# WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

NOVEMBER 1952

VOL. 29 No. 350 THREE SHILLINGS AND SIXPENCE

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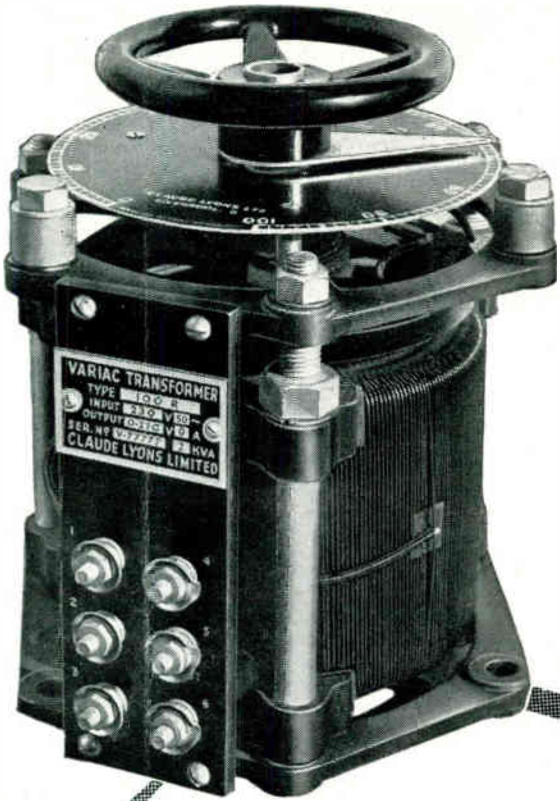


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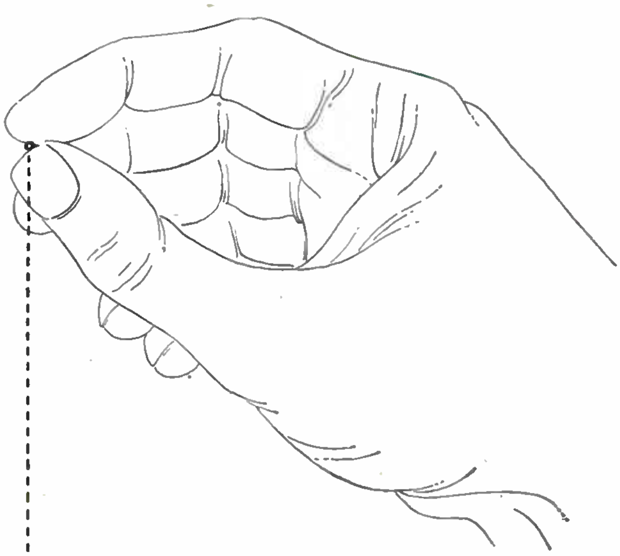

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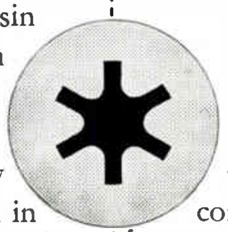

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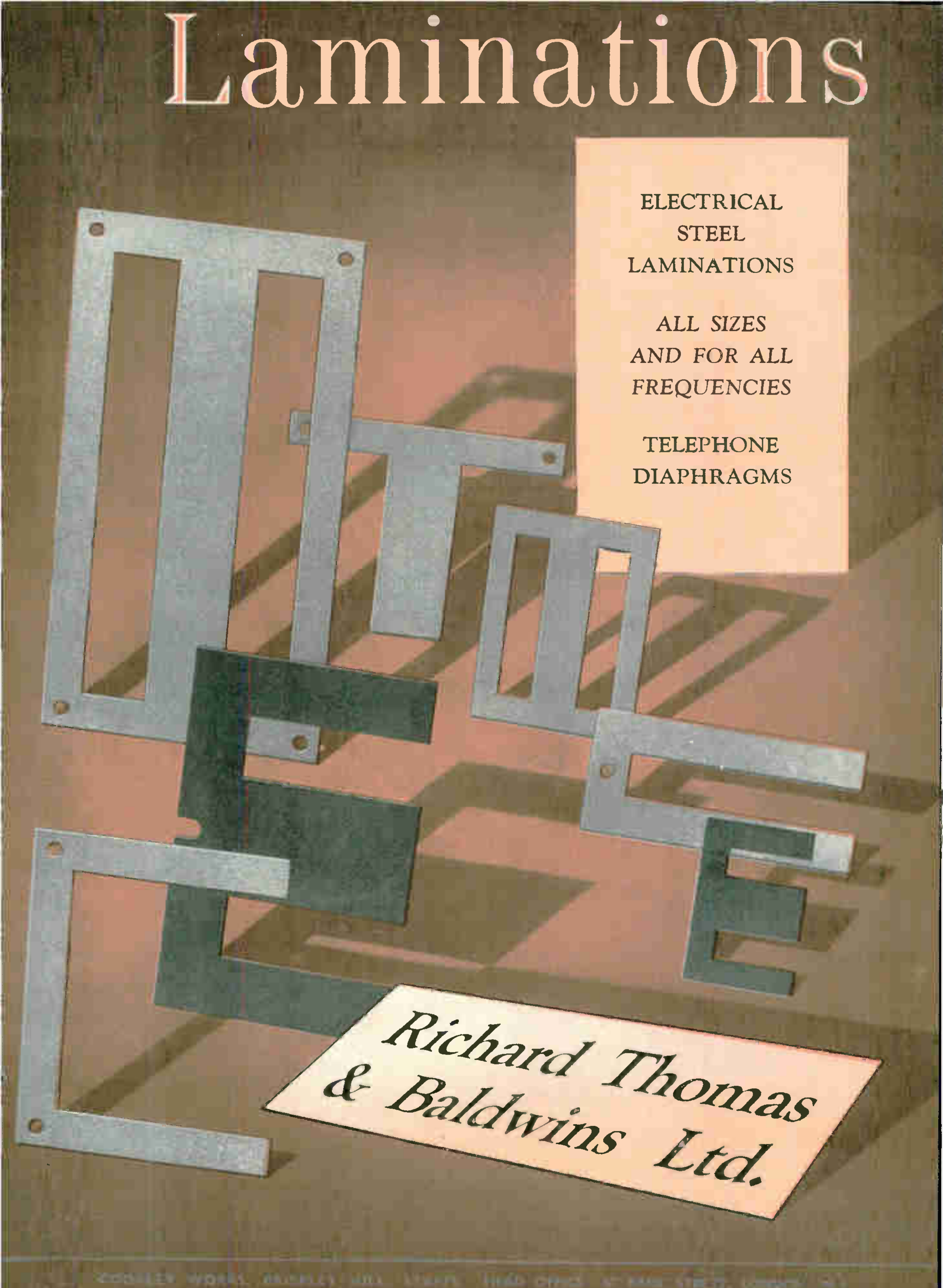
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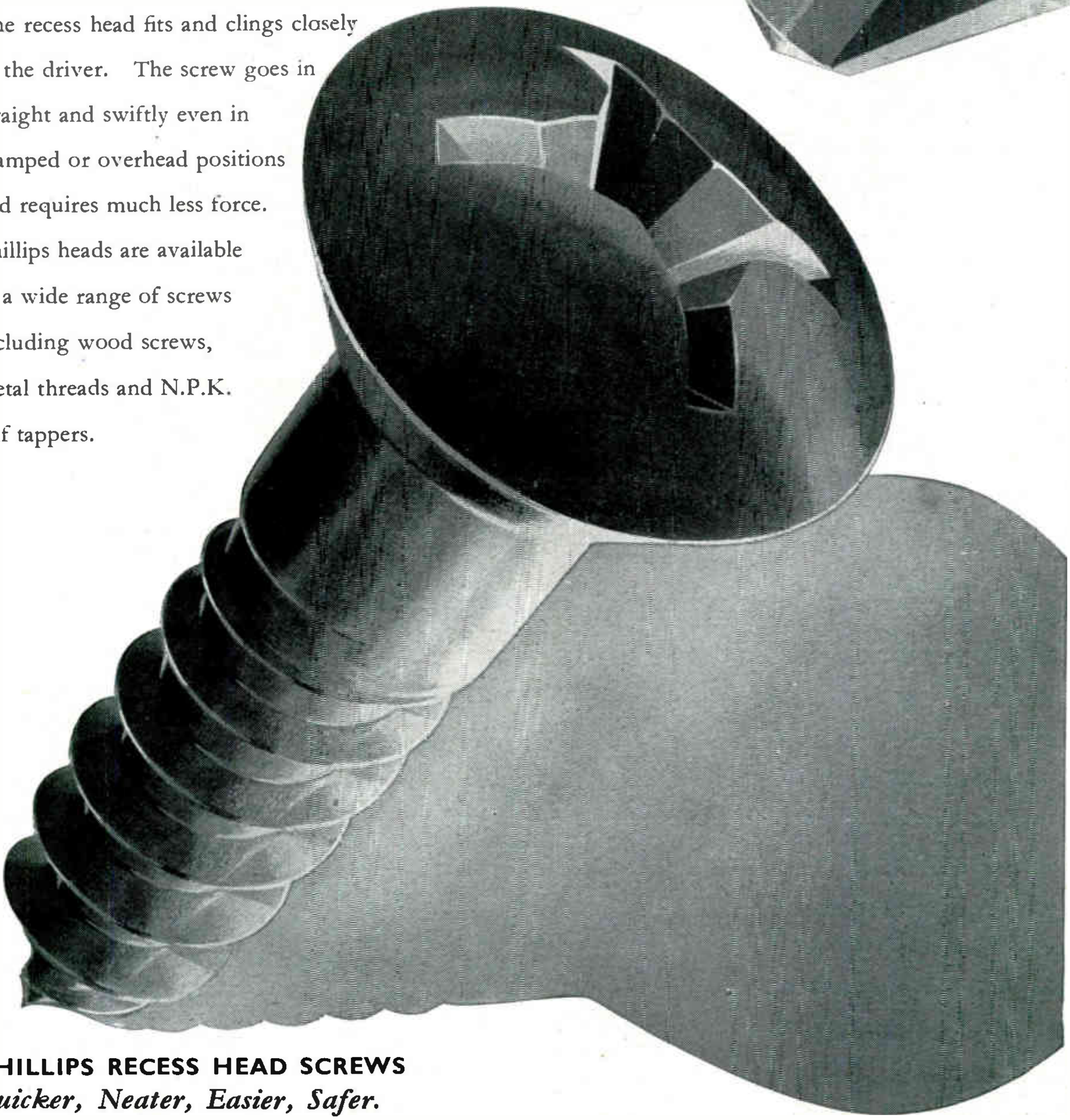

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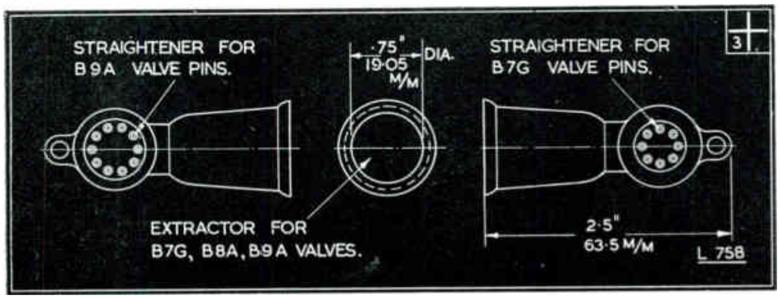


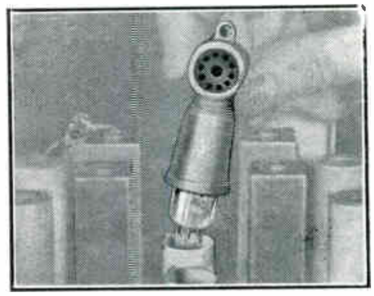

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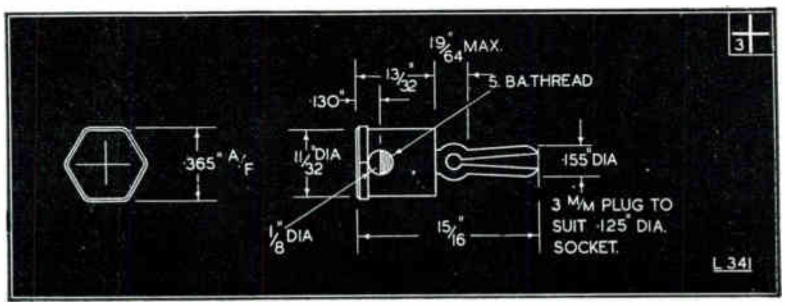


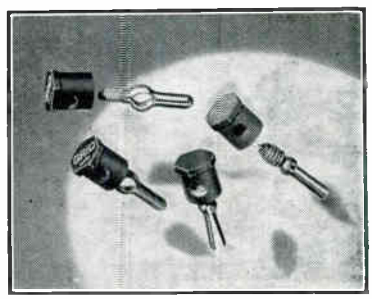

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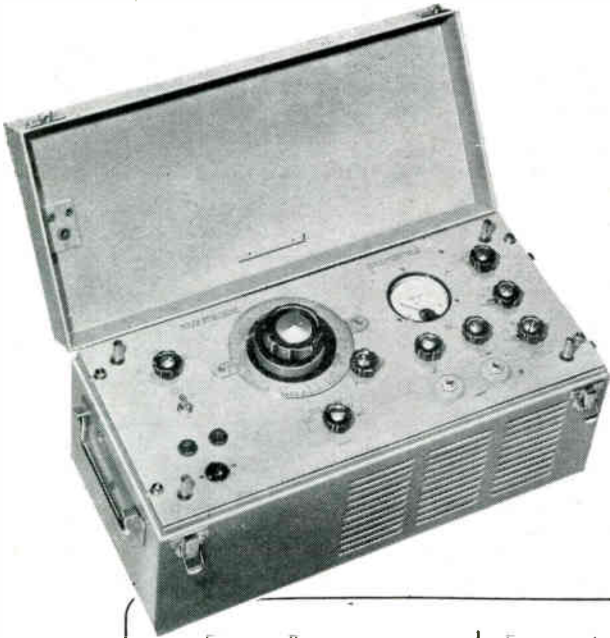

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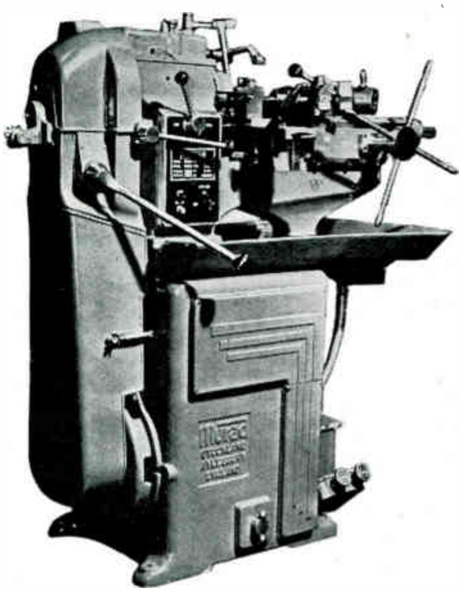

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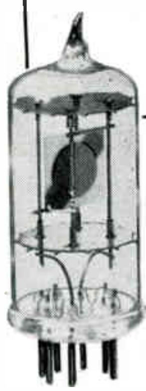

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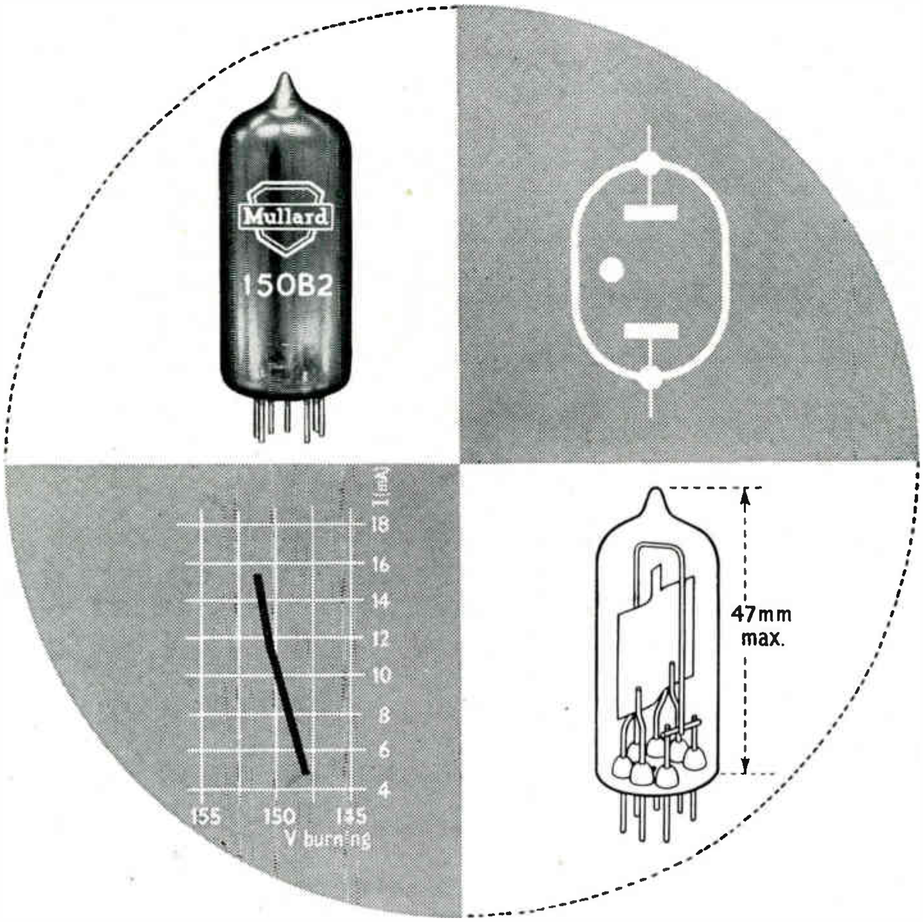
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# WIRELESS ENGINEER

Vol. 29 NOVEMBER 1952 No. 350

## A Novel Form of D.C. Motor

IN *Elektrotechnische Zeitschrift* of 1st February 1952, p. 76, Professor P. Böning describes a unipolar motor which was developed during the war at the Technische Hochschule in Breslau. It was realized only in the form of a small model in 1944. They were asked to design a d.c. motor of high power for a low voltage but large currents, supplied by accumulators. Fig. 1, which is reproduced from the *E.T.Z.*, shows a diagrammatic section of the model; the iron core (a) is a double cone made in two parts, its diameter is about 4 in.; it has a bearing at each side and constitutes the rotor. In the gap between the two cones there is a spiral of insulated copper strip (b), but there is an air-gap between the winding and the iron, so that the iron can rotate without touching the coil, the outer end of which is fixed to a metal block (c). The inner end (d) of the coil makes rubbing contact with the iron by means of a brush. The current enters at (c) and, after flowing through the coil and the central iron core, leaves by means of a wire connected to the bearing at (e). In the model the current was from 100 A to 200 A and the voltage from 2 V to 4 V; it is simply said that it ran at a high speed.

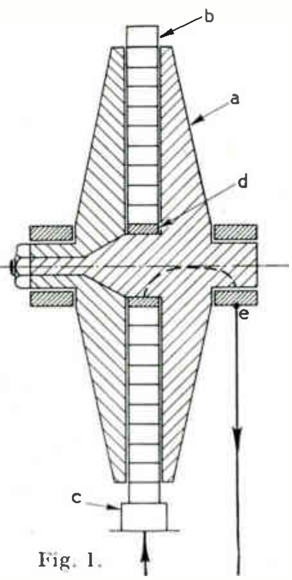



Fig. 1.

Our interest in this is due to the fact that we received a letter from Germany asking for our views on the question, how and where does the torque arise? Different answers had been given by physicists and electrical engineers who had been consulted. It is certainly an interesting question, but there need be no uncertainty about the answer.

Perhaps the most important point to grasp is the fact that a spiral current may be regarded as made up of two components, one circular and the other radial. One could picture the coil as shown in Fig. 2 where, after completing the first purely circular turn, there is a short radial step leading to the second circular turn, and so on. This would give a purely circular magnetizing winding together with a single radial conductor made up of all the short elements. This radial conductor, being situated in the magnetic field set up by the circular magnetizing winding, would experience a torque and would distort the field crossing the gap in its neighbourhood. If the winding is truly spiral, the radial component will be distributed over the whole winding and not concentrated in one radius. The two components could be pro-

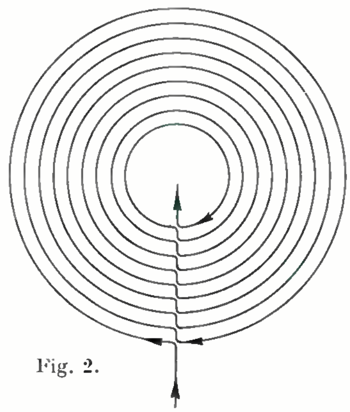


Fig. 2.



B

duced by two entirely separate windings; the circular magnetizing component by two spirals side by side, one right-handed and the other left-handed, connected at their inner ends but insulated from the iron. Their magnetizing effects would be additive but their radial components would cancel each other. The radial component could then be supplied by a metal disc, the current entering at the outer edge and flowing radially to the inner edge which is in contact with the iron core. This is shown in Fig. 3 in which, for the sake of symmetry, the current is supplied by means of copper tubes connected to the disc and to the bearing by means of another disc. In the left-hand iron cone the flux will be undistorted, but on passing through the disc it will be distorted by the radial current and will enter the right-hand cone at an angle, so that there is a circumferential tension in the field. This does not exert a force on the pole face, as many people imagine, but is transmitted along the flux to the central part of the core, which is carrying the current from the bottom of the disc to the bearing. The effect of this current is to take out of the flux the circumferential component given to it by the radial current in the disc, and the torque acting on the iron will be exactly equal and opposite to that

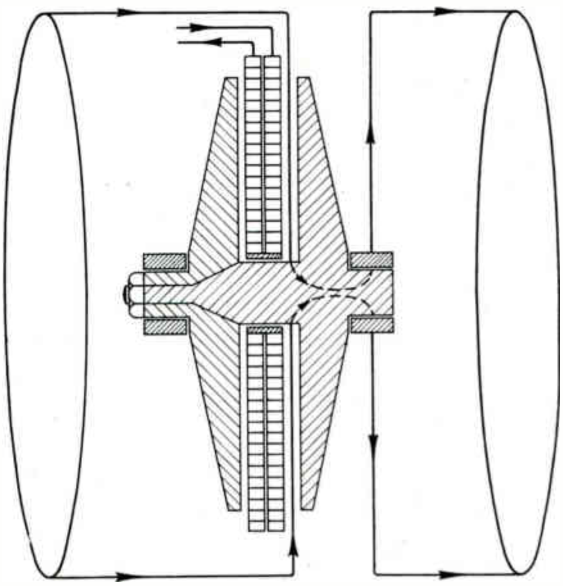


Fig. 3.

acting on the disc, so that it is here that the driving torque is operative. If the magnetizing spirals were inoperative, the currents in the discs and central co e would produce a circular magnetic field in the right-hand cone, and, when the spirals are operative, this field is compounded with the main field.

The location of the driving torque is perhaps more evident in the arrangement shown in Fig. 4, in which the current flows through radial copper wires or a disc embedded in the iron core, instead of flowing through the core itself, and is then taken away by an axial copper wire. The total current through the radial wires is the same as that through the spiral or disc and the total magnetic flux is the same in both cases, so that the two torques are equal and opposite. Hence, in the actual motor, the driving torque is exerted on the iron core carrying the current, and the reaction comes on the radial component of the fixed spiral winding. That the two torques are equal is easily proved in the case of the embedded disc. If the spiral or large disc has external and internal radii of $r_1$ and $r_2$ and if $x$ is any radius then the total torque on the large disc will be

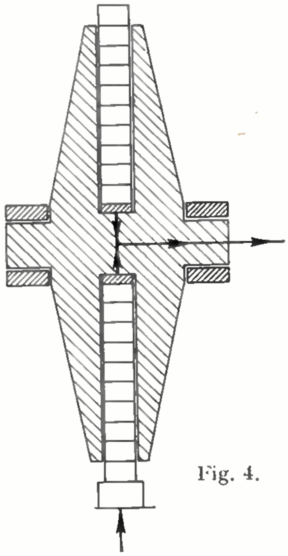


Fig. 4.

$$I\int_{r_2}^{r_1} B_x x dx = I\Phi/2\pi$$

since $\Phi = \int_{r_2}^{r_1} B_x 2\pi x dx.$

The flux density in the iron core may be assumed uniform and equal to $\Phi/\pi r_2^2$ and the torque on the embedded disc will be

$$IB\int_0^{r_2} x dx = I\frac{\Phi}{\pi r_2^2}\int_0^{r_2} x dx = I\Phi/2\pi.$$

Hence the torques on the two discs are equal and opposite. An interesting question arises if the pole face, instead of being plane, is made with radial grooves as shown in Fig. 5; one is tempted to say that the skewed magnetic flux entering the pole face must surely exert a torque on the sides of the grooves. Any bunching of the flux will not alter the fact that the torque on the spiral winding is still equal to $I\Phi/2\pi$ nor will it affect the driving torque exerted on the core or embedded disc. These two torques are still equal and opposite and therefore there cannot be any torque acting on the grooved iron, or more correctly, all the torques acting on it must give zero resultant. The explanation of this is shown roughly in Fig. 5(c) which represents two of the radial grooves and the intermediate tooth with the current-carrying disc.

The flux entering the face of the tooth is refracted but exerts no tangential force on the surface; the flux entering the side (ab) will exert an attractive force on the surface, but this will be counter-balanced by the force on the side (cd) due to the lateral pressure of the crowded flux and the catapult action at the corner (d). The action is complicated but there seems to be no escape from the conclusion that the resultant rotational force on the teeth and slots must be zero.

Going back to the rotor with a smooth polar surface, the point has been raised—also in a letter from Germany—that my statement that the magnetic flux is refracted on passing through the surface, without exerting any tangential force on the iron, assumes that the iron has no hysteresis. This is not correct; no such assumption is made. If the iron has hysteresis, so that a certain amount of permanent magnetism is imparted to it, this will be of the same value at all points of the circle, and there will be no tendency to vary the magnetic condition as the iron rotates. Consequently the hysteresis involves no expenditure of energy and therefore no tangential force. If the magnetic field at no point of the iron undergoes any change whatever either in magnitude or direction, then hysteresis can play no part in the rotation.

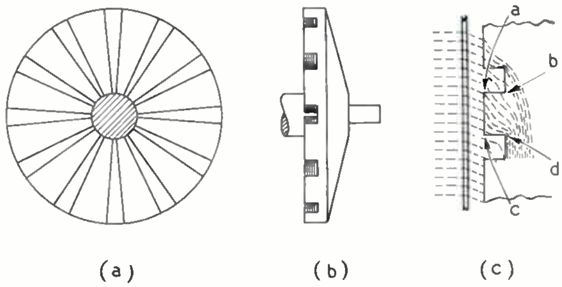



Fig. 5.

One can easily understand how this apparently simple type of motor may lead to much discussion, and show up weak points in one's grasp of electro-magnetic fundamentals.

G. W. O. H.

# CALCULATION OF SKY-WAVE FIELD STRENGTH

By K. Rawer

(*Service de Prévision Ionosphérique Militaire*, France*)

**SUMMARY.**—A method for the calculation of the field of the sky-wave, based upon the contributions of the different transmission paths, has been applied since 1940. It takes account of the effects of the lower ionospheric layers, such as absorption and cut-off, and of the geometrical optics of the reflecting layer. The trend of actual development in this field seems to be that former integral formulae are replaced by such differential methods.

## Introduction

WHILE the field of the ground-wave can be calculated with considerable accuracy, the field of the sky-wave has been calculated for a long while by rather inaccurate methods. During the last war (in the years 1940/41) the author introduced a new method of calculation, taking account of the most important details of ionospheric radio propagation, such as, geometrical optics, absorption and cut-off. Since then, this method has been developed and there are now a few publications on the subject (the first printed in 1943)[1,2], but hitherto none in English.

The starting point of our method is the idea that a sufficiently correct calculation is only possible if the *different paths* actually present in ionospheric propagation are considered *separately*. This differential method is based on a rather simple model of the ionosphere which seems to be sufficient for practical application. The occurrence of fading will not be considered here, because it is not of major importance in this case. There is no doubt that the problem of ionospheric propagation is a very complicated one, and a certain number of approximations must always be made if a calculation is not to become practically impossible. On the other hand integral methods, though they have been used frequently[3], cannot give a sufficiently correct description of the very different phenomena existing in sky-wave propagation of h.f. waves.

First let us introduce an appropriate notation. It is practical to use a reference field-strength on the transmitter side; viz., the field $E_0$ existing at a distance of 1 kilometre from the transmitting aerial.

Thus we avoid introducing unnecessary details like the transmitting power and details of the aerial. Normally, we assume an aerial having no

* Referred to as S.P.I.M.

MS. accepted by the Editor, February 1952

directivity, a perfectly-reflecting soil and equal partition of energy between the different polarizations in which we are interested. In most cases we shall consider only the ordinary ray of geomagnetic split, the extraordinary ray suffering more from absorption. We then have the formula

$$E_0 = 5470\sqrt{N}\ \mu\text{V/m} \quad .. \quad .. \quad .. \quad (1)$$

where $N$ is the radiated power in watts

We prefer a logarithmic form of this equation: $<E_0> = 74{\cdot}8 + 10 \log_{10} N$ in db above $1\mu$V/m. The brackets $<>$ will always indicate that the field in question is given in decibels above 1 microvolt per metre. The formulae in the following are written in the Giorgi-system (m, kg, s, A, V), but field strengths are in $\mu$V/m, frequencies in Mc/s and the distance $D$ in km.

At the receiver we may have a smaller field $E$. The total loss of field strength can be written in the decibel system:

$$\delta = 20 \log_{10} (E_0/E) = <E_0> - <E> \quad (2)$$

Since there are different effects causing a loss of energy, $\delta$ can be split up into several parts. The multiplication of weakening factors is replaced in our logarithmic system by a simple addition. We write:

$$\delta = \delta_1 + \delta_2 + \delta_3 + \delta_4 \quad .. \quad .. \quad .. \quad (3)$$

$\delta_1$ gives the influence of geometrical optics (rarefying of energy in an expanding bundle of rays); $\delta_2$ corresponds to the absorption loss caused by the D layer (non-selective absorption), $\delta_3$ to absorption loss occurring in the E layer (deviating or selective absorption), $\delta_4$ to losses occurring by partial reflection in the $E_S$-layer. We shall see that the first two terms are the most important; the third will be considered in connection with cut-off phenomena. We now proceed to a detailed calculation.

## 1. Weakening Effects for a Given Path

Let us consider a certain transmission path containing one or more hops reflected alternately by a reflecting ionospheric layer and the earth (Fig. 1), the number of hops being $p$.

### 1.1. *Geometrical Optics (Decrement $\delta_1$)*

The geometrical optics of ionospheric propagation are rather complicated, because the surface of the earth and the reflecting layers are curved in an opposite sense. The effect of the concave curvature of the layers is always more important than that of the convex curvature of the earth. This causes an increase of field strength[1] in comparison with the usually assumed law of variation with the inverse distance. On the other hand the path of the ray is extremely oblique, nearly grazing, so that a considerable astigmatism must be expected. We therefore consider a small bundle of rays [Fig. 2(a)], calculating separately the diameter $\Delta_H$ in the horizontal direction, and that $\Delta_V$ in a direction perpendicular to it. Assuming a parabolic, curved refracting layer[4] we finally found that[5]

$$\left.\begin{aligned} \frac{\Delta_V}{\Delta\beta} = \left(\frac{R}{R_0}\right)^2 \frac{Y_m}{q}\, .\, \sin^2\beta \Bigg\{ &(1-2\epsilon).\, \log_{10} \left|\frac{q' + \cos\alpha_0}{q' - \cos\alpha_0}\right| + \\ &+ 4\,\frac{\epsilon}{q}\,(2\cos\alpha_0 - \sec\alpha_0) - 2\,\frac{\sec\alpha_0 - \cos\alpha_0}{q'^2 - \cos^2\alpha_0}.\, q\left[1 - \epsilon\left(2 + \frac{1+\cos^2\alpha_0}{q^2}\right)\right]\Bigg\} \\ &+ 2\,\frac{R\sin\beta}{R_0\cos\alpha_0}.\left(R_0\cos\alpha_0 - R\sin\beta\right) \end{aligned}\right\} \quad .. \quad (4)$$

where $\epsilon = Y_m/R_0$; $q' = q - (\epsilon \sin^2\alpha_0)/q$, $R$ = radius of the earth, $H$ = height of the lower edge of the layer, $R_0 = R + H$, $Y_m$ = half-thickness of the parabolic layer, $q = f_c/f$, $f_c$ = critical frequency, $f$ = working frequency. This formula is for one hop only. With $p$ hops we have a $p$-fold enlargement of $\Delta_V$, but also a $p$-fold increase of the distance of transmission. The horizontal diameter is independent of refraction phenomena, corresponding to the simple geometry of Fig. 2(b).

$$\frac{\Delta_H}{\Delta\gamma} = \frac{R}{\cos\beta}.\, \sin\,(D/R) \quad .. \quad .. \quad .. \quad (5)$$

We finally calculate the cross-section of the bundle as $\Delta_V$. $\Delta_H$; this should be compared with the cross-section at a distance of 1 kilometre from the transmitter.

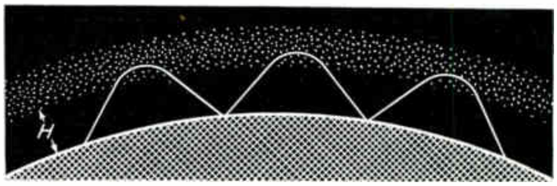



Fig. 1. *Example of a transmission path* ($3 \times F$).

Field strength is proportional to the square root of the inverse cross-section, consequently:

$$\delta_1 = 20 \log_{10} \sqrt{\frac{\Delta_H}{\Delta\gamma}.\frac{\Delta_V}{\Delta\beta}}$$

$$= 10\left(\log_{10}\frac{\Delta_H}{\Delta\gamma} + \log\frac{\Delta_V}{\Delta\beta}\right) \quad .. \quad .. \quad (6)$$

A detailed calculation has been made with these formulae, leading (for each value of $q$) to a curve like those of Fig. 3. There are three focusing effects, two of these originate from a zero-value of $\Delta_V$, namely: (a) at the skip-distance (in consequence of refraction phenomena[4]), (b) for the largest distance attainable with a certain mode of propagation; i.e., for $\beta = 0$ (this effect is caused by the curvature of the reflecting layer[1]). A third effect arises from $\Delta_H = 0$ for the antipodes. The second effect is the most important one, its influence being already important for $\beta \leqslant 10°$. The first effect cannot be considered in normal calculations because of the rapid variations of skip distance.

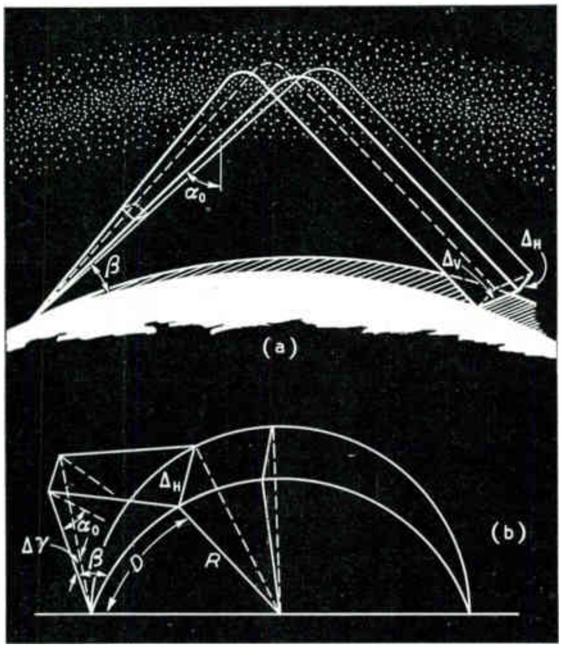
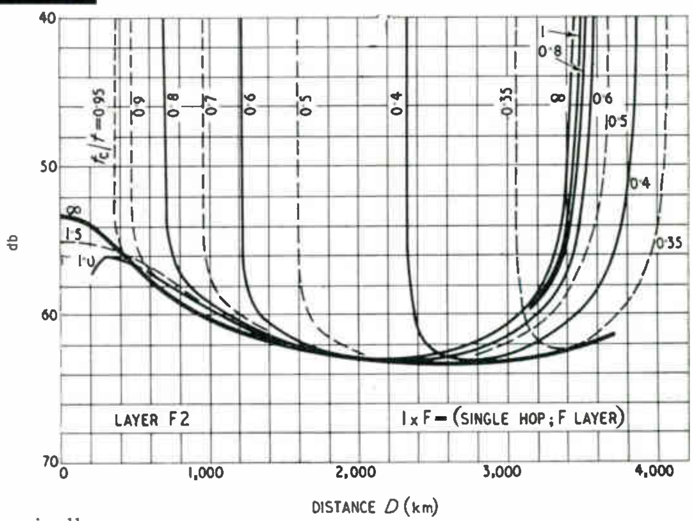



Fig. 2 (above). *Geometrical optics for a small bundle of rays.*

Fig. 3 (right). *Attenuation resulting from the variation of the quasi-vertical diameter $\Delta_V$ of the bundle. Parameter: ratio of critical to working frequency. Heavy curve: envelope, as used for prediction work.*




In order to eliminate such fluctuations, we are accustomed to use the envelope of the different curves calculated in Fig. 3 (thick curve); the corresponding field can be expected in any case. The third focusing effect (at the antipodes) is very sensitive to deformations of the reflecting layer, consequently it cannot be expected regularly. It has been practically eliminated in our service values[6] (Fig. 4). In the figures, 3 × E means three hops with reflection from the E layer.

