**

Preliminary Studies on the Design of a Microwave Linear Accelerator.—Halpern, Everhart, Rapuano & Slater. (*See* 3788.)

621.385.18.029.64 **3814**

Gas Discharge Switches for controlling Low Power Microwave Signals.—T-S.Ke & L. D. Smullin. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 698.) The keep-alive electrode in a t.r. switch was placed unusually near the r.f. gap. With this arrangement, "in a modified 1B24 filled with 12-mm nitrogen, 44-db attenuation was obtained when the keep-alive current was 0 4 mA." Summary of Amer. Phys. Soc. paper.

621.385.18.029.64 **3815**

Phenomenological Theory of the TR Switch Spike.—T. Holstein. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 698.) Summary of Amer. Phys. Soc. paper.

621.385.18.029.64 **3816**

The Band-Pass TR Switch : Part 1 — The Switching Action.—M. D. Fiske. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 699.) The switch consists of a waveguide section with a number of uniformly spaced resonant breakdown gaps within it. With argon at a pressure of 10 mm Hg breakdown times of 5×10^{-9} sec are possible. Recovery time with pure argon is long (100 μsec) but may be reduced by a small addition of water vapour. Summary of Amer. Phys. Soc. paper.

621.385.18.029.64 **3817**

The Band-Pass TR Switch : Part 2 — Linear Electrical Characteristics.—W. C. Caldwell. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 699.) By the combination of several resonant circuits in the waveguide, band-pass characteristics over a 12% wavelength range can be obtained. Summary of Amer. Phys. Soc. paper.

621.385.18.029.64 : 537.5 **3818**

Cross Sections for Capture of Electrons from TR-Tube Recovery Measurements.—C. G. Montgomery, F. L. McMillan, I. H. Dearnley & C. S. Pearsall. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 699.) Summary of Amer. Phys. Soc. paper.

621.385.18.029.64 : 537.525 **3819**
Low Pressure Gas Discharges in Microwave TR Tubes.—L. D. Smullin. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 698.) Summary of Amer. Phys. Soc. paper.

621.385.2 **3820**
Theory of the Diode.—J. K. Knipp. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 700.) The behaviour of the parallel plate diode for radio frequencies is discussed theoretically, taking account of space charge effects and of the distribution of velocity amongst the electrons. Summary of Amer. Phys. Soc. paper.

621.385.3 **3821**
The Application of Dimensional Analysis to Triode Valves at Very High Frequencies.—G. Lehmann. (*Onde élect.*, May 1946, Vol. 26, No. 230, pp. 175–187.) After a brief discussion of the advantages and the principles of the dimensional method, it is shown that the performance of similar valves depends only on the single parameter $\phi = Fd/\sqrt{V}$ where F = frequency, d = a linear dimension of the valve and V = a voltage of the system. The output, gain, voltage magnification, etc., of similar tubes can all be expressed in terms of ϕ, which is proportional to the transit angle of the electrons. For valves having the same type of cathode, the products F^3d and F^4V must be maintained constant for a constant output.

By simplified study of the movements of electrons in a valve in the class-B regime, it can be shown that the characteristics of a valve at low frequencies are conserved without material deterioration up to values of ϕ in the region of 2.5, where F is in Mc/s, d is the anode-cathode distance in cm, and V is the anode voltage in volts. Also, for this value, the Q of the output circuit will be about 18.

621.385.4.029.6 **3822**
Principles of Operation of the Resnatron.—F. W. Boggs. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 700.) A powerful u.h.f. tetrode oscillator with substantial transit time, unusual grid, and resonant cavities in the vacuum envelope. Summary of Amer. Phys. Soc. paper.

621.385.5 : 621.317.723 **3823**
A New Electrometer Valve.—J. A. Darbyshire. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, p. 277.) A double tetrode, in which each section has the characteristic of a single tetrode of type FP54, for use in a balanced bridge circuit. It has better grid insulation than earlier double-triode valves.

621.385.832 **3824**
Ion Burn in Cathode-Ray Tubes.—G. Liebmann. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 289–290.) Experimental evidence that the ions responsible for fluorescent screen destruction are generated by the activation process of the cathode. Recent suggestions for the suppression of ion burn are outlined. See also a paper by C. H. Bachman (*Gen. elect. Rev.*, 1945, Vol. 48, p. 13) and 2403 of August (Liebmann).

621.396.611 : 621.385.1 **3825**
Modulation and Tuning of Cavity Oscillators by Electron Beams.—D. S. Saxon. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 700.) A theoretical study of tuning by passing the electron beam through an auxiliary cavity tightly coupled to the oscillator. Summary of Amer. Phys. Soc. paper.

621.396.615.17 : 621.317.755 **3826**
Time-Base Converter and Frequency-Divider.—P. Nagy & M. J. Goddard. (*Wireless Engr*, Oct. 1946, Vol. 23, No. 277, pp. 286–287.) A reply to criticisms of earlier papers. See 2093 of July (Moss) and back references.

621.396.645.014.332 **3827**
Peak Pulse Currents in Class B Amplifiers.—Sturley. (*See* 3563.)

MISCELLANEOUS

001.89 **3828**
Royal Society Empire Scientific Conference.—(*Nature, Lond.*, 27th July 1946, Vol. 158, No. 4004, pp. 136–141.) Report of discussions and recommendations on a number of subjects including the use of radar in map-making, cosmic-ray research, improvement in scientific information services, standards of measurement, and commonwealth co-operation in science.

5 + 6] : 778.53 **3829**
The Future of Scientific Films.—A. S. C. Lawrence. (*J. R. Soc. Arts*, 21st June 1946, Vol. 94, No. 4720, pp. 461–469.) Discussion of the requirements for satisfactory films, and their value for various purposes.

620.193 : 669.14 **3830**
Corrosion of Stainless Steel Sheet in Marine Atmospheres.—(*J. Franklin Inst.*, May 1946, Vol. 241, No. 5, pp. 372–373.) Short note only.

621.3.078 **3831**
Robot Dynamics—Theory of Non-Linear Automatic Control Systems.—M. Avramy. (*Phys. Rev.*, 1st/15th June 1946, Vol. 69, Nos. 11/12, p. 697.) Summary of Amer. Phys. Soc. paper.

621.317 **3832**
Scientific Instruments in Britain.—C. Darwin. (*Engineer, Lond.*, 26th July 1946, Vol. 182, No. 4724, pp. 78–79.) Lecture delivered at the Exhibition of British Scientific Instruments in Stockholm, describing the development and outstanding achievements of the industry during the present century, important war-time instruments, and the function of the (British) National Physical Laboratory.

ABSTRACTS AND REFERENCES INDEX

The Index to the Abstracts and References published throughout the year is in course of preparation and will, it is hoped, be available in February, price 2s. 8d. (including postage). As supplies will be limited our Publishers ask us to stress the need for early application of copies.

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C = *Correspondence* ; *E* = *Editorial*.

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