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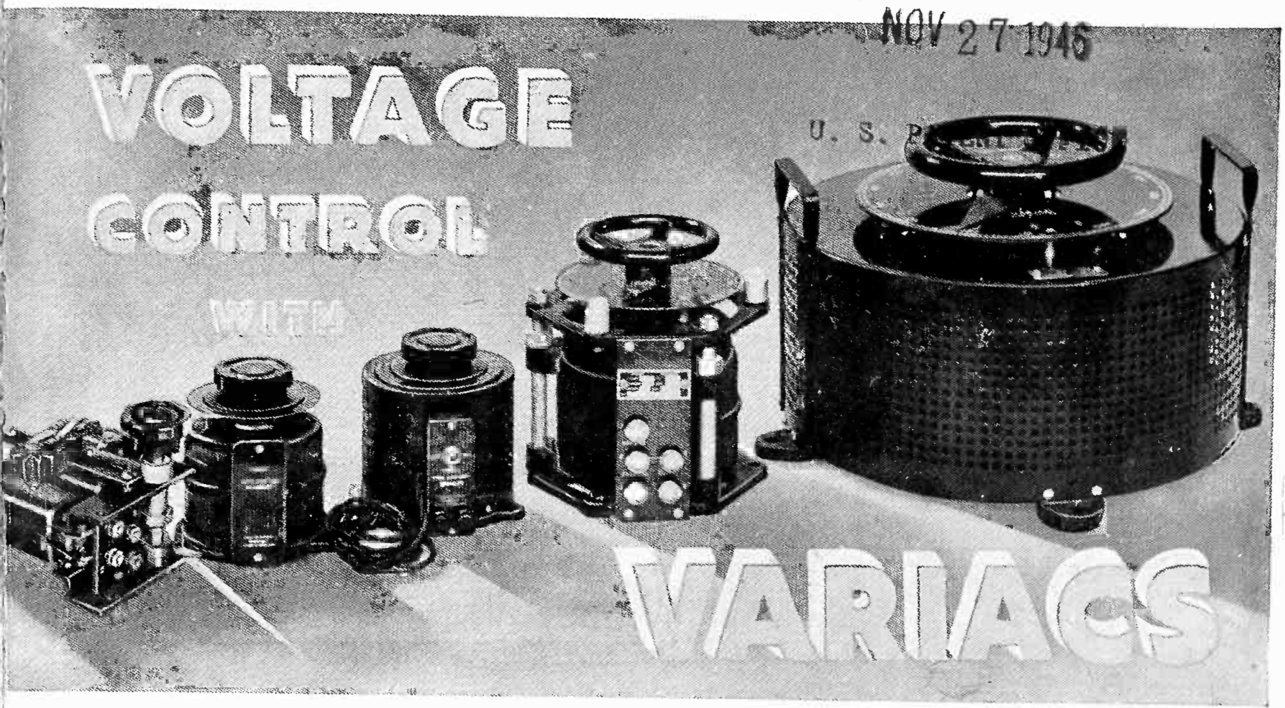

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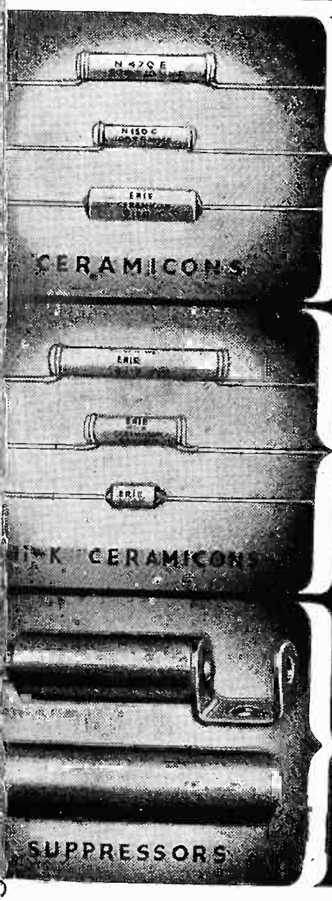

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VOL. 23 No. 278

WIRELESS ENGINEER

NOVEMBER 1946.

EDITORIAL

Permeability of Iron-Dust Cores

IN the Editorial of January 1933 we considered this subject from what we thought at the time to be a new point of view; viz., by picturing the iron particles to be cubes arranged in a certain way. As we mentioned recently we subsequently found that this same assumption had been made by Doebke in 1930. In this current number we publish a letter from H. W. Lamson dealing with the subject but containing some misunderstandings which we wish to clear up. In the first place we must emphasize that we were considering practical iron-dust cores, that is, material in which the iron occupies the major part of the space, and we made approximations based on this hypothesis; in fact, the whole treatment assumed that the spaces between the cubes—the interstices as we called them—were relatively small. It is therefore not surprising if the formulae derived give quite erroneous results when applied to cases in which the iron only occupies a small fraction of the volume. In a covering letter Mr. Lamson says that he was "somewhat puzzled to note that, applying the condition of minute concentration of iron to your equation in terms of α, the value of μ approaches $1/\mu$, rather than unity as α approaches zero." Mr. Burgess also refers to this point in a letter published in this number. We were not concerned with minute concentrations of iron but with iron-dust cores, and the formulae developed were not intended to be applied to a dielectric containing a sparse sprinkling of iron particles.

The formulae that we derived, viz.

$$\mu = \frac{\mu_1 - \frac{2}{3}\delta\,(\mu_1 - 1)}{1 + \frac{1}{3}\delta\,(\mu_1 - 1)}$$

where μ_1 is the permeability of the iron particles and δ the small fraction of the total volume occupied by the insulating material, approximates to $\mu = \frac{3}{\delta} - 2$ as μ_1 is increased. As we showed in 1933, if μ_1 is infinitely great the formula gives $\mu = 28$ for $\delta = 0.1$ and 58 for $\delta = 0.05$.

Mr. Lamson is mistaken when he says that all three hypotheses are based on the assumption that the flux through the medium is in the form of parallel straight lines. The Poisson-Maxwell formula for spherical particles—to give it the name suggested by Mr. Fairweather in our August number—which was used by Mr. Burgess in June, makes no such assumption. It assumes that the flux is concentrated in the sphere just as it would be if no other sphere were near it. Maxwell* makes this quite clear and says "when the distance between the spheres is not great compared with their radii, then other terms enter into the result which we shall not now consider." The only one of the three hypotheses discussed by Mr. Lamson which ignores the concentration of flux in the iron particles in preference to the surrounding medium is the second one, which he himself

**Elec. & Mag.* Vol. 1, Section 314.

has suggested. With his so-called random alignment of cubes the flux density is the same everywhere, and it is not surprising that it gives results entirely different from those given by the other two hypotheses. It is reassuring to note that the other two hypotheses, although so fundamentally different, give results which differ so little for practical values of the space-factor.

The large discrepancies between these calculated values and the experimental results obtained by Legg and Given are very surprising but very satisfying from a practical point of view. It was rather a poor outlook for dust cores when it was thought that the permeability, even with the best material, could not exceed about 50. In a Special Report issued by the Radio Research Board in 1934 and published by the Stationery Office, entitled "Magnetic Materials at Radio Frequencies," it was stated that "all the effective permeability formulae . . . . agree in the main conclusion . . . that a figure of about 80 is the highest practically attainable, even with particles of the highest permeability." If the figures given by Legg and Given are reliable a dust-core permeability of over 150 can now be obtained with particles of which the permeability is only 220, but we must confess that we are not convinced that such a result can be obtained if the particles are properly insulated from each other. It could be obtained if the iron were linked up in the form of threads in the direction of the magnetic field. To take two extreme cases, laminations normal to the flux, i.e. in effect as in Lamson's hypothesis, would have a resultant permeability equal to $\mu_1/[\mu_1 - p\,(\mu_1 - 1)]$ which for $\mu_1 = 220$ and $p = 0.9$ gives a permeability of 9.6, whereas for the same quantity of iron, that is, the same value of p, arranged in the form of fine iron wires in the direction of the field, the resultant permeability would be simply $1 + p(\mu_1 - 1)$ which is equal to 198.1. Our formula for cubes gives 24 which seems to us to be more probable than the figure 128.3 given by Legg and Given unless the iron is largely in the form of fine threads in the direction of the field—a very desirable achievement.

G. W. O. H.

DOUBLE-DERIVED TERMINATIONS*

An Extension to Filter Theory

By R. O. Rowlands, B.Sc.

(The General Electric Co., Ltd., Coventry).

Introduction

IN an earlier paper[1] the author described a method of terminating complementary filters at their common ends in such a way that the real part of the image impedance at these terminals is that of a double-derived section.

When the impedance function is prescribed, however, the attenuation function of the terminating section is determined.

In the present paper the method is extended to allow more latitude in the choice of attenuation function when the impedance function is prescribed.

Composite Filters

A composite filter is built up as a ladder network by connecting a number of conventional derived-sections in tandem with the termination. Since the actual impedance looking in at one end of the filter depends upon the degree of matching at the other end, the filter will normally be terminated with a double-derived half-section at the end remote from the common terminals. The "m" values chosen for the intermediate sections are such that the composite filter gives the required attenuation in its stop range. A typical filter is shown in Fig. 1, $W'_{1km_2m_1}$ being the impedance function whose real part is equal to $W_{1km_2m_1}$.