For comparison, Fig. 4 also gives the curve for a decrease with the reciprocal distance and that used actually by the C.R.P.L.[7].* There is a considerable difference for large distances. We find that measured values of field strength and traffic experience cannot be compared with the very steep $1/D$ decrease. We know, for example, of intensity measurements of paths encircling the earth, which gave about a $1/D$ decrease of the *effective* field strength,[8] although these paths are subjected to a non-negligible absorption which must also be accounted for.

### 1.2. *Non-Selective Absorption in the D-Layer* ($\delta_2$)

Ionospheric absorption originates from collisions of oscillating electrons and molecules. Booker's detailed analysis[9] distinguished selective absorption, occurring at the same time as refraction, and non-selective absorption. In the second case considerable approximations can be applied, and this case concerns the D layer, where refraction phenomena are negligible (for h.f. waves at least). Furthermore, the quasi-longitudinal approximation of the dispersion formula is nearly always valid. Then the absorption coefficient

$$k = \frac{e^2/m}{2c\epsilon_0} \frac{\nu N}{\nu^2 + (\omega \pm \omega_L)^2}$$

$$= 1{\cdot}34 \times 10^{-13} \frac{\nu N}{(f \pm f_L)^2} \quad .. \quad .. \; (7)$$

where $\nu$ = number of collisions ($\nu \ll \omega$), $c$ = velocity of light, $e$ = charge, $m$ = mass of the electron, $\epsilon_0$ = dielectric constant of a vacuum,

* C.R.P.L. = Central Radio Propagation Laboratory (Bureau of Standards, Washington).

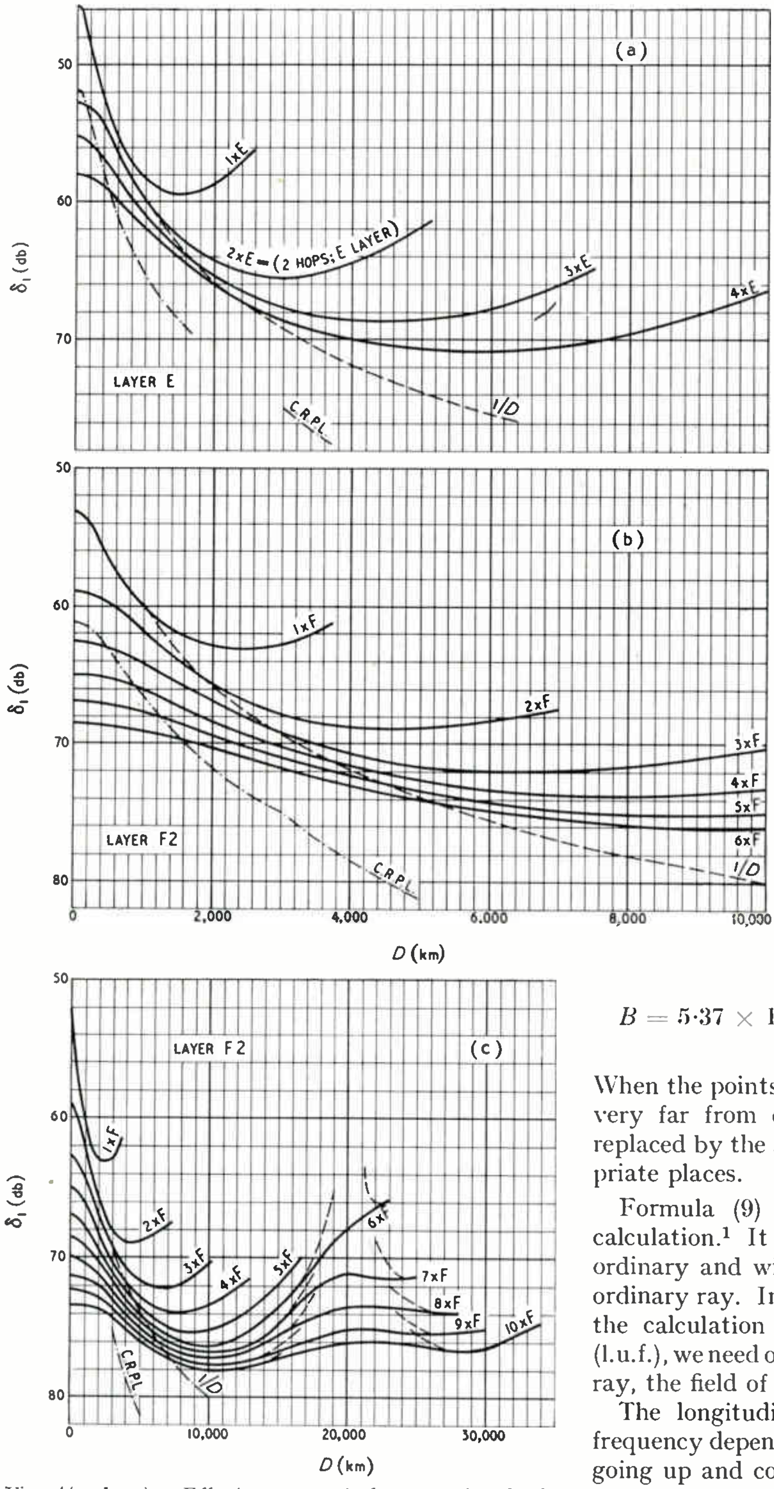



Fig. 4(a, b, c). *Effective geometrical attenuation $\delta_1$ for different transmission paths. (Faint broken lines are obtained when antipode focusing is admitted.) For comparison: C.R.P.L.-curves and 1/D curve.*

$N$ = electronic density, $\omega = 2\pi f$, $\omega_L = 2\pi f_L = B \cdot \cos\theta \cdot e/m$, $B$ = magnetic induction, $\theta$ = angle between the direction of propagation and the magnetic field of the earth and $f_L$ is the longitudinal component of the gyrofrequency. The double sign $\pm$ is for the ordinary and extraordinary ray. The total absorption follows by integration:

$$\delta_2 = 2p \int k(s).ds \text{ decibels}$$

The integration path follows the ray, penetrating $2p$ times into the D layer. It follows from symmetry that it is sufficient to consider only the first part of the path, up to the first point of reflection; the subsequent parts give equal contributions, represented in our formula by a factor $2p$. At the same time we replace $s$ by $z \cdot \sec \alpha_D$ (see Fig. 5):

$$\delta_2 = 20 \times 2p \times \sec \alpha_D . \int k(z)dz$$

With (7) we can write

$$\delta_2 = \frac{p.B \sec \alpha_D}{(f \pm f_L)^2} \quad .. \quad (9)$$

$$B = 5{\cdot}37 \times 10^{-12} \int_0^{z_{max}} \nu(z)N(z)dz \quad .. \quad (9a)$$

When the points of penetration of the D layer are very far from one another, the product $pB$ is replaced by the sum of the $B$ values at the appropriate places.

Formula (9) is the basis of our absorption calculation.[1] It holds with the upper sign for the ordinary and with the lower sign for the extraordinary ray. In most applications, especially for the calculation of the lowest usable frequency (l.u.f.), we need only take account of the ordinary ray, the field of which is much higher.

The longitudinal component $f_L$ of the gyrofrequency depends on the angle $\theta$, and is different going up and coming down. In our latitudes we can take an average value of 1·2 Mc/s. The geometrical conditions of the path have been examined with a model of parabolic reflecting layers (discriminating between E and F). We thus found[6] the values of sec $\alpha_D$ given in Fig. 6.

The characteristic data of the absorbing D layer are summarized by the value $B$, which can be obtained by ionospheric absorption measurements. The ionization of this layer is extremely small during the night, and in daytime there is a marked variation with the sun's zenith angle $\chi$.

$$B \approx \cos^m \chi \quad \ldots \quad (10)$$

Theoretical calculations of the exponent gave different results.[10,1] Experience seems to favour a value slightly below 1; we generally use 3/4. In any case, large fluctuations of short period (10 min.) are revealed by all observations, so that no exact law exists, but only a statistical one.

Unfortunately, absorption measurements are very rare and very few are performed at low latitudes. The only series over many years is that of the British station at Slough. By kindness of Sir Edward Appleton, the author has had the opportunity of examining these results[11] which give the following formula, valuable for monthly mean values:

$$B = 430\,(1 + 0{\cdot}0035\bar{R}\cdot)\cos^{3/4}\chi \quad \ldots \quad (11)$$

$\bar{R}$ is (one year's) sliding average of the sunspot number $R$. Variation with sunspot cycle is slightly less than supposed by the C.R.P.L.[7] In our latitudes (10) and (11) cannot be applied in winter as the absorption is then higher than the $\cos^{3/4}\chi$ law would indicate.

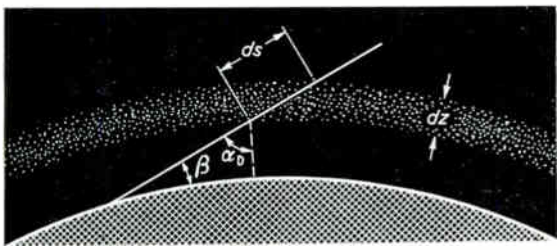



Fig. 5. *Penetration of the D-layer (definition of $\alpha_D$).*

### 1.3. *Other Influences diminishing the Field of the Sky-Wave*

Rarefaction of energy and absorption in the D layer are the principal ways in which the field is weakened in ionospheric propagation. There are still some other factors of less importance. Selective absorption exists in layer E. Frequencies near the m.u.f.-E (maximum usable frequency, reflected from the E layer) suffer an extra absorption, growing rapidly with approximation to m.u.f.-E.

Under these conditions the propagation approximately follows the quasi-traverse formulae. For the ordinary ray we find, following Booker[9] (always $\nu \ll \omega$; $\mu$ = refraction index):

$$k = \frac{e^2/m}{2c\epsilon_0}\cdot\frac{1}{\mu}\cdot\frac{\nu N}{\nu^2+\omega^2} = 1{\cdot}34 \times 10^{-13}\cdot\frac{1}{\mu}\cdot\frac{\nu N}{f^2} \quad (12)$$

The corresponding formula for the extraordinary ray is more complicated, but it is of no interest here, because this ray, suffering more from blanketing and from absorption, only gives a very small contribution to the resulting field.

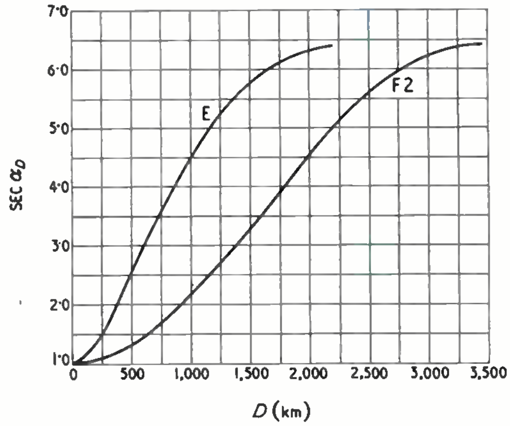



Fig. 6. *Factor of obliquity sec $\alpha_D$ for rays reflected from the E and $F_2$ layers. (Altitude of the D-layer: 80 km; layers E and $F_2$ are represented by parabolic models with the lower edge at 100 km and 240 km, the upper at 150 km and 432 km respectively.*

It is the factor $1/\mu$, which introduces selective absorption; everywhere $\mu$ is small. Since attenuation is also proportional to $\int \mu^{-1}dz$, the decrement of selective absorption $\delta_3$ is directly proportional to the attenuation, which is caused by refraction in the E layer. We shall account for this effect, when considering the blanketing phenomena (2.1).

The corresponding effect exists also in the $F_2$ layer, but it is noticeable only at night, because it is too small, compared with daytime D absorption. The reason for this is the very low value of the number of collisions in the F layer (in spite of its greater thickness).

While the E and F layers are homogeneous, the ionization of the $E_S$ layer exists in the form of thin ionic 'clouds', the structure of which is somewhat like that of the 'cumulo-cirrus' type, well known in meteorology. A layer of this type produces a partial reflection, which should also be taken into account. Actually this has not yet been done exactly in our calculations, because we are just collecting sufficient data, using a special technique of observation.[12] On the other hand, it is not a loss of energy which originates directly from this effect, but rather another distribution between different paths. We shall show in the next paragraph, that, in daytime, the final result is a loss, because the energy reflected obliquely from $E_S$

suffers more from D absorption. We actually consider this effect by using sporadic-E data for the calculation of blanketing,[13] whenever this effect is important; i.e., in summer. One might think that energy is also lost when reflection occurs at the surface of the earth in the case of a multiple reflected path. Actually this effect does nct seem to be very important, because the reflection coefficient at glancing incidence is always very nearly unity. In any case it is negligible for oversea transmission. We have just mentioned the relative high field observed for paths encircling the earth; this fact indicates that earth reflection losses are not important. It would be interesting to note whether such an effect exists for paths having an earth reflection point in a dry desert, like the Sahara.

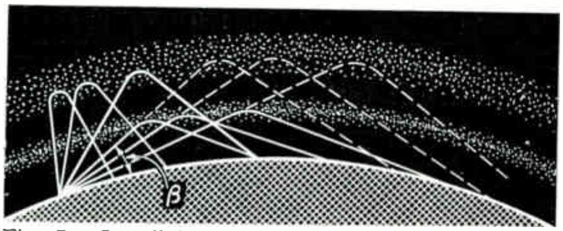



Fig. 7. *Cut-off in consequence of the existence of the E-layer.*

## 2. Selection of the Different Paths

We have just examined the different phenomena which affect the field obtained with a single given path. Now there are some other conditions for the existence of a path, originating from skip phenomena. Before we can proceed to compose different paths we should first discuss these conditions.

### 2.1. *Blanketing Phenomena (Cut-Off)*

These can only arise for a path reflected from the upper of the two reflecting layers, namely from F. If a lower layer like E exists (distance and frequency being given), the propagation by means of an F reflection may be cut off if reflection occurs in the E layer. We thus obtain a limiting low frequency, because higher frequencies more easily penetrate the E layer. For a given frequency $f$, cut-off exists above a certain distance, which is given by its angle of departure $\beta$ (Fig. 7). The limiting condition of cut-off is that E reflection does not take place; i.e.,

$$f \geqslant \sec \alpha_E \, . fE = fA \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

($fE$ critical frequency of the E layer, $\alpha_E$ the angle of incidence at this layer). $fA$ as defined by (13) is the limiting frequency of cut-off. The 'cut-off factor' $\sec \alpha_E$ can be derived from the geometry of reflected rays. We shall not enter into the details here, because these will be treated in another publication.[13] We shall only give some generalities.

D-absorption [see equ. (9)] increases with the number of hops $p$ and with the angle of penetration $\alpha_D$. The influence of $p$ is more important, and the flattest path, which has the smallest value of $p$, has always the lowest absorption, but cut-off just prevents the use of these paths, leaving only the steeper ones. Thus the influence of cut-off is unprofitable, because it renders impossible the more favourable flat paths reflected by the F layer. If the distance is great, paths reflected by the E layer must penetrate the D layer many times, where they suffer much from absorption. Consequently transmission is taken over, when cut-off exists, by steeper paths reflected a greater number of times by the F layer. These too suffer more from absorption than those which are cut off.

If the transmitting station is faint, cut-off of the flattest possible path may yet be decisive for the l.u.f. (lowest-usable frequency), since other paths suffer too much from absorption. But if the transmitter is powerful, steeper paths will replace those which have been eliminated by cut-off. There the l.u.f. is reached with a low angle of departure if the power is small, but with a higher angle if it is large.

Recently other prediction services than ours have also begun to take account of the cut-off effect. This has been done since 1948 by the C.R.P.L.,[7] but only for medium distances (see Section 4). At the same time the Australian Ionospheric Prediction Service has begun to base its calculation of the l.u.f. merely upon cut-off.[14] Its method of calculation essentially consists in prescribing a minimum angle of departure of about 10°, which is assumed to exist for the l.u.f. The condition (13) is applied for this angle (corresponding to a transmission distance of 1000 km reached by E-reflection). This method can only be regarded as a first approximation; it is probably valuable in some way for a certain power.

### 2.2. *Survey of Propagation Possibilities*

Having examined separately the propagation of the different paths, we can now proceed to arrange them in order to give a complete description of propagation possibilities. Here we must take account of the skip phenomena limiting the usable range at high frequencies.

The maximum usable frequency (m.u.f.) is obtained from ionospheric records by means of the ingenious method of N. Smith.[15] Of course, the m.u.f. is different for different paths, for example $1 \times F$ and $2 \times F$ reflection. With increasing number of reflections (or with decreasing distance), the m.u.f. decreases. We may best characterize the different influences in sky-wave propagation by an example, showing clearly the frequency ranges where the different paths exist. We start with a normal ionospheric record, like that of

Fig. 8, showing reflection height versus frequency. First we consider only the first echo received above the direct signal. We distinguish the trace of echoes coming from the E layer on frequencies below 3·3 Mc/s and with a height of about 110 kilometres. For frequencies higher than 3·4 Mc/s, however, we obtain echoes from the $F_2$ layer with

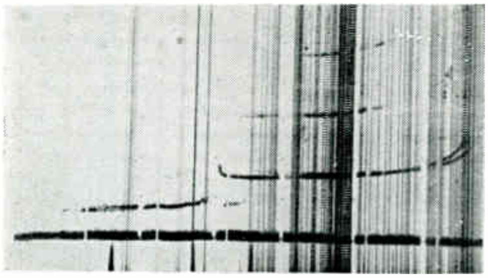


Fig. 8. *Example of an ionospheric echo record (type: winter day), obtained at Freiberg on 24th January 1950 (11 h. local mean time).*

virtual heights of 220 kilometres and more. There is a retardation effect at both sides of the transition frequency $f$A and echoes are fainter here, in consequence of selective E absorption. At higher frequencies the $F_2$ echo splits up into the two magneto-ionic components. The critical frequency of the ordinary ray $f_0F_2$ (11·8 Mc/s) is about 0·6 Mc/s lower than that of the extraordinary ray $f_xF_2$. No echoes at all occur on higher frequencies. Above these echoes, we may realize others which are multiples, reflected two and even three times between the ionosphere and the earth. Of course, at vertical incidence these multiple echoes show the same critical frequency as the first echo does. But in the case of oblique incidence this is no longer true. Because multiples are less oblique than simple echoes, their critical frequency is considerably lower, if the distance is great.

Applying the method of N. Smith[15] (see Fig. 9) the record of Fig 8 has been transformed for a distance of 2000 kilometres. The result is shown in Fig. 10(a), in so far as the first echo is concerned. Here only the geometrical transformation has been performed, without regarding absorption influences* (the E trace of Fig. 9 has, therefore, been extrapolated towards low frequencies and the transition-cusp at 3·3 Mc/s towards great heights). Doubling of the echo trace occurs near the critical frequency. The upper trace corresponds to the so-called 'Pedersen ray', which has a considerable retardation. On the other side the critical frequency of the E layer, is increased considerably more by the Smith-transformation, than the frequency of cut-off. Therefore, we now find three successive echoes in the frequency range 6 to 14 Mc/s; the first trace belongs to normal E reflection; the second is the Pedersen ray of the E transmission; the third is the F reflection. Up to 11 Mc/s this third trace is also retarded in consequence of its double transition through the E layer.

Let us now consider the intensity of these transmission traces. First the geometrical optics of the Pedersen rays is very unsuitable, as Foersterling and Lussen have proved[4] long ago. The retarded part of the F echo also suffers from a rarefying of energy because the corresponding bundles of rays expand rapidly, as recently proved.† On the other hand the selective absorption occurring in the E layer is very large for these rays, which are retarded by the same layer. Finally we must take account of D absorption, which increases slowly with decreasing frequency. In consequence of all these attenuations, we obtain Fig. 10(b) instead of 10(a). The retarded rays have almost disappeared and the low-frequency part of the E reflection is destroyed by D absorption.

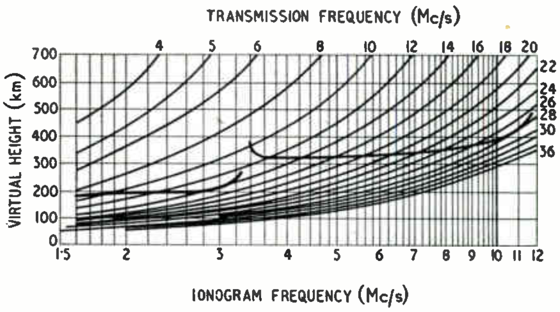



Fig. 9. *Application of Smith's method for the transformation of virtual reflection height with distance. The record Fig. 8 was plotted into the system of transmission curves for 2,000 kilometres. Correction for curvature of the earth was applied by a corresponding shift of the record curve. Intersection with transmission curves gives the virtual reflection height.*

Finally, we must admit the same transformations for multiple echoes. We thus arrive at Fig. 10(c) showing traces of 1 × E, 2 × E, 1 × F, 2 × F, 3 × F. For each of these paths transmission is realized in another frequency range. The highest m.u.f. is that of 1 × F, reaching 28·5 Mc/s. The corresponding l.u.f. is only 10·5 Mc/s, while the paths 1 × E and 2 × F reach 8·2 Mc/s and 7·7 Mc/s respectively. The path 2 × E suffers much from D absorption; higher E multiples are completely absorbed. Absorption also greatly diminishes the range of 4 × F.

Summarizing these considerations, we realize that all possible transmission paths must be considered. The resulting transmission is a mosaic made up of the contributions of the

* Fig. 10 refers only to the ordinary rays. We have neglected extraordinary rays, because the figures would become too complicated. Our calculation method takes account of these rays, but they are practically only important for the m.u.f.

† This point will be explained in detail in a following publication[13] There exists also a restriction for 'Pedersen rays' introduced by wave optics.[16]

different paths. Generally, it is necessary to consider the five paths just mentioned for transmission distances up to 3000 kilometres. In most cases the m.u.f. of all paths is given by that of $1 \times F$, but there are rare cases (for distances of about 1500 to 2000 kilometres), where the E layer gives a higher value. These conditions frequently exist, when sporadic E occurs. On the other side the l.u.f. is often given by $2 \times F$ or $3 \times F$, especially if the power of the transmitter is high.

The influence of power is such that the effect of D absorpti n increases with decreasing power. Therefore, higher multiples disappear by absorption if the power is low. With a faint transmitter we may realize only the $1 \times F$ path. Therefore, the l.u.f. depends considerably on the transmitted power, while the m.u.f. is nearly independent of it (apart from contributions of sporadic E, for which partial reflection exists).

$\delta_1$ is given by (6) (see Fig. 4) and $\delta_2$ by (9); $\delta_3$ has a strong relation to cut-off (accuracy will be given in a further publication[13]).

In order to obtain the effective field, we must combine the contributions of the different paths (index $l$) arriving at the receiver. All these waves have been influenced by ionospheric refraction, resulting in a distortion of polarization and phase. In consequence of very small ionospheric changes, which always exist, the polarization and the phase at the receiver vary rapidly. Most aerials are only sensible to a certain linear polarization; in the case of an arbitrary polarization, only the component parallel to the aerial is effective. Without restriction, we can consider a linear polarization, having an instantaneous angle $\Phi_l$ with the aerial (an arbitrary polarization is decomposed into two linear oscillations). The phase of the wave $l$ is given by an angle $\phi_l$. As $\Phi_l$ and $\phi_l$ always vary, all values have equal probability. The amplitude of the wave is largely influenced by propagation conditions. There is also the polar diagram of the transmitting aerial (the corresponding one of the receiving aerial must be considered in connection with the input to the receiver). We may assume that the effects of all these influences (but not that of polarization) are contained in the amplitude $E_l$. The resulting field $E_r$, effective for reception, is obtained by complex addition ($j = \sqrt{-1}$):

$$E_r = \sum_l E_l \cdot \cos \Phi_l \,.\, \exp (j\phi_l) \quad \ldots \quad \ldots \quad (15)$$

$$\left|E_r\right|^2 = \left\{\sum_l E_l \cos \Phi_l \cos \phi_l\right\}^2 + \left\{\sum_l E_l \cos \Phi_l \sin \phi_l\right\}^2$$

This expression can easily be transformed into

$$\left|E_r\right|^2 = \sum_l E_l^2 \cdot \cos^2\Phi_l + \sum_l \sum_i E_r E_l \cos \Phi_i \cos\Phi_l \cdot \cos (\phi_i - \phi_l)$$

(in the double sum $l \pm i$).

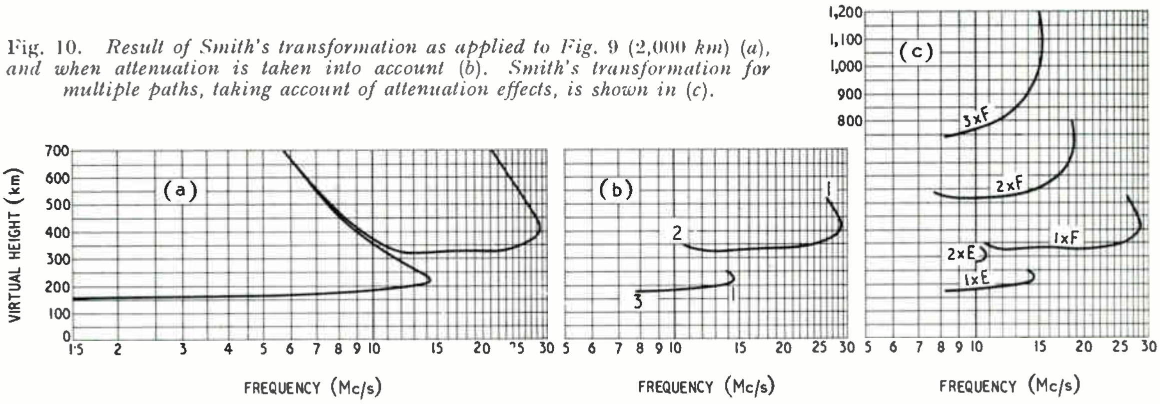



Fig. 10. *Result of Smith's transformation as applied to Fig. 9 (2,000 km) (a), and when attenuation is taken into account (b). Smith's transformation for multiple paths, taking account of attenuation effects, is shown in (c).*

Finally, from Fig. 10(c) we can easily learn something about the angles under which the different paths are received. Approximately, this angle increases with the heights indicated in Fig. 10(c). For mean distances there are rather different angles. This is no longer true for distances exceeding 3000 kilometres. Here E echoes are no longer important, so that the variation of the transmission conditions with frequency is more regular. The angle increases with decreasing frequency, because the l.u.f. is reached with a higher multiple than the m.u.f. (in consequence of cut-off phenomena). It has been proved experimentally that this variation exists; conditions vary with the solar cycle as the critical frequency does.[17]

## 3. Resulting Field and Lowest Usable Frequency

### 3.1. *Resulting Field*

For a given mode of propagation the average field can be obtained from the formulae (1) and (3), from which we obtain:

$$<E> = <E_0> - \sum \delta_i \quad \ldots \quad \ldots \quad (14)$$

With regard to the fact that all values of $\Phi$ and $\phi$ have equal probability and that they are independent of each other, we can obtain an average value representing a period, which is not too small (some minutes). Averaging first over the phase $\phi$, the second term on the right-hand side will disappear, because

$$\overline{\cos(\phi_i - \phi_l)} = \frac{1}{2\pi}\int_{o}^{2\pi} \cos u \cdot du = 0$$

Averaging now over the polarization $\Phi$, we have

$$\overline{\cos^2 \Phi_l} = \frac{1}{2\pi}\int_{o}^{2\pi} \cos^2 u \cdot du = \tfrac{1}{2}$$

and finally,

$$\overline{\left| E_r \right|^2} = \tfrac{1}{2} \sum_l E_l^2$$

We therefore may define as the average value of the resulting field strength:

$$\tilde{E}_r = \frac{1}{\sqrt{2}} \cdot \sqrt{\sum_l E_l^2} \quad \ldots \quad \ldots \quad (16)$$

In the special case, when the $m$ amplitudes $E_l$ were equal, we should have:

$$\tilde{E}_r = \sqrt{\frac{m}{2}} \cdot E_l$$

In consequence of geometrical addition, the important contributions are only those which are approximately equal to the strongest component. If, for example, the field of a second component is three times smaller, the resulting field increases by 5% only. Consequently in most cases one contribution is by far the most important and the others may be neglected. This is nearly always true in daytime, when absorption and cut-off differentiate the conditions of propagation for the different paths. At night, these influences are not effective and we often have nearly equal contributions.

Of course, interference fading is more important with nearly equal contributions. For some applications the effect of fading is so disturbing that the increase of field strength, introduced by a second mode of propagation, cannot balance this negative influence. Therefore, restrictions must be made for the use of the resulting field $\tilde{E}_r$, which does not always give a correct impression of the real conditions of transmission.

### 3.2. *Calculation of the l.u.f. in Daytime*

By these methods we can estimate the resulting field in the case of Fig. 10(c). Though for the path 1 × F the maximum of field strength should exist at a frequency near the m.u.f., the maximum of the effective field is perhaps received on a lower frequency, if the contribution of multiple reflections is important. Towards lower frequencies the resulting field decreases. 2 × F, 3 × F and 1 × E co-exist over a large range but finally only 2 × F remains. In this special case the effective l.u.f. (for all possible transmission paths) is identical with that of the path 2 × F.

Generally, it is sufficient to determine the l.u.f. for all possible paths and to select the *lowest* of these values. But restrictions must be made for paths reflected from the F layer, because of cut-off phenomena. [For the moment, we shall replace the sliding influence of selective E absorption ($\delta_3$) by a sharp cut-off,[13] according to (13)]. The l.u.f. of a path reflected from the F layer can originate either from cut-off or from absorption. Therefore both limits must be calculated; the *upper* of them determines the l.u.f. of a path with F reflection. For E reflection only the absorption limit exists.

The lowest usable frequency as determined by absorption can be calculated from (14):

$$<E> = <E_0> - \delta_1 - \delta_2$$

In this equation only $\delta_2$ varies with frequency (in a decreasing sense). If the minimum field necessary for reception, $E_{min}$ is known, we may reverse this equation, in order to obtain the frequency corresponding to $E_{min}$. On frequencies lower than this value, we should only obtain an insufficient field. We assume that $E_{min}$ is practically independent of frequency in daytime because then the level of atmospherics is very low. In accordance with the definitions of the Atlantic City Conference,[18] we adopt a fixed minimum value (e.g., 1 microvolt/metre for telegraphy). This is suitable in any case, because for most stations, especially mobile ones, man-made interference is not quite negligible and the gain of the receiver is also limited.*

With a constant $E_{min}$ we can solve (14), considering (9); thus we have for the lowest usable frequency (where the field is just $E_{min}$):

$$\text{l.u.f.} = \{pB \sec \alpha_D / (<E_0> - <E_{min}> - \delta_1)\}^{\frac{1}{2}} - f_L \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

If the distance exceeds 3000 km, the sun's position is no longer constant along the transmission path. We then replace $pB$ by summing up the contributions of the different penetration points. Thus we obtain [with the numerical values of equ. (11)]:

$$\text{l.u.f.} = \left\{ \frac{215(1 + 0{\cdot}0035\bar{R}) \cdot \sec \alpha_D \cdot \sum_{q=1}^{2p} \cos^{\frac{3}{4}} \cdot \chi_q}{<E_0> - <E_{min}> - \delta_1} \right\}^{\frac{1}{2}} - f_L \quad \ldots \quad (18)$$

* This practice is different from that recently adopted by the C.R.P.L.,- whose $E_{min}$ is based night and day on the variable level of atmospherics only.

In so far as absorption determines the l.u.f., it can be calculated for each path with (17) and (18) respectively. The limit introduced by cut-off is approximately given by (13). With a double selection, as above indicated, we finally deduce (from the data of all possible paths) the effective lowest value†.

The figures in all of the above quoted absorption formulae have been deduced from British observations.* As they are median values, they can be suitably used for an estimation of the average field to be expected. But for practical application the fluctuation of absorption as well as of cut-off is rather important.

So far no precise ionospheric basic values can be predicted for a single day, but it is possible to predict (with the aid of former ionospheric observations) the median values of a month and their range of fluctuation. In practice, we do not use median values, but we calculate the l.u.f. twice. First such 'cautious' basic values are chosen (for a given month) that they are only exceeded by the three 'worst days' (with respect to absorption or cut-off); consequently the l.u.f., thus obtained, has a probability of 90%. Then calculation is made with 30% only, using less cautious basic values. In addition, we adopt the same practice for the maximum usable frequency (m.u.f.). In a diagram of frequency versus time of day we thus obtain regions with graduated probability of transmission. These diagrams are first established for the most interesting path, then they are combined, in order to give the probability of transmission by any path at all. When independent probabilities are combined, the probability values of the different paths ($u$, $v$) must be added according to the formula for the resulting probability:

$$U = u + v - uv \qquad \ldots \qquad (19)$$

The whole procedure is illustrated by Fig. 11.

### 3.3. *Calculation of the l.u.f. at Night*

With sunset, the normal layers E and D disappear rapidly. The remaining sporadic ionization seems to be so concentrated in a very thin layer that considerable absorption does not exist. Therefore, the field strength is much higher at night than in the daytime. On the other hand (and in consequence of improved propagation conditions) the atmospheric noise is also much more intense at night.

For the moment we use a method of calculation which neglects absorption, but takes account of the systematic variation of the intensity of atmospherics, with frequency on one hand and propagation conditions on the other. The procedure is essentially that of the preceding paragraph except that $E_{min}$ is now the only term that varies with the frequency ($\delta_2 = 0$). Summarizing American estimations,[20] we have established the following expression for $E_{min}$ as determined by atmospherics (for telegraphy)

$$\langle E_{min} \rangle = 7{\cdot}5 + 6{\cdot}5k - 20 \log_{10} f_m \qquad (20)$$

† Recently a Hollerith method for both calculation and selection has been established by Gallet.[19]

* It is possible that these figures are somewhat too high; we now find slightly lower values at Freiburg.

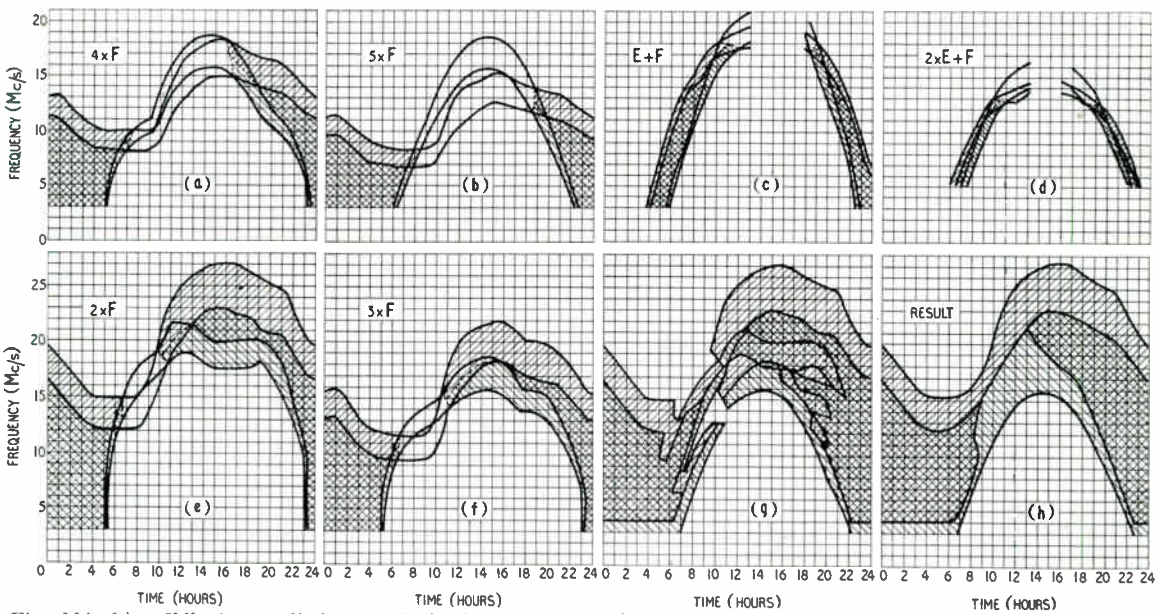



Fig. 11(a–h). *Effective prediction as obtained with graphs (a)–(f), for different paths; (g), combination of (a)–(f); (h) final prediction graph taking account of the combination of probability values.*

($k$ depends on the zone and varies between 0·5 and 5; $f_m$ = frequency in Mc/s).* Introducing this in (14) we solve for the frequency and obtain:

$$\log_{10}(\mathrm{l.u.f}_m.) = \{\delta_1 - \langle E_0 \rangle + 7{\cdot}5 + 6{\cdot}5k\}/20 \quad .. \quad (21)$$

in which l.u.f$_m$. is in Mc/s.

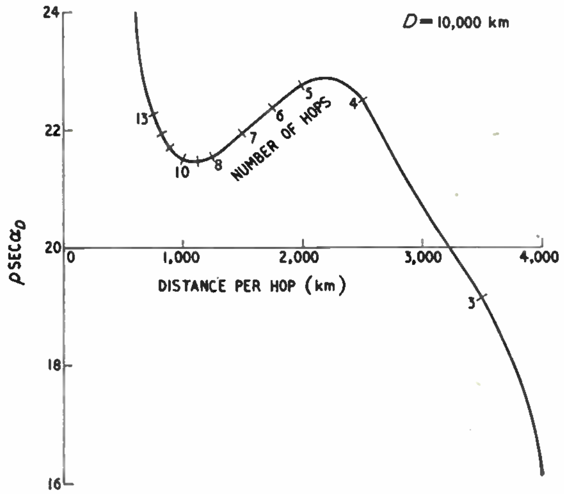



Fig. 12. *Variation of $p$ sec $\alpha_D$. Parameter; number of hops reflected from the $F_2$-layer.*

But our formula (20) is only valid for frequencies at which the atmospherics are received without a skip-zone; that is, for rather low frequencies. On higher frequencies, having an important skip zone, the atmospherics are less intense than indicated by (20), because all parasites originating in the skip-zone are not received. We therefore have calculated a correction which always reduces the l.u.f. when the skip-zone is important. This correction, based on *actual* m.u.f. values, varies with the hour.† Details of this calculation will be published elsewhere.

This method should be considered as a provisional one. A slight loss of energy must take place, when reflection occurs at the earth, as well as at the $F_2$ layer. Perhaps these losses, though unimportant in the daytime, must be taken into account at night. Besides, the practical question whether a frequency is usable at night depends very much on the distribution of emissions with frequency; it is not only a question of propagation.

## 4. Comparison with the New C.R.P.L. Method

During the last war, two methods were developed for the calculation of the field strength, which are generally known as the Anglo-American and the German methods. We have just described the method of S.P.I.M., which is a further development of the latter, essentially the same fundamentally. At that time the C.R.P.L. used a method which did not discriminate between the different paths. After the war, it was announced by the C.R.P.L. that the matter was being taken up again. The result was published in 1948.[7] The new method distinguishes long, medium, and short distances. For long distances the war-method is left unchanged, while for medium distances (400-3200 kilometres) a new method, including discrimination of different paths, has been introduced, which is in rather good accordance with our method. While we prefer formulae, the C.R.P.L. frequently uses graphs. For comparison, we have transformed some of them into formulae. In this section we only discuss the calculation of field strength. The difference existing in the calculation of l.u.f. with regard to $E_{min}$ has been mentioned above.

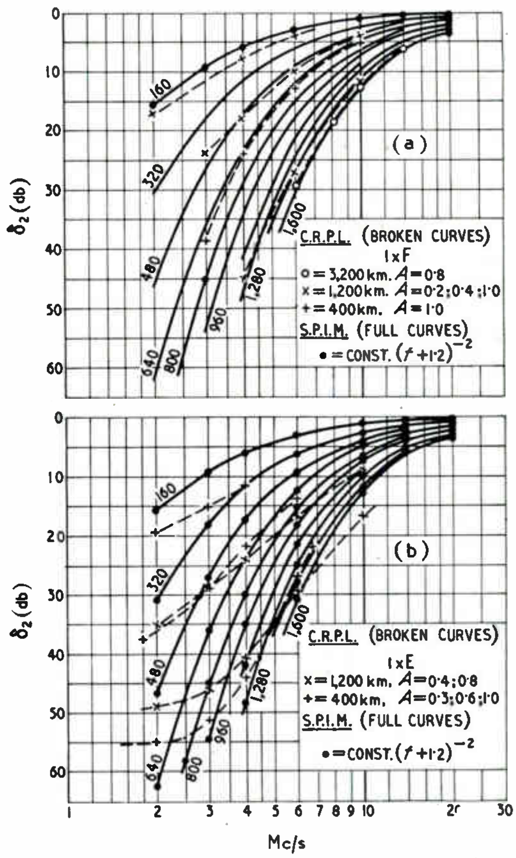



Fig. 13. *Variation with frequency of absorption decrement. The system of faint lines corresponds to our formula; heavy broken lines were obtained with medium distance graphs of the C.R.P.L.*[7]. (a) *for one hop $F_2$ propagation fits well with our lines;* (b) *for one hop E propagation fits less well.*

* Perhaps the numerical values should be somewhat changed according to the results of measurements of the British D.S.I.R. (Thomas method).

† The method of comparing the field with the atmospheric noise level has been introduced by the C.R.P.L.[7]; our method differs from it (1) in assuming a rather uniform variation of this level [see (20)], and (2) in introducing on the other hand the influences of the *actual* m.u.f. values. In other words, we prefer to separate the influence of sources and of propagation conditions, both existing in atmospheric noise; the latter influence must be the same for noise and reception.

### 4.1. *Long Distances*

For distances $D$ above 3200 kilometres the graph of the C.R.P.L. corresponds to the formula

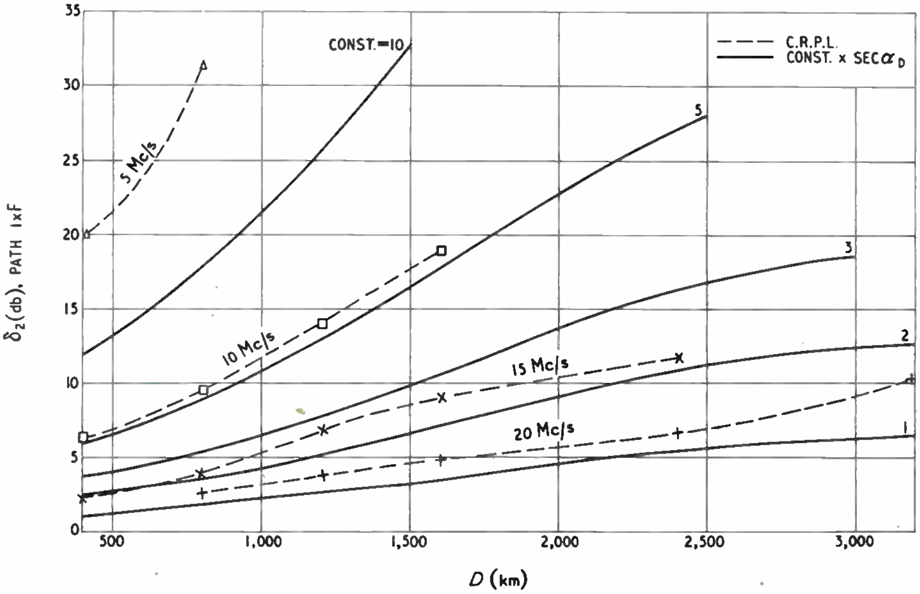
$$\delta_2{}^* = 0{\cdot}512 \cdot A \cdot D \cdot f_m{}^{-1.92} \quad \ldots \quad (22)$$

The term $A$, indicating solar activity, contains three contributions with regard to the solar cycle ($Q$), the season ($I$) and the actual altitude $\chi$ of the sun ($K$):

$$A = QI\bar{K} \quad \ldots \quad (22a)$$

with $Q = 1 + 0{\cdot}005\bar{R}$ ($\bar{R}$ monthly number of sunspots), $I$ a correction for winter months ($1 \leqslant I \leqslant 1{\cdot}3$) and $\bar{K}$ the average value, taken over the whole distance, of

$$K = 0{\cdot}142 + 0{\cdot}858 \cos \chi \quad \ldots \quad (22b)$$




This variation of absorption with $\chi$ is rather similar to ours, namely $\cos^{\frac{1}{2}}\chi$. The constant $0{\cdot}142$ has the effect of extending the absorption influence till the sun is $9{\cdot}5°$ below the horizon. Also the seasonal influence $I$ is not very different from ours. Only for the variation with the solar cycle we have found a somewhat lower value ($0{\cdot}0035$ instead of $0{\cdot}005$), based on the British observations. The variation with frequency is somewhat less important than ours [see (9)] but it must be borne in mind that the variation of the total field is a different thing from that of the field corresponding to a single path (see Sections 2.2 and 3.1).

In the mentioned publication of the C.R.P.L.[7] further use of former formulae is made with the statement that the effect of the number of hops nearly counteracts the contrary effect of inclination for long distances, such that the absorption limit is not essentially different for different paths. We have checked this assertion with our own values of $\sec \alpha_D$ (as calculated with a parabolic layer) and find it justified because $p \sec\alpha_D$ is nearly constant (see for example Fig. 12 with $D = 10\,000$ kilometres). There is one exception, namely for a rather grazing path ($3 \times$ F in

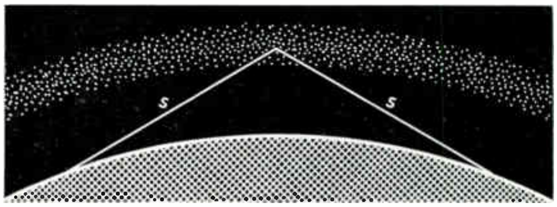



Fig. 15 (above). $s$ = *half length of path.*

Fig. 14 (left). *Variation with distance of absorption decrement. The faint lines are const. sec $\alpha_D$ (see Fig. 7), corresponding to our formula; heavy broken lines were obtained with the graphs of C.R.P.L.[7]), for one hop $F_2$ propagation (different frequencies).*

Fig. 16 (below). *Variation of absorption with frequency for small distances (see Fig. 13).*

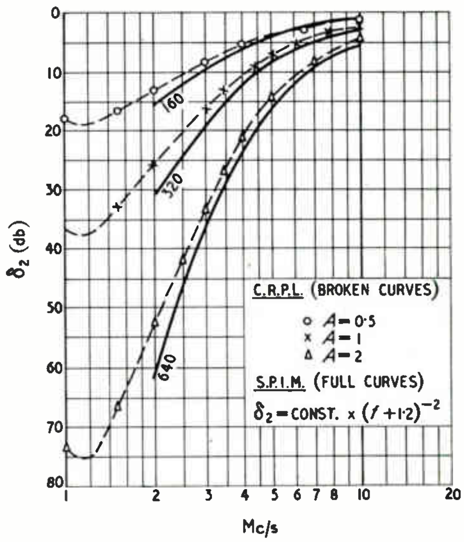


Fig. 12). This exception is important for the field obtained with higher frequencies (and consequently for the l.u.f. in the case of a faint transmitter). If we adopt our values of $p \sec \alpha_D$ (Fig. 12) we find with our formulae (9) and (11) approximately the same decrement of absorption for the most favourable mode of propagation, as results from the C.R.P.L. formula (22).

On the other hand, there is a serious difference between the two methods of determining the influence of geometrical optics ($\delta_1$). While we assume a higher field strength, compared with a $D^{-1}$ law, due to focusing by the curved ionosphere, the C.R.P.L. assumes a lower one, using a law with about $D^{-1\cdot4}$ (see Fig. 4):

$$\delta_1{}^* = 28{\cdot}2 \log_{10} D - 23 \text{ decibels} \quad .. \quad (23)$$

where $D$ is in kilometres. In consequence of this assumption the field as calculated by C.R.P.L. methods is always somewhat lower than our method indicates.

### 4.2. *Medium Distances*

For $400 \leqslant D \leqslant 3200$ kilometres, the new method of the C.R.P.L.[7] considers separately the paths 1 × E, 2 × E, 1 × F and 2 × F (while we think that 3 × F must also be considered, if $D \geqslant 1500$ kilometres). For the paths reflected from the F layer the influence of cut-off has also now been introduced , using normal E data and assuming a specular F reflection from a fixed altitude.

The influence of absorption is given by a series of graphs, which cannot be represented by a

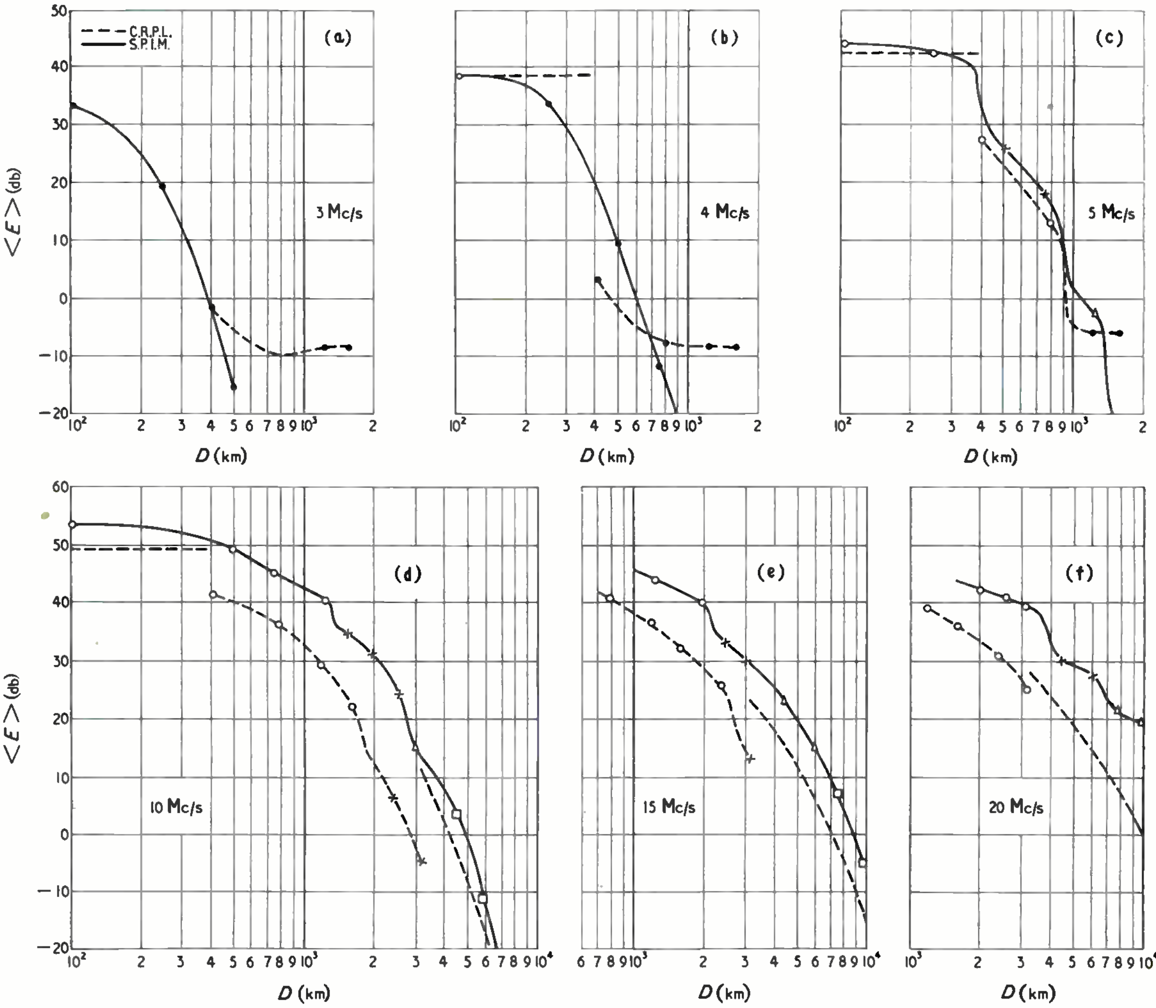



Fig. 17 (a–f). *Variation of effective field at different frequencies as derived from our formulae (heavy lines) and from the graphs of C.R.P.L. (broken lines). Effective radiated power 1 kW. $E_o$ = 110 db.*

simple formula. We first consider (for some examples corresponding to different distances) the variation with frequency (Fig. 13). As a reference, a family of curves based on a constant $\times (f+1{\cdot}2)^{-2}$ has been chosen, corresponding to formula (9). The curves obtained by means of the C.R.P.L. graphs are in heavy broken lines. They are not essentially different in Fig. 13(a), corresponding to the path $1 \times$ F. But Fig. 13(b), which is for $1 \times$ E, shows considerable differences for low frequencies, because a maximum of absorption is assumed at vertical incidence for a frequency of 1·2 Mc/s. This maximum is transferred to higher frequencies with increasing distance of transmission. The physical interpretation of this behaviour might be given by a lower layer having a critical frequency of 1·2 Mc/s. We hope that the new technique of pulse investigation on low frequencies[21] will clear up this point. The variation of absorption with distance, given by $\sec \alpha_D$ in our formula (9), is very similar in the C.R.P.L. graphs, as is demonstrated by Fig. 14. The influence of solar activity is the same as assumed for long distances [see (22a)]. The constant absorption (corresponding to $A = 1$; i.e., subsolar point and minimum of the solar cycle) is 500 db $(\text{Mc/s})^2$, while we use 430 [see (11)], a value which is not very different. Here again the most important difference of the two methods arises from the geometrical term $\delta_1$. The C.R.P.L. has now

$$\delta_1{}^{**} = 20 \log_{10}(2s) \text{ decibels} \quad \ldots \quad \ldots \quad (24)$$

$2s$ (see Fig. 15) is the equivalent path in km calculated with a specular reflection (altitudes 105 and 320 kilometres respectively for E and F layers). Consequently the C.R.P.L. field strength is somewhat lower than ours for medium distances too; the difference can attain 15 decibels, but it is less in most cases.

### 4.3. *Short Distances*

For distances below 400 kilometres the C.R.P.L. has not yet considered different paths. The corresponding graph[7] even assumes that the field (of the sky-wave) is independent of the distance, an assumption which is not in accord with the new medium-distance method. This discrepancy is made more serious by an extremely low value, adopted for the absorption constant (280, instead of 500 in 4.2). The absorption formula is here:

$$\delta_2{}^{***} = 280A \times S(f) \text{ decibels} \quad \ldots \quad (25)$$

We prove with Fig. 16 that the frequency function $S(f)$ is not essentially different from const. $\times (f + 1{\cdot}2)^{-2}$. In consequence of the low absorption value adopted here, the field calculated by means of (25) is rather high.

The interior discrepancy of the C.R.P.L. methods, used for short, medium and long distances, is considerable, especially for low frequencies (it attains 30 decibels!). This is illustrated by Fig. 17, where the variation of field strength with distance, as calculated with the different methods, is represented.

Surely the short-distance graph of the C.R.P.L. must be considered as provisional,* and only to be applied for very short distances. Its medium-distance method does not seriously differ from ours, though the field values are lower generally. The long-distance method gives results which do not differ materially from ours.

We think that two facts are most important: (1) that the two methods of field calculation have now become rather similar by adoption of the differential method, and (2) that the absorption figures, obtained with very different methods of observation, are in good agreement. The differences which still exist should be soon examined by suitable pulse experiments.

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# MUTUAL RADIATION RESISTANCE OF AERIALS AND ARRAYS

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**SUMMARY.**—The two most important methods of calculating the radiation resistance of an aerial are the Poynting-vector method and the e.m.f. method. However, for calculating the mutual resistance of two aerials or two aerial arrays only the latter method seems to have found explicit application. In this paper a simple expression for the mutual resistance of two aerial arrays with known array characteristics is derived on the basis of the Poynting-vector method. The application of this expression is illustrated by two examples.

## 1. Introduction

FOR calculating the radiation resistance of an aerial the two most important methods are the Poynting-vector method and the e.m.f. method. Both of these methods are based on the theorem concerning the energy flow in an electromagnetic field stated by Poynting[1] in 1884. In the case of the first-mentioned method, the Poynting vector is integrated over a spherical surface with its centre near the aerial and with its radius so large that the spherical surface is situated in the far-zone of the aerial, where the expressions for the field components are particularly simple. This method was first used by Hertz[2] in 1888 who applied it for calculating the total effect radiated by a 'Hertz dipole.' The second method is based on an integration of the Poynting vector over the surface of the aerial. The basis of this method was given by Brillouin[3] in 1922. The method was used in 1927 for practical aerial calculations by Kliatzkin[4], whose work was made known in the western countries through a paper by Pistolkors[5] two years later.

The Poynting-vector method has been used also for calculating the radiation resistance of aerial arrays; for example, Foster has calculated the radiation resistance of a linear array of Hertz dipoles[6], whereas Bontsch-Bruewitsch[7] has treated the more complicated case of a linear aerial array of thin linear aerials of finite length. The radiation resistance of an aerial array consisting of several sub-arrays may easily be calculated when the self-radiation resistances of the single sub-arrays and the mutual radiation resistance of the sub-arrays, two by two, are known. However, the Poynting-vector method does not seem to have been applied for a direct calculation of the mutual radiation resistance of two aerials or two aerial arrays. The reason for this seems to be the fact that before any serious interest had arisen in the possibility of calculating the mutual impedance of two aerials, the e.m.f.-method had been developed, and this method allowed one to calculate not only the real part, but also the imaginary part of the mutual impedance. The mathematical technique of calculations of this kind has been developed in papers by Pistolkors[5], Bechmann[8], Carter[9] and several others. Finally, during the last decade, efforts have been made to develop a more exact theory for the calculation of aerial impedances. This development which was started by Hallén[10] has been carried further by King and Harrison[11] and Tai[12].

It is the purpose of the present paper to develop an expression for the mutual radiation resistance of two aerial arrays on the basis of the Poynting-vector method. In some cases it is easier to use this expression than the corresponding expression derived on the basis of the e.m.f.-method. The application of the expression will be illustrated by two examples.

MS accepted by the Editor, February 1952

## 2. Derivation of an Expression for Mutual Resistance

We consider two aerial arrays, 1 and 2, both of them composed of the same kind of similar and similarly oriented aerials. Denoting by $\bar{r}$ the position vector, each of the two arrays is assumed to have a current distribution with the current density $\bar{J}_j(\bar{r})$ ($j = 1$ or 2) that may be expressed as

$$\bar{J}_j(\bar{r}) = I_j \bar{i}_j(\bar{r}), \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where $I_j$ is a reference current for the aerial array $j$, whereas $\bar{i}_j(\bar{r})$ is a vector function associated with the array $j$, this function being independent of the current $I_j$. For the two aerial arrays one may then define such self-impedances $Z_{11}$ with the reference current $I_1$, and $Z_{22}$ with the reference current $I_2$, and such a mutual impedance $Z_{12}$ with the reference currents $I_1$ and $I_2$ that the complex effect†, $P - iQ$, absorbed by the aerial from the generator may be expressed by [8,13]

$$2(P - iQ) = Z_{11}I_1I_1^* + Z_{12}(I_1I_2^* + I_2I_1^*) + Z_{22}I_2I_2^*, \quad \ldots \quad (2)$$

where $a^*$ denotes the complex conjugate value of $a$. Corresponding to a reference current $I$ for the super array formed by the two arrays, 1 and 2, we define an impedance $Z$ through the equation

$$2(P - iQ) = Z\,I\,I^* \ldots \quad \ldots \quad \ldots \quad (3)$$

Denoting by $R_{11}$ the real part of $Z_{11}$, etc., we find by equating the right-hand sides of equations (2) and (3) and taking the real part of the resulting equation the following equation for determining the self-radiation resistance, $R$, of the super array

$$RII^* = R_{11}I_1I_1^* + 2R_{12}\,\mathrm{Re}\,(I_1I_2^*) + R_{22}I_2I_2^*. \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

We express the reference current $I_j$ for the array $j$ by the reference current $I$ for the super array in the following way

$$I_j = \kappa_j\,I. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

By introducing this in equation (3) and rearranging we obtain the following expression for the mutual radiation resistance, $R_{12}$, of the arrays 1 and 2

$$R_{12} = \frac{R - R_1\kappa\kappa^* - R_2\kappa_2\kappa_2^*}{2\,\mathrm{Re}\,(\kappa_1\kappa_2^*)}. \quad \ldots \quad (6)$$

Let an aerial identical with those of which the arrays 1 and 2 are composed be situated at an arbitary reference point A, and let the current at the input terminals of the aerial be $I_o$. Let the electric field strength, $\bar{E}$, in the far-zone field of this aerial be

$$\bar{E} = E_\theta\hat{\theta} + E_\phi\,\hat{\phi}, \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

where $\hat{\theta}$ and $\hat{\phi}$ are unit vectors in the directions of the $\theta$ and $\phi$ axes in a spherical co-ordinate system $(\rho, \theta, \phi)$, and where

$$E_\theta = I_o\,\zeta\,\frac{e^{ik\rho}}{\rho}\,f_\theta\,(\theta, \phi), \quad \ldots \quad \ldots \quad (8)$$

$$E_\phi = I_o\,\zeta\,\frac{e^{ik\rho}}{\rho}\,f_\phi\,(\theta, \phi). \quad \ldots \quad \ldots \quad (9)$$

In these expressions $\zeta = \sqrt{\mu/\epsilon}$ denotes the intrinsic impedance, $k = \omega\sqrt{\mu\epsilon}$ the intrinsic transmission coefficient of free space, $\rho$ the distance from the origin to the point where the field is calculated, and $f_\theta(\theta, \phi)$ and $f_\phi(\theta, \phi)$ dimension-free functions of the pole distance $\theta$ and the azimuth $\phi$. The radiation resistance $r$, of the aerial in question, referred to the current $I_o$ at the input terminals is then[14]

$$r = \zeta\int_0^\pi\int_0^{2\pi}[f_\theta f_\theta^* + f_\phi f_\phi^*]\sin\theta\,d\theta\,d\phi. \quad (10)$$

Let $G_1\,(\theta, \phi)$ and $G_2\,(\theta, \phi)$ denote the array characteristics of the aerial arrays 1 and 2, both of them with the reference point A, but with the reference currents respectively $I_1$ and $I_2$. The self-radiation resistances, $R_{11}$ and $R_{22}$, of aerials 1 and 2 with the reference currents respectively $I_1$ and $I_2$ are

$$R_{11} = \zeta\int_0^\pi\int_0^{2\pi}[f_\theta f_\theta^* + f_\phi f_\phi^*]\;G_1G_1^*\sin\theta\,d\theta\,d\phi, \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

$$R_{22} = \zeta\int_0^\pi\int_0^{2\pi}[f_\theta f_\theta^* + f_\phi f_\phi^*]\;G_2G_2^*\sin\theta\,d\theta\,d\phi. \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

The radiation resistance $R$ of the super array formed by the arrays 1 and 2 with the reference current $I$ then becomes

$$R = \zeta\int_0^\pi\int_0^{2\pi}[f_\theta f_\theta^* + f_\phi f_\phi^*]\,[\kappa_1G_1 + \kappa_2G_2]\,[\kappa_1G_1 + \kappa_2G_2]^*\sin\theta\,d\theta\,d\phi. \ldots \quad (13)$$

By inserting the expressions (11), (12), and (13) for $R_{11}$, $R_{22}$, and $R$ in (6) we finally obtain the following expressions for the mutual radiation resistance $R_{12}$ with the reference currents $I_1$ and $I_2$

$$R_{12} = \zeta\int_0^\pi\int_0^{2\pi}[f_\theta f_\theta^* + f_\phi f_\phi^*]\,\frac{\mathrm{Re}\,(\kappa_1\kappa_2^*\,G_1G_2^*)}{\mathrm{Re}\,(\kappa_1\kappa_2^*)}\sin\theta\,d\theta\,d\phi. \ldots \quad \ldots \quad \ldots \quad (14)$$

If the phase difference between $\kappa_1$ and $\kappa_2$ is an integral number times $\pi$ or if the phase difference between $G_1$ and $G_2$ is an integral number times $\pi$, the expression for $R_{12}$ is reduced to

† Time factor: $e^{-i\omega t}$.

$$R_{12} = \zeta \int_0^{\pi} \int_0^{2\pi} [f\theta f\theta^* + f\phi f\phi^*] \ \mathrm{Re}\ (G_1 G_2^*) \sin\theta\, d\theta\, d\phi. \quad \ldots \quad (15)$$

In the last case the Re-sign is unnecessary.

For a thin, linear aerial with the length $2l$, coinciding with the axis $\theta = 0$, we have

$$f\theta = -\frac{i}{2\pi} \frac{\cos\ (kl \cos\ \theta) - \cos\ kl}{\sin\ kl \sin\ \theta}, \quad \ldots \quad (16a)$$

$$f\phi = 0. \quad \ldots \quad (16b)$$

The mutual radiation resistance of two aerial arrays composed of aerials of this type becomes accordingly

$$R_{12} = \frac{\zeta}{4\pi^2} \int_0^{\pi} \int_0^{2\pi} \frac{[\cos\ (kl \cos\ \theta) - \cos\ kl]^2}{\sin^2 kl \sin\ \theta} \frac{\mathrm{Re}\ (\kappa_1 \kappa_2^*\ G_1 G_2^*)}{\mathrm{Re}\ (\kappa_1 \kappa_2^*)} \sin\theta\, d\theta\, d\phi. \quad \ldots \quad (17)$$

The application of the expressions developed here for the mutual radiation resistance of two aerial arrays will be demonstrated by two examples.

## 3. Examples

### 3.1 *Two Parallel Linear Aerials*

Let each of the two aerial arrays consist of a single thin linear aerial with the length $2l$, the aerials being parallel to the $z$-axis in a rectangular co-ordinate system $(x, y, z)$. The aerials are supposed to carry identical currents, $I_1 = I_2 = I$, at the input terminals and are placed with their mid-points at respectively $(-\frac{d}{2}, 0, 0)$ and $(\frac{d}{2}, 0, 0)$, see Fig. 1. Choosing the origin as reference point in expressing the array's characteristics we have

$$G_{\frac{1}{2}} = \exp.\ (\pm\ ik\tfrac{d}{2} \sin\ \theta \cos\ \phi). \quad \ldots \quad (18)$$

By introducing this in (17) we find the following expression for the mutual radiation resistance of the two aerials with $I$ as the reference current

$$R_{12} = \frac{\zeta}{4\pi^2} \int_0^{\pi} \int_0^{2\pi} \frac{[\cos(kl \cos\theta) - \cos kl]^2}{\sin^2 kl \sin\theta} \cos(kd \sin\theta \cos\phi) d\theta\, d\phi$$

$$= \frac{\zeta}{\pi} \int_0^{\pi/2} \frac{[\cos(kl \cos\theta) - \cos kl]^2}{\sin^2 kl \sin\theta} \mathrm{J}_0(kd \sin\theta) d\theta. \quad \ldots \quad (19)$$

In deriving the above expression we have used Sommerfeld's integral formula for a Bessel function[15].

As far as the author knows, the integral by means of which we have expressed $R_{12}$ has not been expressed by known functions in the literature. On the other hand, by using the e.m.f.-method, Bechmann[8] has previously derived an expression for the mutual resistance, $R_{12}$, of two parallel linear aerials; with the notation used here the expression obtained by Bechmann is as follows

$$\begin{aligned} R_{12} = \frac{\zeta}{4\pi \sin^2 kl} \Big( & 4\mathrm{Ci}(kd) - 2\mathrm{Ci}\{k(\sqrt{d^2 + l^2} + l)\} - 2\mathrm{Ci}\{k(\sqrt{d^2 + l^2} - l)\} \\ & + \cos 2kl\, [2\mathrm{Ci}(kd) + \mathrm{Ci}\{k(\sqrt{d^2 + 4l^2} + 2l)\} + \mathrm{Ci}\{k(\sqrt{d^2 + 4l^2} - 2l)\} \\ & - 2\mathrm{Ci}\ \{k(\sqrt{d^2 + l^2} + l)\} - 2\mathrm{Ci}\ \{k(\sqrt{d^2 + l^2} - l)\}] \\ & + \sin 2kl\ [\mathrm{Si}\{k(\sqrt{d^2 + 4l^2} + 2l)\} - \mathrm{Si}\{k(\sqrt{d^2 + 4l^2} - 2l)\} - 2\mathrm{Si}\{k(\sqrt{d^2 + l^2} + l)\} \\ & + 2\mathrm{Si}\{k(\sqrt{d^2 + l^2} - l)\}]\Big) \quad \ldots \quad (20) \end{aligned}$$

In the present example the e.m.f.-method is seen to be superior to the method developed here.

As a bi-product of the investigation made here we obtain by comparing (19) and (20) the following integral formula

$$\begin{aligned} \int_0^{\pi/2} \frac{[\cos\ (a \cos\ \theta) - \cos\ a]^2}{\sin\ \theta} \mathrm{J}_0(b \sin\ \theta) d\theta = \frac{1}{4}\Big\{ & 4\mathrm{Ci}(b) - 2\mathrm{Ci}(\sqrt{a^2 + b^2} + a) \\ & - 2\mathrm{Ci}\ (\sqrt{a^2 + b^2} - a) + \cos 2a\, [2\mathrm{Ci}(b) + \mathrm{Ci}(\sqrt{4a^2 + b^2} + 2a) + \mathrm{Ci}(\sqrt{4a^2 + b^2} - 2a) \\ & - 2\mathrm{Ci}\ (\sqrt{a^2 + b^2} + a) - 2\mathrm{Ci}\ (\sqrt{a^2 + b^2} - a)] + \sin 2a\, [\mathrm{Si}(\sqrt{4a^2 + b^2} + 2a) \\ & - \mathrm{Si}\ (\sqrt{4a^2 + b^2} - 2a) - 2\mathrm{Si}\ (\sqrt{a^2 + b^2} + a) + 2\mathrm{Si}\ (\sqrt{a^2 + b^2} - a)]\Big\}. \quad \ldots \quad (21) \end{aligned}$$

Apparently, by using the method described in this paper in connection with the e.m.f. method one may generate several integral formulae of the type exemplified by (21). This subject will be reserved for a separate paper.

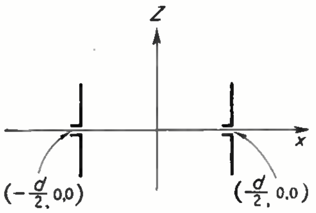



Fig. 1. *Co-ordinates used in calculating the mutual radiation resistance of two parallel linear aerials.*

### 3.2. *Two Concentric Ring Arrays*

A homogeneous ring array is defined as an array of a certain number of aerials placed equidistantly along the periphery of a circle and carrying currents at their input terminals, having the same numerical value, but with a phase that increases uniformly along the periphery of the circle. The current phase of each aerial being uniquely determined but for a multiple of $2\pi$, the current phase must increase an integral number, $H$, times $2\pi$ during one revolution. The homogeneous ring array was introduced by Chireix[16]; the theory of this array was recently developed in detail by Page[17,18]. Further references to the literature concerning ring arrays have been given by the author elsewhere.[19]

For certain purposes two or more concentric homogeneous ring arrays are used, as proposed by Hansen and Woodyard.[20] The radiation resistance of an aerial system of this type may be calculated when besides the self-radiation resistances of the single ring arrays also the mutual radiation resistances of the ring arrays, taken two by two, are known. On the basis of the method developed in this paper we shall calculate the mutual radiation resistance of two concentric homogeneous ring arrays.

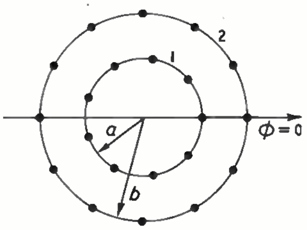



Fig. 2. *Co-ordinates used in calculating the mutual radiation resistance of two concentric ring arrays.*

Let the two ring arrays, 1 and 2, have the radii $a$ and $b$, and let the ring arrays be situated in the plane $\theta = \pi/2$ in a spherical co-ordinate system $(\rho, \theta, \phi)$ with their common centre at the origin, see Fig. 2. The number of aerials in the two ring arrays is assumed to be respectively $N_1$ and $N_2$, and the increment of the current phase during one revolution is assumed to be $H2\pi$ for both rings. In expressing the array characteristic $G_1$ of array 1 we choose the origin as reference point and $N_1$ times the current in the aerial situated at $\phi = 0$ as the reference current $I_1$, and correspondingly for array 2. If the number of aerials in each of the two arrays is sufficiently large, the array characteristics may then approximately be expressed[16] by

$$G_1 = J_H(ka \sin \theta), \quad \ldots \quad (22)$$

$$G_2 = J_H(kb \sin \theta). \quad \ldots \quad (23)$$

Inserting these expressions in (14) we find the following expression for the mutual radiation resistance, $R_{12}$, with the reference currents $I_1$ and $I_2$.

$$R_{12} = \zeta \int_0^{\pi} \int_0^{2\pi} [f_\theta f_\theta^* + f_\phi f_\phi^*] J_H(ka \sin \theta) J_H(kb \sin \theta) \sin \theta \, d\theta \, d\phi \quad \ldots \quad (24)$$

Setting $a = b$ in this expression we obtain the self-radiation resistance of a homogeneous ring array with the radius $a$ and with the increment of the current phase, $H2\pi$, during one revolution.

We shall here especially carry out the calculation of the mutual radiation resistance of two concentric homogeneous ring arrays of vertical, linear $\lambda/2$-aerials carrying currents at their input terminals with the same phase; i.e., with $H = 0$. From (24) and (16) we obtain

$$R_{12} = \frac{\zeta}{\pi} \int_0^{\pi/2} \frac{\cos^2(\pi/2 \cos \phi)}{\sin \phi} J_0(ka \sin \theta) J_0(kb \sin \theta) d\theta \quad \ldots \quad \ldots \quad (25)$$

As far as the author knows this integral cannot be expressed in any simple manner. Denoting by $\lambda$ the wavelength, we have made a numerical calculation of $R_{12}$ for values of $a/\lambda$ and $b/\lambda$ between 0 and 0·8. In Fig. 3 $R_{12}$ is plotted as a function of $b/\lambda$ for various values of $a/\lambda$.

In the present example a calculation of the mutual radiation resistance on the basis of the e.m.f. method would have been rather complicated; in this case the method developed here seems to be superior to the e.m.f.-method.