The attenuation provided by the termination on the right-hand side is equivalent to that of a conventional section with m equal to m_2, while that provided by the termination on the left-hand side is that of two half-sections with m values equal to m_2, and m_1 times m_2. The filter, therefore, contains $1\frac{1}{2}$ sections with m equal to m_2. This is uneconomical. The problem is therefore how to get rid of a section with m equal to m_2

* MS accepted by the Editor, April 1946.

from the filter without affecting the impedance characteristic.

The formulae given in Appendix I enable us to interchange the m_2 and m_3 sections of the filter of Fig. 1. The m_2 section will now be adjacent to a conventional m_4 section, and so they can be interchanged by the application of the same formulæ. By $n - 2$ repeated applications the m_2 section can be moved so that it is adjacent to the conventional m_2 half-section preceding the double-derived half-section.

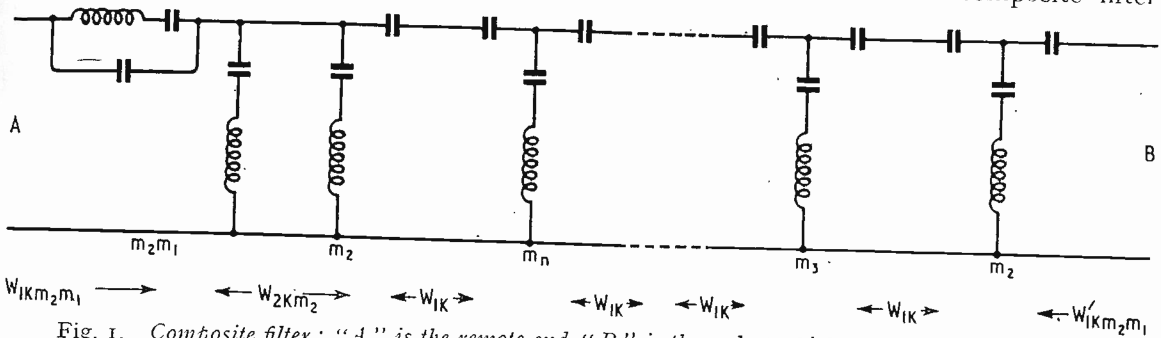


Fig. 1. *Composite filter; "A" is the remote end, "B" is the end at which the filter is connected in parallel with its complement.*

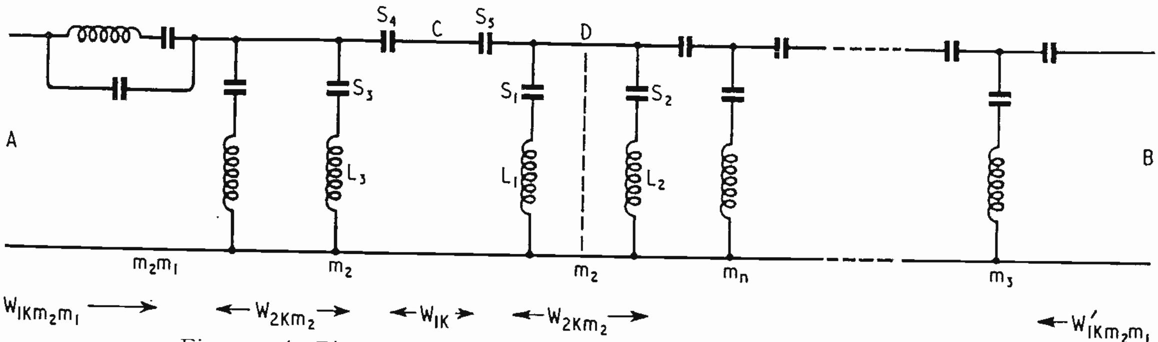


Fig. 2. *As Fig 1, but with m_2 section moved towards the "A" terminals.*

The filter will now be as shown in Fig. 2.

It will be seen that the coefficient of the component S_5 is "a," which is always equal to m_2, the value of this coefficient in a conventional section. If the transferred m_2 section, the shunt components of which are L and S, is split along the dotted line D into L_1 and S_1 in parallel with L_2 and S_2 in such a way that L_1 and S_1 are respectively equal to L_3 and S_3, then the image impedance of the half-section comprising S_5, S_1 and L_1 is W_{1k} at the junction C and W_{2km_2} at the junction D. But W_{1k} was the image impedance at C before the network was split at D, so by the theorem proved in Appendix II the image impedances looking in both directions at the junction D are equal.

The section comprising L_1, S_1, S_5, S_4, S_3 and L_3 may, therefore, be taken out of the network and the remaining parts joined with perfect impedance matching at the junction. This means that a whole m_2-section has been removed from the network without affecting the latter's impedance characteristic at Terminals A and B. The composite filter may, therefore, be designed to have a prescribed double-derived impedance function but with latitude in the choice of the attenuation function of all but two half-sections which will have m values of m_2 and m_1 times m_2.

A filter made up of shunt-derived sections may be treated in the same way. The coefficients of the components "a," "b," etc., will in this case be the inverse of those for series-derived sections.

Practical Simplification

It may appear at first sight that in a filter with many sections the process of transferring the m_2 section from one end of the filter to the other is long and laborious. In practice this is not the case, for suppose q differs from its value in a conventional section by the factor δ;

$$\text{i.e., } q = \frac{1}{2m_2} + \delta$$

Then $$u = \frac{2m_3 + (m_3 - m_2)^2\,(1/2m_2 + \delta)}{(m_3 + m_2)^2}$$
$$= \frac{4m_2m_3 + (m_3 - m_2)^2}{2m_2(m_3 + m_2)^2} + \frac{(m_3 - m_2)^2\delta}{(m_3 + m_2)^2}$$
$$= \frac{1}{2m_2} + \left(\frac{m_3 - m_2}{m_3 + m_2}\right)^2\delta$$

The factor δ has been considerably reduced by the transformation. This value u now becomes q for the second transformation and so δ will be reduced a further amount. The best order in which to connect the sections of the composite filter of Fig. 1 so as to reduce δ, in the minimum number of transformations, to such a small value that it may be neglected is, to make

$$|m_3 - m_2| < |m_4 - m_2| < \text{etc.}$$

As soon as δ has reached this value the m_2 section may be removed from the filter without the necessity of any further transformation.

APPENDIX I

If the networks of Fig. 3 are equivalent with respect to their input and output terminals then we have the following transformation matrices.

For $\frac{1}{2}Z_{1k}$,

$$\begin{Vmatrix} a+b, & -b, & 0 \\ -b, & b+c+d, & -d \\ 0, & -d, & d+e \end{Vmatrix} = \begin{Vmatrix} 1 & x & 0 \\ 0 & y & 0 \\ 0 & z & 1 \end{Vmatrix} \cdot \begin{Vmatrix} f+g, & -g, & 0 \\ -g, & g+h+j, & -j \\ 0, & -j, & j+k \end{Vmatrix} .$$

$$\begin{Vmatrix} 1 & 0 & 0 \\ x & y & z \\ 0 & 0 & 1 \end{Vmatrix} = \begin{Vmatrix} f+(1-x)g, & -g+x(g+h+j), & -xj \\ -yg, & y(g+h+j), & -yj \\ -zg, & z(g+h+j)-j, & (-z+1)j+k \end{Vmatrix} .$$

$$\begin{Vmatrix} 1 & 0 & 0 \\ x & y & z \\ 0 & 0 & 1 \end{Vmatrix} = \begin{Vmatrix} f+(1-x^2)g+x^2(h+j), & -yg+xy(g+h+j), & -zg+zx(g+h+j)-xj \\ -yg+xy(g+h+j), & y^2(g+h+j), & y(g+h+j)-yj \\ -zg+xz(g+h+j)-xj, & yz(g+h+j)-yj, & z^2(g+h)+(1-z)^2j+k \end{Vmatrix} \qquad \ldots \quad \ldots \quad (1)$$

And for $2Z_{2k}$ substituting 0 for f, h, and k; p for g, and q for j,

$$\begin{Vmatrix} u & -u & 0 \\ -u & u+v & -v \\ 0 & -v & -v \end{Vmatrix} = \begin{Vmatrix} (1-x)^2p+x^2q & -yp+yx(p+q) & -zp+xz(p+q)-xq \\ -yp+xy(p+q) & y^2(p+q) & y(p+q)-yq \\ -zp+xz(p+q)-xq & yz(p+q)-yq & z^2p+(1-z)^2q \end{Vmatrix} \qquad \ldots \quad \ldots \quad (2)$$

Equation (2) Col. 2 gives

$$-u + (u + v) - v = -yp + yx\,(p + q) + y^2\,(p + q) + yz(p + q) - yq = 0$$

or $(p + q)(x + y + z) = (p + q)$

i.e., $x + y + z = 1$ $\qquad \ldots \quad \ldots \quad (3)$

Equation (1) Col. 1 row 3 gives

$$-zg + xz(g + h + j) - xj = 0$$

or $xz(g + h + j) = zg + xj$ $\qquad \ldots \quad \ldots \quad (4)$

Equation (2) Col. 1 row 3 gives

$$-zp + xz(p + q) - xq = 0$$

or $xz(p + q) = zp + xq$ $\qquad \ldots \quad \ldots \quad (5)$

From (3), (4) and (5)

$$x = \frac{jp - gq}{jp - hq - gq}\ ; \qquad z = \frac{jp - gq}{jp + hp - gq}$$
$$y = 1 - (x + z)$$