To demonstrate the application of the curves in Fig. 3, let us calculate the radiation resistance of an aerial array composed of two concentric ring arrays with vertical, linear $\lambda/2$ aerials with currents having the same phase, with the radii $a = 0{\cdot}1\lambda$ and $b = 0{\cdot}7\lambda$, and with the total currents $I_1$ and $I_2$, where $I_2 = -2I_1$. For the calculation of the radiation resistance with $I_1$ as the reference current we then have

$$\kappa_1 = 1,$$

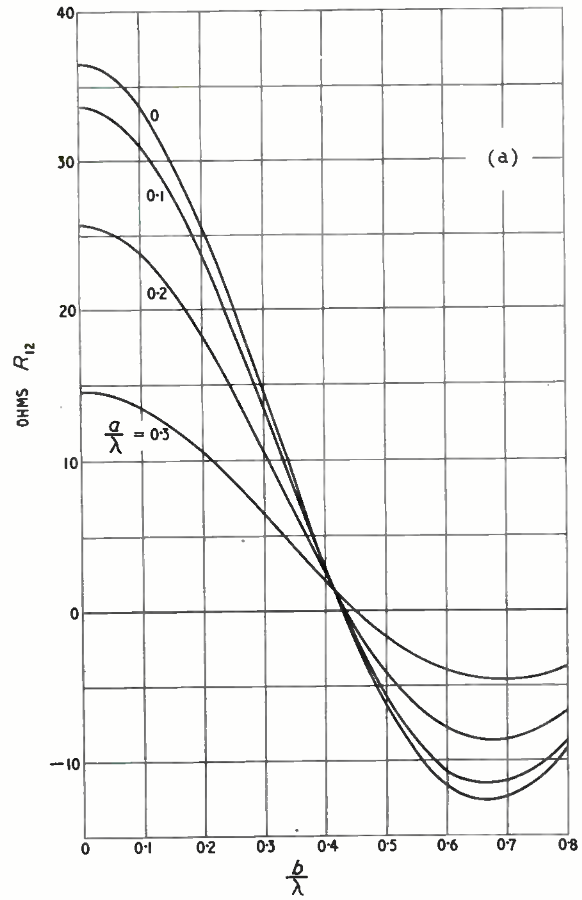
$$\kappa_2 = -2,$$

and from Fig. 3

$$R_{11} = 31{\cdot}0 \text{ ohms},$$
$$R_{12} = -11{\cdot}4 \text{ ohms},$$
$$R_{22} = 4{\cdot}8 \text{ ohms}.$$

Inserting these values in (4) we obtain

$$R = 31{\cdot}0 \times 1^2 + 2(-11{\cdot}4) \times 1 \times (-2) + 4{\cdot}8 \times (-2)^2 = 31{\cdot}0 + 45{\cdot}6 + 19{\cdot}2 = 95{\cdot}8 \text{ ohms}.$$



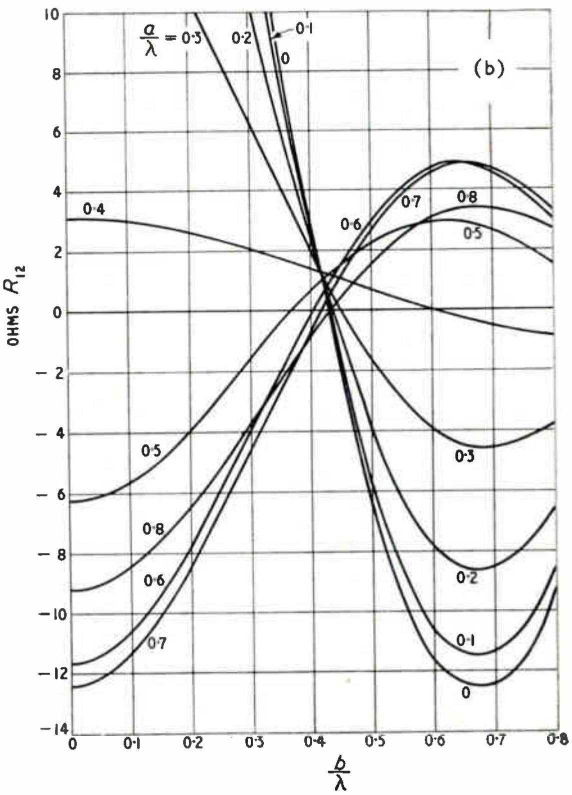




Fig. 3. *The mutual radiation resistance of two concentric ring arrays of aerials with currents in the same phase. The radii of the ring arrays are* a *and* b. *In* (b) *a portion of* (a) *is shown to an enlarged scale.*


## 4. Acknowledgment

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# 600-Mc/s FIELD-STRENGTH METER

By A. C. Gordon-Smith

(*Communication from the National Physical Laboratory*)

**SUMMARY.**—The paper describes equipment developed for measuring field strength at frequencies in the region of 600 Mc/s. The equipment has been calibrated both by the field-radiation method and by a laboratory method involving the injection of a known voltage. Good agreement between the two methods has been obtained.

## 1. Introduction

FIELD-STRENGTH measuring equipment suitable for operation at frequencies in the very-high-frequency band has been previously described[1,2]. This equipment, though adequate for most purposes at frequencies less than about 300 Mc/s, is not very sensitive at frequencies as high as 600 Mc/s. In view of the increasing application of these higher frequencies, it seemed desirable to try to improve on the performance of the earlier equipment, and the present paper describes work directed to this end. The receiver has been designed primarily for use in the study of radio-wave propagation at 600 Mc/s and has a fairly wideband intermediate-frequency amplifier to ensure that a received signal remains in tune during long periods of recording. As a calibrated instrument, however, it may be used for the accurate comparison of radio-field strengths over a frequency range 500-700 Mc/s. It can be operated either with a continuous-wave signal or with a modulated signal: in the latter case a narrow-band audio-frequency amplifier is added and the overall sensitivity of the equipment is about 18 db greater than with an unmodulated signal.

## 2. Description of Equipment

The general arrangement of the complete receiver is shown in Fig. 1. It consists of a crystal frequency changer connected through a matching unit to the aerial feeder, a 30-Mc/s intermediate-frequency amplifier incorporating a piston-attenuator and a 1,000-c/s selective amplifier followed by a rectifier and a d.c. instrument. A detailed drawing of the crystal frequency-changer is given in Fig. 2.

### 2.1 *The Crystal Frequency-Changer*

The input signal from a dipole aerial is fed through a 70-ohm concentric transmission line and adjustable matching stubs to a silicon-crystal mixer. The local-oscillator voltage is obtained from a butterfly-type oscillator, and is fed through a probe which is adjusted to give a crystal current of about 0·5 mA. The ends of the sleeve through which the probe passes are slit to improve the contact. A signal-frequency quarter-wavelength choke is inserted in the intermediate-frequency lead from the crystal and a low impedance path for the signal frequency is provided by a polystyrene washer around the crystal.

MS accepted by the Editor, March 1952

### 2.2 *The Intermediate-Frequency Amplifier*

The amplifier has a bandwidth of about 0·5 Mc/s centred about a mean frequency of 30 Mc/s. This is considered to be the best arrangement to give an adequate signal-to-noise ratio and at the same time ensure that the signal remains in tune, although small frequency drifts may occur. A piston attenuator of known characteristics is incorporated in the amplifier. The attenuating cylinder has an internal diameter of 6·35 cm, and a corresponding theoretical attenuation of 5·04 db per cm over the linear range. An amplifier is needed before the attenuator to make up for the insertion loss; the linearity of this amplifier used in conjunction with the frequency changer was carefully checked by applying various inputs from a 600-Mc/s signal generator, the output of which was controlled by another standard piston attenuator. The output from the final stage of the amplifier was kept constant by suitable adjustment of the intermediate-frequency piston attenuator and it was found that the corresponding changes in the attenuators agreed to within ±0·5 db over the desired range of about 60 db.

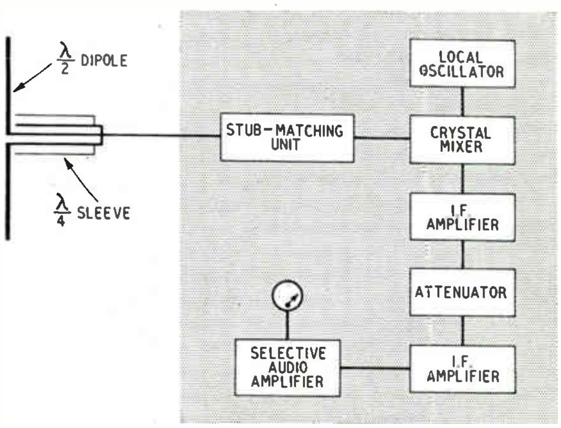


Fig. 1. *Block diagram of field-strength meter.*

In previous field-strength measuring sets[1] resistance attenuators were used as intervalve couplings, but experience has shown that an increased accuracy is obtainable with the piston-type attenuator when used over long periods.

### 2.3 *Selective Audio Amplifier*

If the transmission is suitably modulated, then a narrow-band audio-frequency amplifier may be used and a much improved signal-to-noise ratio obtained.

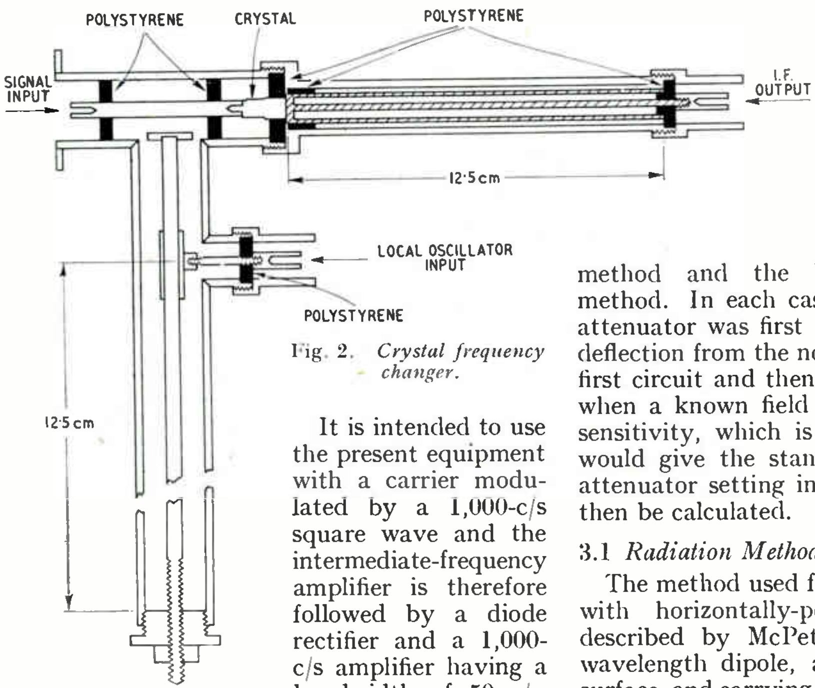


Fig. 2. *Crystal frequency changer.*

It is intended to use the present equipment with a carrier modulated by a 1,000-c/s square wave and the intermediate-frequency amplifier is therefore followed by a diode rectifier and a 1,000-c/s amplifier having a bandwidth of 50 c/s. Finally, a germanium crystal is used to rectify the output and the resulting direct current used to operate a pen recorder. A current of about 3 mA is required to give a full-scale deflection. By feeding back the unidirectional voltage output to the grids of the valves in the second intermediate-frequency amplifier an output of 3 mA can be made to correspond to 60 db increase in signal. For field operation the recorder is replaced by a micro-ammeter having a full-scale deflection for 500 $\mu$A. For continuous-wave measurements this instrument can also be plugged into a socket to give the current in the diode at the end of the intermediate-frequency amplifier.

### 2.4 *Aerial Systems*

During the development, and for the calibration described below, a simple half-wavelength dipole was used. The transformation from balanced dipole to unbalanced line was effected by means of a suitable transformer consisting of a quarter-wavelength choke in the form of a cylinder connected around the transmission line with the open end near to the dipole.

At frequencies as high as 600 Mc/s it is possible to make an aerial system with a gain of at least 15 db relative to a half-wavelength dipole without the mechanical size of such a system becoming inconveniently large for a fixed installation. It is therefore possible to achieve considerably greater sensitivity than can be obtained with the half-wavelength dipole. For general field measurements a smaller array is probably desirable.

## 3. Calibration

It was decided to standardize the equipment by calibrating it in two ways, using the field-radiation method and the laboratory direct-injection method. In each case the setting of the piston attenuator was first adjusted to give a standard deflection from the noise voltage developed in the first circuit and then to give the same deflection when a known field or input was applied. The sensitivity, which is defined as the field which would give the standard deflection at the first attenuator setting in the absence of noise could then be calculated.

### 3.1 *Radiation Method*

The method used for obtaining a standard field with horizontally-polarized waves was that described by McPetrie and Pressey[3]. A half-wavelength dipole, at a height $h_T$ above a flat surface, and carrying a current $I$, as measured by a thermojunction, produces at a point, at height $h_R$ and distance $d$, a field given by

$$E = 240\,\pi \frac{I h_R}{\lambda d^2} h_T \text{ volts/metre} \quad \ldots \quad \ldots \quad (1)$$

where distances, heights and wavelength are measured in metres and the current in amperes.

A modification of this method was also used; the radio-frequency power available at the end of the transmission line was measured in a tunable bolometer unit, and the transmission line was then connected to the dipole. Preliminary experiments were carried out using a standing-wave detector, first, to make small adjustments in the length of the dipole so that it was matched to the transmission line and, secondly, to confirm that when the bolometer matching stubs were adjusted to give a maximum indication, there was a standing-wave ratio of unity. A length of cable with an attenuation of 10 db and a characteristic impedance of 70 ohms was interposed between the generator and the transmission line so that the correct output impedance was presented by the generator. The expression for the field strength in terms of the power is

$$E = 90 \frac{\sqrt{W}}{\lambda d^2} h_R \, h_T \text{ volts/metre} \quad \ldots \quad (2)$$

where $W$ is the power in watts, and the other quantities are as before.

### 3.2 *Laboratory Method*

The laboratory method is advantageous when there is difficulty in obtaining the suitable open site which is essential for the radiation method. Briefly, the field-strength set is calibrated in terms of a known power fed from a generator with an output impedance of 70 ohms. The input-voltage sensitivity thus obtained is readily converted to a field-strength sensitivity allowing for the effective height of the dipole. The generator actually used was the same as in the previous method and the output from the attenuating cable was similarly measured with a bolometer. It was found that the smallest power that could be accurately measured with the bolometer would overload the field-strength set, and so the first intermediate-frequency amplifier was replaced by a cable and the change in gain observed in terms of the piston attenuator. Additional attenuation was still needed and this was obtained from a length of 70-ohm cable having a measured attenuation of 28·0 db.

The measurements in all cases were made using a continuous wave and a 1,000-c/s square-wave modulated signal. The field obtained from the expressions given is in r.m.s. volts per metre. In the square-wave modulation case the field is sometimes expressed as the r.m.s. value during the on-period and not over the whole period: to express the results in this manner the sensitivity values tabulated for the square wave must be multiplied by $\sqrt{2}$. The mean sensitivities, together with an indication of the repetition accuracy, are given in the table.

**Sensitivity Calibration of Field-Strength Meter**

| Sensitivity | Radiation Method | | | | Laboratory Method | |
|---|---|---|---|---|---|---|
| | Thermojunction | | Bolometer | | Bolometer | |
| | μV/m | db above 1 μV/m | μV/m | db above 1 μV/m | μV/m | db above 1 μV/m |
| Continuous Wave | 37 ± 3 | 31 ± 1 | 35 ± 3 | 31 ± 1 | 32 ± 1 | 30·1 ± 0·3 |
| Square Wave | 5 ± 1 | 14 ± 2 | 4·5 ± 1 | 13 ± 2 | 4·1 ± 0·2 | 12·3 ± 0·5 |

## 4. Conclusions

The results are mutually consistent within experimental accuracy and show that at a frequency of 600 Mc/s a field can be set up and measured with an accuracy of about ±2 db. The sensitivity of the bolometer and the thermo-junction used was such that an error of about 1 db could be introduced when the smaller powers or currents available in the square-wave modulation case were measured, and this probably accounts for the wider variations obtained in these cases. The repetition accuracy obtained in the laboratory can probably never be fully realized in field measurements, even with a perfect site, because of small re-radiation effects from the set to the dipole; but on occasions the equipment may be used to standardize the output from signal generators when the power is too small to be measured directly by means of a bolometer, and then the greatest attainable accuracy is desirable. With an aerial array of about 15 db gain relative to a half-wavelength dipole the final sensitivity for the modulated case should be better than 1 μV/m.

It is too early yet to say how constant the conversion factor of the crystal will be over long periods. Some instability was experienced with one batch of crystals, but there has been no further evidence of this trouble. However, periodic checking of the calibration is obviously advisable and work is proceeding in an endeavour to make a satisfactory diode noise generator for this frequency, which would then be available as a monitor.

## Acknowledgments

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# CORRESPONDENCE

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

### Networks with Maximally Flat Delay

SIR,—Mr. T. C. Nuttall has drawn my attention to some arithmetical errors in my paper "Networks with Maximally-Flat Delay" in the October issue. Tables 1 and 2, $n = 6$, are affected; the corrected values are:

| Table 1(a) | 1(b) | 2 |
|---|---|---|
| $-4 \cdot 2484$<br>$\pm j0 \cdot 8675$ | $-1 \cdot 5836$<br>$\pm j0 \cdot 3142$ | 8·4967<br>18·8011 |
| $-3 \cdot 7357$<br>$\pm j2 \cdot 6263$ | $-1 \cdot 3529$<br>$\pm j0 \cdot 9511$ | 7·4714<br>20·8528 |
| $-2 \cdot 5159$<br>$\pm j4 \cdot 4927$ | $-0 \cdot 9111$<br>$\pm j1 \cdot 6270$ | 5·0319<br>26·5140 |

The numerical example following Table 4 will require corresponding changes, but the errors are not large enough to make any practical difference.

W. E. THOMSON.

Dollis Hill, N.W.2.
10th October 1952.

### Precision Voltage Source

SIR,—The recent paper by V. H. Attree concerning a "Precision Voltage Source" (*Wireless Engineer*, Vol. 29, p. 226) describes an interesting application of an incandescent lamp as a nonlinear circuit element. There are two small points in connection with the use of a lamp as such an element which are overlooked in the paper of Mr. Attree and in others cited by him.

Mention is made of the fact that a sinusoidal current in the lamp leads to a nonsinusoidal voltage across it. In addition to a sinusoidal component of voltage, there are also cosinusoidal components at both the frequency of the current and three times this frequency. If the frequency is sufficiently low, or the current sufficiently large, these cosinusoidal components are no longer of equal amplitude, as is often and incorrectly stated. The fundamental cosinusoidal component becomes smaller and ultimately vanishes as frequency approaches zero. If the frequency becomes higher or the current becomes smaller, the amplitudes of the two components do approach equality.

A more important comment for precision applications has to do with the statement which is made implying that the resistance of a lamp is dependent only upon the r.m.s. value of the current in it. If by resistance is meant the ratio of the amplitude of the fundamental sinusoidal voltage to that of the sinusoidal current (and this is the quantity of importance in the bridge circuit described), the statement is not quite correct. There is a fluctuation in temperature of the lamp, occurring at twice the fundamental frequency. When combined with the sinusoidal current, this fluctuation leads to a small additional sinusoidal component of voltage.

The additional voltage produces a small increase in the apparent resistance of the lamp. Its resistance with a sinusoidal current, therefore, is slightly larger than its resistance with a direct current, if the r.m.s. values of the two currents are identical. The small increase approaches zero as the current becomes sufficiently small or the frequency becomes sufficiently high. A further change in the apparent resistance is produced by a similar mechanism if a third-harmonic component is present in the current in the lamp.

These points are discussed in two papers, the first in the *Journal of Applied Physics*, 1952, Vol. 23, p. 658, and the second scheduled to appear soon in the *Review of Scientific Instruments*.

W. J. CUNNINGHAM.

Yale University,
Connecticut, U.S.A.
2nd October 1952.

### Screen Dissipation of Pentodes

SIR,—Many applications of modern valve circuitry demand information not readily obtainable from the characteristics given in the manufacturer's catalogue.

A typical presentation of a valve's characteristics is shown in Fig. 1. The maker also states that the maximum permissible anode and screen dissipations are 2·5 W and 0·9 W respectively. A common use for such a valve would entail operation under the following 'quiescent' conditions: anode load and voltage as small as possible, grid bias zero, positive h.t. supply about 300 V. We can suppose for the sake of simplicity that the 'active' condition of the valve, cut-off, lasts for a very short time and is repeated at relatively long intervals. In such a case the load line for the valve is found by joining points

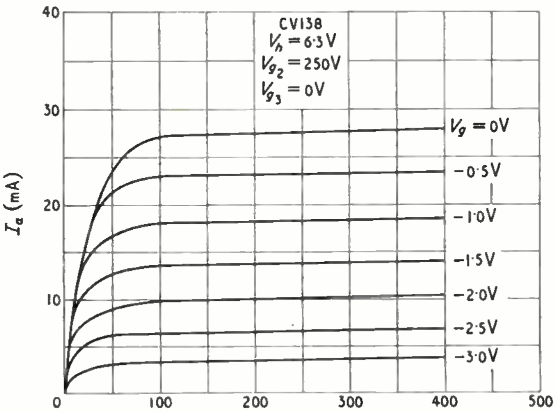



Fig. 1

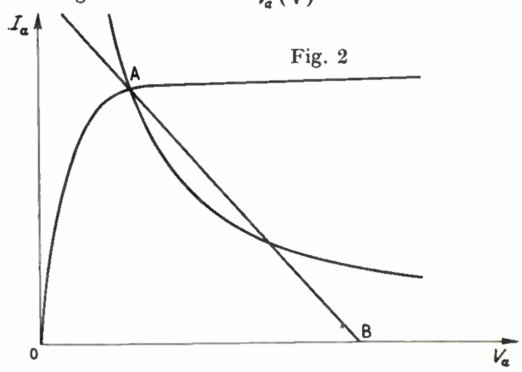



Fig. 2

A and B as in Fig. 2. A is the intersection of the $V_g = 0$ curve and the 2·5-W power hyperbola, B is the h.t. voltage on the axis of abscissae. If the screen dissipation is evaluated, it will be found to be excessive.

It will be seen that optimum conditions will obtain when the dissipating powers of the anode and screen are fully exploited simultaneously. This means that the working area in the $V_a$–$I_a$ plane will be limited by the axes, the anode-power line and a screen-power line. It is instructive to discover how this area is affected by the choice of screen voltage. A fixed voltage is applied to the screen of the valve, and anode and screen currents measured for those pairs of anode and grid voltages which load the screen to its maximum value. The results are shown in Fig. 3.

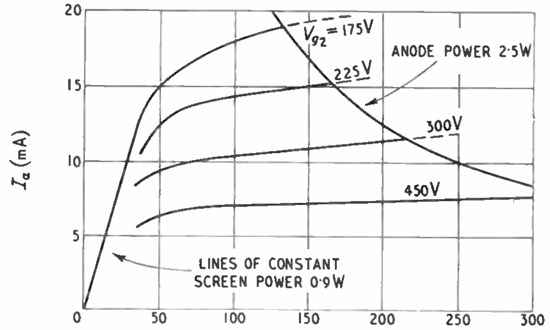



Fig. 3

Moving to the right along a screen-power line, the grid-bias is approaching zero. Numerical values of bias have been omitted to avoid confusion. The useful working area increases as the screen voltage is reduced. The greatest area is obtained when the intersection of the anode- and screen-power lines occurs at $V_g = 0$. For a screen voltage slightly less than the optimum the power lines intersect at a positive value of bias and for a rather lower voltage the screen is fully loaded with zero volts on the anode. The optimum value of screen voltage can be found experimentally by connecting the control-grid to cathode and adjusting anode and screen voltages till these electrodes are fully loaded. Once found this value may be used to plot a set of curves similar to those in Fig. 1, but whose range of validity is completely defined. Such a diagram is shown in Fig. 4.

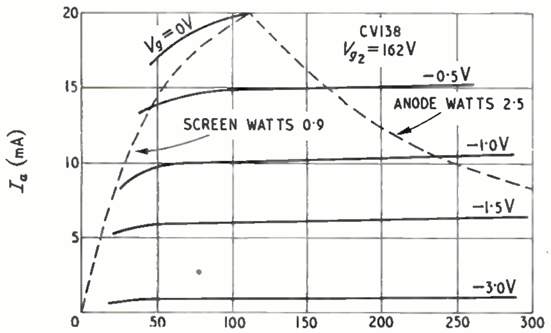



Fig. 4

It is suggested that valve users would find these last curves most useful and that valve makers could at least quote the optimum value of screen voltage.

SIDNEY C. DUNN.

London, N.4.
25th August 1952.

## I.E.E. MEETINGS

12th November. "Radio Telemetering," by E. D. Whitehead, M.B.E., B.Sc., and J. Walsh, B.Sc.

17th November. "The Field of Application of Metal Rectifiers," Discussion to be opened by S. A. Stevens, B.Sc.(Eng.).

18th November. "Harmonic Response Testing Apparatus for Linear Systems," by D. O. Burns, B.Sc.(Eng.), and C. W. Cooper, B.Sc.(Eng.). "A Simple Connection Between Closed-Loop Transient Response and Open-Loop Frequency Response," by J. C. West, B.Sc., and J. Potts, B.Sc.

24th November. "Recent Progress in Radar Duplexers with special reference to Gas-Discharge Tubes," by P. O. Hawkins.

3rd December. "A Survey of Present Knowledge of Thermionic Emitters," by D. A. Wright, M.Sc.

These meetings will be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2, and will commence at 5.30.

## STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

*Values for September 1952*

| Date 1952 September | Frequency deviation from nominal: parts in $10^8$ | | Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds |
|---|---|---|---|
| | MSF 60 kc/s 1029-1130 G.M.T. | Droitwich 200 kc/s 1030 G.M.T. | |
| 1 | 0·0 | −3 | −64·5 |
| 2 | +0·1 | −2 | −64·2 |
| 3 | +0·1 | −4 | −64·3 |
| 4 | +0·1 | −4 | −63·4 |
| 5 | +0·2 | −5 | −63·2 |
| 6 | +0·1 | −5 | −63·0 |
| 7 | +0·1 | −4 | −62·7 |
| 8 | +0·1 | −4 | −62·6 |
| 9 | +0·2 | −2 | −63·4 |
| 10 | +0·2 | −4 | −61·9 |
| 11 | +0·2 | −3 | −62·1 |
| 12 | +0·2 | −3 | −61·2 |
| 13 | +0·4 | −4 | −61·5 |
| 14 | +0·4 | −3 | −61·1 |
| 15 | +0·4 | −3 | −59·7 |
| 16 | +0·3 | −3 | −59·9 |
| 17 | +0·4 | −2 | −59·8 |
| 18 | +0·5 | −2 | −59·3 |
| 19 | +0·5 | −2 | −57·9 |
| 20 | +0·5 | −2 | −56·3 |
| 21 | +0·6 | −2 | −55·2 |
| 22 | +0·6 | −2 | −54·0 |
| 23 | +0·6 | −2 | −55·4 |
| 24 | +0·6 | −1 | −53·0 |
| 25 | +0·6 | 0 | −52·2 |
| 26 | +0·6 | 0 | −50·9 |
| 27 | +0·7 | 0 | −49·9 |
| 28 | +0·7 | 0 | −48·3 |
| 29 | NM | 0 | NM |
| 30 | +0·7 | 0 | −45·8 |

The values are based on astronomical data available on 1st October 1952.

NM = Not measured.

# ABSTRACTS and REFERENCES

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

*The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of 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 it.*



## ACOUSTICS AND AUDIO FREQUENCIES

534.22-16 : 539.217.1 **2962**

**Velocity of Sound in Porous Media.**—H. Labhart. (*Z. angew. Math. Phys.*, 15th May 1952, Vol. 3, No. 3, pp. 205–211.) Measurements show a very close relation between sound velocity and pore volume in a Ni-Zn ferrite. A theoretical expression for the velocity in a porous medium is derived that gives a good fit with the experimental curve.

534.231-13/-14 **2963**

**Second-Order Acoustic Fields: Relations between Density and Pressure.**—J. J. Markham. (*Phys. Rev.*, 1st June 1952, Vol. 86, No. 5, pp. 710–711.) A general relation is derived connecting pressure and density, taking account of the flow of the medium. A non-absorbing ideal fluid is considered, and general thermodynamic principles are applied. The results justify the neglect of the flow terms which is usual in considering more complex media.

534.231-13/-14 **2964**

**Second-Order Acoustic Fields: Energy Relations.**—J. J. Markham. (*Phys. Rev.*, 1st June 1952, Vol. 86, No. 5, pp. 712–714.) The expression for the energy stored in an acoustic field is examined. Two corrections to the usually accepted formula are found to be required; these are small for a liquid, but of major importance for a gas. Their physical significance is explained, using thermodynamic theory.

534.232.003 : 534.321.9 **2965**

**The Economical Generation of Ultrasonic Oscillations for Industrial Purposes by means of Electroacoustic Transducers.**—H. H. Rust. (*Elektrotech. Z.*, 15th April 1952, Vol. 73, No. 8, pp. 261–262.) As an alternative to valve-driven ultrasonic generators, which are not considered economical, it is proposed to use a simple type of quenched-spark generator with either a magnetostriction or a capacitive type of oscillator, a rectifier being used in the latter case to furnish a d.c. charging current.

534.26 **2966**

**On the Diffraction of an Acoustic Pulse by a Wedge.**—J. W. Miles. (*Proc. roy. Soc. A*, 22nd May 1952, Vol. 212, No. 1111, pp. 543–547.) The pressure in the pulse is assumed to be a homogeneous function of $r/ct$, where $r$ is the distance from the edge, $c$ the velocity of sound and $t$ the time. The scattered wave is determined by reducing the original wave equation to Laplace's equation with the aid of a Tschplygin transformation, and applying Poisson's formula to the sectoral domain cut out of the circle $r < ct$ by the wedge. The result appears in a form simpler than that previously obtained by Sommerfeld.

534.321.9-14 : 534.6 **2967**

**Ultrasonic Measurement Technique in Fluids.**—J. Koppelmann. (*Acustica*, 1952, Vol. 2, No. 2, pp. 92–95. In German.) A description is given of a microphone for probing fields at frequencies above 100 kc/s. Oscillations are picked up on the exposed tip of a screened steel wire 20 cm long and transferred to a quartz crystal attached to the other end of the wire. The work of Hertz & Mende (1092 of 1940) on application of Langevin's formula for acoustic radiation pressure is extended. Operation of the ultrasonic generator increases the density of the liquid in the ultrasonic beam, owing to the transport of liquid towards the axis.

534.6 **2968**

**Design and Analysis of Subjective Acoustical Experiments which involve a Quantal Response.**—D. L. Richards. (*Acustica*, 1952, Vol. 2, No. 2, pp. 83–91.) Certain statistical methods that have been found useful in biological investigations are shown to be well adapted to subjective acoustic measurements. Examples are given of their use in analysis of the quality of telephony circuits.

534.6 **2969**

**Modern Methods for Noise Measurement. Use of the Octave-Band Analyser.**—(*Radio tech. Dig., Édn franç.*, 1952, Vol. 6, Nos. 2 & 3, pp. 109–117 & 135–138.) Survey of methods and apparatus for acoustic measurements, with 25 references.

534.76 **2970**

**The Stereophonic Reproduction of Speech and Music.**—J. Moir & J. A. Leslie. (*J. Brit. Instn Radio Engrs*, June 1952, Vol. 12, No. 6, pp. 360–366.) The fundamentals of stereophony are discussed; previously proposed methods for obtaining true or pseudo stereophonic effects are described, and various theories of stereophonic perception are compared. Tests have been made to determine the influence on stereophonic audition of acoustical conditions in existing theatres; the loudness difference between the two ears makes no significant contribution to the accuracy of source location.

534.78 **2971**

**The Analysis and Automatic Recognition of Speech Sounds.**—C. P. Smith. (*Electronic Engng*, Aug. 1952, Vol. 24, No. 294, pp. 368–372.)

534.84 **2972**

**Radiation Problems in the Acoustics of Buildings.**—J. Brillouin. (*Acustica*, 1952, Vol. 2, No. 2, pp. 65–76. In French.) Both theory and experiment show that the amount of external energy radiated into a room cannot be deduced from the mean amplitude of vibration of the walls. Flexural waves in a partition do not radiate unless their velocity is greater than that of sound in air; the radiation index of a partition can thus be widely different for forced and for free vibrations. A tentative theory of the suspended ceiling is presented and some observations are explained. Transient phenomena may exhibit effects not found in the steady state; some relevant experiments are discussed.

534.843 **2973**

**The Correlation Coefficient as a Criterion of the Acoustic Quality of a Closed Room.**—S. G. Gershman. (*Zh. tekh. Fiz.*, Dec. 1951, Vol. 21, No. 12, pp. 1492–1496.) The correlation coefficient for the oscillations at two points of the field gives a much fuller indication of the acoustic properties of a closed room than the reverberation time. The theory of the coefficient is discussed and measurements of it are described.

534.843 **2974**

**Notes on Geometrical Room Acoustics.**—E. Meyer & W. Kuhl. (*Acustica*, 1952, Vol. 2, No. 2, pp. 77–83. In German.) Discussion of the effects of reflected sounds reaching a listener shortly after the sounds transmitted directly. If the delay due to the first reflections is $< 50$ ms, reinforcement occurs. Formulae are given relating this effect to the energy density in the diffuse sound field. Practical applications of multiple reflectors to increase speech intelligibility in the rebuilt opera house, Hamburg, the large hall in the students' hostel, Bonn, and the theatre, Hanover, are described.

534.843 **2975**

**Standing-Wave Patterns in Studio Acoustics.**—C. G. Mayo. (*Acustica*, 1952, Vol. 2, No. 2, pp. 49–64.) An approximate analysis is made of the sound field in a rectangular room excited by a spherical source. Two different kinds of characteristic frequencies are observed, one of which is the set of eigentones. A general picture is obtained of the relative importance of the various modes. High-frequency eigentones are relatively unimportant.

534.851 + 681.85 **2976**

**Microgroove Recording and Reproduction.**—E. D. Parchment. (*J. Brit. Instn Radio Engrs*, May 1952, Vol. 12, No. 5, pp. 271–276.) A survey of basic problems, under the headings (*a*) mechanical considerations, (*b*) recording characteristics, (*c*) cutting problems, (*d*) tracing distortion, (*e*) pickups.

621.395.61 : 546.431.824 **2977**

**Producing Barium-Titanate Transducers.**—J. M. C. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 162 . . 174.) Processes described include the production of the $BaTiO_3$ cylinders from the raw powder, 'forming' to produce the required piezoelectric properties, and calibration of the transducers.

621.396.615.029.3 : 621.385.5 **2978**

**Simultaneous Generation of Several Audio-Frequency Oscillations by means of Electron Coupling in a Multi-electrode Valve.**—Spengler & Rust. (See 3044.)

621.395.623.7 **2979**

**The Loudspeaker with Phase Reversal.**—H. Gemperle. (*Elektrotech. Z.*, 15th May 1952, Vol. 73, No. 10, pp. 339–342.) Theory of the action of loudspeakers with phase reversal is based on the equivalent circuit for the mechanical system. The theory is applied to the design of the resonator for a concert loudspeaker with a natural frequency of 38 c/s and diaphragm diameter of 35 cm, in order to obtain a two- to three-fold enhancement of the low frequencies over a bandwidth of at least 30 c/s.

621.395.625.3 **2980**

**Magnetic Print-Through. Its Measurement and Reduction.**—L. J. Wiggin. (*J. Soc. Mot. Pict. Televis. Engrs*, May 1952, Vol. 58, No. 5, pp. 410–414.) A simple dynamic method of measurement is described. Application of an ultrasonic erasing bias during playback reduces the effect below the audibility limit.

621.395.625.3 **2981**

**Some Aspects of Magnetic Sound Recording.**—O. K. Kolb. (*J. Brit. Instn Radio Engrs*, May 1952, Vol. 12, No. 5, pp. 307–316.) The history of the development of sound recording by magnetizing wire or tape is reviewed, and a description is given of modern sound-film equipment using the process. Various explanations of the improvement produced by h.f. biasing are discussed. Comparison is made between signal-erasing methods using mains-frequency and h.f. currents, and the effect of erasing at reduced film speed is investigated.

621.395.625.3 : 168.2 **2982**

**Classification of Magnetic-Recording Tapes.**—F. Grammelsdorff & W. Guckenburg. (*Funk u. Ton*, May & June 1952, Vol. 6, Nos. 5 & 6, pp. 247–257 & 311–323.) Detailed discussion of a proposed classification based on a characteristic parameter of the tape material.

621.395.92 **2983**

**Trends in Hearing-Aid Design and Technique.**—R. F. Burton. (*Proc. Instn Radio Engrs, Aust.*, June 1952, Vol. 13, No. 6, pp. 253–262.) Various types of hearing defect are discussed and recent progress in the design of hearing aids is reviewed.

## AERIALS AND TRANSMISSION LINES

621.315.2 : 621.397.5 **2984**

**An Improved Television Camera Cable System.**—(*Engineer, Lond.*, 23rd May 1952, Vol. 193, No. 5026, p. 699.) A brief description of the 'Polypole III' coupler, which is smaller and lighter than earlier types. Up to 36 circuits are provided for. The overall diameter is 0·82 in.; unit lengths can be combined as required.

621.315.212 **2985**

**Calculation of the Transmission Characteristics of Rotationally Symmetrical Connecting Units for Coaxial Cables from the Properties of Plane Electrostatic Fields.**—H. H. Meinke & A. Scheuber. (*Arch. elekt. Übertragung*, June 1952, Vol. 6, No. 6, pp. 221–227.) Analysis shows that every rotationally symmetrical unit has an analogous plane representation which has nearly the same transmission characteristics and admits of relatively simple calculation. This principle is applied to the design of a reflection-free junction for coaxial cables with both inner and outer conductors of different diameters. See also 2429 of September.

621.315.212 : 621.317.34 **2986**

**Measurement of the Attenuation and Characteristic Impedance of Transmission Lines. Tests on Coaxial Cables.**—Hontoy. (See 3169.)

621.392.017.13 : 621.3.011.2 **2987**

**The Radiation Resistance of Resonant Transmission Lines.**—R. A. Chipman, E. F. Carr, N. A. Hoy & M. Yurko. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 613–620.) Measurements of input admittance as a function of line length were made on a line comprising parallel vertical silver rods above a metal ground plane, over the frequency range 300–1 400 Mc/s; the experimental procedure is described. The radiation resistance is obtained as the difference between the resistance values found for the same resonant section unshielded and shielded; it is independent of line length and top termination, and its value is approximately $120\pi^2(d/\lambda)^2$, where $d$ is the separation of the rods.

621.392 + 621.315.212].018.44 **2988**

**Experimental Verification of the Theory of Laminated Conductors.**—H. S. Black, C. O. Mallinckrodt & S. P. Morgan, Jr. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 902–905.) To test Clogston's theory (2908 of 1951), an experimental coaxial line was constructed with a laminated inner conductor. The phase velocity of the transmitted wave was varied by introducing $TiO_2$ cylinders or disks into the interconductor space. Critical dependence of attenuation on phase velocity was observed. At the optimum setting the attenuation, though greater than predicted by theory, was less than that of the corresponding conventional coaxial line.

621.392.2 **2989**

**Steady-State Waves on Transmission Lines.**—D. L. Waidelich. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1521–1524.) Various methods of determining the steady-state response of transmission lines to nonsinusoidal voltage inputs are considered. Experimental results are in good agreement with theory.

621.392.2 : 621.396.611.39 **2990**

**Superdirectivity with Directional-Coupler Arrays.**—H. J. Riblet. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 994–995.) Discussion on 562, 2099 and 2909 of 1951 (Bolinder).

621.392.26 **2991**

**Symmetrically Placed Inductive Posts in Rectangular Waveguide.**—H. Gruenberg. (*Canad. J. Phys.*, May 1952, Vol. 30, No. 3, pp. 211–217.) An expression is derived for the susceptance of two symmetrically placed posts in a rectangular waveguide. Curves are drawn that are valid for all rectangular guides in their normal operating range, for different post diameters and offsets from the guide walls. Satisfactory agreement was obtained between calculated values and measurements at wavelengths of 10·7, 4·74 and 3·2 cm.

621.392.26 **2992**

**Dominant-Wave Transmission Characteristics of a Multimode Round Waveguide.**—A. P. King. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 966–969.) In the 4-kMc/s frequency band transmission losses are lower with oversize round waveguide than with rectangular waveguide. Mode conversion effects in the round guide have been examined experimentally and found to be small; hence cross-polarized dominant modes can be used to provide two reasonably independent channels at the same frequency in the same guide. Experimental results are given for a straight guide of internal diameter 2·812 in. and length 150 ft; the effect of bending the guide is indicated.

621.392.26 **2993**

**Field Expandability in Normal Modes for a Multilayered Rectangular or Circular Waveguide.**—J. van Bladel. (*J. Franklin Inst.*, April 1952, Vol. 253, No. 4, pp. 313–321.) Proof is given that the field can be expressed as a linear sum of normal modes, and a method of determining the field excited by a given current distribution in a multilayered waveguide is explained.

621.392.26 : 621.315.611 **2994**

**Dielectric Image Line.**—D. D. King. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 699–700.) A modification of the dielectric-rod waveguide investigated by Chandler (1079 of 1950) and Elsasser (1080 of 1950) is discussed; it consists of a rod with half-round section lying on a conducting image plane. The influence of rod diameter on the field is indicated. Values determined by experiment and by calculation are given for the attenuation of a polystyrene line of diameter 0·42 cm on an image plane of width 20 cm, for use at 1·23-cm wavelength.

621.396.67 **2995**

**Radiation Characteristics of Helical Antennas of Few Turns.**—O. C. Haycock & J. S. Ajioka. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 989–991.) Square helices suitable for ionosphere measurements at 3–8 Mc/s are considered. An investigation is made of the resistance loading required to obtain circularly polarized axial radiation from a single-turn aerial.

621.396.67 **2996**

**Radiation Characteristics of a Turnstile Antenna Shielded by a Section of a Metallic Tube Closed at One End.**—A. Baños, Jr, D. S. Saxon & L. L. Bailin. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 688–696.) The system examined comprises a pair of crossed wires arranged transversely within a circular waveguide, the two wires being excited by voltages with a 90° phase difference. The waveguide is first considered to be infinitely long, and the conditions are determined under which only the dominant ($TE_{11}$) mode is important. The case is then considered of the semi-infinite waveguide, excited in the $TE_{11}$ mode, radiating into free space. Using a solution found by Levine & Schwinger (1845 of 1948 and an unpublished paper), values of reflection coefficient and gain function were calculated at the N.B.S. Institution for Numerical Analysis. These results are compared with values found experimentally and by the Kirchhoff method.

621.396.67 **2997**

**The Radiation Resistance of a Dipole near an Ellipsoid of Revolution with Good Conductivity.**—R. G. Mirimanov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1951, Vol. 80, No. 2, pp. 189–192. In Russian.) A formula (29) is derived expressing the radiated power of a dipole arranged along the axis of revolution of the ellipsoid. The case where the dipole is arranged perpendicular to the axis can be treated in a similar manner.

621.396.67 : 621.396.933.1 **2998**

**Cage-Type Very-High-Frequency Phase-Comparison Omnidirectional Radio Range Antenna.**—Lundburg & Bucher. (See 3097.)

621.396.67.011.21 **2999**

**Self and Mutual Impedances of Parallel Identical Antennas.**—R. King. (*Proc. Inst. Radio Engrs*, Aug.

1952, Vol. 40, No. 8, pp. 981–988.) A method is presented in which the impedance of an isolated aerial is determined with second-order accuracy while the mutual impedance due to the coupled aerial is determined with first-order accuracy. The values obtained are shown in numerous curves.

621.396.67.012.71 **3000**

**Universal Method of Calculating the Radiation Distribution of Electric and Magnetic Dipoles, as well as Slot and Reflector Aerials, by means of Kirchhoff's Formula.**—H. Kleinwächter. (*Arch. elekt. Übertragung*, June 1952, Vol. 6, No. 6, pp. 247–253.) Many different methods have hitherto been used for determining the radiation characteristics of different types of aerial. It is here shown that Kirchhoff's formula is applicable in general; its use for the different types of aerial mentioned is outlined and suitable formulae are derived.

621.396.67.029.63 **3001**

**Some Types of Omnidirectional High-Gain Antennas for use at Ultra-high Frequencies.**—J. Epstein, D. W. Peterson & O. M. Woodward, Jr. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 137–162.) A description is given of the construction and operation of the following three u.h.f. transmitting aerials for operation in the frequency band 500–900 Mc/s: (*a*) a cylindrical multi-slot aerial, (*b*) an inverted turnstile aerial, (*c*) a disk-loop aerial. The elements of (*a*) and (*b*) are fed in quadrature and those of (*c*) in phase. The primary disadvantages of all three systems are their frequency sensitivity and the multiplicity of feed points. The use of quadrature feed facilitates the matching of input transmission lines, the maintenance of equal division of power in the radiating elements, and the diplexing of two signals into a common aerial.

621.396.677 **3002**

**A Method for Calculating the Current Distribution of Tschebyscheff Arrays.**—D. Barbiere. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, p. 991.) Corrections to paper noted in 1211 of May.

621.396.677 **3003**

**Relay Aerials for the Decimetre Waveband.**—G. Voigt. (*NachrTech.*, April 1952, Vol. 2, No. 4, pp. 108–112.) An estimate is made of the efficiency of a pair of directive dm-wave aerials used at a relay station, and possible substitutes consisting of refracting prisms are described. One of these consists essentially of an assemblage of square-section waveguides whose lengths change gradually from the base to the vertex of the prism. The other prism is of the Venetian-blind type producing double reflections of the incident wave. Theory of the action of such prisms is given and design parameters are determined for prescribed deviation of an e.m. wave. A model prism of height 3 m and width 2 m, designed for wavelengths of 20–25 cm, gave results in good agreement with theory. Application possibilities are briefly discussed.

621.396.677 **3004**

**Lattice Lenses for Centimetre Waves.**—J. Moussiegt. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2178–2179.) Discussion of the principles of lenses based on diffraction by metal particles arranged at the nodes of a lattice such that the divergent waves issuing from a point source are rendered parallel. For this to be possible, the nodes must be located on paraboloids of revolution having the direction of the diffracted beam as common axis, the nodes being on the intersections of these paraboloids with a set of equidistant planes normal to the axis. The total number of diffracting particles required is much less than the number used in a lens of the artificial-dielectric type. Resonant $\lambda/2$ dipoles consisting of narrow thin metal strips may be used instead of metal particles, the strips being parallel to one another and lying in the nodal planes, thus fixing the polarization of the emergent wave.

621.396.677 **3005**

**General Theory of Electromagnetic Horns.**—A. F. Stevenson. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 599–600.) Corrections to paper abstracted in 1841 of July.

621.396.677.012 **3006**

**The Radiation Pattern of an Antenna over a Circular Ground Screen.**—J. E. Storer. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 588–593.) Using previously developed formulae for the input impedance of an aerial over a finite ground screen, an expression is obtained for the entire radiation pattern. Simple formulae are derived for the number of lobes, their angular position, and the angle within which they occur.

## CIRCUITS AND CIRCUIT ELEMENTS

621.3.015.7 **3007**

**A Note on the Reproduction of Pulses.**—D. K. Cheng. (*Proc. Inst. Radio Engrs*, Aug. 1951, Vol. 40, No. 8, pp. 962–965.) A discussion of the relative significance of rise time and percentage energy content of rectangular pulses. For a single pulse the value of rise time is different from that for a train of periodic pulses.

621.3.015.7 : 621.317.755 **3008**

**A Single-Channel Pulse-Height Discriminator of High Speed and Stability.**—G. T. Wright. (*J. sci. Instrum.*, May 1952, Vol. 29, No. 5, pp. 157–160.) Each pulse and its differential are applied to the $x$ and $y$ plates respectively of a c.r.o. whose screen is scanned in the $x$ direction with a narrow optical slit and photomultiplier. The pulse-height distribution is displayed on a second c.r.o. The equipment is free from zero drift, and from drift of channel width.

621.3.015.7 : 621.387.4 **3009**

**A Fast Amplitude Discriminator and Scale-of-Ten Counting Unit for Nuclear Work.**—F. H. Wells. (*J. sci. Instrum.*, April 1952, Vol. 29, No. 4, pp. 111–115.) Description of an instrument which can accept randomly spaced pulses at a rate up to $10^6$/sec; the dead time after each recorded pulse is $0{\cdot}25 \pm 0{\cdot}05\ \mu s$. The scaling circuit uses the technique of step charging a capacitor by the discriminator output pulses. A new clamping circuit is used to eliminate the effects of capacitor charge leakage.

621.3.015.7 : 621.387.422 **3010**

**Pulse-Amplitude Analyzers for Spectrometry.**—G. G. Kelley. (*Nucleonics*, April 1952, Vol. 10, No. 4, pp. 34–37.) The design of multichannel analysers for counting rates of $10^4$–$2 \times 10^4$ per sec is discussed.

621.314.22.015.7 **3011**

**New Pulse Transformer gives Faster Response.**—(*Tech. Bull. nat. Bur. Stand.*, May 1952, Vol. 36, No. 5, pp. 78–79.) The anode, grid and output windings of the transformer consist respectively of 13, 12, and 6 turns of 24-gauge enamelled Cu wire on a toroidal ferrite core of diameter $< 1$ in. The anode and grid windings are wound together to obtain very tight inductive coupling. Used in a conventional blocking-oscillator circuit with a 500-$\Omega$ load, the measured pulse width was $< 0{\cdot}06\ \mu s$, the rise time from 0 to 90 V was $< 0{\cdot}02\ \mu s$, output impedance about 100 $\Omega$, and peak pulse power about 20 W.

621.314.3† 3012

**Predicting Magnetic-Amplifier Control Curves.**—H. Lehmann. (*Elect. Engng, N.Y.*, April 1952, Vol. 71, No. 4, p. 311.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part II.

621.314.3† 3013

**Response Time of Magnetic Amplifiers.**—E. L. Harder & W. F. Horton. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1130–1138. Discussion, pp. 1138–1141.) Theoretical and experimental information on response time is presented, the various factors involved are reviewed, and proposals are made for the treatment of response time in definitions and standards.

621.314.3† 3014

**A Mathematical Analysis of Parallel-Connected Magnetic Amplifiers with Resistive Loads.**—L. A. Pipes. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 625–629.)

621.314.3† 3015

**Series-Connected Saturable Reactor with Control Source of Comparatively High Impedance.**—H. F. Storm. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1299–1309.) The results of mathematical analysis are presented in normalized graphs which enable the effect of any circuit parameter to be readily determined. A numerical example illustrates the use of the graphs.

621.314.3† 3016

**Determination of Steady-State Performance of Self-Saturating Magnetic Amplifiers.**—E. J. Smith. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1309–1317.) Analysis for the half-wave circuit is extended to full-wave and doubler circuits. Effects of rectifier leakage and control-circuit impedance are computed for each type of circuit and transfer curves are determined for practical conditions. Numerical results are given for amplifiers with orthonik and hypersil cores.

621.314.634 : 621.318.57 3017

**Miniature Rectifier Computing and Controlling Circuits.**—An Wang. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 931–936.) Circuits are described incorporating Se rectifier elements and capable of operating at very high speed. Highly compact constructions have been developed.

621.316.86 : 537.312.6 3018

**The Pressure Coefficient of Resistance of Thermistors.**—A. D. Misener & L. G. D. Thompson. (*Canad. J. Technol.*, April 1952, Vol. 30, No. 4, pp. 89–94.) The pressure coefficient of resistance of one type of thermistor used for underground temperature measurements was determined experimentally at pressures up to 2 000 lb/in.$^2$ at temperatures of 0°, 25° and 50°C. The coefficient appears to be independent of temperature, but decreases with increase of pressure. For temperature measurements to be accurate to within $\pm$ 0·1°C a pressure correction is necessary even under moderate pressures.

621.316.935.1 3019

**The Design of Reactors for Radio-Interference Filters.**—L. I. Knudson. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1294–1298.) Discussion of various useful types of inductor, with graphical presentation of data for available core materials. Composite cores are shown to be particularly useful in certain cases, both for toroids and straight inductors.

621.319.4 3020

**Pyralene-Impregnated-Paper Capacitors for Alternating Current. Factors affecting Capacitance and Losses.**—J. Coquillion. (*Rev. gén. Élect.*, May 1952, Vol. 61, No. 5, pp. 205–213.) The discussion is confined to capacitors using kraft paper. Losses are greater at very low voltage than at nominal voltage, and their value is an indication of the ionic purity of the impregnant. At nominal voltage losses depend only on paper characteristics and on the permittivity of the impregnant.

621.392 3021

**RC Coupling Networks.**—G. Bowers. (*Radio & Televis. News, Radio-Electronic Engng Section*, June 1952, Vol. 47, No. 6, p. 32.) Nomogram for finding phase-shift and attenuation.

621.392 3022

**An Optimization Theory for Time-Varying Linear Systems with Nonstationary Statistical Inputs.**—R. C. Booton, Jr. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 977–981.)

621.392 3023

**Circuits with Frequency-Dependent Resistance and Frequency-Independent Reactance.**—H. Fricke. (*Funk u. Ton*, May 1952, Vol. 6, No. 5, pp. 225–234.) By connecting between the voltage divider and the valve grid in a normal reactance circuit a device producing a grid-voltage phase shift of $\pm$ 90°, the frequency-dependence characteristics of the resistive and reactive components of the impedance are interchanged, so that between the reactance-valve terminals a series arrangement of a frequency-dependent resistance and a frequency-independent reactance is obtained, whose magnitudes can be varied by altering the slope of the valve characteristic. The magnitudes and frequency dependence of the resistive and reactive components are calculated for various possible arrangements, and the design of the phase shifter is considered, with discussion of the effects produced by departure of the phase shift from its nominal value.

621.392 3024

**Network Synthesis by the Use of Potential Analogs.**—R. E. Scott. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 970–973.)

621.392.4 3025

**Two-Terminal Networks consisting of Reactively Connected Valves.**—F. Broch-Toniolo. (*Poste e Telecomunicazioni*, May 1952, Vol. 20, No. 5, pp. 215–220.) The equivalent circuit is determined for a valve whose grid voltage is derived by means of a potential divider from the anode voltage. Operation as generator, reactance, or variable resistance is considered. Reactance-valve arrangements with high values of inductance and very low values of capacitance are attainable.

621.392.4 3026

**Equivalences for the Analysis of Circuits with Small Nonlinearities.**—W. J. Cunningham. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 653–657.) When the amount of nonlinearity is not too large, the nonlinear element can be replaced by a linear resistance together with voltage or current generators. The analysis can be applied to a highly nonlinear element if a suitable linear resistance is connected in parallel with it. Calculations for a Type-1N34 crystal diode in parallel with a 50-Ω resistor are reported.

621.392.43.018.424 3027

**Wide-Band Transformation at High Frequencies.**—(*Fernmeldetech. Z.*, June 1952, Vol. 5, No. 6, pp. 252–255.) The design and performance of band-pass coupling circuits discussed previously (1613 of 1950), and developments of these, are reviewed. Curves show the relative error likely to occur in practice as a function of bandwidth for different circuit arrangements giving transformation ratios of 2, 3 and 4.

621.392.5 **3028**

**A General Theory of Linear Signal-Transmission Systems.**—L. A. Zadeh. (*J. Franklin Inst.*, April 1952, Vol. 253, No. 4, pp. 293–312.) Full treatment of the analytical method outlined in 1225 of May. Detailed discussions of various aspects of the theory and its practical applications are to be given in subsequent papers.

621.392.5 **3029**

**A New Approach in the Design of Equalized Filters and Delay Lines.**—M. M. Levy. (*J. Brit. Instn Radio Engrs*, May 1952, Vol. 12, No. 5, pp. 317–320.) The phase characteristics of filter networks and delay lines can be equalized by bridging mutual-inductance sections with capacitors. The corresponding *n*th-order equations are difficult to solve, but an approach which considers the transient response yields a simple solution. See also British Patent No. 614720 and Abstract 1746 of 1948 (Espley).

621.392.5 **3030**

**Quadripole Theory, a Fresh Approach.**—M. Skalicky. (*Elektrotech. u. Maschinenb.*, 15th May 1952, Vol. 69, No. 10, pp. 239–242.) The network equations of Wilberforce [see 1536 of 1944 (Skalicky)] are developed for a quadripole in a simple form involving only three parameters: (*a*) the voltage step-up ratio with output terminals on open circuit, (*b*) the input impedance with open-circuited output, (*c*) the output impedance with input terminals short-circuited. A simple expression is derived for the current in any branch of a network fed with a single terminal voltage.

621.392.5 **3031**

**Equivalent Circuits of the Nonreversible Quadripole.**—W. Klein. (*Arch. elekt. Übertragung*, May 1952, Vol. 6, No. 5, pp. 205–208. Corrections, *ibid.*, Aug. 1952, Vol. 6, No. 8, p. 351.) Schulz's network-matrix analysis (68 of January) is extended to obtain generalized theory for quadripoles violating the reciprocity relation. The equivalent circuit of the nonreversible quadripole is derived as a generalized L, T or Π circuit by introducing a coupling element termed a 'dual converter' ('Dualübersetzer') comprising three ideal valves and a complex impedance. This circuit element is also useful in designing transformers with complex transformation ratio. The admittance matrix of the quadripole can also be used for deriving an equivalent circuit.

621.392.5 : [621.396.645 + 621.317.733 **3032**

**Particular Applications of Single-T and Double-T Networks.**—B. Lavagnino. (*Alta Frequenza*, June 1952, Vol. 21, No. 3, pp. 116–129.) Description of (*a*) a 3-stage RC-coupled amplifier in which high selectivity is achieved by application of feedback through a T network either to input grids or cathodes, (*b*) a bridge of T-network type for the measurement of capacitance and losses at audio and ultrasonic frequencies, and suitable for tests on capacitors with a guard electrode.

621.392.52 **3033**

**Design of Channel Filters using Quartz Crystals.**—N. Valentini. (*Poste e Telecomunicazioni*, May 1952, Vol. 20, No. 5, pp. 221–228.) A new quick method of designing lattice filters is described in detail and illustrated with examples.

621.392.52 : 534.113 **3034**

**Study of a Narrow-Band Electromechanical Filter.**—A. Marro. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Feb. 1952, Vol. 30, No. 2, pp. 41–50. In French.) The type of filter considered consists of one or more units formed of parallel pairs of steel rods supported so as to be capable of lateral vibration, electromechanical transformers being used at the ends for conversion from electrical to mechanical oscillations and vice versa. Theory is based on purely mechanical considerations, and design formulae are derived which involve the dimensions and physical constants of the rods. Comparison is made with equivalent electrical-network filters. The action of the transformers is explained and a description is given of a complete 3-unit filter using rods of Swedish steel, with details of the methods of adjustment of frequency and bandwidth. Practical applications in carrier-frequency telephony and frequency-shift telegraphy are discussed briefly.

621.392.52 : 621.396.611.21 **3035**

**A Mode of Operation of a Simple Quartz Filter.**—J. Marique. (*HF, Brussels*, 1952, Vol. 2, No. 2, pp. 29–33.) Analysis is presented for a simple bridge-type crystal filter in which the impedance constituting the median arm of the bridge is a very high resistance (R). This type of filter is often used in superheterodyne receivers. The analysis shows that the selectivity of such a filter approaches that of the crystal itself, and that the gain can be greater than unity, which is not the case if R is small.

621.392.52 : 621.396.67.029.63 **3036**

**Separating Networks for the Operation of Several Decimetre-Wave Radio Sets on One Aerial.**—G. Pusch. (*Fernmeldetech. Z.*, June 1952, Vol. 5, No. 6, pp. 262–268.) Tuned-cavity couplings are described. Practical designs for both series- and parallel-connected networks for transmitter-transmitter and transmitter-receiver operation are illustrated. These operate satisfactorily when the frequency separation is > 7 Mc/s.

621.392.52.025.4 **3037**

**Synthesis of Polyphase RC Filters.**—G. B. Madella. (*Alta Frequenza*, June 1952, Vol. 21, No. 3, pp. 130–136.) A method for the synthesis of polyphase filters with prescribed transfer characteristics is described and applied to a practical example. A particular feature of polyphase filters is their ability to discriminate positive from negative frequencies.

621.392.52.072.6 **3038**

**Alignment and Adjustment of Synchronously Tuned Multiple-Resonant Circuit Filters.**—M. Dishal. (*Elect. Commun.*, June 1952, Vol. 29, No. 2, pp. 154–164.) Reprint. See 627 of March.

621.396.6 **3039**

**Nonlinear Elements and Applications in A.F. and R.F. Circuits.**—H. E. Hollmann. (*Tele-Tech*, April & May 1952, Vol. 11, Nos. 4 & 5, pp. 46–47, 127 & 56–57 . . 128; *Proc. nat. Electronics Conf., Chicago*, 1951, Vol. 7, pp. 130–140.) Discussion of the properties and applications of saturable reactors, ferroelectric capacitors, and varistors, including the 'polaristor'. See also 2538 of September.

621.396.611.1 + 534.01 **3040**

[Oscillations in] **Delayed-Action Systems.**—N. Minorsky. (*C. R. Acad. Sci., Paris*, 12th May 1952, Vol. 234, No. 20, pp. 1945–1947.) Treatment of the differential equations for self-maintained oscillations in dynamic (mechanical or electrical) systems is simplified by use of what is termed a 'stroboscopic' method, an account of which has previously been given (2951 of 1951).

621.396.611.1 **3041**

**The Response of RLC Resonant Circuits to E.M.F. of Sawtooth Varying Frequency.**—J. Marique. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 945–950.) Analysis previously given by Hok (671 of 1949) for the case of a single frequency sweep is extended to the case where the frequency sweep is repeated as, e.g., in frequency analysers. The response is composed of two terms, one related to the instantaneous conditions and the other resulting from the preceding frequency sweeps. Response curves obtained by graphical integration are compared with curves computed by other authors. The influence of the limits of exploration is discussed.

621.396.611.4.017.21 **3042**

**Surface Losses in Electromagnetic Cavity Resonators.**—I. Paghis. (*Canad. J. Phys.*, May 1952, Vol. 30, No. 3, pp. 174–184.) The effective skin resistance of brass was determined at microwave frequencies by means of $Q$ measurements. The results are in essential agreement with theory, provided the surface treatment is confined to polishing by hand. The effect of surface scratches was found to be small compared with the effect of distortion of the crystal lattice due to surface working.

621.396.615 **3043**

**The Frequency Spectrum of a Pulled Oscillator.**—T. J. Buchanan. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 958–961.) Experiments are described in which a signal from a Type-CV87 reflex klystron is injected into the circuit of the oscillator valve under test, the two generators being mounted at opposite ends of a waveguide. A loosely coupled probe feeds part of the output to a c.r.o. spectrometer, the effect of varying the klystron wavelength around the centre value of 3·2 cm being studied. The results are discussed on the basis of theory previously worked out by Adler (2522 of 1946).

621.396.615.029.3 : 621.385.5 **3044**

**Simultaneous Generation of Several Audio-Frequency Oscillations by means of Electron Coupling in a Multi-electrode Valve.**—W. Spengler & H. H. Rust. (*Arch. elekt. Übertragung*, June 1952, Vol. 6, No. 6, pp. 254–261.) A frequency multiplier is described which produces four frequencies simultaneously. The fundamental frequency is generated in a feedback circuit using grids 1 and 2 of a hexode, the higher frequencies being produced by shock excitation of oscillatory circuits connected to the other electrodes and tuned to required harmonics. Nearly sinusoidal oscillations can be obtained by use of loosely coupled filters to minimize modulation of the harmonics by the fundamental. Design of circuit components to obtain optimum results is discussed.

621.396.615.12 **3045**

**A High-Frequency Generator with Uniform RC-Line as Feedback Element determining the Frequency.**—F. W. Gundlach. (*Funk u. Ton*, June 1952, Vol. 6, No. 6, pp. 298–304.) Description, with full circuit details, of a generator with a continuous range of 0·1–1·5 Mc/s. The output of 3 V into 200 Ω is constant to within 10% over the whole range. Frequency variation is effected by varying the capacitance of the RC-line, which is of simple mechanical construction.

621.396.615.14 : 621.385.3 **3046**

**Ultra-High-Frequency Triode Oscillator using a Series-Tuned Circuit.**—J. M. Pettit. (*Proc. Instn Radio Engrs, Aust.*, May 1952, Vol. 13, No. 5, pp. 132–135.) Reprint. See 2452 of 1950.

621.396.615.141.2 : 621.316.729 **3047**

**An Analysis of the Injection Locking of Magnetrons used in Amplitude-Modulated Transmitters.**—J. S. Donal, Jr, & K. K. N. Chang. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 239–257.) Analysis is presented for an anode-modulation single-loop magnetron, with load matched to the transmission line and the synchronizing current injected at a plane distant $\lambda/2$ from the magnetron. The r.f. phase modulation during the a.m. cycle is calculated and the power output required from the locking oscillator is determined. For a particular magnetron, using a locking amplifier capable of a power output of 10% of the peak system output, the expected r.f. ph.m. is about $\pm$ 20° for an a.m. factor of 0·74.

621.396.615.17.029.63 **3048**

**Tetrodes improve Harmonic Generation at V.H.F. and U.H.F.**—D. H. Preist. (*Tele-Tech*, April 1952, Vol. 11, No. 4, pp. 60–61 . . 123.) Description of the performance of tetrodes such as Type 4X150A and Type 4X150G with positive feedback, for frequency multiplication at high power levels.

621.396.619.13 : 621.392.5 **3049**

**Contribution to the Theory of Frequency-Modulated Signals in Linear Networks.**—L. Kosten. (*Tijdschr. ned. Radiogenoot.*, May 1952, Vol. 17, No. 3, pp. 117–133.) By using the concepts of negative resistance and inductance, any linear network can be transformed into one containing no capacitances, whose operation can then be expressed by first-order differential equations. Matrix theory is used in combination with this transformation to determine the output current of a linear quadripole fed with a frequency-modulated wave. The formula derived is a series differing from those of Carson & Fry (464 of 1938) and Stumpers (2221 of 1947) in that it is convergent and contains finite differences rather than derivatives of the transadmittance.

621.396.645 **3050**

**Effective Bandwidth of Video Amplifiers.**—F. J. Tischer. (*Arch. elekt. Übertragung*, June 1952, Vol. 6, No. 6, pp. 241–246.) An expression for the effective bandwidth is derived directly from the complex amplification function for steady-state oscillations, taking account of phase shift and phase errors. The effective bandwidths for theoretical standard amplifier functions give a good idea as to the bandwidth to be expected in practical amplifiers and what improvement can result from compensation of the phase errors.

621.396.645.371 **3051**

**Negative Feedback.**—W. O. Baldwin. (*Proc. Radio Cl. Amer.*, 1952, Vol. 29, No. 2, pp. 3–11.) The use of negative feedback for amplifier gain stabilization, distortion reduction, and improvement of frequency response and phase characteristics is considered, frequency and phase characteristics being specially dealt with, since if they are known the gain and distortion characteristics can be quickly calculated. A particular feature of the treatment is the use of curves showing the reciprocal of the gain plotted against frequency. This has the advantage of eliminating the addition and division of vectors necessary when gain/frequency curves are used.

## GENERAL PHYSICS

530.162 : 519.21 **3052**

**A Generalization of the Classical Random-Walk Problem, and a Simple Model of Brownian Motion based thereon.**—G. Klein. (*Proc. roy. Soc. Edinb. A*, 1950/1951, Vol. 63, Part 3, pp. 268–279.) A precise mathematical model of Brownian motion is derived by introducing a 'persistence' factor in analysis of the random-walk problem. This is equivalent to the assumption of a discrete velocity distribution of three variates instead of the continuous probability distribution formerly assumed. General results concerning averages are obtained and applied to special cases of conservative and dissipative systems.

535.223 **3053**

**The Velocity of Light determined by the Band Spectrum Method.**—D. H. Rank, R. P. Ruth & K. L. Vander Sluis. (*Phys. Rev.*, 1st June 1952, Vol. 86, No. 5, p. 799.) Preliminary account of a determination based on observations of the 103 and 004 bands of HCN; the value of $c$ obtained is 299 776 $\pm$ 7 km/s.

535.37 + 535.215 **3054**

**The Physics of Crystal Phosphors.**—F. Stöckmann. (*Naturwissenschaften*, May & June 1952, Vol. 39, Nos. 10 & 11, pp. 226–233 & 246–254.) A comprehensive study with 63 references.

535.376 **3055**

**Electroluminescence observed in the Anodic Polishing of Zinc.**—M. Krieg & E. Lange. (*Naturwissenschaften*, May 1952, Vol. 39, No. 9, p. 208.)

535.42 : 538.56 **3056**

**On the Diffraction of an Electromagnetic Pulse by a Wedge.**—J. W. Miles. (*Proc. roy. Soc. A*, 22nd May 1952, Vol. 212, No. 1111, pp. 547–551.) The vector problem of the diffraction of a plane wave discontinuity with arbitrary polarization and direction of propagation is reduced to a pair of two-dimensional scalar problems. The solution of one of these is identical with that previously obtained for the analogous acoustical problem (2966 above); the second problem is treated in a similar manner, using a Tschplygin transformation to reduce the boundary-value problem to one in potential theory, which is then solved by classical methods.

535.421 : 538.566 **3057**

**Electromagnetic Reflection and Transmission by Gratings of Resistive Wires.**—E. A. Lewis & J. P. Casey, Jr. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 605–608.) Honerjäger's theory (1754 of 1949) is extended to take account of the finite conductivity of the wires. Formulae and charts are given to facilitate calculations, and a practical example is worked out.

537.11 : 537.226 **3058**

**The Physical Mechanism of Charge in Solid Dielectrics.**—H. Bonifas. (*Rev. gén. Élect.*, May 1952, Vol. 61, No. 5, pp. 223–231.)

537.122 **3059**

**A New Classical Theory of Electrons: Part 2.**—P. A. M. Dirac. (*Proc. roy. Soc. A*, 7th May 1952, Vol. 212, No. 1110, pp. 330–339.) Analysis of the motion of a stream of electrons obeying Lorentz's equations of motion leads to a more general action principle than that of an earlier paper (1574 of June), two new field variables being introduced. The theory allows vorticity in the electron stream, while still involving $e$ and $m$ only in the ratio $e/m$. A Hamiltonian formulation of the equations is deduced.

537.311.31 + 537.312.62 **3060**

**The High-Frequency Resistance of Metals in the Normal and Superconducting State.**—C. J. Grebenkemper & J. P. Hagen. (*Phys. Rev.*, 1st June 1952, Vol. 86, No. 5, pp. 673–679.) Measurements were made on Pb, In and Sn at frequencies of about 9 kMc/s and on Sn at 24 kMc/s, using resonant-cavity techniques which are described. The influence of surface finish is investigated. Results for the metals in the normal state support the Reuter-Sondheimer theory of the anomalous skin effect; for the superconducting state the h.f. resistance varied with frequency according to a 3/2-power law rather than the theoretically predicted square law.

537.311.33.001.11 **3061**

**Carrier Concentrations and Fermi Levels in Semiconductors.**—J. S. Blakemore. (*Elect. Commun.*, June 1952, Vol. 29, No. 2, pp. 131–153.) Review of present-day semiconductor theory. 23 references.

537.312.6 : 621.315.592 **3062**

**Tentative Explanation of the Law giving the Resistance of Thermistors as a Function of the Temperature.**—Y. Doucet & J. P. Guignard. (*C. R. Acad. Sci., Paris*, 5th May 1952, Vol. 234, No. 19, pp. 1856–1858.)

537.525 : 538.56 **3063**

**A Nonlinear Theory of Oscillations in an Electron Plasma.**—A. I. Akhiezer & G. Ya. Lyubarski. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1951, Vol. 80, No. 2, pp. 193–195. In Russian.)

537.525 : 621.396.822 **3064**

**Observations on Radio-Frequency Oscillations in Low-Pressure Electrical Discharges.**—N. R. Labrum & E. K. Bigg. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 356–368.) Random noise of high intensity was observed at frequencies near 200 Mc/s and also below 2 Mc/s in several types of discharge tube, and was found to be associated with a field reversal in the discharge. Coherent oscillations were also found at low radio frequencies, and these are apparently related to the striations of the positive column.

537.525.001.11 **3065**

**The Initiation of Electrical Breakdown in Vacuum.**—L. Cranberg. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 518–522.) The hypothesis is suggested that initiation of high-voltage breakdown in vacuum is due to traversal of the high-voltage gap by a clump of loosely adhering material. A summary of published results which support this conclusion is presented.

537.525.5 **3066**

**The Theory of Gaseous Arcs: Part 1 — The Fundamental Relations for the Positive Columns.**—K. S. W. Champion. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 329–344.) Theory is developed for low-pressure arcs with high electron densities in which ionization by stages is important. By taking account of recombination, this theory can be applied to medium- and high-pressure arcs with high degree of ionization. The theory includes the effect of a longitudinal magnetic field.

537.525.5 **3067**

**The Theory of Gaseous Arcs: Part 2 — The Energy-Balance Equation for the Positive Columns.**—K. S. W. Champion. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 345–356.) The energy-balance equation proposed by Suits is considered and modifications of his theory are suggested which result in better agreement between theory and experiment. Radiation losses are neglected, since in most cases measurement shows them to be small. Theory of the effect of a longitudinal magnetic field on a high-pressure arc predicts that the effect will tend to a limit with sufficiently strong fields. Part 1: 3066 above.

537.525.5 : 621.385.132 **3068**

**Studies of Externally Heated Hot-Cathode Arcs: Part 2 — The Anode-Glow Mode.**—W. M. Webster, E. O. Johnson & L. Malter. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 163–182.) In this mode all ionization and excitation occur in a thin electron sheath close to the anode surface. Theory indicates that the electron current should vary as the fourth power of the difference between the applied potential and the ionization potential of the gas in the discharge tube. Experiment confirms this. Evidence is presented to show that the plasma density distribution is one in which the lowest diffusion mode predominates. Part 1: 959 of April.

537.533.8 **3069**

**Theory of the Production of Secondary Electrons in Solids.**—A. J. Dekker & A. van der Ziel. (*Phys. Rev.*, 1st June 1952, Vol. 86, No. 5, pp. 755–760.) The problem is formulated on the assumption of a simple Coulomb interaction between primary electrons and lattice electrons; the energy losses of the bombarding primaries are examined. The basic features of previously presented theories are discussed as approximations to the present formulation. The numbers of secondaries emitted according to Wooldridge's theory (147 of 1940) and Baroody's theory (107 of January) are compared, and the range of applicability of their approximations is discussed.

537.58 : 538.221 **3070**

**Thermionic Emission from Ferromagnetic Materials.**—A. V. Sokolov & A. Z. Veksler. (*C. R. Acad. Sci. U.R.S.S.*, 1st Nov. 1951, Vol. 81, No. 1, pp. 27–30. In Russian.) The anomalous variation with temperature of the thermionic emission from ferromagnetic materials may be due to disappearance of spontaneous magnetization when passing through the Curie point. On this assumption, and using the model of the exchange interaction between the valence and inner electrons proposed by Vonsovski (2074 of 1947), a formula (15) is derived showing the temperature dependence of the saturation current and its deviation from the normal temperature dependence (16).