If the network on the right-hand side of Fig. 3 is a conventional section joined to a double-derived terminating section then its components values will be as follows:—

$$f = m_3$$
$$g = \frac{1 - m_3^2}{2m_3}$$
$$h = m_2 + m_3$$
$$p = 1/(2m_3)$$
$$q = \frac{1 + m_1m_2}{m_2(1 + m_1)(1 + m_2)}$$
$$j = \frac{(1 - m_2)(1 + m_1m_2)}{m_2(1 + m_1)} = (1 - m_2^2)q$$
$$k = (1 + m_1m_2)$$

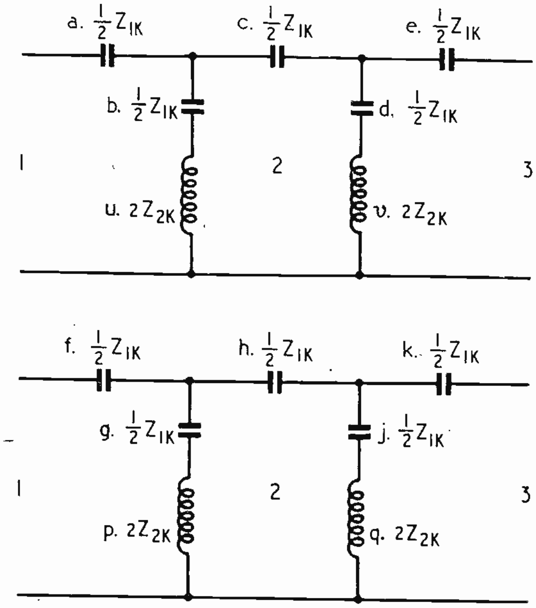


Fig. 3. *Equivalent circuits.*

And so

$$x = \frac{m_2 - m_3}{m_2 + m_3}$$
$$z = \frac{(m_3 - m_2)q}{(m_3 - m_2)q + 1}$$
$$y = \frac{(m_3 - m_2)^2q + 2m_3}{(m_3 + m_2)\{(m_3 - m_2)q + 1\}}$$

The component values of the network on the left-hand side of Fig. 3 are then given by

$$u = \frac{2m_3 + (m_3 - m_2)^2q}{(m_3 + m_2)^2}$$
$$v = \frac{2m_3 + (m_3 - m_2)^2q}{2m_3\{1 + (m_3 - m_2)q\}^2} \cdot q$$
$$a = m_2$$
$$b = \frac{(1 - m_2^2)\{2m_3 + (m_3 - m_2)^2q\}}{(m_3 + m_2)^2}$$
$$c = \frac{2m_3 + (m_3 - m_2)^2q}{1 + (m_3 - m_2)q}$$
$$d = \frac{(1 - m_3^2)\{2m_3 + (m_3 - m_2)^2q\}q}{2m_3\,\{1 + (m_2 - m_2)q\}^2}$$
$$e = k + \frac{(m_3^2 - m_2^2)q}{1 + (m_3 - m_2)q}$$

The above formulae are given in terms of m_2, m_3, q and k, and so they may be applied directly to obtain the first transformation. For the second and subsequent transformations, all that need be done is to substitute m_4 etc. for m_3 and use the appropriate values for q and k.

APPENDIX II

Theorem

If the four-terminal network N_{13} of Fig. 4 can be split into two cascade-connected four-terminal networks N_{12} and N_{23} in such a way that the image impedance at terminals 1, 1′ of both N_{12} and N_{13} is W_1, then the image impedances of both N_{12} and N_{23} at terminals 2, 2′ are equal.

Proof

Let the general circuit parameters of N_{12} and N_{23} in matrix form be $\begin{Vmatrix} A & B \\ C & D \end{Vmatrix}$ and $\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$ then the parameters of N_{13} are[2],

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \times \begin{Vmatrix} a & b \\ c & d \end{Vmatrix} = \begin{Vmatrix} Aa + Bc & Ab + Bd \\ Ca + Dc & Cb + Dd \end{Vmatrix}$$

For the network N_{12}, $W_1{}^2 = \dfrac{AB}{CD}$

For the network N_{13}, $W_1{}^2 = \dfrac{(Aa + Bc)\ (Ab + Bd)}{(Ca + Dc)\ (Cb + Dd)}$

So $\dfrac{A\ B}{C\ D} = \dfrac{(Aa + Bc)(Ab + Bd)}{(Ca + Dc)(Cb + Dd)}$

i.e., $AB\{C^2ab + CD(ad + bc) + D^2cd\}$
$= CD\{A^2ab + AB(ad + bc) + B^2cd\}$

or $ACab(BC - AD) = BDcd(BC - AD)$

i.e., $\dfrac{ab}{cd} = \dfrac{BD}{AC}$

$W'_2 = W_2$

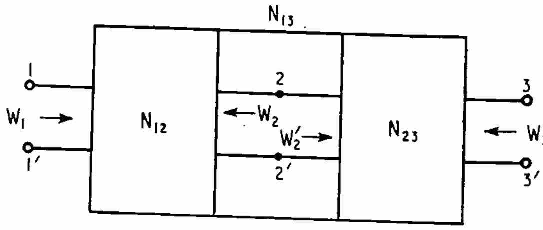


Fig. 4.

Acknowledgments

The author is grateful to the General Electric Co. for permission to publish this article, and to his colleague Mr. Li Wei Chen for helpful criticism.

REFERENCES

1 *Wireless Engineer*, Feb. 1946, the same notation will be used except that m and m_1 become m_2 and m_1 respectively in the present article.

2 See Guillemin's "Communication Networks," Vol. II p. 138, p. 145 and p. 171.

CHARACTERISTICS OF R.F. CABLES*

Determination of Impedance and Propagation Constants

By N. C. Stamford, M.Sc.Tech., and R. B. Quarmby, M.Sc.

(Electrotechnics Department, Manchester University)

Introduction

DURING the early stages of the war, and before more refined techniques, such as those described elsewhere by Dr. L. Essen, had been developed, the need arose for measurements at about 600 Mc/s of the phase and attenuation constants and the characteristic impedance of the Polythene insulated cables which were finding wide application in radiolocation equipments. For this purpose a technique was developed which was fundamental in principle and required only simple apparatus, and although it has now been superseded it would still seem to be advantageous for use in the instruction of students. The technique is equally applicable to coaxial- or twin-type cables and the frequency of 600 Mc/s happens to be a very convenient one at which to carry out the measurements.

* MS. accepted by the Editor, April 1946.

1. Measurement of the Phase Constant

The length of cable on which measurements are to be made is magnetically coupled to the oscillator at one end and left open at the other, as shown in Fig. 1. A thermojunction,

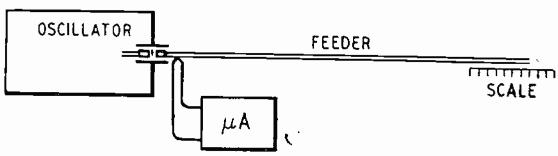


Fig. 1. *Arrangement of apparatus for the measurement of phase constant.*

the heater circuit of which is included in the coupling loop, enables the input current to the line to be measured. The procedure consists of cutting short lengths from the open end of the line and observing the input current for each value of line length. A curve of input current against line length is plotted as the readings are taken, so that the size of the cut can be varied according to the steepness of the curve.

The input current is governed by the value of the input impedance of the line, namely $Z_0 \,.\, \coth\,(\alpha + j\beta)l$, where Z_0 is the characteristic impedance of the line, α the attenuation constant, β the phase constant, and l the line length. This impedance passes through maxima for line lengths which are even multiples of one-quarter of a wavelength and through minima for line lengths which are odd multiples. The input current remains sensibly constant while the line impedance is low compared with the source impedance and falls sharply when the line impedance approaches a maximum value. The actual shape of the curve depends, of course, not only on the cable itself but also on the magnitude and phase of the coupling loop impedance. A typical curve is shown in Fig. 2.