538.122 + 537.212 **3071**

**The Two-Dimensional Magnetic or Electric Field inside a Semi-infinite Slot terminated by a Semicircular Cylinder.**—N. Davy & N. H. Langton. (*Brit. J. appl. Phys.*, May 1952, Vol. 3, No. 5, pp. 156–158.) Exact calculations, with tables and graph of results.

538.249 **3072**

**Theory of Magnetic Diffusion After-Effect.**—L. Néel. (*J. Phys. Radium*, May 1952, Vol. 13, No. 5, pp. 249–264.)

621.3.011.4 **3073**

**Calculation of the Electrostatic Capacitance of a Conductor.**—W. Gross. (*R. C. Accad. naz. Lincei*, May 1952, Vol. 12, No. 5, pp. 496–506.)

## GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.72 + 523.8] : 621.396.822 **3074**

**Radio Astronomy.**—(*Engineer, Lond*, 9th May 1952, Vol. 193, No. 5024, pp. 640–641.) A brief survey including a note about the 265-ft steerable radio telescope planned to be installed at Jodrell Bank for Manchester University.

523.72 : 621.396.822 **3075**

**Solar Radio-Noise Bursts.**—(*Tech. Bull. nat. Bur. Stand.*, May 1952, Vol. 36, No. 5, pp. 65–67.) Radio-astronomy methods were used for observation of the radio-noise bursts, which are considered to originate in the many high-velocity streams of ionized plasma in the corona, being the result of the direct conversion of the kinetic energy in the plasma to e.m. energy. Some evidence indicates correlation of the noise bursts with sudden ionosphere disturbances, and they also tend to accompany, precede or follow flurries of solar activity.

523.72 : 621.396.822.029.65 **3076**

**Detection of Millimeter Wave Solar Radiation.**—W. M. Sinton. (*Phys. Rev.*, 1st May 1952, Vol. 86, No. 3, p. 424.) Solar radiation over a band with an average wavelength of 1·4 mm was detected by allowing the sun to drift across the field of a mm-wave telescope, a Golay infrared detector being used at the focus of a modified 24-in. searchlight. Typical records are shown.

523.78 **3077**

**Observations of the Solar Eclipse of 25th February 1952 in the Sudan.**—H. von Klüber. (*Naturwissenschaften*, May 1952, Vol. 39, No. 9, pp. 199–206.) Illustrated account of the equipment of different research groups and their programme of observations.

550.38 "1952.04/.06" **3078**

**Indices of Geomagnetic Activity of the Observatories Abinger, Eskdalemuir and Lerwick, April to June 1952.**—(*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 5, pp. 306–308.)

551.510.535 **3079**

**A Search for Radio Echoes of Long Delay.**—K. G. Budden & G. G. Yates. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 5, pp. 272–281.) An account of attempts to detect long-delay echoes of the type reported by Størmer (1929 Abstracts, pp. 38, 565 & 623) and others. High-power transmitters operating on frequencies of approximately 13·5 and 20·7 Mc/s were used, but no long-delay echoes were observed. Possible explanations of this failure are suggested.

551.510.535 **3080**

**A Method for studying Sporadic-E Clouds at a Distance.**—O. G. Villard, Jr, A. M. Peterson & L. A. Manning. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 992–994.) A pulsed transmitter is used in conjunction with a rotatable Yagi aerial to track moving clouds of sporadic-E by means of the back-scattered echoes, which are displayed on a plan position indicator. P.p.i. photographs obtained at Stanford University on 15th December 1951 are shown together with the corresponding *h'f* records.

551.510.535 **3081**

**The Graphical Representation of the Longitude Effect in $F_2$ Region.**—C. M. Minnis. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 5, pp. 261–265.) Discussion leads to the conclusion that for commercial use the best solution of the problem would be a set of hourly charts each showing the $fF_2$ distribution at a fixed universal time.

551.510.535 : 551.557 **3082**

**A Radio-Astronomical Investigation of Winds in the Upper Atmosphere.**—A. Maxwell & C. G. Little. (*Nature, Lond.*, 3rd May 1952, Vol. 169, No. 4305, pp. 746–747.) Results of observations using three receivers at the corners of a triangle (spacing about 4 km) indicate that F-region irregularities have a steady translational movement, which is usually maintained in the same direction for many hours. During May–June and September–October 1951 the most favoured direction was towards the west, the variation in direction during a 4-hour period being generally $<25°$ and the average velocity about 350 km/hr.

551.510.535 : 551.557 **3083**

**A Radio Echo Method for the Investigation of Atmospheric Winds at Altitudes of 80 to 100 km.**—J. S. Greenhow. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 5, pp. 282–291.) The variations of wind velocity with height between altitudes of 80 and 100 km can be determined from the fluctuations in amplitude and the changes in width of the recorded radio echoes from meteor trails. Results of observations are presented, with typical records, and discussed.

551.510.535 : 621.3.087.4 **3084**

**Study and Design of an Ionospheric Radar Sounder.**—M. Geffroy. (*Radio franç.*, May 1952, No. 5, pp. 16–24.) Full circuit details are given of a vertical-incidence recorder with transmitter peak power of 2 kW, frequency range 5–10 Mc/s, pulse width 100 $\mu$s and repetition frequency 50/sec. The control circuits are shown and the derivation of pulses of different waveform for c.r.o. calibration and transmitter switching is described stage by stage. The construction of a pulse transformer for anode modulation is illustrated. A complete circuit diagram of the receiver is given.

551.594.22 **3085**

**The Relation between Point Discharge Current and Field.**—J. A. Chalmers. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No. 5, pp. 292–300.)

551.594.22 **3086**

**Point Discharge Currents.**—J. A. Chalmers. (*J. atmos. terr. Phys.*, 1952, Vol. 2, No.5, pp. 301–305.)

551.594.221 **3087**

**Lightning and Buildings. Statistical Study of Lightning Strokes occurring in Switzerland from 1925 to 1947.**—(*Bull. schweiz. elektrotech. Ver.*, 17th May 1952, Vol. 43, No. 10, pp. 428–432. In French.)

551.594.221 : 001.891 **3088**

**Experimental Lightning Research.**—H. Norinder. (*J. Franklin Inst.*, May 1952, Vol. 253, No. 5, pp. 471–504.) Historical account of methods of investigation from Franklin's time to the present day. 51 references.

## LOCATION AND AIDS TO NAVIGATION

621.396.9 **3089**

**Some Modern Developments in Radar Equipment for Shipboard Use.**—C. B. Broersma. (*Tijdschr. ned. Radiogenoot.*, May 1952, Vol. 17, No. 3, pp. 139–145. Discussion, pp. 145–146.) Postwar development of radar for merchant ships is reviewed. Current trends are toward greatest possible simplicity and toward the use of large c.r.o. screens. The relation between the desirable size of screen and the duration of the radar pulse is discussed. A description is given of a modern 38-valve equipment using a 16-in. tube and a magnetron producing 0·2-$\mu$s pulses with a peak power of 7 kW. The supply is a.c. at 2 kc/s.

621.396.9 : 621.396.825 **3090**

**Echo and Noise in a Radar System subject to Deliberate Interference.**—U. Tiberio. (*Alta Frequenza*, June 1952, Vol. 21, No. 3, pp. 137–151.) When a radar system is jammed by transmissions from the target, the echo/noise ratio has a value dependent on the range. This dependence is analysed for practical applications, mainly naval ones. Formulae are derived for the maximum detection range possible for a given ratio of jammer to radar power.

621.396.9.002.2 **3091**

**The Engineering of Radar Equipments designed for the R.A.F.**—G. W. A. Dummer. (*Electronic Engng*, Aug. 1952, Vol. 24, No. 294, pp. 348–355.) Discussion of factors affecting design, including sealing, pressurizing, heat dissipation, weight reduction, accessibility for servicing, simplicity of controls, corrosion, packaging, and transport risks.

621.396.93 **3092**

**The Measurement of Angles by Direction-Finding Technique.**—W. Messerschmidt. (*Arch. tech. Messen*, April 1952, No. 195, pp. 73–80.) Discussion of the principles of various methods and review of applications in air, marine and ground radiolocation systems, with indication of the limitations imposed by the aerial characteristics.

621.396.932 **3093**

**Conference of the Committee for Radio Navigation.**—Kronjäger. (*Fernmeldetech. Z.*, June 1952, Vol. 5, No. 6, pp. 287–289.) Summaries of nine papers read in Hamburg, March 1952, on marine navigation systems.

621.396.932 **3094**

**Microwave Lighthouse.**—A. Roberts. (*Radio & Televis. News, Radio-Electronic Engng Section*, June 1952, Vol. 47, No. 6, pp. 6–7, 31.) Description of a cheap and simple navigation aid for small ships. The 7-kW shore transmitter uses a 3-cm magnetron modulated at 500 pulses per sec by a rotary spark gap, and a twin-beam aerial keyed in one of the usual interlocking codes. The ship-borne receiver is integral with a parabolic-cylinder aerial, and has a crystal detector; its sensitivity is such that a signal of duration 1$\mu$s and power $10^{-8}$ W can be heard above receiver noise. An accurate fix on the shore station can be obtained.

621.396.932/.933(43-15) **3095**

**Integration of the Recently Installed Air-Navigation Safety System of the Federal German Republic with the Existing West European Network.**—F. C. Saic. (*Elektrotech. u. Maschinenb.*, 1st May 1952, Vol. 69, No. 9, pp. 203–207.) The principles of the Decca system are outlined and the two-frequency Decca-Telefunken system due to O'Brien and Schwarz is described. In this system, signals from two transmitters, with frequencies which are different multiples of a common frequency, are picked up on separate receivers in a ship or aircraft and multiplied in frequency so as to derive two signals of identical frequency, whose phase difference is measured by a phase bridge enabling location in the hyperbola system to be determined to within about 4 m. The master transmitter at Madfeld, Westphalia, operates on a frequency $6f_0$, from which are derived, by frequency division and subsequent multiplication, the frequencies $8f_0$, $9f_0$ and $5f_0$ of the three slave transmitters, which are symmetrically located round the master transmitter at a distance from it of 200 km. Three combinations give frequencies of $24f_0$, $18f_0$ and $30f_0$ for use in the phase-measurement bridge. The signals for the 'coarse' location, with frequencies interchanged, are transmitted during short breaks in the 'fine' location transmissions. The transmitter power is 2·4 kW and vertical wire-cage aerials are used. Standby Diesel generators are provided in case of mains failure, with battery feed during the starting-up period. See also 1923 of July.

621.396.933 : 657.7 **3096**

**The Application of Telecommunications to Civil Airways.**—D. P. Taylor. (*J. Brit. Instn Radio Engrs*, June 1952, Vol. 12, No. 6, pp. 341–359.) An account of the development of facilities for promoting safety and regularity in civil aviation operation in the U.K. in accordance with decisions taken by the Ministry of Civil Aviation in 1948. The airways system is described and a list is given of communication facilities and navigation aids essential for its operation. Descriptions are given of the v.h.f. air-to-ground R/T system, using area-coverage networks, and of the m.f. radio ranges and beacons and v.h.f. fan markers. References are included to more detailed accounts of individual features of the system.

621.396.933.1 : 621.396.67 **3097**

**Cage-Type Very-High-Frequency Phase-Comparison Omnidirectional Radio Range Antenna.**—F. J. Lundburg

& F. X. Bucher. (*Elect. Commun.*, June 1952, Vol. 29, No. 2, pp. 108–116.) Description of an aerial system consisting of a dipole rotating within a cage of vertical metal rods, together with an upper cage extension serving to suppress vertical polarization. Tests carried out on the system show that it has good azimuth accuracy, a small cone of silence, and vertical polarization 50 db below horizontal polarization for an upper-cage length of 12 ft, the whole system being mounted on a circular metal counterpoise 35 ft in diameter and 15 ft above the ground. Details are given of the tone wheel and magnetic pickup that provide the fixed-phase reference signal.

621.396.933.23 + 621.317.79 **3098**

**Airborne Receivers and Test Gear for Instrument Landing Systems.**—F. G. Overbury. (*Elect. Commun.*, June 1952, Vol. 29, No. 2, pp. 122–130.) A description has previously been given of the ILS-2 ground equipment [2513 of 1950 (Hampshire & Thompson)]. Details are now given of the operation of the SR.14 and SR.15 airborne receivers which derive suitable course indications from comparison of the modulation depths of the transmitted 90- and 150-c/s tones. Sources of error and means adopted for reducing them are discussed. In the SR.14 localizer receiver, a.v.c. is derived at the detector, delay being determined by a neon reference tube. In the SR.15 glide-slope receiver an audio type of a.v.c. is used. An outline description is given of portable field test equipment which enables accurate checking of audio, filter and rectifier circuits on one crystal-controlled channel in the localizer and glide-slope frequencies. R.f. circuits are checked by functional tests.

621.396.93 **3099**

**Radio Research Special Report No. 22. The Siting of Direction-Finding Stations.**[Book Review]—W. Ross & F. Horner. Publishers: H.M. Stationery Office, London, 1952, 38 pp., 1s. 6d. (*Nature, Lond.*, 24th May 1952, Vol. 169, No. 4308, p. 875.) "The main conclusions of the report are summarized in tables showing the minimum tolerable distances for different objects when it is desired to achieve specified accuracies."

621.396.933 **3100**

**Radio Research Special Report No. 21. Radio Direction-Finding and Navigational Aids; some Reports on German Work issued in 1944-45.** [Book Review]—Publishers: H.M. Stationery Office, London, 1951, 92 pp., 3s. 6d. (*Nature, Lond.*, 24th May 1952, Vol. 169, No. 4308, p. 875.) Translations of nine hitherto unpublished papers by German experts.

## MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.13 **3101**

**Knudsen Gauges.**—W. Steckelmacher. (*Vacuum*, Oct. 1951, Vol. 1, No. 4, pp. 266–282.) The design of improved forms of suspended-vane metal and glass instruments is discussed. Gauges can be constructed for the pressure range $10^{-2}$–$10^{-8}$ mm Hg with phosphor-bronze taut-strip suspension and eddy-current damping. The inherently narrow range of the instrument is extended by means of an alternating magnetic field acting inductively on the vane system. The theory of the Knudsen gauge is developed. 48 references.

531.788.7 **3102**

**Use of Penning's Gauge. Experimental Comparison with the Ionization Gauge.**—J. Vermandé. (*Le Vide*, March 1952, Vol. 7, No. 38, pp. 1145–1150. Discussion, pp. 1150–1152.) Calibration and operation of the vacuum gauge [1423 of 1950 (Penning & Nienhuis)] are described; its advantages are summarized.

531.788.7 **3103**

**Thermocouple Micromanometer. Theoretical and Experimental Study.**—D. Degras. (*Le Vide*, March 1952, Vol. 7, No. 38, pp. 1153–1171.) Description and theory of the instrument, and discussion of factors affecting sensitivity and the aging of the thermocouple.

535.215 : 537.311.33 : 546.23 **3104**

**Photoconductivity in Vacuum Coated Selenium Films.**—P. H. Keck. (*J. opt. Soc. Amer.*, April 1952, Vol. 42, No. 4, pp. 221–225.) The influence of base-plate temperature and process timetable on the growth of crystals in evaporated Se coatings was investigated. The presence of a small amount of crystalline Se increases red sensitivity, but high insulation is maintained only if the crystals are well separated by the vitreous matrix. The effect on the spectral response of Te additions is considered. See also 1925 of 1951.

535.215 : 546.482.21 **3105**

**Note on Quenching of Photoconductivity in Cadmium Sulfide.**—E. A. Taft & M. H. Hebb. (*J. opt. Soc. Amer.*, April 1952, Vol. 42, No. 4, pp. 249–251.) Experiments were made on a single crystal $1\times1\times4$ mm in size, subjected to a small unidirectional field and simultaneously irradiated with two monochromatic beams, one of constant and the other of variable intensity. There appear to be two independent but similar quenching processes, with peaks at variable-beam energies of 0·9 and 1·5 eV respectively. An interpretation based on Frerichs' theory (450 of 1948) is proposed.

535.215 : 549.328.1 **3106**

**Antimony Content and Photoelectric Effect of Different Samples of Galena.**—J. E. Hiller & H. G. Smolczyk. (*Naturwissenschaften*, May 1952, Vol. 39, No. 9, p. 208.) Results of tests on 57 samples indicate that a Sb content of $<0\cdot03\%$, a negatively directed photoelectric effect (current from contact point to galena) and a positive thermoelectric effect are characteristic of samples which are good detectors.

535.343 : [546.817.221 + 546.817.231 + 546.817.241 **3107**

**The Absorption Spectra of Single Crystals of Lead Sulphide, Selenide and Telluride.**—A. F. Gibson. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 378–388. Correction, *ibid.*, 1st July 1952, Vol. 65, No. 391B, p. 555.) The spectra were examined over the temperature range 20–600°K; they are characterized by a sharp absorption 'edge' coincident with the long-wave limit of the photoconductivity of each material.

535.37 **3108**

**The Third All-Union Conference on Luminescence and the Applications of Luminescent Materials.**—P. Feofilov. (*Uspekhi fiz. Nauk*, Nov. 1951, Vol. 45, No. 3, pp. 445–457.) Report on a conference held in Moscow, June 15–21, 1951. Summaries of 45 papers are given.

535.37 : 546.412.84 **3109**

**Optical Properties of Calcium-Silicate Phosphors.**—G. R. Fonda & F. J. Studer. (*J. opt. Soc. Amer.*, May 1952, Vol. 42, No. 5, p. 360.) Further investigations indicate that the optical properties of these phosphors are dependent on structure and not on lead content. See also 107 of 1950.

535.372 **3110**

**Luminescence of Alkali Sulphides and Sulphates.**—H. Gobrecht & D. Hahn. (*Z. Phys.*, 10th April 1952, Vol. 132, No. 1, pp. 111–128.) By reduction of the alkali sulphates, materials are obtained giving red or blue luminescence when excited by Hg radiation of wavelength 366 mμ or 254 mμ. The red luminescence is due to the production of polysulphides, the blue to alkali atoms in the sulphate lattice. Investigations of the luminescence spectra at different temperatures are described and discussed.

537.226 : 546.311.88 **3111**

**Ferroelectric Properties of Tantalates and Niobates of Alkali Metals.**—N. V. Kozhevnikova & A. I. Medovoi. (*Zh. tekh. Fiz.*, Nov. 1951, Vol. 21, No. 11, pp. 1383–1387.) The temperature dependence of the dielectric constant and coefficient of linear expansion was investigated for certain tantalates and niobates of alkali metals, and their lattice parameters were determined. Over the temperature range 20°C–500°C these materials did not show any ferroelectric properties. These results are contrary to those obtained by Matthias (*Phys. Rev.*, 1949, Vol. 75, p. 1771) and by Matthias & Remeika (3023 of 1951).

537.226.2 **3112**

**Theory of the Dielectric Constant of Mixtures.**—G. Eckart. (*Z. angew. Phys.*, April 1952, Vol. 4, No. 4, pp. 134–136.) A formula based on calculations of Darwin and Hartree is derived for the dielectric constant of a material containing globular particles of a second material embedded in it. Curves are drawn to simplify calculations. Application of the formula to the case of water drops or vapour in air is illustrated. Experimental evidence indicates that the formula is only useful if the dielectric constants of the two materials differ by a factor $<10$.

537.226.31 **3113**

**The Effect of Orientation on the Dielectric Losses in Polar Polymers.**—G. P. Mikhailov. (*Zh. tekh. Fiz.*, Nov. 1951, Vol. 21, No. 11, pp. 1395–1401.)

537.312 **3114**

**Measurement of the Resistance of Thin Insulating Layers between Gold Contacts within the Range of the Tunnel Effect.**—I. Dietrich. (*Z. Phys.*, 14th May 1952, Vol. 132, No. 2, pp. 231–238.) Results of measurements on $TiO_2$ layers show that, for layer thicknesses $<100$ Å, contact resistance is governed by the tunnel effect, being independent of the specific resistance of the layer material and, for layer thicknesses $<80$ Å, independent of temperature between $-160°$ and $+20°$C.

538.221 **3115**

**Minute Eddy Currents due to Displacement of Domain Boundaries.**—N. S. Akulov & G. S. Krinchik. (*C. R. Acad. Sci. U.R.S.S.*, 11th Nov. 1951, Vol. 81, No. 2, pp. 171–174. In Russian.)

538.221 **3116**

**Theory of the Coercive Force and Magnetic Susceptibility of Ferromagnetic Powders (Dependence on the Density of Packing).**—E. Kondorski. (*C. R. Acad. Sci. U.R.S.S.*, 11th Sept. 1951, Vol. 80, No. 2, pp. 197–200. In Russian.)

538.221 **3117**

**The Magnetization of Highly Coercive Ferromagnetic Materials in Weak Fields.**—D. I. Volkov. (*C. R. Acad. Sci. U.R.S.S.*, 21st Sept. 1951, Vol. 80, No. 3, pp. 349–351. In Russian.)

538.221 **3118**

**New Ferromagnetic Materials with High Coercivity, High Permeability and Low Losses.**—C. Guillaud. (*Onde élect.*, June 1952, Vol. 32, No. 303, pp. 238–253.) The domain theory of ferromagnetism is outlined and the properties of recently developed permanent-magnet and magnetically soft materials are described, including both solid materials and those produced by powder-metallurgy technique, ferrites being particularly considered. Applications of the new materials for filter-coil cores, wide-band transformers, magnetostriction devices, magnetic amplifiers, etc. are briefly discussed. 27 references.

538.221 **3119**

**Calculation of the Magnetic Skin-Effect in Sheet Permalloy and Determination of its Characteristic Parameters.**—A. A. Shvarts. (*Zh. tekh. Fiz.*, Nov. 1951, Vol. 21, No. 11, pp. 1293–1310.) The usual equation (1) of the hysteresis loop is valid only for the case of a quasistatic field and ceases to be accurate if the field varies with a finite frequency. A generalized equation (14) is derived for investigating the behaviour of ferromagnetic materials in weak alternating fields both with and without taking account of their domain structure. A new method is proposed for separating the losses in sheet materials, and an experimental determination of the parameters of sheet permalloy is reported.

538.221 **3120**

**The Spontaneous Magnetization of Magnesium Ferrite and Magnesium Ferrite-Aluminate Powders at Low Temperatures.**—G. O. Jones & F. F. Roberts. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 390–391.)

538.221 : 061.3 **3121**

**Soft Magnetic Materials in Telecommunications.**—(*Nature, Lond.*, 31st May 1952, Vol. 169, No. 4309, pp. 905–906.) Report of discussions at the Post Office Engineering Research Station, London, April 1952, at which 34 papers were presented.

538.221 : 538.541 **3122**

**Eddy Currents in Solid Cylindrical Cores having Nonuniform Permeability.**—H. Aspden. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 523–528.) A method of estimating magnetization losses due to eddy currents in inhomogenous ferromagnetic materials is given. A case in which the permeability changes across the core section is considered and the solution is extended to a homogeneous core whose permeability changes with the degree of magnetization.

538.221 : 669.15.24-198 **3123**

**Study of a Ferronickel Alloy of Very Low Strain Energy in Steady and Alternating Magnetic Fields.**—I. Épelboin & G. Gilardin. (*C. R. Acad. Sci., Paris*, 5th May 1952, Vol. 234, No. 19, pp. 1860–1862.) Discussion of measurements on very thin mumetal strip, the thickness of which was successively reduced electrolytically, with subsequent annealing in an atmosphere of $H_2$.

538.221.001.8 **3124**

**Some Applications of Ferroxcube.**—W. Six. (*Philips tech. Rev.*, May 1952, Vol. 13, No. 11, pp. 301–311.) Review of the properties of ferroxcube and of applications for filter coils, loading coils for telephone circuits, wideband h.f. transformers, 'palisade' screening, u.h.f. modulation, and in television line-scan circuits.

538.221.096 : 546.726-3 **3125**

**Thermomagnetic Study of a Single Crystal of $Fe_2O_3\alpha$.**—L. Néel & R. Pauthenet. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2172–2174.) Measurements of the magnetization of a natural single crystal of $Fe_2O_3\alpha$ are shown graphically for the temperature range 20–950°K. A discontinuity occurs at about 250°K.

539.234 : 537.311.31 : 546.92 **3126**

**Electrical Conductivity of Thin Deposits of Platinum on Dielectric Layers evaporated in Vacuo.**—C. Feldman. (*C. R. Acad. Sci., Paris*, 5th May 1952, Vol. 234, No. 19, pp. 1858–1860.) Measurements show that the resistivity of Pt films deposited on evaporated layers of KBr or $CaF_2$ is much higher than that of Pt films on glass. The difference is not so great for films on layers of $SiO_2$. An explanation is suggested.

546.217 : 621.317.335.3.029.64 **3127**

**The Dielectric Constant of Dry Air.**—J. V. Hughes & H. L. Armstrong. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 501–504.) Measurements by a two-cavity method similar in some respects to that of Birnbaum et al. (1426 of 1951) give a value of 1·000569 for the dielectric constant of dry air at N.T.P., for a frequency of 3 kMc/s. The value previously reported by Hughes & Lavrench (3047 of 1951) was found to be too high because of insufficient drying of the air.

546.23 : [535.323 + 535.343 **3128**

**Properties of Amorphous Selenium and its Use as an Optical Material.**—H. A. Gebbie & C. G. Cannon. (*J. opt. Soc. Amer.*, April 1952, Vol. 42, No. 4, p. 277.) Measurements were made of the transmission over the wavelength range 1–25 $\mu$. Results are discussed in relation to values of optical constants previously reported by Gebbie & Saker (*Proc. phys. Soc.*, 1st April 1951, Vol. 64, No. 376B, pp. 360–361) and by Dowd (1013 of April).

546.24 : [537.311.33 + 538.632 **3129**

**The Hall Effect and Electrical Resistivity of Tellurium.**—V. E. Bottom. (*Science*, 23rd May 1952, Vol. 115, No. 2995, pp. 570–571.)

546.24 : 538.632 **3130**

**Interpretation of the Double Reversal of the Hall Effect in Tellurium.**—H. Fritzsche. (*Science*, 23rd May 1952, Vol. 115, No. 2995, pp. 571–572.)

546.24 : 621.314.632 **3131**

**Contact Rectification with Tellurium.**—J. Lagrenaudie. (*J. Phys. Radium*, May 1952, Vol. 13, No. 5, p. 308.) Systematic measurements have been made of mean rectified current and upper-limit value of reverse voltage for single-crystal and polycrystalline specimens of Te with metal point contacts. Rectification is obtained with contact metals having low work function and coated with oxide. A theoretical explanation is advanced for the different results observed with different contact metals. Measurements made with unidirectional voltages are also reported.

546.28 : 537.323 **3132**

**The Sign of the Thermal E.M.F. of Silicon.**—J. Savornin & F. Fourrier-Savornin. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2165–2167.) Experiments carried out on small bars of Si (98% Si, 1·4% Al, 0·6% Fe), with Cu and constantan contacts at the ends, show that the thermal e.m.f. of Si with respect to Cu is positive, not negative, as given in tables of physical constants. For a Si-Pb couple the thermal e.m.f. is 408 $\mu$V/1°C, as against 80 $\mu$V/1°C for a Pb-Bi couple.

546.281.26 : 537.311.4 **3133**

**Contribution to the Theory of the Silicon Carbide Contact.**—E. Holm. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 509–517.) The high limiting contact voltage of 40–50 V between SiC single crystals of the black-green variety is explained on the basis of the known temperature-voltage relation. The electrical properties of the surface layer on the crystals are investigated with special reference to the 'tunnel' effect, which affords an explanation of the resistance at low voltages.

546.289 : 537.311.33 **3134**

***p-n* Junction Method for Measuring Diffusion in Germanium.**—W. C. Dunlap, Jr, & D. E. Brown. (*Phys. Rev.*, 1st May 1952, Vol. 86, No. 3, pp. 417–418.) Diffusion of an *n*-type impurity into a *p*-type semiconductor creates a *p-n* junction which can be detected electrically by means of a probe. Measurements of the rate of diffusion by this method and by a radioactive-tracer method gave results in good agreement.

546.289 : [621.314.63 + 621.314.7 + 621.383.5 **3135**

**Single-Crystal Germanium.**—G. K. Teal, M. Sparks & E. Buehler. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 906–909.) When single crystals of Ge are used, the properties of the barriers between *p*-type and *n*-type specimens can be predicted from measurements on the separate specimens. The long life of carriers injected into single crystals and the good chemical controllability are particularly useful characteristics from the point of view of developing rectifiers, transistors and photocells. The range of properties of available Ge crystals is indicated.

546.289 : 669.054.83 **3136**

**Germanium from Coal.**—R. C. Chirnside & H. J. Cluley. (*G.E.C. J.*, April 1952, Vol. 19, No. 2, pp. 94–100.) An account of the methods developed for the production of high-purity Ge from flue dusts, with some details of the treatment of $GeCl_4$ with Cu turnings to remove traces of As.

546.431.824-31 : 537.226 **3137**

**The Effective Fields in Barium Titanate.**—V. Kh. Kozlovski. (*Zh. tekh. Fiz.*, Nov. 1951, Vol. 21, No. 11, pp. 1388–1394.)

546.72-3 : 537.311.33 **3138**

**Semiconducting Properties of Oxides of Iron.**—J. Martinet. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2167–2169.) Results of measurements on $Fe_3O_4$, $Fe_2O_3\alpha$, $Fe_2O_3\gamma$ and intermediate mixtures from − 190° to + 100°C are presented and discussed.

546.722.21 : 538.22 **3139**

**Paramagnetism of Sulphides of Iron.**—R. Benoît. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2174–2175.) Graphical presentation and discussion of measurements on various sulphides in the temperature range 0–1 000°C.

546.817.221 + 546.817.231 + 546.817.241] : 537.311.33 **3140**

**Electrical Conductivity in the Compounds PbS, PbSe, PbTe.**—E. H. Putley. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 388–389.) Measurements on single crystals give electron and hole mobilities two or three times those reported for multicrystal specimens.

548.0 : 537.228.1 : 539.32 **3141**

**The Elastic Constants of Piezoelectric Crystals.**—R. F. S. Hearmon. (*Brit. J. appl. Phys.*, April 1952, Vol. 3, No. 4, pp. 120–124.) Published values of the elastic constants of Rochelle salt, $KH_2PO_4$(KDP), $(NH_4)H_2PO_4$(ADP), quartz, $NaClO_3$ and $NaBrO_3$ crystals are assembled and discussed. 23 references.

548.0 : 537.228.1 : 539.4 **3142**

**Mechanical Strength of Piezoelectric Crystals.**—R. Bechmann & P. L. Parsons. (*Brit. J. appl. Phys.*, May 1952, Vol. 3, No. 5, pp. 147–150.) A direct mechanical method and an electrical method have been used to determine the breaking strength of crystals of $NaClO_3$, $NaBrO_3$, ADP, EDT and $Li_2SO_4$. Results are tabulated. New measurements on quartz crystals were used to check the methods. A formula for the current due to the piezoelectric polarization is given which covers the longitudinal flexural, contour, and thickness modes of vibration considered. The calculated maximum safe currents are tabulated for resonators of various materials and cuts.

549.211 : 621.317.335.3 **3143**

**The Dielectric Constant of Diamond.**—F. P. Pietermaat, W. van Dyck & F. de Keuster. (*HF, Brussels*, 1952, Vol. 2, No. 2, pp. 47–51.) Bridge measurements on pure diamonds at frequencies from 100 c/s to 1 Mc/s gave a permittivity value of 5·6, independent of frequency. The value for industrial diamonds at frequencies $< 5$ kc/s was slightly higher.

549.514.51 : 621.396.611.21 **3144**

**Heat Treatment and Internal Friction of Piezoelectric Quartz Resonators.**—G. Frigerio. (*Alta Frequenza*, April 1952, Vol. 21, No. 2, pp. 102–104.) Brief account of an experimental investigation of the effect of heat treatment on crystal structure and $Q$-value.

620.197 : 621.396.6 **3145**

**A Colonial talks about Tropicalization.**—E. Dawance. (*Toute la Radio*, June 1952, No. 166, pp. 177–182.) Discussion of the various mechanical and electrical faults commonly found in radio equipment used in the tropics, with detailed suggestions as to the treatment of components, assemblies and complete units, necessary to ensure reliable operation under difficult conditions.

621.3.066.6 **3146**

**Materials for Electrical Contacts.**—H. Gagel & H. Dittler. (*Elektrotech. Z.*, 1st May 1952, Vol. 73, No. 9, pp. 292–294.) Review of the special characteristics of the metals and alloys commonly used, with a summary of their relative advantages and disadvantages.

621.314.632 : [549.325.2 + 546.784.221 **3147**

**Rectification Effects with Molybdenite and Tungstenite.**—J. Lagrenaudie. (*J. Phys. Radium*, May 1952, Vol. 13, No. 5, pp. 311–312.) Results are reported of measurements on sheets of natural molybdenite ($MoS_2$) soldered to a large-contact base, and on artificial tungstenite ($WS_2$). For $MoS_2$ the results are not affected by the particular contact metal used, for $WS_2$ the nature of the contact metal has some influence. The forward resistance of the $MoS_2$ rectifier is high, due to the laminated nature of the material. Modifications of the characteristics obtained by lightly firing the contact are described.

621.315.613.1 **3148**

**Processing Mica Paper for Electrical Insulation.**—R. L. Griffeth & E. R. Younglove. (*Elect. Engng, N.Y.*, May 1952, Vol. 71, No. 5, pp. 463–465.) A.I.E.E. Winter General Meeting paper, January 1952. An account of the production and properties of the type of mica paper developed in France by Bardet. See also 1407 of 1951 (George & Metzger).

621.315.613.1 **3149**

**Synthesis of Mica.**—A. Van Valkenburg & R. G. Pike. (*Bur. Stand. J. Res.*, May 1952, Vol. 48, No. 5, pp. 360–369.) An account of the preparation and properties of a phlogopite-type mica in which the (OH) ions present in natural mica are replaced by fluorine.

621.316.87 : 541.18 : 537.311.35 **3150**

**The Electrical Properties of Colloidal Suspensions and Mixtures and their Use in the Manufacture of Nonlinear Resistors.**—H. E. Hollmann. (*Arch. elekt. Übertragung*, May 1952, Vol. 6, No. 5, pp. 178–186.) See 2538 of September.

621.318.2 : 669.1-492.2 **3151**

**Permanent Magnets from Ultrafine Iron Powder.**—B. Kopelman. (*Elect. Engng, N.Y.*, May 1952, Vol. 71, No. 5, pp. 447–451.) A.I.E.E. Winter General Meeting paper, January 1952. The salient points of the domain theory pertaining to such magnets are reviewed and the properties of magnets at present available are described. Theoretically it is possible to produce magnets with coercive forces of 2 500 oersted or more, saturation magnetization of the order of 11 000 gauss, and remanence of 5 000 gauss, but actual figures are considerably below these values. $BH_{max}$ values are of the same order as for alnico-3, but the iron-powder magnets are much lighter, containing only about 50% Fe. Possible methods for obtaining improved magnetic properties in this type of magnet are discussed.

621.318.23 **3152**

**Modern Permanent Magnets and their Application.**—F. Latscher. (*Elektrotech. u. Maschinenb.*, 15th April 1952, Vol. 69, No. 8, pp. 188–192.)

## MATHEMATICS

517.946 : 517.949.8 : 518.12 **3153**

**Numerical Solution of Boundary-Value Problems in Elliptic Partial Differential Equations.**—E. Batschelet. (*Z. angew. Math. Phys.*, 15th May 1952, Vol. 3, No. 3, pp. 165–193.) Partial differential equations of the elliptic type are solved by finite-difference approximation. If the boundary conditions involve derivatives, such approximation may be difficult. It is shown how the normal derivative may be approximated for a curved boundary without any corner. The finite-difference solutions converge to the exact solution of the differential equation as the mesh side tends to zero; this is proved, under certain conditions, by a method similar to that given by Gerschgorin. Relaxation technique is considered and it is proved that the residuals for inner and for boundary points converge to zero. 24 references.

517.946 : 518.12 **3154**

**Numerical Determination of Periodic Solutions for Nonlinear Oscillations.**—L. Collatz. (*Z. angew. Math. Phys.*, 15th May 1952, Vol. 3, No. 3, pp. 193–205.) Description of a relatively simple multipoint method, with worked-out examples.

681.142 : 512.3 **3155**

**The Solution of Algebraic Equations on the EDSAC.**—R. A. Brooker. (*Proc. Camb. phil. Soc.*, April 1952, Vol. 48, Part 2, pp. 255–270.) Three iterative methods are examined: Bernoulli's method, the root-squaring method, and the Newton-Raphson method. Quadratically convergent methods are found preferable to those less rapidly convergent. Examples are given.

681.142 : 621.3.042.143 **3156**

**Static Magnetic Matrix Memory and Switching Circuits.**—J. A. Rajchman. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 183–201.) Description of recent developments in this type of memory device. See also 2258 of August (Papian).

## MEASUREMENTS AND TEST GEAR

531.76 : 621.3.015.7 **3157**

**The Use of a Pulse-Height Analyzer for Time-Interval Measurements.**—G. Jenssen & A. Sunde. (*Physica*, April 1952, Vol. 18, No. 4, pp. 265–269.) Description of an instrument adapted from the pulse-height analyser of Elmore & Sands (2007 of 1950).