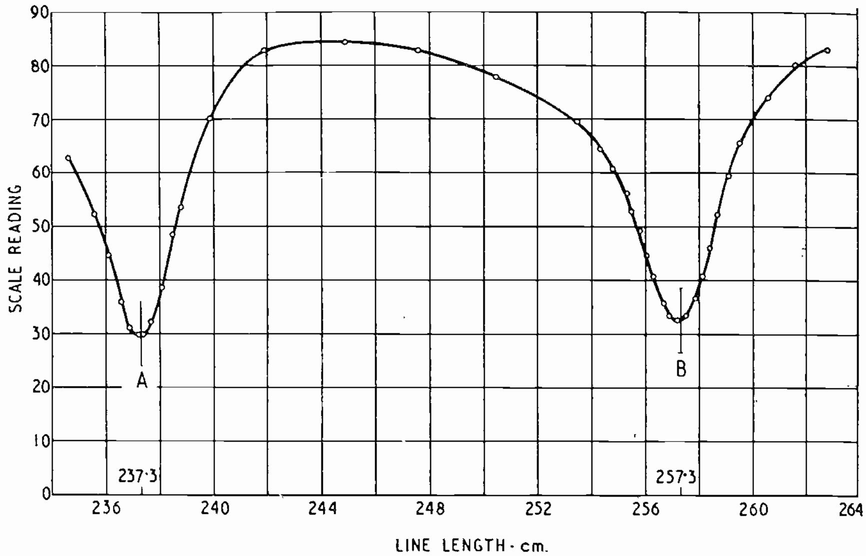


Fig. 2. *Curve of input current against line length for a screened twin feeder.*

Since the amount cut off between successive minima is a half-wavelength for the velocity of propagation in the line, it corresponds to a phase change of π radians. Thus if A and B are successive minima and x_1 is the distance in cm between them, the phase constant β is given by the relationship :

$$\beta = \pi/x_1 \text{ radians/cm} \qquad \ldots \quad \ldots \quad (1)$$

In the curve of Fig. 2, for example, the minima occur at line lengths of 237.3 and 257.3 cm respectively. The distance x_1 is therefore 20.0 cm and the value of β is $\pi/20.0 = 0.157$ radian/cm.

Greater accuracy in the determination of the phase constant may be attained by making measurements over a number of half-wavelengths so that if the length of cable between $(n + 1)$ minima, having n maxima between them, is x_n cm the phase constant is :

$$\beta = n\pi/x_n \text{ radian/cm} \qquad \ldots \quad \ldots \quad (2)$$

and an error in the location of one of the minima produces only $(1/n)$th of this error in the final answer.

This increase in accuracy can be obtained without cutting back the line over the full number of half-wavelengths for every sample of cable tested, if the equivalent length of the coupling loop is known. This may be determined by a trial experiment in which a length of the cable is cut back through a succession of minima until very short. Since it is then possible to predict with accuracy where the first minimum would come, and since this should be exactly at zero line length, it is easy to say what equivalent length of line must be attributed to the coupling loop. If this length is c cm and the $(n + 1)$th minimum occurs at a line length of l_n cm the value of x_n which must be used in equation (2) is $x_n = l_n + c$. The phase constant is then :

$$\beta = \frac{n\pi}{l_n + c} \text{ radian/cm} \qquad \ldots \quad \ldots \quad (3)$$

Where there is any doubt as to the value of n, this may be found by cutting back the line until two minima are obtained, dividing the distance between them into the total line length (corrected for the equivalent length of the coupling loop), and taking n as the nearest integer.

Consider the curve of Fig. 2 again, in order to obtain a more accurate figure for β. A previous experiment had shown the equivalent length of the coupling loop to be 2.0 cm for this type of cable. The minima occur at line lengths of 237.3 and 257.3 cm which, when corrected, become 239.3 and 259.3 cm respectively. The separation between minima has already been seen to be 20.0 cm, and dividing this into the corrected line lengths shows that these correspond to 12 and 13 half-wavelengths respectively. For the former, the value of β is thus $12\pi/239.3 = 0.1578_4$ radian/cm and for the latter, $\beta = 13\pi/259.3 = 0.1578_3$ radian/cm.

2. Measurement of the Attenuation Constant

The attenuation constant of the cable can be found by comparing the outputs of short and long lengths of line having equal inputs. To do this it is essential that the power measuring device be correctly matched to the line so that no standing wave exists along it. A thermojunction is used to measure the power output and is matched to the line through a "quarter-wave" transformer. If the line and thermojunction were both purely resistive, matching would be effected by a transformer having a characteristic impedance equal to the geometric mean of the line and thermojunction impedances, and a length of exactly a quarter-wave. Since, however, the thermojunction does not present a purely resistive load, the reactive component must be eliminated by alteration of the matching transformer length about the exact quarter-wavelength value. By successive adjustment of the characteristic impedance and length of the transformer an impedance match for both amplitude and phase is obtained.

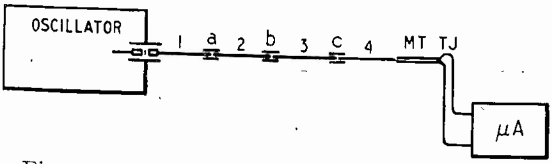


Fig. 3. *Arrangement of apparatus for attenuation measurements.*

Correct termination of the line is conveniently proved by observation of the output current as the line length is varied over a half-wavelength. The practical arrangement for doing this is shown in Fig. 3. The cable under test is coupled to the oscillator through a small coupling loop. Lengths 1, 2, 3 and 4 of the cable are linked together by sleeve-type couplings *a*, *b* and *c*. MT is the matching transformer between the end of the line and the thermojunction TJ, the response of which is measured on a micro-ammeter.

Of the four lengths of cable used, sections 1 and 4 are of arbitrary length, section 3 consists in the first instance of a short length L_1 and then of a long length L_2 by which means the attenuation of a length $(L_2 - L_1)$ of feeder is determined, and the length of section 2 is varied in steps over a range of at least three-quarters of a wavelength to test for the presence of a standing wave.

The couplings *a*, *b* and *c* consist of sections of brass tube into which the two ends of the cable to be joined are a push fit, so that the continuity of the outer conductor is maintained. The ends of the tube are split and provided with bushings which may be screwed along the split portions to increase their grip on the cable. Inside the tube is a spacer of the same dielectric material as that of the feeder to

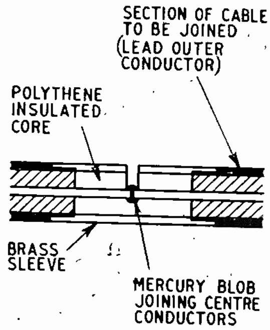


Fig. 4. *Coupler for joining two lengths of coaxial feeder.*

be tested, with drilled holes for the insertion of the inner conductors to be joined, small pools of mercury in the holes ensuring that a good contact is obtained. The form of the couplings for use with coaxial feeders is illustrated in Fig. 4.

The matching transformer MT consists of two parallel rods, each having an end cap of telescopic tubing so that the overall length of the transformer can be varied for phase matching. The rods are mounted so that the distance between them can be adjusted to vary the characteristic impedance.

The existence of a mismatch is observed by inserting a number of short sections of progressively increasing length between the couplings *a* and *b*, and plotting the output current against inserted length. The length and spacing of the matching transformer rods are successively adjusted and the test repeated until the output current variation is reduced to a minimum; ideally, to zero. The attenuation of a length $(L_2 - L_1)$ of the feeder line is then determined from the ratio of the currents indicated by the thermojunction when short and long lengths of cable respectively are inserted as section 3 between the couplings *b* and *c*. Thus, if the indicated currents are I_1 for the short length of L_1 cm and I_2 for the long length of L_2 cm the attenuation constant is given by the relationship :

$$\alpha = \frac{20 \log_{10} (I_2/I_1)}{(L_2 - L_1)} \text{ decibels/cm}$$

3. Measurement of Characteristic Impedance

The characteristic impedance of the cable is determined using a simple variation of the arrangement used for the measurement of attenuation. In this connection, it has already been explained how, when all four sections of the line are of the same characteristic impedance, the thermojunction can be matched to give a substantially constant output current as the length of the line is varied incrementally in section 2, Fig. 3.

If section 3 of the system is now replaced by a quarter-wavelength of line having a characteristic impedance different from that of the cable, then, due to the transformer action of this section, the line beyond the coupling *b* no longer satisfies the conditions for correct termination and variation of the length of section 2 produces variations in the output current.

The first step in the practical procedure is to form all sections of the line from the cable under test and to adjust the matching of the thermojunction as for an attenuation measurement.

Section 3 is then replaced by a quarter-wavelength device of which the characteristic impedance can be varied systematically, and for each value of this characteristic impedance the output current variation is observed as the length of section 2 is changed. For one value of the characteristic impedance there will be no output current variation for small changes in the length of section 2 and this gives the desired cable impedance.

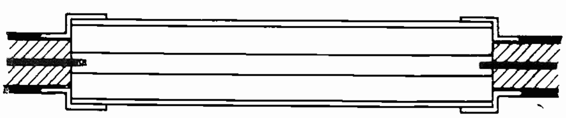


Fig. 5. *Air-spaced coaxial line with detachable end pieces and centre conductor of variable diameter.*

For measurements on coaxial cables a suitable form for this quarter-wavelength device is obtained by using air-spaced coaxial tubes, the impedance variation being effected by changing the diameter of the centre conductor. Satisfactory attachment to the test cable can be made by means of end pieces in the manner shown in Fig. 5. For twin feeders, quarter-wavelength lines having variable spacing may be used.

Acknowledgment

The technique described was developed during 1940-41 in the Electrotechnics Laboratories of the Victoria University of Manchester in a Research Group under the direction of Professor Willis Jackson to whom due acknowledgment is made.

BOOKS RECEIVED

Radio Valve Vade-Mecum, 1946, 6th Edition.

Pp. 232 + xii. Published by P. H. Brans, 28, rue du Prince Leopold, Anvers (Borgerhout), Belgium. Distributed by Ritchie Vincent & Telford, Ltd., Harrow, Middx. Price 12s. 6d. (Postage paid.)