531.764.5 3158

**Development of a Clock whose Rate is Accurately the Arithmetic Mean of the Rates of Several Clocks.**—B. Decaux, J. Lucas & V. Yanouchevsky. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2164–2165.) Description of a method particularly applicable to quartz clocks. By a process of simple frequency mixing and division, a frequency is derived which is the exact arithmetic mean of the fundamental 100-kc/s nominal frequencies of several clocks, or of nominal frequencies of 1 kc/s derived by frequency division. In the latter case a synchronous motor can then be used to drive mechanism for recording the mean time or operating seconds contacts.

621.317.2(44) : 621.317.361 3159

**Recent Developments in the Frequency-Measurement Department of the Laboratoire National de Radio-électricité.**—B. Decaux. (*Onde élect.*, June 1952, Vol. 32, No. 303, pp. 219–231.) An outline is given of the organization of the department and of its functions, with descriptions of the measurement equipment, including the standard oscillators (installed underground), frequency meters up to 4 kMc/s, synchronous recording drums, beat-frequency counters, etc. A new microwave meter is to range up to 12 kMc/s.

621.317.3 : 621.396.611.21 3160

**Measurement of the Parameters of a Quartz Crystal. Use of the Two-Circle Abac.**—J. Coulon. (*C. R. Acad. Sci., Paris*, 12th May 1952, Vol. 234, No. 20, pp. 1965–1968.) Discussion of the application of an orthogonal system of circles to the determination of crystal parameters. See also 2550 and 2549 of September.

621.317.3 : 621.396.822 3161

**Characteristics of Noises and Noise Voltages.**—H. Bittel. (*Z. angew. Phys.*, April 1952, Vol. 4, No. 4, pp. 137–146.) The frequency spectrum of a noise voltage often gives insufficient data on the character of the noise; a knowledge of the statistical amplitude distribution is required. In many practical cases this distribution is Gaussian. Deviations are due to non-overlapping of the voltage pulses; the frequency characteristic of the transmission system may contribute to this. The effect of the amplitude distribution on the rectification process is analysed and measurement apparatus is described. For resistance and valve noise a Gaussian distribution is confirmed experimentally.

621.317.3.017.143 : 621.396.611.4 3162

**An Approximate Theory of the Cavity-Resonator Method of Determining the Dielectric Loss of Solids at Microwave Frequencies.**—S. K. Chatterjee. (*J. Indian Inst. Sci.*, April 1952, Vol. 34, No. 2, Section B, pp. 43–49.) The field equations for a cylindrical cavity resonator and the perturbation formula due to Bethe & Schwinger are applied to the calculation of the real and imaginary parts of the generalized dielectric constant of a small sample of solid dielectric rod introduced into the resonator. The loaded $Q$ of the cavity is determined from the field equations and the Poynting vector.

621.317.3.029.5/.6 3163

**High-Frequency Measurement Technique.**—W. Druey. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Feb. 1952, Vol. 30, No. 2, pp. 50–56. In German.) Reprint. See 1954 of July.

621.317.32 : 537.221 3164

**Measurement of the Volta Effect.**—R. Bourion. (*Ann. Phys., Paris*, May/June 1952, Vol. 7, pp. 360–395.) Investigation of the sources of error in contact-potential measurements resulted in the development of a reliable method, a detailed account of which is given, including a description of the technique for obtaining the very high vacuum necessary to obtain consistent results. Values obtained for the contact e.m.f. for a layer of Cu condensed on a W wire are discussed in relation to results published by other investigators. See also 1885 of July.

621.317.331.029.51 : 621.316.993 3165

**The Value of H.F. Measurements on Lightning-Protection Earths.**—W. Bulla. (*Elektrotech. u. Maschinenb.*, 15th March 1952, Vol. 69, No. 6, pp. 140–146.) Discussion indicates that h.f. measurements on earthing systems supply little additional information to that furnished by measurements with a l.f. bridge.

621.317.335.3 : 518.4 3166

**The Computation of Dielectric Constants.**—R. M. Redheffer, R. C. Wildman & V. O'Gorman. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 505–508.) Charts are provided which enable the complex dielectric constant to be determined for any type of sample from measurements by the shorted-line method.

621.317.335.3 : 621.316.726 3167

**A Frequency-Stabilization System for Microwave Gas Dielectric Measurements.**—W. F. Gabriel. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 940–945.) In a method based on observing the shift of resonance frequency of a cavity when filled with the gas, the frequency of the klystron oscillator used is automatically controlled by means of a double-loop servo system. One loop is of the type described by Pound (1311 of 1948) and the other of the type described by Rideout (276 of 1948). The value of $(n - 1)$, where $n$ is the refractive index,can be obtained accurate to three or four significant figures.

621.317.336 : 621.315.212 3168

**The Sweep-Frequency Response of RG-6U** [cable].—W. T. Blackband. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 995–996.) A discussion of the causes of frequency dependence and irregularity of the measured characteristic impedance noted by Alsberg (728 of March).

621.317.34 : 621.315.212 3169

**Measurement of the Attenuation and Characteristic Impedance of Transmission Lines. Tests on Coaxial Cables.**—P. Hontoy. (*HF, Brussels*, 1952, Vol. 2, No. 2, pp. 35–46.) A method of measurement applicable to all uniform lines is described. If a line has a variable purely reactive termination, the locus, in the complex plane, of its input impedance is a circle whose position and radius are functions of the attenuation and characteristic impedance. The mathematical theory of the method makes use of the properties of certain transformations in the complex plane. The necessary formulae are established for the representation in cartesian coordinates and in Smith's diagram. Tests on coaxial cables for a very large range of frequencies gave attenuation values in good agreement with wattmeter measurements.

621.317.35.029.3 3170

**Gated Amplifier Wave Analyzer.**—V. R. Nelson. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 136–139.) Description of an instrument giving a direct-reading quantitative indication of the spectral components of complex a.f. waveforms. The waveform under test and gating pulses from a variable-frequency multivibrator are fed to an amplifier having in its output circuit a meter whose deflection varies as a function of the phase difference between the two inputs.

621.317.351 : 534.442.2 3171

**Some Problems in Audio-Frequency Spectrum Analysis.**—S. V. Soanes. (*Electronic Engng*, June & July 1952, Vol. 24, Nos. 292 & 293, pp. 268–270 & 312–318.) Theory is presented for analysers of the type using a fixed-frequency filter and a swept-frequency heterodyne oscillator. A description is given of a double-heterodyne analyser for general laboratory use covering the working range 20 c/s–20 kc/s; the useful range of input voltage is 1 mV–300 V, the sweep frequency is variable between 0·1 c/s and 30 c/s and the filter bandwidth is variable between 10 c/s and 500 c/s. The response is displayed on a long-persistence c.r. tube.

621.317.361 **3172**

**A Recording Frequency Comparator.**—R. Walter & H. Voigt. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, May/June 1952, Vol. 4, Nos. 5/6, pp. 111–114.) A special heterodyne method is described in which a sawtooth oscillation of the one frequency is multiplicatively mixed in a pentode with pulses repeated at the other frequency; the resulting beat has a sawtooth form, enabling the direction of frequency deviation to be recognized immediately. A practical arrangement is illustrated in which several oscillators can be compared simultaneously with the same reference oscillator, the results being recorded on a single paper-strip chart.

621.317.361.029.6 **3173**

**Frequency Measurement in the Microwave Range.**—B. Koch. (*Arch. tech. Messen*, May 1952, No. 196, pp. 111–116.) Review of different methods and apparatus, including wavemeter methods, direct heterodyne methods and others involving frequency multiplication. A list of 64 $NH_3$ absorption lines between 19 and 40 kMc/s is given. 47 references.

621.317.444.087 **3174**

**A Recording Fluxmeter of High Accuracy and Sensitivity.**—P. P. Cioffi. (*Bell Lab. Rec.*, June 1952, Vol. 30, No. 6, pp. 247–251.) Description of an instrument which plots magnetization curves and major and minor hysteresis loops of ring and bar samples on standard coordinate paper.

621.317.7 : 537.311.33 **3175**

**Apparatus for Electrical Measurements on Semiconductors.**—H. K. Henisch & J. Ewels. (*Research, Lond.*, May 1952, Vol. 5, No. 5, pp. 235–237.) Description of apparatus facilitating measurements over a wide temperature range and in controlled gas atmospheres; it is intended mainly for d.c. operation. Experiments have been made on Se, Ge and $TiO_2$; typical results are given.

621.317.715 **3176**

**Integrating and Other Galvanometers.**—A. H. Bebb. (*J. sci. Instrum.*, April 1952, Vol. 29, No. 4, pp. 105–111.) The theory, design and construction are discussed of an integrating galvanometer with a free period of 80 sec. The damping/control ratio is large enough to enable measurement of the change of flux through an exploring coil of considerable resistance connected in series, even though the flux change may take several minutes. The small degree of control is achieved by attaching a magnetized needle to the upper end of a glass tube whose lower end is secured to the moving-coil system, the needle being located in an auxiliary field of opposite polarity to that of the needle. The effect of shunting the integrating galvanometer is examined and the theory confirmed experimentally.

621.317.723 **3177**

**A Mechanically Astatized Leaf Electrometer.**—H. W. Lücking. (*Z. angew. Phys.*, May 1952, Vol. 4, No. 5, pp. 169–173.) The instrument described is some hundreds of times more sensitive than earlier types of leaf electrometer, as a result of (*a*) the astatization, and (*b*) arranging the direction of electric force to coincide with the gravitational force. Both direct and h.f. voltages can be measured.

621.317.725 : 621.318.572 **3178**

**Anodige: a Discrete-Digit Voltage-Indicating Device.**—(*Tech. Bull. nat. Bur. Stand.*, May 1952, Vol. 36, No. 5, pp. 70–71.) Description of equipment which measures continuously variable voltages and indicates their values on a digital panel or records them on a strip of electrosensitive paper. Essentially the instrument consists of an electronic counter which counts the number of equal increments of charge required to raise the terminal voltage of a capacitor up to the value of the unknown voltage. 400 readings per second are possible with the present model, but this can easily be increased.

621.317.729 **3179**

**Electrolyte Tank with Automatic Recording of Equipotential Lines.**—H. Schmidl. (*Elektrotech. u. Maschinenb.*, 1st April 1952, Vol. 69, No. 7, pp. 155–161.)

621.317.733 : 621.316.8.011.6 **3180**

**A Precision Bridge for Determination of Time Constants of Resistors for Measurement Apparatus.**—E. Blechschmidt. (*Elektrotechnik, Berlin*, May 1952, Vol. 6, No. 5, pp. 199–202.) Description of a bridge, developed by G. Zickner at the German Office of Weights and Measures, for measurement of the time constants of resistors in the range 1 Ω–100 kΩ. The phase shift due to the time constant of the resistor under test is compensated by means of a special capacitor in parallel with one arm. The actual evaluation of the time constant is effected by a substitution method, stretched twin wires, screened or unscreened, serving as time-constant standards for resistance values up to 10 kΩ, and screened carbon-film resistors for values from 10 kΩ to 100 kΩ.

621.317.75.029.4 **3181**

**Applications of the Muirhead-Pametrada Wave Analyser Type D-489: Part 1 — Aircraft-Engine Research.**—B. D. Banks. (*Muirhead Technique*, April 1952, Vol. 6, No. 2, pp. 11–14.) An instrument of the tuned-filter type for measuring amplitude and frequency of any component of a complex wave. Frequency range is 19 c/s–21 kc/s. Percentage frequency accuracy is high and constant at all frequencies. In vibration measurements described, a resistance strain gauge or moving-coil pickup is used.

621.317.75.029.42 **3182**

**Adapting the Wave Analyser for Very-Low-Frequency Measurements.**—(*Muirhead Technique*, April 1952, Vol. 6, No. 2, pp. 15–16.) Description of a mains-operated ring-modulator unit extending the range of the Type D-489 analyser (3181 above) down to 2 c/s. A RC filter in a selective feedback circuit provides 40-db attenuation above 100 c/s for suppressing unwanted frequencies.

621.317.755 : 531.765 **3183**

**Circular-Sweep Chronograph for Single Millisecond Time Intervals.**—A. Linz, Jr. (*Rev. sci. Instrum.*, May 1952, Vol. 23, No. 5, pp. 199–203.) Description, with circuit details, of equipment comprising (*a*) a scaling-circuit interval timer driven by a 100-kc/s frequency standard, and (*b*) a c.r.o. with a 10-μs circular sweep driven from the same standard. The scaling circuit measures the interval between two electrical signals to within 10 μs, readings on the c.r.o. being used for interpolation to within 10 mμs. Suitable pulse-sharpening circuits and a high-speed gate circuit are also described.

621.317.755 : 621.314.7.012 **3184**

**Display of Transistor Characteristics on the Cathode-Ray Oscillograph.**—G. B. B. Chaplin. (*J. sci. Instrum.*, May 1952, Vol. 29, No. 5, pp. 142–145.) Pulse and step waves are generated and applied to the grids of two cathode-follower circuits, the outputs from which are fed to the appropriate transistor electrodes. Any of the following families of characteristics can then be displayed: (*a*) $I_e$ against $V_c$ or $V_e$, with $I_c$ as parameter; (*b*) $I_c$ against $V_c$ or $V_e$, with $I_e$ as parameter, where *e* and *c* denote emitter and collector respectively. The equipment is designed for testing *n*-type transistors; the modifications necessary for *p*-type transistors are indicated.

621.317.78.029.64 **3185**

**Arrangement for the Measurement of High Powers at Microwave Frequencies.**—S. Giustini & R. Tozzi. (*Alta Frequenza*, April 1952, Vol. 21, No. 2, pp. 67–76.) Description of a calorimetric arrangement which has practically no energy losses and has a measurement range up to some hundreds of watts with an error < 6%.

621.317.79 + 621.396.933.23 **3186**

**Airborne Receivers and Test Gear for Instrument Landing Systems.**—Overbury. (See 3098.)

621.317 **3187**

**Electrical Measurements.** [Book Review]—F. K. Harris. Publishers: J. Wiley & Sons, New York, 784 pp., $8.00. (*Tech. Bull. nat. Bur. Stand.*, May 1952, Vol. 36, No. 5, p. 79.) "Basic instrument theory is thoroughly discussed, and direct-current and low-frequency measurements are covered in detail."

## OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.719.33 **3188**

**The F.R.B. Servo-Gauge.**—Bonhomme & Droin. (*Électronique, Paris*, May 1952, No. 66, pp. 30–35.) Equipment is described for measuring the depth of liquids and signalling the result to a remote point. The principle of operation is to arrange just above and just below the surface of the liquid a pair of 'feelers' attached to a vertical metal strip which is driven up or down by a servomechanism according as the liquid level rises or falls.

534.321.9 : 539.32 **3189**

**A Simple Method for Measurement of Elastic Constants, using Ultrasonic Pulses.**—A. Lutsch. (*Z. angew. Phys.*, May 1952, Vol. 4, No. 5, pp. 166–168.) The velocities of waves propagated longitudinally and transversely in a medium are determined in a single operation. The piezoelectric generator/detector is of the type used for nondestructive testing, and the c.r.o. display is self-calibrated.

534.321.9 : 672.8 **3190**

**Cleaning Work with the Aid of Ultrasonic Vibration.**—C. R. Fay. (*Machinery, Lond.*, 15th May 1952, Vol. 80, No. 2061, pp. 853–855.) Description of a machine in which small metal parts are cleaned by ultrasonic agitation of a solution in which they are immersed. A quartz resonator with a natural frequency of 750 kc/s is used.

621-57 : 621.318 **3191**

**Magnetic-Powder Clutch.**—O. Grebe. (*Elektrotech. Z.*, 1st May 1952, Vol. 73, No. 9, pp. 281–284.) Discussion of operating torque characteristics and description of typical equipment made by Elektro-Mechanik G.m.b.H.

621.316.7 **3192**

**Control Technique.**—(*Elektrotech. Z.*, 1st April 1952, Vol. 73, No. 7, pp. 181–251.) A symposium of papers dealing with numerous aspects and applications of electrical control equipment.

621.365.54† **3193**

**Equipment for Inductive Surface Hardening.**—K. Kegel. (*Z. Ver. dtsch. Ing.*, 21st April 1952, Vol. 94, Nos. 11/12, pp. 331–338.) Review of general-purpose and special-purpose equipment and discussion of power requirements for specified hardening depths.

621.365.54/.55† **3194**

**Radio-Frequency Heating.**—(*Brown Boveri Rev.*, Nov. 1951, Vol. 38, No. 11, pp. 315–371.) A collection of papers describing equipment for, and methods and applications of r.f. heating.

621.38 : 529.78 **3195**

**Application of Electronics to the Control of the Rate of Watches and Clockwork Movements.**—J. Dusailly. (*Électronique, Paris*, June 1952, No. 67, pp. 10–15.) Description of equipment giving a record on a paper band of the rate of a watch or clock movement relative to a standard frequency derived from a quartz-crystal oscillator. Each tick of the watch serves to initiate a h.v. spark which perforates and blackens the paper.

621.383.001.8 **3196**

**Amplification of Light-Intensity Fluctuations by means of Photoconductive Cells.**—M. Ploke. (*Funk u. Ton*, June 1952, Vol. 6, No. 6, pp. 305–310.) Discussion of the use of PbS and CdS photocells, which have definite advantages over Se and Tl cells as regards sensitivity.

621.384.611.2† **3197**

**Synchrotron.**—Please note that 621.384.612 will be used in future for synchrotrons in place of 621.384.611.2† used hitherto.

621.384.612 : 621.311.6 **3198**

**The Bevatron Power Plant.**—J. V. Kresser. (*Elect. Engng, N.Y.*, April 1952, Vol. 71, No. 4, pp. 338–343.) Description of the power-supply arrangements for the bevatron at the University of California.

621.384.62 **3199**

**Expression for the Electromagnetic Field in Linear Ion Accelerators.**—M. Bernard. (*C. R. Acad. Sci., Paris*, 5th May 1952, Vol. 234, No. 19, pp. 1862–1865.) A solution of Maxwell's equations is obtained for a semi-infinite cylinder excited by application of a difference of potential between the cylinder and a metal diaphragm across its end.

621.384.62 **3200**

**Numerical Calculation of the Electromagnetic Field in Linear Ion Accelerators.**—M. Bernard. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2175–2178.) The series previously given for the field are in general difficult to evaluate numerically. Simple approximate formulae for the field on the axis are derived.

621.384.62 **3201**

**Application of the W.B.K. Method to the Dynamics of Linear Accelerators.**—M. Hoyaux. (*Rev. sci. Instrum.*, April 1952, Vol. 23, No. 4, pp. 173–175.) The dynamics of 'small motions' in a linear accelerator is studied for conditions as general as possible. It is concluded that heavy particles cannot be accelerated up to the $10^9$-eV range by any practical combination of TM and/or TE travelling and/or stationary waves. Several methods are, however, possible for electrons.

621.385.833 **3202**
**An Approximation Method for the Sinuous Trajectories of Highly Convergent** [electron] **Lenses.**—F. Bertein. (*J. Phys. Radium*, May 1952, Vol. 13, No. 5, p. 309.)

621.385.833 **3203**
**Study of an Electron Lens by the W.K.B. Method.**—C. Muscia. (*R.C. Accad. naz. Lincei*, May 1952, Vol. 12, No. 5, pp. 575–582.)

621.385.833 **3204**
**Electronoptical Velocity Filters.**—M. Schiekel. (*Optik*, 1952, Vol. 9, No. 4, pp. 145–153.) Chromatic aberration in the electron microscope can be reduced by use of a unipotential lens with a negative middle electrode as a velocity filter for the electrons scattered inelastically at the object. The image-forming properties of such filters are calculated for different potential distributions. The optimum resolving power is 110 Å.

621.385.833 : 061.3 **3205**
**The Fourth Annual Convention of the German Association for Electron Microscopy, Tübingen, 6th–8th June 1952.**—(*Optik*, 1952, Vol. 9, No. 4, pp. 189–191.) Titles are given of all the papers presented.

621.385.833 : 061.3 **3206**
**Report of Conferences on Electron Microscopy, Washington and Philadelphia 1951.**—V. E. Cosslett. (*Brit. J. appl. Phys.*, May 1952, Vol. 3, No. 5, pp. 137–139.)

621.387.4(083.72) **3207**
**Standards on Gas-Filled Radiation Counter Tubes: Definitions of Terms, 1952.**—(*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 924–926.)

621.387.4(083.74) **3208**
**Standards on Gas-Filled Radiation Counter Tubes: Methods of Testing, 1952.**—(*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 926–930.)

621.387.422 : 621.385.2 **3209**
**Performance of Pulsed Photomultipliers.**—R. F. Post. (*Nucleonics*, May 1952, Vol. 10, No. 5, pp. 46–50.) Report of investigations on selected type-931A and type-1P21 tubes fed with pulses of duration up to 3 $\mu$s, the applied voltages corresponding to peak secondary emission with total amplification up to $10^9$. Short resolving times are obtained. Time dispersion effects are estimated.

621.387.424 **3210**
**Geiger-Müller Counters.**—N. Warmoltz. (*Philips tech. Rev.*, April 1952, Vol. 13, No. 10, pp. 282–292.) The different possible ways of operating gas-filled tubes as counters of ionizing particles are discussed, and descriptions are given of recently developed types of G-M counter, the importance of the quenching gas being emphasized.

621.387.462 : 549.211 **3211**
**The Texture of Diamonds used for Counting $\alpha$, $\beta$ or $\gamma$ Particles as found from Divergent-Beam X-Ray Photographs.**—H. J. Grenville-Wells. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 313–320.)

## PROPAGATION OF WAVES

621.396.11 : 523.4 **3212**
**Planetary Position Effect on Short-Wave Signal Quality.**—J. H. Nelson. (*Elect. Engng, N.Y.*, May 1952, Vol. 71, No. 5, pp. 421–424.) A.I.E.E. Winter General Meeting paper, January 1952. Investigations extending over seven years indicate distinct correlation between the fading of s.w. transatlantic radio signals and certain planetary configurations in which the heliocentric angles differ by multiples of 90°. Typical configurations which were accompanied by severe fading are shown. A forecasting system based on planetary indications, solar observations and day-to-day signal analysis has given good service throughout 1950 and 1951. See also **1997** of 1951.

621.396.11 : 550.38 **3213**
**Some Aspects of the Average Monthly Radio Propagation Conditions of the Circuit New York-Amsterdam during the Last Three Years, and their Relation with the Average Monthly Geomagnetic Activity and the Maximum Usable Frequency.**—B. van Dijl & D. van Sabben. (*Tijdschr. ned. Radiogenoot.*, May 1952, Vol. 17, No. 3, pp. 135–137.) Correlation is sought between graphs showing the mean monthly values from October 1949 to April 1952 of (*a*) the percentage of hours lost, (*b*) the percentage of hours during which the *K* index (at Witteveen) had a value of 4 or more, and (*c*) the lowest daily value of m.u.f. According as the m.u.f. value is low or high, the number of hours lost is higher or lower than would be expected from the geomagnetic activity. It is noted that magnetic activity increased throughout the period, though the sunspot maximum occurred 4–5 years before.

621.396.11 : 621.317.353.3 **3214**
**Resonance in Gyro-interaction of Radio Waves.**—V. A. Bailey, R. A. Smith, K. Landecker, A. J. Higgs & F. H. Hibberd. (*Nature, Lond.*, 31st May 1952, Vol. 169, No. 4309, pp. 911–913.) Experiments carried out in Australia during the past two years are described which have completely confirmed Bailey's theoretical predictions (2437 of 1937 and 9 of 1939). The gyro-wave *A* was radiated vertically from a horizontal aerial at Armidale, New South Wales, and the wanted wave *B* was radiated from Brisbane, Queensland, on 590 kc/s with a power of 10 kW. The principal observations of *B* were made at Katoomba, New South Wales, Armidale being very nearly at the mid-point of the 740-km path from Brisbane to Katoomba. The pulse power of *A* was about 36 kW, frequencies from 1 255 to 1 880 kc/s being used, the estimated gyro-frequency being about 1 530 kc/s. The results show that a notable degree of resonance occurs as the frequency of the disturbing wave *A* passes through the gyro-frequency. Both double-humped and single-humped resonance curves were obtained. A detailed report of the investigations is to be published elsewhere.

621.396.11.029.55 **3215**
**New Propagation Forecasts from WWV.**—(*QST*, June 1952, Vol. 36, No. 6, p. 19.) From 1st July 1952, forecasts of s.w. radio disturbances will be broadcast from WWV on the standard frequencies (2·5, 5, 10, 15, 20 and 25 Mc/s). The forecasts are prepared four times daily, and are transmitted in code at 19·5 and 49·5 minutes past each hour. The letters N, V, W denote respectively the existing normal, unsettled, or disturbed conditions. The following number indicates on the N.B.S. scale the expected quality of future reception, 1 representing 'impossible' and 9 'excellent'. The forecasts refer only to North Atlantic paths, such as Washington to London or New York to Berlin.

621.396.11.029.62/.64 **3216**
**Transmission beyond the Horizon at Frequencies between 40 and 4 000 Mc/s.**—(*Bell Lab. Rec.*, June 1952, Vol. 30, No. 6, pp. 245–246.) A short account of experimental results which show that the power received at points beyond the horizon is substantially independent

of frequency, aerial height, and weather effects, and that the signal strength decreases much more slowly with increase of distance than the rapid decrease predicted from the classical smooth-earth theory. A fuller report is to be published.

621.396.11.029.62 **3217**

**The Propagation of Ultrashort Waves beyond the Horizon, with Particular Reference to the Meteorological Influences.**—B. Abild, H. Wensien, E. Arnold & W. Schikorski. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, May/June 1952, Vol. 4, Nos. 5/6, pp. 85–100.) A study is made of the meteorological conditions in western Germany causing ultrashort waves to be propagated to abnormally great distances; both mean values and detailed variation of field strength are examined. Predictions from theory are compared with results of measurements recorded at a number of receiving stations. Previous investigations [e.g. 2580 of September (Abild)] have indicated that field-strength fluctuations depend mainly on vapour pressure and temperature in the lower troposphere. Probable secondary influences are turbulence in the lower atmosphere and variations of the state of the ground.

621.396.11.029.64(442.6/.8) **3218**

**Study of the Propagation of Centimetre Waves in Northern France.**—P. Chavance. (*Ann. Télécommun.*, June 1952, Vol. 7, No. 6, pp. 254–261.) An account of investigations on wavelengths of 9·5 and 3·2 cm, using equipment described previously [3115 of 1951 (Maillard, Voge & Chavance)]. The aim was to obtain statistical information on propagation over a 76-km path with insufficient ground clearance. Seasonal and diurnal effects on signal strength and fading are shown graphically and discussed, and records of typical fading effects are displayed and analysed.

621.396.81 **3219**

**Interpretation of High-Frequency C.W. Field-Intensity Records with the Aid of Simultaneous Pulse Data.**—R. Silberstein. (*Proc. Inst. Radio Engrs.*, Aug. 1952, Vol. 40, No. 8, pp. 974–976.)

## RECEPTION

621.396.62 : 061.4 **3220**

**Radio at the Paris Fair.**—(*TSF et TV*, June 1952, Vol. 28, No. 284, pp. 187–189.) Comment on the exhibits and classification of 133 receivers shown.

621.396.621(083.74) (44) **3221**

**French Standard C92-120 on Battery-Operated Receivers.**—Radionyme. (*Toute la Radio*, June 1952, No. 166, pp. 193–195.) Analysis of the specifications for receivers of different types, with an outline of test methods for sensitivity, selectivity, distortion, etc.

621.396.8 + 621.396.1 **3222**

**Reception of Broadcasting from all over the World.**—Lhombreaud. (See 3228.)

621.396.97 : 621.396.823 : 351.819(44) **3223**

**The New French Regulations for the Protection of Broadcasting against Interference of Industrial Origin.**—M. Adam. (*Rev. gén. Élect.*, April 1952, Vol. 36, No. 4, pp. 197–200.) Maximum permissible interfering voltages are specified for the long-, medium- and short-wave bands respectively. Methods of measuring such voltages are indicated. Apparatus must be fitted with suppressor devices before being offered for sale.

## STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **3224**

**Basic Communication Theory.**—L. S. Schwartz. (*Radio & Televis. News, Radio-Electronic Engng Section*, June & July 1952, Vol. 47, Nos. 6 & 7, pp. 3–5, 28–30 & 11–13.) A nonmathematical presentation of the theory developed by Shannon, Wiener and others.

621.39.001.11 : 519.21 **3225**

**Convexity and Information.**—R. Féron. (*C. R. Acad. Sci., Paris*, 5th May 1952, Vol. 234, No. 19, pp. 1840–1841.) Proof is given that the necessary and sufficient condition that the gain of information should not be negative for any pair XY of aleatory variables is that a certain function of the distribution function of Y should be a concave function.

621.396.029.6 **3226**

**Radio Communication on Short Waves.**—H. Köppen. (*NachrTech.*, May 1952, Vol. 2, No. 5, pp. 136–139.) A short review of present-day technical developments in communication on m, dm and cm waves, and of recent investigations of the practicability of using wavelengths in the range 25–100 m for communication in mines.

621.396.1 **3227**

**Wavelength Problems in Telephony and Television Broadcasting.**—G. Pedersen. (*Teleteknik, Copenhagen*, May 1952, Vol. 3, No. 2, pp. 49–60.) An outline is given of the principles governing the international allocation of wavelengths. The heavy bandwidth demands of television are discussed with special reference to the plans for television in Denmark.

621.396.1 : 621.396.8 **3228**

**Reception of Broadcasting from all over the World.**—C. Lhombreaud. (*TSF et TV*, April 1952, Vol. 28, No. 282, pp. *Doc. tech.* 1–3.) Report of a survey made in the light of the Copenhagen frequency allocation. This article is the first of a series giving station operating details and an indication of the quality of reception near Bordeaux, starting with European stations.

621.396.4.029.53 **3229**

**Microwave Systems for 960 and 2 000 Mc/s.**—R. V. Rector & W. E. Sutter. (*Trans. Amer. Inst. elect. Engrs*, 1950, Vol. 69, Part II, pp. 1100–1108. Discussion, pp. 1108–1109.) In the 2-kMc/s transmitter, 2–5 W output is obtained from a type-SRL-7C klystron rated at 10 W. Good frequency stability is obtained by accurate voltage and temperature control. Pulse-duration modulation is used and 24 channels are provided, each of which can give 18 two-way control channels. The 960-Mc/s transmitter provides 7 channels, each giving either two-way voice communication or 18 two-way control channels. Block diagrams of both equipments are given with description and illustrations.

621.396.619.16 **3230**

**A System of Pulse-Code Modulation using Circulated Pulses.**—S. Fedida. (*Electronic Engng*, Aug. 1952, Vol. 24, No. 294, pp. 356–361.) A method is described for converting sample pulses into sequences of up to five on/off pulses, which when interpreted as digits in a binary system of units, reproduce the original information represented by the sample pulses. Two possible methods of decoding to derive the original within a prescribed tolerance are outlined.

621.396.619.16 : 621.396.4 **3231**

**Nonsynchronous Pulse Multiplex System.**—A. L. Hopper. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 116–120.) An experimental time-sharing multiplex system is described in which the inputs to the different transmitters are converted to p.a.m. by sampling with random pulses, these a.m. pulses being converted to equal and opposite pulse pairs separated by a constant delay whose value is selected by means of a switch. This delay constitutes the identifying characteristic at the receiver. The system can be used for rural radio-telephony and for communication between moving vehicles. It has the disadvantage that it is not economical of channel capacity, and would probably be useful for the transmission of intelligence rather than high-quality speech.

621.396.619.16 : 621.396.41 **3232**

**Electronic Pulse Systems for Telegraphy.**—G. Montessori. (*Alta Frequenza*, April 1952, Vol. 21, No. 2, pp. 77–101.) Synchronization, regeneration and channel separation are provided electronically in a time-division multiplex telegraphy system using ring distributors controlled by a frequency-stabilized pulse generator, the synchronizing signal being produced by modifying the regular pulse rhythm. The system has been used by the Italcable Co. for high-speed telegraphy.

621.396.65 : 621.396.43 **3233**

**Multiple-Channel Telephony on V.H.F. Radio Links.**—B. R. Tupper & P. B. Patton. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 913–916.)

621.396.65 : 621.396.43 **3234**

**Design Fundamentals for Beam Radio Systems.**—H. Werrmann. (*Funk u. Ton*, June 1952, Vol. 6, No. 6, pp. 281–297. Correction, *ibid.*, July 1952, Vol. 6, No. 7, p. 380.) Discussion of the various factors which must be taken into account, including effects of normal attenuation, ground proximity and operation beyond the optical range, aerial aperture and gain, interference and system noise, and the type of modulation to be used.

621.396.65.029.6 : 621.316.925 : 621.311.1 **3235**

**Protective Relaying Systems using Microwave Channels.**—H. W. Lensner. (*Elect. Engng, N.Y.*, May 1952, Vol. 71, No. 5, pp. 400–405.) A.I.E.E. Winter General Meeting paper, January 1952. Several practical applications in power systems are outlined.

621.396.65.029.63 : [621.396.5 + 621.317.083.7 **3236**

**Microwave Radio Links of Bonneville Power Administration.**—S. Metzger, N. H. Gottfried & R. W. Hughes. (*Elect. Commun.*, June 1952, Vol. 29, No. 2, pp. 87–92.) Description of the FTL-10B 23-channel system now in operation. See also 1777 of 1951 (Stevens & Stringfield).

621.396.72.029.62 **3237**

**The Inauguration of F8REF.**—J. Ferré. (*Radio franç.*, May 1952, No. 5, p. 15.) Note of s.w. R/T transmissions to be made twice weekly from a central station for the benefit of French amateurs.

621.396.8.029.53 **3238**

**Medium-Wave Broadcasting Coverage in the NWDR Area.**—G. Paulsen. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, May/June 1952, Vol. 4, Nos. 5/6, pp. 101–110. Correction, *ibid.*, July/Aug. 1952, Vol. 4, Nos. 7/8, p. 141.) A résumé is given of the theory of radio wave propagation and of transmission requirements for a satisfactory broadcasting service. Interference between transmissions on (*a*) common channels and (*b*) adjacent channels is discussed and the limiting values adopted by the NWDR for the ratio between wanted and unwanted signals in various cases are shown graphically. The principles of system planning to cover the greatest possible fraction of the population are discussed in relation to the area; about 70% of the population is adequately served. The complementary uses of medium-wave and u.s.w. services are indicated.

621.39.001.11 **3239**

**La Cybernétique—Théorie du Signal et de l'Information.** [Book Review]—L. de Broglie (Ed.). Publishers: Éditions de la Revue d'Optique Théorique et Instrumentale, 1951, 318 pp., 1600 fr. (*Brit. J. appl. Phys.*, April 1952, Vol. 3, No. 4, p. 133.) Papers presented at a conference at the Henri Poincaré Institute, Paris, 1950.

## SUBSIDIARY APPARATUS

621-526 : 621.313.281 **3240**

**Amplifying Dynamos: their Use in Servomechanisms.**—G. Lehmann. (*Bull. Soc. franç. Élect.*, April 1952, Vol. 2, No. 16, pp. 198–209.)

621.314.632 : 546.289 **3241**

**The New G-10 Germanium Dot Rectifier.**—T. J. Ferguson. (*Radio & Televis. News*, June 1952, Vol. 47, No. 6, pp. 42–43.) Description and some performance figures of a rectifier unit suitable for supplying power to radio and television equipment. The G-10 is a series combination of two 'button' rectifiers each consisting of a pellet of spectroscopically pure Ge, $\frac{1}{8}$-in. square, placed at the centre of a metal dish sealed with butyl rubber and mounted on a 2-in.-diameter metal cooling fin. Units are selected to ensure equal division of peak back voltage across the two associated rectifiers.

621.314.634.012 **3242**

**Static and Dynamic Characteristic Curves for Selenium Rectifiers.**—I. Somos. (*Elektrotechnika, Budapest*, May 1952, Vol. 45, No. 5, pp. 154–159.) Methods of measurement are described which give reproducible results.

621.316.722.1 : 621.326 **3243**

**Incandescent Lamp Bulbs in Voltage Stabilizers.**—W. J. Cunningham. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 658–662.) An approximate analysis is made of the operation of lamps used as sources of reference voltage in a.c. stabilizers. The equivalent-circuit theory developed in 3026 above is used to determine the distortion due to the nonlinearity of the lamp I/V characteristic. The effects of changes of frequency and current are demonstrated.

621.316.93 **3244**

**Lightning Protection since Franklin's Day.**—K. B. McEachron. (*J. Franklin Inst.*, May 1952, Vol. 253, No. 5, pp. 441–470.) Historical account of the development of the various types of protective device in use to-day. 46 references.

## TELEVISION AND PHOTOTELEGRAPHY

621.397.5 **3245**

**Optimum Number of Lines and Screen Dimensions.**—P. Stroobants. (*Télévision*, May 1952, No. 23, pp. 113–117.) The lowest number of scanning lines $N$ consistent with invisibility of line structure in the television image is expressed in terms of the angular resolution of the eye and the ratio between the viewing distance (as selected naturally by average viewers) and the screen height $h$. Based on subjective judgments, curves are plotted showing the variation of $N$ with $h$ for 95% and for 100% observer satisfaction. By reference to these curves line standards of 625, 819 and $>819$ are shown to be appropriate respectively for receivers with screen diameters up to 22 cm, between 22 and 40 cm, and over 40 cm.