This is a new edition of international valve data which has been extended by the inclusion of German and Italian military types of valves. Valve base connections are included as well as characteristics.

The presentation is in tabular form and the explanatory pages in English.

Quality Through Statistics (2nd Edition).

By A. S. Wharton, F.S.S., A.I.I.A. Pp. 62 + iv. Published by Philips Lamps, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. Price 6s.

Demonstrations of Radio Aids to Civil Aviation.

Pp. 80+ vii. Published by H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 5s.

Short technical descriptions are given of equipment shown in the United Kingdom by the Research and Development Establishments of the Ministry of Supply during the demonstrations given on behalf of the Provisional International Civil Aviation Organization.

Institute of Physics

A MEETING of the Electronics Group of the Institute of Physics will be held on Friday, November 8th, 1946, at 7 p.m., at the Lecture Theatre, New Physics Building, The University, Oxford Road, Manchester.

The subject will be "Contact Potentials," by Dr. F. A. Vick.

CORRECTION

Two errors occurred in the advertisement pages of *Wireless Engineer* for October 1946. Inadvertently, the price of the M.I.P. Series 100 Multi-Range Test Set advertised by Measuring Instruments (Pullin) Ltd., was given as £8, instead of the correct figure of £8 10s. 0d.

The 15in Goodmans Industries Ltd. loudspeaker advertised in the same issue was quoted as Type T2/1205/15. This should have read T10/1501/15.

NEGATIVE RESISTANCE CIRCUIT ELEMENT*

The Dynatron at High Radio Frequencies

By G. A. Hay, M.Sc., A.M.Brit.I.R.E.

(The Radiotherapy Centre at Leeds)

Introduction

THE use of the dynatron as a means of measuring audio- and low radio-frequency resistance is well known, and has been developed by several workers[3, 10, 14, 15, 16]. Apparently, however, the usefulness of this method has not been extended to the higher frequencies, although some work has been done with the dynatron at frequencies up to 25 Mc/s. The ease with which measurements of the dynamic resistance of tuned circuits may be made suggests that the dynatron would be a very useful tool at the higher radio frequencies if more were known about its properties in those regions. The work described below was carried out in an attempt to make the dynatron available for use at frequencies up to 100 Mc/s.

1. Review of Previous Work

The earliest applications of the dynatron at high radio frequencies lay in its use as an oscillator rather than a measuring device. In 1925 Gill and Morrell[6] constructed an oscillator using a tungsten-filament triode, the control grid having a high positive potential applied to it. The oscillator made use of secondary emission from the anode, but was not a true dynatron, as the grid was not held at a constant potential. In this circuit, the finite transit time of the electrons was said to give rise to irregularities above 10 Mc/s, but it appears unwise to draw any rigid conclusions from this work, in view of the unorthodox nature of the valve and circuit.

In 1931 Colebrook[1] used a tetrode as dynatron with a resonant circuit tuned to 20 Mc/s. Calculation showed that the zero-frequency differential resistance of the valve was numerically much smaller than the positive dynamic resistance of the tuned circuit, thus indicating an abnormal effect. No explanation was then attempted.

At about this time the dynatron was used as a measuring instrument by Iinuma[10], who had previously compared its results at frequencies up to 8 Mc/s with those given by other methods, and had found close coincidence. It was then used for measurements up to 25 Mc/s, but no adequate comparisons seem to have been made at these frequencies, beyond a few measurements using the series-resistance variation method, from which agreement was found with a tolerance of 10%. This author neglects dielectric losses in the valve, and although they may have been small in the particular specimen used, they have been found very important in the present work, being of the same order of magnitude as the negative resistance itself at 50 Mc/s or more. The results, however, suggest the type of behaviour to be expected, and have been fully confirmed in the present work.

In 1938 the operation of a triode dynatron as a generator of ultra-short waves was investigated by Meinke[11,12]. In this work the space current was used as a measure of negative resistance (as negative conductance is proportional to space current). Irregularities in behaviour were found at frequencies of the order of 30 to 50 Mc/s, and these were attributed to transit time effects. It is interesting to note that this author has fully realized the necessity for chokes isolating the r.f. circuits from power supplies, a precaution which was found essential in the present work. He also used large bypass capacitors built into the valve so that all electrodes except the anode should be truly at cathode potential for radio-frequencies.

Finally, the nature of dynatron negative impedance was investigated in 1943 by Chakravarti and Das.[2] Here the dynatron was regarded as an unknown impedance, and the magnitude of its resistance component found by a triple current method, using thermocouple meters and a standard resistance. The difficulties and errors in such a method must have been great, and this is

* MS accepted by the Editor, April 1946.

reflected in the results obtained, as in one specimen series of measurements, the numerical value of the negative resistance decreased irregularly from 15 kΩ at 3 Mc/s to a few hundred ohms at 30 Mc/s and then went actually positive at 40 Mc/s. The writer feels that more precise information is necessary to substantiate the results claimed from this work.

Although no further practical work on the dynatron appears to have been published, a theoretical analysis appeared in 1938 by Viti.[18] In this is emphasized the change in conductance due to dielectric losses in the valve, and also the fact that the interelectrode capacitance forms part of the tuned circuit and may change with frequency. Secondly, the effects of lead inductance are analysed, and it is concluded that the most important of these is the feeding back to the control grid of an appreciable fraction of the anode voltage. This occurs because the grid cannot be bypassed completely to cathode because of the grid-lead inductance, and so it acquires an oscillatory potential relative to cathode, which then varies the negative resistance periodically. From an analysis of this effect the author deduces that if the series-resonant frequency of the grid circuit is of the order of 300 Mc/s, the valve will be usable as a measuring instrument up to about 150 Mc/s. This, of course, disregards transit time effects, and attributes any loss in performance to circuit limitations only.

2. Optimum Working Conditions

The measurement of dynamic resistance with the dynatron at low radio frequencies has been fully treated elsewhere[14,15,16], but there are some facts which are not generally appreciated; these are enumerated below.

The process of measurement consists of two parts: (*a*) the neutralizing of a positive dynamic resistance by the negative differential resistance of the valve, and (*b*) the measurement of the negative resistance by a bridge method at 1,000 c/s, which may safely be assumed equal to the zero-frequency value. One must first choose a suitable working point. It is necessary that the growth of oscillation should be limited to a small value, less than one volt peak, by correct choice of the shape of the characteristic, and this will occur at a point of inflexion in the $I_a - V_a$ curve where the gradient of the curve, $\frac{dI_a}{dV_a}$, is a negative maximum.[15]

Most tetrodes and pentodes have a convenient knee in the characteristic at an anode voltage of about 10 volts (Fig. 1), and the proximity of the first bend limits the amplitude to a small value. In addition, the slope of the curve at this point is large, giving a satisfactorily small value of negative resistance for neutralizing bad tuned circuits. Further, it is necessary that the amplitude of the 1,000-c/s voltage applied from the negative-resistance bridge in (*b*) should be approximately the same as the r.f. signal, as if it were to sweep over a different length of curve the average negative resistance would be different.

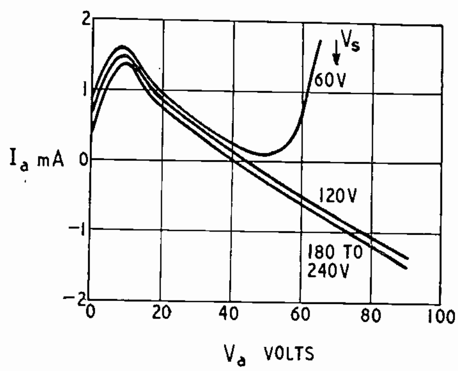


Fig. 1. *Static characteristics of AC/SG for a cathode current of 10 mA.*

In practice such resistance measurements are complicated by two other effects: (1) the anode–earth capacitance C_{ae}, and (2) the dielectric losses due to glass bulb, mica supports, etc. The equivalent circuit is shown in Fig. 2, and it is important to note that R_{diel}, representing the dielectric losses, will vary with frequency. Its value must therefore be known at all frequencies. At normal frequencies the anode–earth capacitance will be unimportant, but at higher frequencies it becomes comparable with the main circuit capacitance and its presence will be troublesome. Moreover, the effective anode–earth capacitance looking into the dynatron terminals will vary at the higher frequencies due to the presence of lead inductance in the valve.

The most useful valve for measurement purposes is the tetrode, although a pentode may be used with suppressor grid connected to screen. The optimum operating conditions have been discussed by the present writer for pentodes,[8] and broadly speaking these remarks apply equally to pentodes and tetrodes, although the behaviour of a pentode at the higher radio frequencies may be abnormal due to the larger anode–screen distance and larger electron transit time.

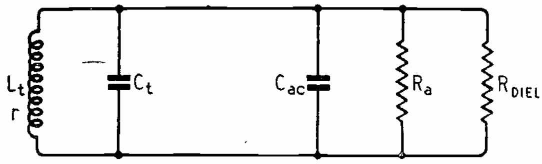


Fig. 2. *Simple equivalent circuit of the dynatron.*

2. Dynatron at High Radio Frequencies.

An approximate calculation of the electron transit time between anode and screen of a conventional tetrode gives a value in the region of 3×10^{-10} sec. This alone can hardly affect the operation of the valve at 100 Mc/s, and, moreover, the dynatron presents least opportunity of all the oscillators for space charges and other interfering factors to appear. It seems possible, therefore, that the abnormalities reported by previous workers might be explained in other ways.

Several methods were available for measurement of the negative resistance of the dynatron at high radio frequencies, but finally the method was chosen of using it to neutralize the positive dynamic resistance of a tuned circuit, which could be measured by one of the standard methods. This approximates most nearly to the conditions under which the valve will be used, and with obvious modifications has been used by Harvey in measurements on magnetron oscillators.[7]

Thus the negative resistance of the valve, R_a, at the working frequency could be found from the dynamic resistance R_d, and if the dynatron is behaving normally this should be equal to the zero-frequency resistance $R°_a$. Hence the ratio $\frac{R°_a}{R_a} = \epsilon$ could be used as a measure of the behaviour of the valve, as any departure from unity would indicate some abnormal effect. It is also necessary to know separately the value of R_{diel} (the dielectric-loss resistance), as the value of this at the working frequency is not the same as at zero frequency. This was measured by connecting the valve across the tuned circuit with the cathode cold.

The negative resistance at zero frequency was measured by a negative-resistance bridge working at 1,000 c/s. The bridge circuit is shown in Fig. 3. Two direct-reading ranges were provided, reading 0 to 5,000 ohms and 0 to 35,000 ohms, and the accuracy of the bridge was checked by rearranging it to measure a known positive resistance. The self-capacitance of the dynatron was compensated by a balancing capacitor as described by Terman[16]. The bridge was fed from a 1,000-c/s low-distortion oscillator, with screened transformers in the generator and detector circuits. The detector comprized a high gain semi-aperiodic amplifier feeding headphones, and the final accuracy of measurement was estimated at ± 2%.

The dynamic resistance of the tuned circuit was measured at various frequencies by the capacitance-variation method, using a calibrated low-loss screened capacitor with a usable capacitance variation of 4 pF.

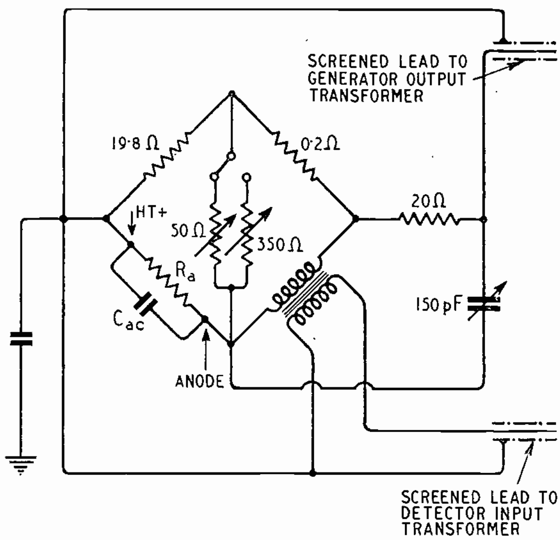


Fig. 3. *Negative-resistance bridge used for measurement of $R°_a$.*

The tuned circuits were built in a conventional manner, and as at the lower frequencies their dynamic resistance was off the range of the negative-resistance bridge, they were shunted by small metallized resistors as required. A voltage was induced in them from a medium-power oscillator very loosely coupled to the circuit to avoid interaction. Extensive screening was not available, and the whole apparatus was placed on an earthed aluminium sheet, and extension handles fitted where necessary.

The complete apparatus for the range 1 to 100 Mc/s is shown in Fig. 4, the valve used being a Mazda AC/SG. The only unconventional feature was the anode-voltage supply, which was designed for smooth variation between 7.5 and 13.5 volts and a very low anode-circuit resistance. The valve was decapped, and all electrodes but the anode were bypassed to cathode by 0.01-μF mica capacitors. The circuit had to be used in two conditions: (1) with the dynatron connected to a tuned circuit for the measurement of R_a, and (2) with the dynatron connected to a negative-resistance bridge for the measurement of R°_{a}. This changeover was made by crocodile clips to minimize the capacitive effects of switches. The valve voltmeter used for the dynamic-resistance measurement, and for detecting and adjusting oscillation amplitude, was connected permanently across the tuned circuit, as its losses were of no interest. For frequencies up to 50 Mc/s it consisted of a conventional square-law voltmeter using an acorn triode.

Measurements were made at first from 1 to 25 Mc/s, and the values of ϵ thus obtained are shown in Fig. 5. It departs little from unity up to 10 Mc/s, but after that irregular changes occur, the significance of which was not at first clear. However, it was noticed that these irregularities were closely related to large increases in tuned circuit losses, and the cause of this was finally traced by a process of elimination to series resonances in power-supply leads. When r.f. chokes had been added (at the points marked X in Fig. 4) to isolate the tuned circuit from everything except the

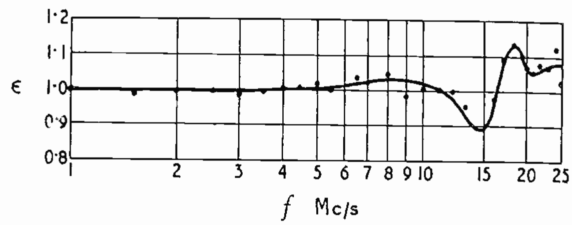


Fig. 5. *First measured values of ε; 1 to 25 Mc/s.*

dynatron and valve voltmeter, the irregularities disappeared completely. Results from 1 to 50 Mc/s are shown in Fig. 6, and values of R_{diel} in Fig. 7. (Inaccuracies in the values for R_{diel} at the lower frequencies are due to the expression for R_{diel} containing the small difference between two large quantities.)

At this point it was thought desirable to confirm the validity of ϵ as a measure of the dynatron's performance. The variation of the ratio with a change of R_d was therefore examined at a fixed frequency of 15 Mc/s.

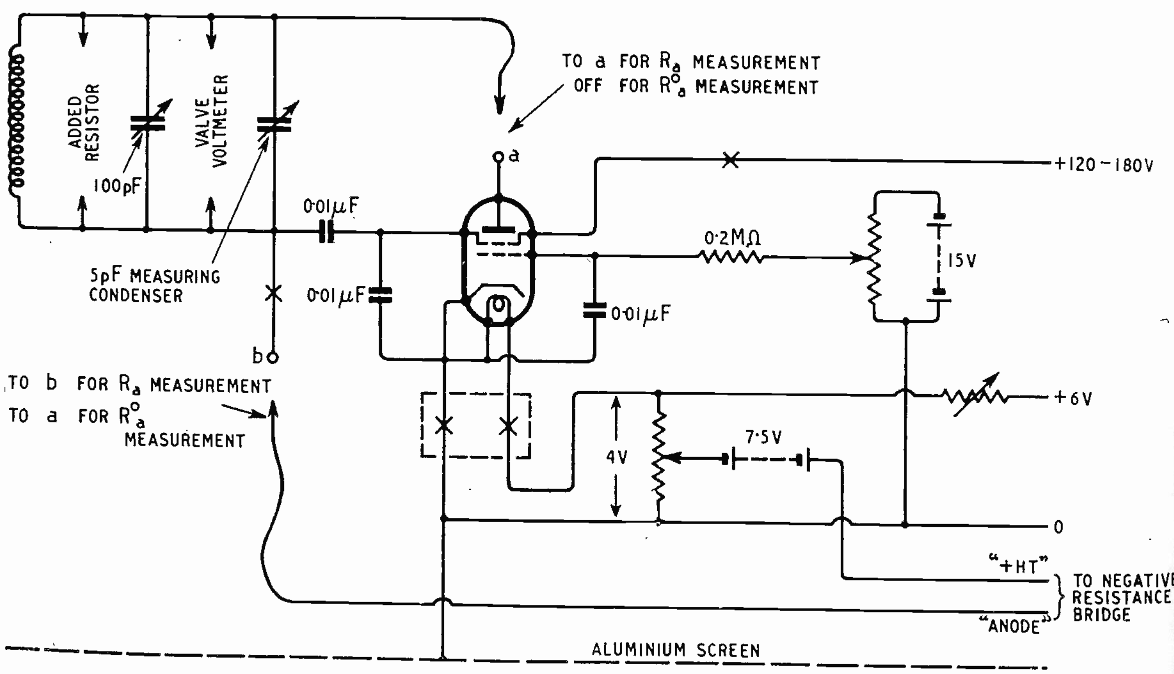


Fig. 4. *Circuit used for measurements: crosses denote the positions of single or double r.f. chokes added later.*

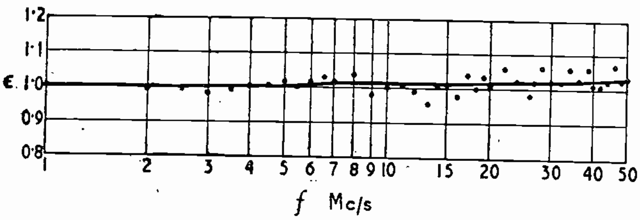
The results are shown in the Table, and confirm that ϵ does not vary appreciably for quite large changes in R_d.