621.397.5 : 061.3 (431.55) **3246**

**Berlin Television Conference.**—(*Funk u. Ton*, May 1952, Vol. 6, No. 5, pp. 258–264.) Summaries are given of papers presented at the conference arranged by the Berlin-Charlottenburg Technical University, March 1952.

621.397.5 : 535.623 **3247**

**Requisite Color Bandwidth for Simultaneous Color-Television Systems.**—K. McIlwain. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 909–912.) Report of subjective tests, using both skilled and lay observers, to determine how far bandwidth can be reduced before picture reproduction becomes unsatisfactory. Under the particular test conditions described a band about 1 Mc/s wide is sufficient for most colour transmissions, provided a further band 4 Mc/s wide is available for transmitting the brightness detail.

621.397.5 : 535.88 : 791.45 **3248**

**A Direct-Projection System for Theater Television.**—F. N. Gillette. (*J. Soc. Mot. Pict. Televis. Engrs*, May 1952, Vol. 58, No. 5, pp. 385–396.) General description of the Simplex Model PB-600 for projecting a full-size television picture on a theatre screen. The system combines simplicity in installation, convenience in maintenance and reliability in operation.

621.397.5 : 621.396.712 **3249**

**The Lime Grove Television Studios of the British Broadcasting Corporation.**—(*Engineering, Lond.*, 25th April 1952, Vol. 173, No. 4500, pp. 518–519.) Details are given of studio arrangements and camera equipment in use. See also 753 of 1951.

621.397.5(204.1) **3250**

**Underwater Television.**—(*Engineer, Lond.*, 9th May 1952, Vol. 193, No. 5024, pp. 642–643.) Description, based on an Admiralty bulletin, of remotely controlled television camera equipment developed by Pye, Ltd, for operation at depths up to 1 000 ft; sea trials have been made in the diving vessel 'Reclaim'. Using a plane window, a 75° viewing angle has been obtained by simple devices.

621.397.5(204.1) **3251**

**Underwater Television.**—(*Engineer, Lond.*, 25th April 1952, Vol. 193, No. 5022, p. 565; *Engineering, Lond.*, 25th April 1952, Vol. 173, No. 4500, p. 531.) Account of a laboratory demonstration of progress made since the first use of underwater television (2053 of July). Camera mounting and lighting arrangements are described. The image-orthicon equipment is modified to permit remote control of focusing and aperture, with remote indication on the parent ship permitting deductions to be made as to size of object and distance from camera; the brand of a packet of cigarettes could be identified at 6–12 ft. A 625-line picture is used.

621.397.5.001.8 **3252**

**Television Technique as an Aid to Observation.**—J. D. McGee. (*J. R. Soc. Arts*, 21st March 1952, Vol. 100, No. 4869, pp. 329–345. Discussion, pp. 346–349.) A survey of applications covering (*a*) the extension of vision in respect of either distance or wavelength range, (*b*) television memory devices.

621.397.6 **3253**

**Improving TV System Transient Response.**—J. Ruston. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 110–113.) A television transmitter/receiver system having the overall frequency characteristic specified by the F.C.C. and R.T.M.A. has unacceptably high transient distortion. This distortion can be reduced by modifying the overall response curve to produce a stepped characteristic with a region of symmetry about the carrier frequency. A network suitable for producing such a modification in the receiver video circuit is illustrated.

621.397.61(494) **3254**

**The Uetliberg as a Site for a Television Transmitter.**—H. Laett. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Feb. 1952, Vol. 30, No. 2, pp. 59–69. In French and German.) An account is given of field-strength and picture-quality measurements in the district within about 40 km of Zürich, which is the most densely populated part of Switzerland. A double-turnstile aerial mounted on a tower at the summit of the Uetliberg, which dominates the district, was fed by a transmitter operating on 62·25 Mc/s with a peak power of 400 W. Field strengths are shown on a map. The results as a whole show clearly the primary importance of operation within the optical range, though diffraction effects rendered reception satisfactory over a considerable part of the region not visible from the transmitter.

621.397.611.2 **3255**

**The Application of Negative Feedback to Flying-Spot Scanners.**—R. Theile & H. McGhee. (*J. Brit. Instn Radio Engrs*, June 1952, Vol. 12, No. 6, pp. 325–339.) Negative feedback between the output of the amplifier following the photomultiplier and the control electrode of the scanning tube affords a convenient means of controlling contrast. Problems introduced by the time delay round the feedback loop are discussed. The influence of feedback on the appearance of screen afterglow is analysed, and the effect on signal/noise ratio is considered.

621.397.611.2 : 621.385.2 **3256**

**A Simple Electrostatic Electron-Optical System with only One Voltage.**—Schagen, Bruining & Francken. (See 3284.)

621.397.62 **3257**

**The Simplification of Television Receivers.**—W. B. Whalley. (*Proc. Instn Radio Engrs, Aust.*, April 1952, Vol. 13, No. 4, pp. 99–103.) Reprint. See 1271 of 1950.

621.397.621.2 **3258**

**The Focusing of Cathode-Ray Tubes for Television Receivers.**—J. A. Hutton. (*J. Brit. Instn Radio Engrs*, May 1952, Vol. 12, No. 5, pp. 295–304.) The problem is examined from the point of view of receiver design rather than tube design. Deflection defocusing and resulting aberrations are discussed and remedies indicated. The influence on focus control of the configuration and position of the focusing field is investigated, and the effect of supply-voltage variation considered.

621.397.621.2 **3259**

**Cathode-Ray Picture Tube with Low Focusing Voltage.**—C. S. Szegho. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 937–939.) Focusing is performed by means of a univoltage e.s. lens with the low-voltage electrode at 0–5% of anode voltage. A description and operating characteristics are given for a particular design incorporating an ion trap. Methods of avoiding breakdown due to high voltage gradients are discussed.

621.397.621.2 : 535.241.48 **3260**

**A Graphical Treatment of the Tone-Reproduction Problem in Television Systems.**—R. B. Mackenzie. (*Brit. J. appl. Phys.*, May 1952, Vol. 3, No. 5, pp. 141–147.) "The impracticability of analysing the tone reproduction properties of a television system in terms of simple mathematical laws is discussed. A construction for a tone reproduction chart is presented which enables a realistic assessment of the overall performance of a system to be made, subjective effects being taken into account. The use of the chart is demonstrated by examining the effects of altering certain parameters of the system."

621.397.621.2 : 535.623 **3261**

**Elimination of Moiré Effects in Tricolor Kinescopes.**—E. G. Ramberg. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 916–923.) The influence of scanning-line width, mask-aperture size, aperture spacing, line separation, orientation of scanning pattern relative to mask, and picture content on moiré effects arising in tubes of the type described by Law (844 of March) is discussed.

621.397.621.2 : 621.397.335 **3262**

**Flywheel Synchronization of Sawtooth Generators in Television Receivers.**—P. A. Neeteson. (*Philips tech. Rev.*, May 1952, Vol. 13, No. 11, pp. 312–322.) The sensitivity of different systems of synchronization to interference is discussed and a detailed description is given of the 'flywheel' method of line synchronization which minimizes the effect of interference. The principles of a.ph.c., particularly important in this system, are fully explained, and two circuits are described in which the functions of phase discriminator and sawtooth-voltage generator are combined in an ordinary pentode.

621.397.74 **3263**

**Maximum Coverage for V.H.F.-U.H.F. TV.**—F. W. Smith. (*Electronics*, July 1952, Vol. 25, No. 7, pp. 146–150.) A series of charts are presented relating transmitter power, aerial height and service area for the two grades of service specified in the F.C.C. report of April 1952 revising the frequency-allocation system.

621.397.82 **3264**

**Reducing TV Receiver Oscillator Radiation.**—E. W. Chapin & W. K. Roberts. (*Electronics*, July 1952, Vol. 25, No. 7, pp. 116–120.) Measurements of the radiation from typical receivers are described and the results are tabulated. Methods of screening the oscillator unit efficiently, and circuit modifications which reduce interference with other receivers, are detailed.

## TRANSMISSION

621.396.61 : 621.396.931 **3265**

**F.M. Transmitter for 42 Mc/s.**—H. G. Stratman. (*Radio & Televis. News, Radio-Electronic Engng Section*, June 1952, Vol. 47, No. 6, pp. 10–13, 31.) Design and performance details are given of a 3-kW transmitter for police communications.

621.396.619.13 **3266**

**Improved Reactance-Valve Circuit.**—J. Wobst. (*NachrTech.*, June 1952, Vol. 2, No. 6, pp. 177–179.) A circuit is described which gives the same maximum frequency swing as can be obtained with the normal reactance-valve modulator, but which suppresses completely the a.m. which usually accompanies the f.m. On account of the frequency dependence of the phase shifter used, the new arrangement is only suitable for a frequency range of about 1:1.3. Design formulae are given and applied to the determination of circuit parameters for a f.m. oscillator covering the range 10–12 Mc/s.

621.396.619.23 **3267**

**Study of the Serrasoid Modulator.**—F. W. Gundlach. (*Fernmeldetech. Z.*, June 1952, Vol. 5, No. 6, pp. 256–262.) The merits of three ways of operating the modulator [342 of 1949 (Day)] are examined by analysing the frequency spectrum of the pulse trains. The only method providing complete freedom from a.m. is that in which the pulses are of constant height, a form of p.w.m. being applied. The effect of slight a.m. on the frequency-multiplier performance is studied. The multiplier should operate in class C with automatic bias.

## VALVES AND THERMIONICS

621.314.7 **3268**

**Crystal Triodes.**—E. G. James & G. M. Wells. (*J. Brit. Instn Radio Engrs*, May 1952, Vol. 12, No. 5, pp. 285–292. Discussion, pp. 293–294.) A brief account is given of developments leading to the production of the Ge triode, and some applications and limitations are indicated.

621.314.7 **3269**

**New Transistors give Improved Performance.**—J. A. Morton. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 100–103.) Design developments leading to improved reliability, reproducibility and frequency response are described briefly. For a fuller account see 2651 of September.

621.383 : 621.385.15 : 535.51 **3270**

**Polarization Effects in Photomultiplier Tubes.**—E. P. Clancy. (*J. opt. Soc. Amer.*, May 1952, Vol. 42, No. 5, p. 357.) Measurements were made of the response of a photomultiplier tube as a function of the angle $\theta$ between the direction of the electric vector of the plane-polarized incident light and the longitudinal axis of the tube. Type 931-A tubes gave the highest value of the ratio of the responses at $\theta = 90°$ and $\theta = 0°$.

621.383.2 **3271**

**Production Testing of Multiplier Phototubes.**—R. W. Engstrom, R. G. Stoudenheimer & A. M. Glover. (*Nucleonics*, April 1952, Vol. 10, No. 4, pp. 58–62.) Account of tests applied in the manufacture of the R.C.A. 5819 photomultiplier, with emphasis on cathode sensitivity.

621.383.27 **3272**

**Non-Linear Amplification in E.M.I. Photomultipliers.**—J. F. Raffle & E. J. Robbins. (*Proc. phys. Soc.*, 1st May 1952, Vol. 65, No. 389B, pp. 320–324.) The heights of the output pulses obtained from E.M.I. photomultipliers are not always proportional to the quantity of light incident on the photocathode, the linear relation failing when the charge density in the multiplier becomes too great.

621.383.5 **3273**

**Response of Barrier-Layer Photocells. Theory permitting the Prediction of the Variations of Output Voltage as a Function of the Illumination and the Load Resistance of a Selenium Photocell.**—G. Blet. (*C. R. Acad. Sci., Paris*, 26th May 1952, Vol. 234, No. 22, pp. 2187–2189.) A single curve is derived which gives results in good agreement with experiment for any value of load resistance and for a very wide range of intensity of illumination.

621.384.5 : 621.318.572 **3274**

**The Cold-Cathode Gaseous Discharge as a Switching Device.**—N. L. Harris. (*Engineer, Lond.*, 4th April 1952, Vol. 193, No. 5019, pp. 460–462.) Applications are described of cold-cathode tubes of various types in over-voltage protection and in radar switching devices.

621.385.029.6 : 621.392.22 3275

**A Broad-Band Interdigital Circuit for Use in Traveling-Wave-Type Amplifiers.**—R. C. Fletcher. (*Proc. Inst. Radio Engrs*, Aug. 1952, Vol. 40, No. 8, pp. 951–955.) Analysis indicates that the interdigital type of structure, which is capable of handling high power, can be designed to have a wide frequency band. Phase-velocity/frequency curves plotted from measurements made on a model operating at 300 Mc/s are of the same general shape as curves derived from the theory.

621.385.029.6 : 621.396.822 3276

**Calculation of the Noise Figure of the Travelling-Wave Valve: Part 1.**—W. Kleen & W. Ruppel. (*Arch. elekt. Übertragung*, May 1952, Vol. 6, No. 5, pp. 187–194.) Recent investigations indicate that fluctuations of density and velocity have a periodic distribution along the electron beam, while the energy fluctuations are uniformly distributed. Because of the periodicity, there is an optimum value of the distance between accelerator electrode and entrance to delay line. The noise figure is approximately proportional to the ratio between the phase constant and the attenuation constant for transmission through the valve, and under optimum conditions is equal to this ratio. The variation of noise figure with dimensions and operating conditions is shown for a valve with helical delay line; in this case the optimum value varies approximately exponentially with frequency, being about equal at 3 kMc/s to the noise figure of a crystal detector in a mixing circuit.

621.385.032.216 3277

**Thermionic Emission and Electrical Conductivity of Oxide-Coated Cathodes.**—S. I. Narita. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, p. 599.) Measurements on both sintered and ordinary oxide-coated cathodes are described and direct comparisons made. The variations of emission and conductivity with temperature and with degree of activation are shown. The sintered cathode was prepared by converting $BaCO_3$ to BaO under conditions of slow speed of exhaust and at very high cathode temperature. The activities of both types of cathode were varied by evaporating Ba on to the surfaces. Three mechanisms of electron conduction in the oxide coating are considered possible, all operating simultaneously in the most general case.

621.385.032.216 3278

**Activation of High-Vacuum Oxide-Cathode Valves.**—G. H. Metson. (*Vacuum*, Oct. 1951, Vol. 1, No. 4, pp. 283–293.) Discussion, based on laboratory experience, of three current theories of activation: chemical reduction, electrolysis and thermodynamic action. None of these gives an adequate explanation of the high initial activation commonly achieved.

621.385.032.216 3279

**Chemical Reactions in Barium-Oxide-on-Tungsten Emitters.**—R. C. Hughes, P. P. Coppola & H. T. Evans. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 635–641.) Alternative theories are examined regarding the reactions responsible for the $Ba_3WO_6$ interface formed when a BaO-on-W cathode is prepared by applying $BaCO_3$ to W and processing normally. Two possibilities are considered: (*a*) formation of $Ba_3WO_6$ from BaO and W, and (*b*) formation of $Ba_3WO_6$ from $BaCO_3$ and W. Experiments made to test these theories are described. A series of four reactions occur at progressively higher temperatures. Prolonged heating at over 1000°C may convert the whole of the oxide layer into $Ba_3WO_6$. The interface can probably be eliminated by applying BaO to oxide-free W and adding the necessary Ba for activation from an outside source.

621.385.032.216 3280

**Physical Processes in the L Cathode.**—D. L. Schaefer & J. E. White. (*J. appl. Phys.*, June 1952, Vol. 23, No. 6, pp. 669–674.) Experiments on the L-type cathode [773 of 1951 (Lemmens, Jansen & Loosjes)] are described; degree of coverage of the W surface with Ba, and rate of evaporation of the Ba were investigated. The evaporation rate is found to be controlled by the surface diffusion of the Ba over the W. Despite incomplete coverage of the emitting surface with Ba, and almost complete absence of streaming of active material out through pores in the surface material, evaporation is sufficient to cause concern in certain applications.

621.385 + 621.326].032.7 : 666.17 3281

**Making Glass Bulbs.**—(*Elect. Rev., Lond.*, 23rd May 1952, Vol. 150, No. 3887, pp. 1124–1128.) Description of the plant and operation of a new factory at Harworth, Notts, manufacturing 1 500 000 bulbs daily from the basic raw materials by a highly mechanized system of 'flow production'. The smaller of two glass-moulding bulb-blowing machines operating on a continuous glass ribbon produces the complete range of valve bulbs of diameter up to 44·5 mm, including all the miniature types. Its output is approximately one million bulbs in 24 hours. The larger machine has a daily output of half a million lamp bulbs of diameter up to 8 cm. For similar descriptions see *Elect. Times*, 22nd May 1952, Vol. 121, No. 3159, pp. 937–940 and *Electrician*, 23rd May 1952, Vol. 148, No. 3858, pp. 1693–1696.

621.385.2 : 546.289 3282

**The Time Lag of the Forward Conductance of Germanium Diodes.**—T. Einsele. (*Z. angew. Phys.*, May 1952, Vol. 4, No. 5, pp. 183–185.) Measurements were made of Ge-diode current with a pulsed input voltage of low duty factor; the forward characteristics obtained at different instants are plotted for a specimen in which the conductance took nearly 1 $\mu$s to reach its static value. With Si diodes no lag was observed; with Ge diodes the lag was longer when large reverse bias was applied. In contrast to the results obtained by Meacham & Michaels (1817 of 1950), no lag was observed in the backward conductance.

621.385.2 : 546.289 : 621.317 3283

**Germanium Diodes for Indicating Instruments and Relays.**—F. J. Lingel. (*Tele-Tech*, April 1952, Vol. 11, No. 4, pp. 42–43 . . 104.) A series of circuit diagrams illustrates the various applications of Ge rectifiers. A table and graphs show the operating characteristics of different available types.

621.385.2 : 621.397.611.2 3284

**A Simple Electrostatic Electron-Optical System with only One Voltage.**—P. Schagen, H. Bruining & J. C. Francken. (*Philips Res. Rep.*, April 1952, Vol. 7, No. 2, pp. 119–130.) Analysis of a system for use in television camera tubes or image converters, in which the cathode and anode are concentric spheres, the anode being the smaller. The effect of providing an aperture in the anode for the passage of the electrons is investigated. The formulae derived from theory were applied to an experimental arrangement with a cathode in part spherical and in part cylindrical; pictures of good definition and freedom from distortion were obtained.

621.385.3/.5 3285

**Determination of Penetration Factor for Amplifier Valves.**—H. Köppen. (*NachrTech.*, April 1952, Vol. 2, No. 4, pp. 112–116.) Charts are provided which enable penetration factors to be readily determined from the physical dimensions of valve electrode systems; their use is illustrated for a directly heated pentode.

621.385.3/.4].029.63 **3286**

**Some New Ultra-high-Frequency Power Tubes.**—P. T. Smith. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 224–238.) Experimental grounded-grid triodes and grounded-cathode tetrodes with close grid-cathode spacing are described. The output of the triodes is 5–10 kW at 900 Mc/s, about the same as at lower frequencies. The tetrodes have lower power gain, but have certain advantages when high-level modulation is required.

621.385.3.029.64 **3287**

**Amplification Constant for Microwave Triodes.**—Y. Koike & S. Yamanaka. (*Technol. Rep. Tohoku Univ.*, 1951, Vol. 15, No. 2, pp. 14–25.) Published results of various workers for microwave valves with parallel-wire grids are reviewed and suitable formulae for calculating the amplification factor are quoted for the two cases where island formation is appreciable or negligible. Formulae for the screening effect of wire-mesh grids are based on experimental results.

621.385.5.018.424 **3288**

**New Valve for Wide-Band Amplifiers.**—P. Meunier. (*Onde élect.*, June 1952, Vol. 32, No. 303, pp. 232–237.) Detailed description of the construction and characteristics of two pentodes, Type PTT216 with noval base and Type PTT214P with standard PTT type-P base. Cathode-current density is 50 mA/cm², grid-cathode distance 0·06 mm, grid pitch 0·065 mm and diameter of grid wires only 8 $\mu$. Seven Type-PTT216 valves were used in an amplifier with 75-Ω input and output impedance, gain 70 db and pass band of 25 Mc/s centred on 70 Mc/s. An equivalent amplifier using Type-6AK5 valves would have required 13 valves.

621.385.83 **3289**

**The Effect of Velocity Distribution in a Modulated Electron Stream.**—D. A. Watkins. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 568–573.) A method of solving electron-beam problems is described which takes account of the thermal spread of velocity. The method is based on Liouville's theorem. The effect of the thermal spread on signal and noise in a drifting stream is calculated by means of a power series (*a*) for small-signal v.m. of the stream, (*b*) with the stream initially possessing full shot noise.

621.385.832 **3290**

**Internal Electrostatic Deflection Yokes.**—K. Schlesinger. (*Electronics*, July 1952, Vol. 25, No. 7, pp. 105–109.) Description of the 'deflectron' electrode design. For deflection in two directions at right angles, composite electrodes with triangular boundaries are used which form the sides of a box. This provides simultaneous horizontal and vertical deflection, equal sensitivities and a common centre of deflection, giving greater freedom from scan distortion and defocusing than a conventional crossed-plate structure. Cylindrical and conical modifications of the design are illustrated; their application and production techniques are described.

621.396.615.14 + 621.396.645].029.64 **3291**

**Generation and Amplification of Oscillations in the Ultra-High-Frequency Region.**—F. W. Gundlach. (*Z. angew. Phys.*, April 1952, Vol. 4, No. 4, pp. 147–157.) The mode of operation and practical constructions of microwave triode, klystron and travelling-wave valves, including multi-segment magnetrons, are described. Sectional drawings of selected types are shown. 70 references.

621.396.615.141.2 : 621.365.55† **3292**

**Industrial Magnetrons for Dielectric Heating.**—R. B. Nelson. (*Electronics*, Aug. 1952, Vol. 25, No. 8, pp. 104–109.) Magnetrons and associated circuits for operation at 915 Mc/s and 2·450 kMc/s are described. A 5-kW oscillator is available for the 915-Mc/s band, and experimental 50-kW models have been produced. A 2-kW model is available for the 2·450-kMc/s band. See also 556 of February.

621.396.615.141.2.016.352 **3293**

**Instabilities in the Smooth-Anode Cylindrical Magnetron.**—L. A. Harris. (*J. appl. Phys.*, May 1952, Vol. 23, No. 5, pp. 562–567.) A magnetically focused space-charge cloud of the type found in the smooth-anode magnetron is examined to determine whether a perturbation of the equilibrium condition will grow. A field analysis is carried out in which radial admittances are matched at the edge of the cloud. The solutions for the characteristic frequencies are complex, indicating that the disturbance grows with time.

621.396.615.141.2.029.63 : 621.396.619.13 **3294**

**Frequency Modulation of Magnetron in the Decimetre Wave Range.**—H. Fricke. (*Arch. elekt. Übertragung*, June & July 1952, Vol. 6, Nos. 6 & 7, pp. 228–240 & 281–287. Corrections, *ibid.*, Aug. 1952, Vol. 6, No. 8, p. 351.) Magnetron characteristics are deduced from circle-diagram analysis of the equivalent circuit for the apparent conductance between two adjacent segments of a multisegment magnetron. This shows that with the usual method of modulation by variation of the anode voltage, amplitude variation is superposed on the frequency modulation. A new method is proposed which results in wide-band f.m. without accompanying a.m. The method consists in varying a capacitive reactance connected in parallel with the oscillatory system. An experimental verification was carried out, using the grid-anode path of a retarding-field valve as the variable reactance.

621.396.615.141.2.029.64 : 621.396.619.13 **3295**

**A 7 000-Mc/s Developmental Magnetron for Frequency Modulation.**—H. K. Jenny. (*RCA Rev.*, June 1952, Vol. 13, No. 2, pp. 202–223.) Description of a 24-vane double-strapped valve operated at the relatively low voltage of 550 V and cathode-current density of 150 mA/cm² to ensure long life. The frequency range is 6·575–6·875 kMc/s, output power 10 W, and efficiency 30–40%; frequency swings up to 16 Mc/s can be handled without a.m. Tuning and modulation curves are derived from consideration of equivalent circuits.

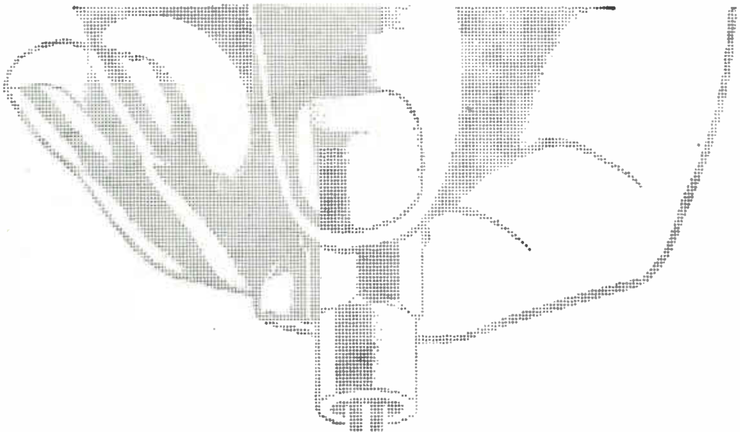
621.396.622.63 **3296**

**An Analysis of Crystal Diodes in the Millivolt Region.**—W. B. Whalley & C. Masucci. (*Tele-Tech*, May 1952, Vol. 11, No. 5, pp. 40–42 . . 131.) The resistance characteristics of different diodes were determined using a balanced a.c. source, a high-gain band-pass RC amplifier and a c.r.o. The overall characteristic is expanded to show the mid-region constant-resistance portion below about 1 mV. This is correlated experimentally with the threshold r.f. detection voltage. Traces obtained with a selector circuit using two diodes are analysed.

## MISCELLANEOUS

621.3 : 061.4 **3297**

**26th Brussels International Fair, 26th April to 11th May 1952.**—(*Radio Revue TV*, May 1952, Vol. 4, No. 5, pp. 173 . . 207.) Note on acoustic and radio apparatus exhibited by certain firms.



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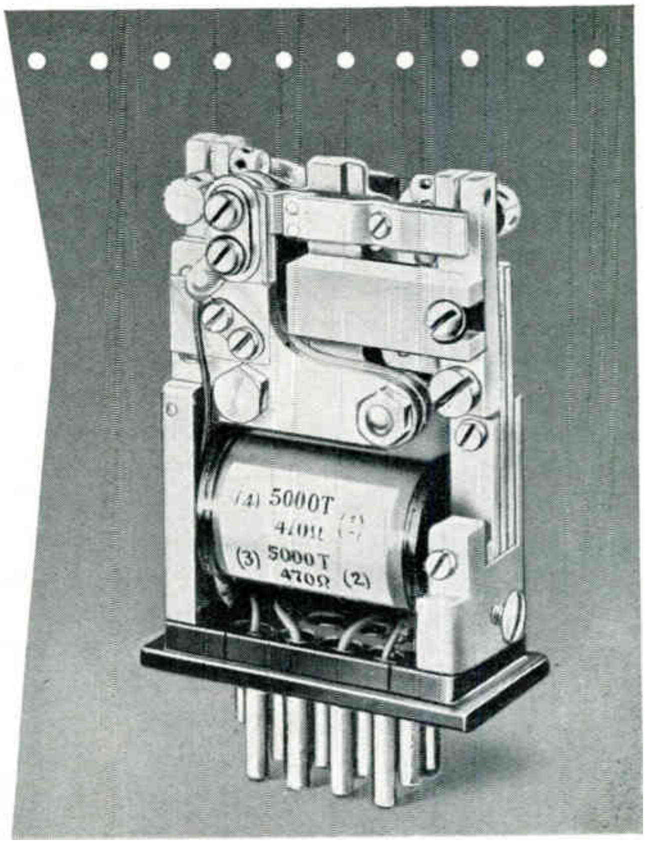


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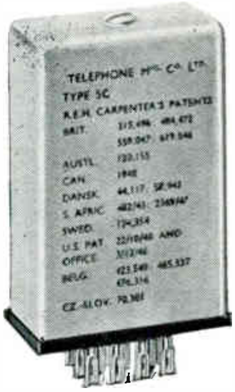


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**Inspectors of Police (Radio Duties)** required by Government of Uganda. Appointment will be on probation for permanent and pensionable employment. Salary in scale £612 rising to £893 a year (including temporary allowance). Outfit allowance £30. Uniform allowance £10 a year. Free passages. Liberal leave on full salary after tour of 30/36 months. Candidates between ages 21 and 30 must be at least 5 ft 8 in in height without footwear, of good physique and normal vision without glasses. They must have good practical experience in the operation, maintenance and repair of modern low and medium power H.F. and V.H.F. radio transmitting and receiving equipment and of petrol/electric and diesel power generating equipment.

Apply at once by letter, stating age, full names in block letters and full particulars of qualifications and experience, and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting on letter M.29571.B. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

**CROWN AGENTS FOR THE COLONIES**

**Technician Grade I** required for radio work by East African Posts and Telecommunications Administration. Appointment will be on probation for permanent and pensionable employment. Commencing salary according to age and experience in scale £687 rising to £1,050 a year (including allowance). Outfit allowance £30. Free passages. Liberal leave on full salary. Normal tour is four years. Candidates aged 23-36 should possess a thorough practical knowledge of the working and maintenance of modern radio transmitting and receiving equipment. General Post Office employees should apply through departmental channels.

Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience, and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting on letter M.29528.B. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

Testers for Electronic Division of Vidor, Ltd., West Street, Erith. Good all-round comm. exp. These vacancies are suitable for ex-R.A.F. Fitters (Air) or skilled R.E.M.E. Apply Personnel Department.

**Senior Electro-Mechanical Engineer** required by new division of prominent engineering establishment in Northern Ireland to lead section engaged in development work on guided weapons. Degree or equivalent in electrical or mechanical engineering, with good practical experience in design of small precision electro-mechanical devices, servo systems or instruments. Good salary and prospects for man with originality, assistance given with housing. Send full particulars of age, qualifications and experience to Box 3251, c/o *Wireless Engineer*.

**CROWN AGENTS FOR THE COLONIES**

**Wireless and Telegraph Supervisor** required by the Nigeria Government Railway Department for one tour of 18 to 24 months in first instance. Option of appointment either (*a*) on agreement with a prospect of permanent and pensionable employment on salary £750 rising to £1,175 a year (including expatriation pay) or (*b*) on a temporary basis at salary £807 rising to £1,269 a year (including contract addition and expatriation pay) with a gratuity on satisfactory completion of final service of £25 or £37 10s. according to salary for each completed period of three months' service. Outfit allowance £60. Free passages for officer and wife and assistance towards cost of children's passages or their maintenance in this country. Liberal leave on full salary. Candidates must have a sound knowledge of International wireless operating, of telegraph working, and of the general running and supervision of a Telegraph and Wireless office. They should have experience of the working and handling of traffic over wireless and telegraph networks, together with technical knowledge of modern H.F. radio transmitters and receivers and of telegraph circuits. Candidates employed by the General Post Office should apply through departmental channels.

Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting on letter M.29579.B. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

The Research Laboratories of the General Electric Company, Ltd., propose to set up an organisation near Adelaide, South Australia, for trials and further development of guided weapon equipment which is at present under development in this country.

Applications are invited from men with qualifications suitable to fill the following vacancies:—

(*a*) An engineer to take charge of trials teams;

(*b*) An engineer or physicist to take charge of a laboratory engaged on the development and use of special test equipment;

(*c*) A physicist or mathematician to take charge of a small group on the analysis and assessment of trials results.

Candidates should have an honours degree or equivalent qualification. For post (*a*) and (*b*) they should have had experience of modern radar or similar equipment and of supervising the work of a small number of experimental staff. For post (*c*), experience or interest in statistics or the interpretation of experimental results is desirable, together with ability to write clear concise reports and supervise the work of a small number of assistants.

The successful applicants will commence employment in this country on the work they will ultimately be doing in Australia, and will be transferred to that country in due course.

Details of conditions of employment, housing, passages to Australia, etc., will be given to candidates who are selected for interview.

Reply quoting reference KTH/AUST, to the Staff Manager, G.E.C., Stanmore Laboratories, The Grove, Stanmore Common, Stanmore, Middlesex, stating age, qualifications and experience.


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**The General Electric Co., Ltd.**, Research Laboratories, Wembley, Middlesex, have vacancies for graduate engineers and physicists for electronic research and development work in the microwave field. Openings are concerned with (*a*) receivers, (*b*) aerials, (*c*) the development of specialised test equipment for airborne radar. An original approach is necessary and a knowledge of microwave techniques or circuit design is essential. Appointments will be at Stanmore (Middx.). Apply to the Staff Manager (Ref. GBLC/S/909), stating age, qualifications and experience.

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**Graduate physicists and engineers** are required at the G.E.C Stanmore Laboratories for work concerned with (*a*) electronic circuitry, (*b*) electronic simulators, (*c*) magnetic amplifiers or small power electric motors, and (*d*) I.F. receivers. Experience in one of these fields will be an advantage. Apply to the Staff Manager (Ref. GBLC/S/910), Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, stating age, qualifications and experience.

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**Electrical and Mechanical Engineers** with an interest in servo-systems and small mechanical devices are required by the Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, for work at Stanmore. University degree or H.N.C. is essential, plus some experience in the development of small mechanisms. Write to the Staff Manager (Ref. GBLC/S/911) stating age and record.

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**Electrical engineer or physicist** with higher national certificate or equivalent is required for the design of small quantities of special transformers for experimental apparatus. This appointment is at Stanmore. Apply to the Staff Manager (Ref. GBLC/S/912), Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, stating age, qualifications and experience.

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**Development Engineer or Physicist** is required for work concerned with transistor and cold cathode valve circuitry. Degree or H.N.C. in electrical engineering or physics with electronics or telecommunications is essential. Previous experience would be useful. Appointment is at Stanmore. Apply to the Staff Manager (Ref. GBLC/S/913), Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, stating age, qualifications and experience.

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**Senior Electronic Development Engineer** required to take charge of Engineering associated with Guided Weapons and like projects.

**Electronic Development Engineers** also required for the same projects.

Reply stating age, qualifications and experience to Staff Manager (Ref. R.G.), G.E.C., Stanmore Laboratories, The Grove, Stanmore Common, Middlesex.

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**Field Trials**—The General Electric Co., Ltd., require Engineers at the Stanmore Laboratories concerned with (*a*) the assessment of field trials of electronic equipment and (*b*) the organisation of and participation in these trials (for this vacancy, some travelling is involved). Experience in similar work would be an advantage. Write to the Staff Manager (Ref. GBLC/S/936), G.E.C. Research Laboratories, Wembley, Middlesex, stating age and record.

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**Senior Mechanical Design Draughtsmen** required with experience of electronic layouts for work on Guided Weapons and like projects. Reply stating age, qualifications and experience to Staff Manager (Ref. R.G.), G.E.C., Stanmore Laboratories, The Grove, Stanmore Common, Stanmore, Middlesex.

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**Belling & Lee, Ltd.**, Cambridge Arterial Road, Enfield, Middlesex, have vacancies for electronic designs engineers in the sales department; duties are liaison with Government and industrial laboratories, and radio and television designs engineers; ownership of car essential; compulsory contributory pension scheme. Remuneration is salary, commission and expenses.

Applications to state (in confidence) qualifications and experience.

---

**EXPERIENCED RADIO TESTERS AND INSPECTORS**

Required for production of communication and radio apparatus. Also instrument makers, wirers and assemblers for factory test apparatus. Apply Personnel Manager, E. K. Cole, Ltd., Ekco Works, Malmesbury, Wilts.

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**The English Electric Co., Ltd.**, Luton, invites applications for permanent posts in a laboratory engaged in development work involving Radar techniques. Senior and junior positions are available to candidates possessing suitable qualifications and a knowledge of one or more of the following: (1) Centimetric systems and measurements; (2) Radar or television receiver practice; (3) Mechanical layout and design work, in connection with the above. Salaries according to qualifications and experience from £450 upwards. The laboratories are new and pleasantly situated. The Company also encourages further study in the case of Juniors. Please reply, quoting ref. 815G, to Central Personnel Services, English Electric Co., Ltd., 336 Strand, London, W.C.2.

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**The English Electric Valve Co., Ltd.**, Chelmsford, Essex, has several attractive vacancies, junior and senior, for Physics and Engineering Graduates to undertake research and development work on vacuum tubes. Applications from graduates who have recently qualified as well as those with industrial and research experience will be considered. Please write, giving full details and quoting ref. 419F to Central Personnel Services, English Electric Co., Ltd., 336 Strand, W.C.2.

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**Belling & Lee, Ltd.**, Cambridge Arterial Road, Enfield, Middlesex, require research assistants in connection with work on electronic components, fuses, interference suppressors and television aerials. Applicants must be graduates of the I.E.E. or possess equivalent qualifications together with similar laboratory experience. Salary will be commensurate with previous experience; five-day week, contributory pension scheme. Applications must be detailed and concise, and will be treated as confidential.

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**Senior Physicist or Engineer** with wide experience in radio communications and radar, is required to direct a research team in these fields. Familiarity with centimetric measuring techniques, circuitry, aerials and propagation is essential together with a real knowledge of the fundamental aspects of such work. This is an appointment at Stanmore (Middx) for a first-class research man and carries an attractive salary commensurate with experience and excellent prospects. Applications should be sent to the Staff Manager (Ref. GBLC/S/914), The Research Laboratories of The General Electric Co., Ltd., Wembley, Middlesex, and should give full details of age, qualifications and experience.

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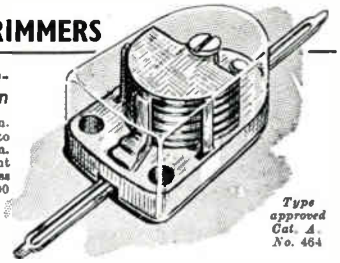

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