Shunt resistance (nominal) (kΩ)	$-R°_a$ (kΩ)	$R_a = R_d$ (kΩ)	ϵ
∞	29.0	28.6	1.01
60	19.3	19.3	1.00
40	17.1	16.6	1.03
20	12.3	12.1	1.02
10	9.0	9.1	0.99

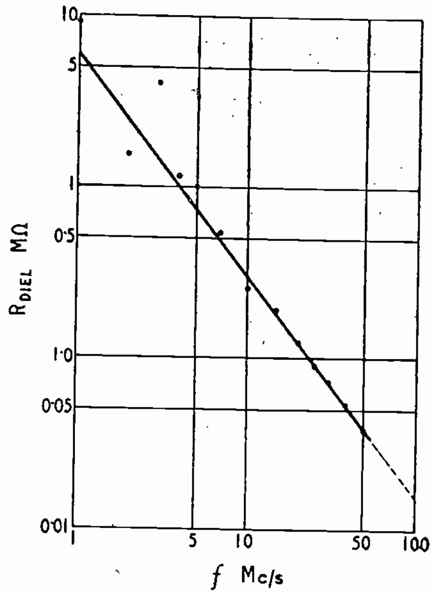
Variation of ϵ with changing R_a; frequency constant at 15 Mc/s.

Fig. 6 (*below*). *Final measured values of* ϵ *; 1 to 50 Mc/s.*

Fig. 7 (*right*). *Values obtained for* R_{diel} *up to 50 Mc/s.*



capacitance of the valve. For still higher frequencies a special valve would be necessary, and it is hoped that this may form the basis of future work.



Above 50 Mc/s an acorn-diode voltmeter with a d.c. amplifier was substituted for the square-law meter, and an improved form of local oscillator was used. It was originally intended to use quarter-wave resonant lines at frequencies above 50 Mc/s, but the losses in the AC/SG at these frequencies were so great that the large resonant impedance of the line conferred no advantage. In addition, the anode–earth capacitance was about 10 pF, and this loaded the line excessively, so that most of it was inside the valve. So the apparatus was rebuilt with conventional tuned circuits of very low-loss construction, and all components grouped closely around the valve. Care was taken to make the anode lead as short as possible, so that its inductance could be neglected in subsequent calculations.

The results obtained were uniformly good, and are shown in Fig. 8. As it was suspected that irregularities might now be due to series resonance in the anode circuit of the dynatron, a rough measurement of this frequency was made and found to be 125 Mc/s. It was quite apparent at this point that any further attempts to increase the frequency would be unsuccessful, as the inductance of the external circuit was at its practical minimum, and the real obstacles lay in the lead inductance and inter-electrode

4. Discussion of Results

Examination of the results given in Fig. 6 shows that if the negative resistance of the AC/SG be measured at zero frequency or at 1,000 c/s, then it will be the same at all frequencies up to 50 Mc/s within a tolerance

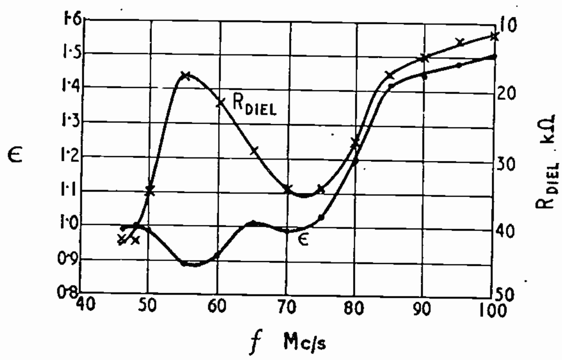


Fig. 8. *Values of* ϵ *and* R_{diel} *from 50 to 100 Mc/s.*

of ± 5%; i.e., ϵ lies between 0.95 and 1.05. No doubt measurements with more refined apparatus would confirm this result to a higher degree of accuracy. This conclusion is true only if the valve and associated r.f. circuits are completely isolated from power supplies, etc., by adequate chokes and bypass capacitors. This is a most important point, and it seems to afford a ready explanation for the irregular results obtained by previous workers.

Above 50 Mc/s irregularities appear in the value of ϵ, (Fig. 8), and it was at first supposed that transit time effects were becoming apparent. Measurement of dielectric losses in the valve, however, showed that these irregularities were exactly coincident with sudden increases in energy absorption by the valve. The first of these occurs at about 56 Mc/s, and it is seen that a decrease in ϵ results. On the other hand, the next large decrease in R_{diel} occurs towards 100 Mc/s and higher, and this results in an increase in ϵ. It is unlikely that electron transit time is responsible for this, and apparently we must look to circuit properties for the explanation.

This idea has been established for triode oscillators by Gavin[5], who states that for triodes of normal construction, limitation of the maximum frequency is first brought about by circuits conditions rather than by transit-time effects. It has already been shown in Sect. 3 that the transit time in an AC/SG is roughly equal to one cycle of a 3,000-Mc/s oscillation, and therefore should not materially influence 100-Mc/s operation.

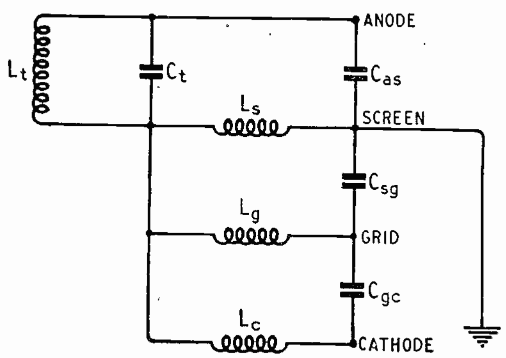


Fig. 9. *Equivalent circuit of dynatron showing inter-electrode capacitances and lead inductances.*

Considering now those circuit conditions which might affect the operation, a much more satisfactory explanation can be advanced. Fig. 9 shows the equivalent circuit of the dynatron, including inter-electrode capacitances and lead inductances, and considering r.f. conditions only. We may assume that the screen is at earth potential, and ignore the anode–grid capacitance. As the anode lead was short and taken to a top cap, its inductance has been neglected, and no account has been taken of mutual inductances and lead resistances.

In the anode circuit, the tuned circuit proper L_t and C_t has in parallel with it a series-resonant circuit L_s and C_{as}. Actually L_s is itself shunted by circuits consisting of L_g, C_{sg} and L_c, C_{gc}, but for simplicity we may assume all these to be lumped together to give an effective screen inductance L'_s.

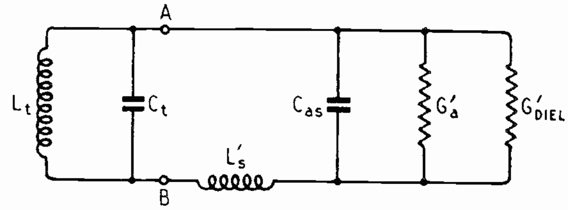


Fig. 10. *Equivalent circuit of dynatron showing effective screen lead inductance.*

This can now be calculated, for the resonant frequency of L'_s and C_{as} is 125 Mc/s (Sect. 3) and C_{as} is about 10 pF (makers' figure), so L'_s is 0.16 μH. By assuming $L_s = L_g = L_c = L$, and $C_{as} = C_{sg} = C_{gc} = C$ (a reasonable assumption from the geometry of the valve) we may calculate L, which is about 0.05 μH. This is the inductance of one of the leads from the base of the valve to the electrodes. By applying the dimensions of such a lead in a chart given by Gavin for the inductance of a straight wire,[5] the theoretical value is found to be 0.08 μH. In a similar manner the external inductance L_t is found to have a value of 0.09 μH, and the calculated figure for the coil alone is 0.05 μH. This neglects connecting leads, which would probably bring the inductance nearer to the experimental value. The agreement between these figures is not close, but in view of the approximations made it is considered to support the correctness of the equivalent circuit used.

In Fig. 10 the equivalent circuit is shown in another form, with

$$G'_a = \frac{1}{R'_a} \quad \text{and} \quad G'_{diel} = \frac{1}{R'_{diel}}.$$

These are the true values of negative conductance and dielectric loss, considered as measured across the anode–screen space, and the measured values (across AB) will only coincide with these if the reactances of L'_s and C_{as} are small and large respectively at the operating frequency, that is, at low and medium radio frequencies. If, however, these quantities become important in the circuit, the values of negative conductance and dielectric loss measured at the working frequency will be the effect of G'_a and G'_{diel} across AB; i.e., G_a and G_{diel}.

For convenience in manipulation, let us consider $G_a + G_{diel} = G$, and $G'_a + G'_{diel} = G'$. At an angular frequency ω, the parallel admittance of the anode–screen space is $(G + j\omega C_{as})$ and the total admittance of the valve between A and B is

$$\frac{(G' + j\omega C_{as})\ 1/j\omega L'_s}{G' + j\omega C_{as} + 1/j\omega L'_s}$$

Simplifying and rationalizing we have

$$Y_{AB} = \frac{G'}{(1 - \omega^2 L'_s C_{as})^2 + \omega^2 L'^2_s G'^2} - j\omega \frac{L'_s G'^2 + C_{as}(1 - \omega^2 L'_s C_{as})}{(1 - \omega^2 L'_s C_{as})^2 + \omega^2 L'^2_s G'^2}$$

At the moment we are mainly interested in the first term, for this gives the value of G for any angular frequency ω. Suppose further that ω_0 is the resonant frequency of L'_s and C_{as}, then $\omega_0^2 L'_s C_{as} = 1$. Hence

$$G = G' . \frac{1}{(1 - \omega^2/\omega_0^2)^2 + \omega^2 L'^2_s G'^2};$$

but $\omega^2 L'^2_s G'^2$ is small;

$$\therefore\ G = k . G' \quad \text{where} \quad k = \frac{1}{(1 - \omega^2/\omega_0^2)^2}$$

$$\therefore\ G_a + G_{diel} = k.(G'_a + G'_{diel})$$

$$\therefore\ G_a = k . G'_a, \quad \text{and} \quad G_{diel} = k . G'_{diel}$$

Now G'_{diel} may be estimated by extrapolation from Fig. 7, and if k were known at any frequency, the apparent G_{diel} could be calculated. But $k = G_a/G'_a = R^\circ_a/R_a = \epsilon$ hence $G_{diel} = \epsilon . G'_{diel}$, and this calculated value is compared with the measured value (obtained from Fig. 8) in Fig. 11. From 75 Mc/s upwards, although numerical agreement is absent, the curves follow exactly the same trend, and it is apparent that some such mechanism as outlined above must be responsible for the behaviour observed. Below 75 Mc/s, however, a sharp peak in G_{diel} occurs, and to explain this we must have recourse to a theory advanced by Viti (Sect. 1) in which the grid is said to acquire an oscillatory potential relative to the cathode. A positive increase of grid voltage causes an increase in anode voltage, and so if the feed-back potential is out of phase with the anode voltage a negative feed-back effect will be produced and the apparent G_a will be less. Hence the ratio $\epsilon = \dfrac{G_a}{G'_a}$ will be less than unity. It is quite impossible to calculate the magnitude of this effect, as so much may depend on stray inductive and capacitive couplings in the circuit and valve, but it may be assumed that the oscillatory control-grid voltage arises because of series resonance in the grid–cathode circuit, and the resonant frequency would appear to be about 55 Mc/s.

5. Conclusion

It now seems clear that any limitations in the behaviour of the dynatron up to 100 Mc/s

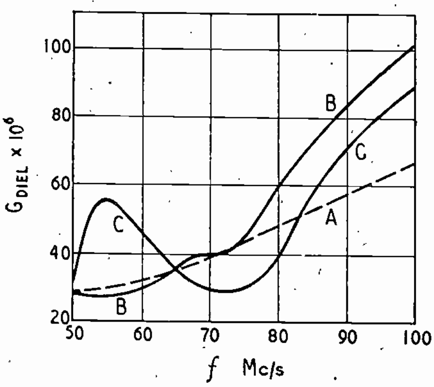


Fig. 11. *Comparison of measured values of G_{diel} with values obtained from theory: curve* A, *G'_{diel} obtained by extrapolation from Fig. 7; curve* B, *G_{diel} calculated from G'_{diel} and ϵ; curve* C, *G_{diel} measured.*

are not due to transit time effects, but merely to circuit conditions associated with the construction of the valve. Irregularities in behaviour may also arise as a result of resonance in power supply leads, etc. The use of the dynatron for measuring r.f. resistance at still higher frequencies would require a special valve designed with the above considerations in mind.

Acknowledgment

Acknowledgment is due to the University of Durham for permission to publish this work, which was submitted in extended form for the degree of M.Sc.

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TRANSIENT RESPONSE OF FILTERS*

By C. C. Eaglesfield.

(Mullard Radio Valve Company).

IN a recent article Tucker[1] has discussed the problem of the transient response of filters. Among other matters he referred to a "6-element symmetrical" filter section used between resistive terminations equal to its design resistance, and found its analysis intractable.

The object of this note is to demonstrate that a useful solution is easily obtained if the assumption is made that the pass-band of the filter is small compared to the mid-frequency. This is a very likely practical case. The result obtained confirms the correct form of the empirical solution given by Tucker.

For convenience the circuit diagram of the filter and the proportioning of the elements are reproduced from Tucker's article. Thus

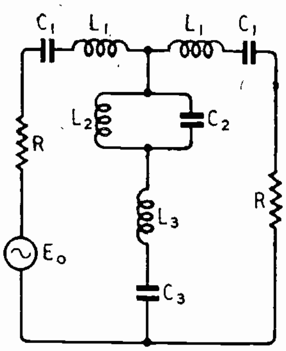


Fig. 1. *6-element symmetrical filter.*

his Fig. 3 becomes Fig. 1 here, and the list of symbols is :—

m = the derivation parameter

n = fractional bandwidth

$= \dfrac{\text{actual bandwidth}}{\text{mid-band frequency}}$

R = design impedance

Then

$$L_1 = \frac{m}{n}\cdot\frac{R}{\omega_0} \qquad C_1 = \frac{n}{m}\cdot\frac{1}{R\omega_0}$$

$$L_2 = \frac{n}{2m}\cdot\frac{R}{\omega_0} \qquad C_2 = \frac{2m}{n}\cdot\frac{1}{R\omega_0}$$

$$L_3 = \frac{1-m^2}{2mn}\cdot\frac{R}{\omega_0} \qquad C_3 = \frac{2mn}{1-m^2}\cdot\frac{1}{R\omega_0}$$

[1] "Transient Response of Filters," by D. G. Tucker. *Wireless Engineer*, March 1946, Vol. 23, p. 84.

It may be worth remarking that ω_0 is the mid-band angular frequency. The symbol $\omega_1 = n\omega_0$ is also required.

Tucker's equation (15) gives the output voltage (across the right-hand R of Fig. 1) due to the applied E_0 :—

$$\frac{\textit{Output volts}}{\frac{1}{2}E_0} = \frac{1 + \dfrac{1-m^2}{m^2}M^2}{1 + 2M + \dfrac{1+m^2}{m^2}M^2 + \dfrac{M^3}{m^2}} \quad \ldots \quad (1)$$

$$\text{where } M = \frac{m}{n}\left(\frac{p}{\omega_0} + \frac{\omega_0}{p}\right) \quad \ldots \quad \ldots \quad (2)$$

and p is the differential operator d/dt.

Equation (1) may be written

$$V = 2 \times \text{Output volts} = \Phi[M(p)] \,.\, E_0 \quad \ldots \quad \ldots \quad (3)$$

The problem is to evaluate (3) when E_0 is of the form

$$\cos \omega_0 t\, \mathbf{1} \quad \ldots \quad \ldots \quad (4)$$

that is, the angular frequency ω_0 modulated by the Heaviside Unit Function ; or to put it in another way, a sudden application of $\cos \omega_0 t$. (The case of the applied angular frequency differing from ω_0 will not be considered.)

Equation (3) becomes :—

$$V = \Phi[M(p)] \,.\, \epsilon^{j\omega_0 t}\, \mathbf{1} \quad \text{(real part)}$$

$$= \epsilon^{j\omega_0 t} \,.\, \Phi[M(p + j\omega_0)] \,.\, \mathbf{1} \quad \text{(real part)} \quad \ldots \quad \ldots \quad (4)$$

This last step is an application of the Heaviside "Shift" Theorem.

We shall find (with the assumption already referred to) that

$$\Phi[M(p + j\omega_0)]$$

is real. Assuming this in advance :—

$$V = \cos \omega_0 t \,.\, \Phi[M(p + j\omega_0)]\, \mathbf{1}$$

Thus the envelope of V (call it V_e) is

$$V_e = \Phi[M(p + j\omega_0)]\, \mathbf{1} \quad \ldots \quad \ldots \quad (5)$$

The next step is to evaluate $M(p + j\omega_0)$.

* MS. accepted by the Editor, April 1946.

From equation (2) :—

$$M(p) = \frac{m}{n}\frac{(p^2 + \omega_0^2)}{\omega_0 p}$$

Therefore

$$M(p + j\omega_0) = \frac{m}{n}\frac{(p + j\omega_0)^2 + \omega_0^2}{\omega_0 (p + j\omega_0)}$$

$$= \frac{mp}{\omega_1}\frac{p + 2j\omega_0}{p + j\omega_0}$$

$$= \frac{mp}{\omega_1}\frac{2\omega_1 - jnp}{\omega_1 - jnp},$$

since $n\omega_0 = \omega_1$.

$$\to \frac{2mp}{\omega_1} \text{ as } n \to 0$$

Thus for the stated condition, that the pass-band is small compared to the mid-frequency, we may write

$$M(p + j\omega_0) = \frac{2mp}{\omega_1}$$

Substitute this in equation (5) :—

$$V_e = \Phi\left[\frac{2mp}{\omega_1}\right] \mathbf{1}$$

Changing the time scale to $t' = \frac{\omega_1 t}{2m}$, we get the simpler expression :—

$$V_e = \Phi(p)\,\mathbf{1} \qquad \ldots \qquad \ldots \qquad (6)$$

Referring to equation (1) for the form of Φ, it will be seen that we now have a cubic in p in the denominator, instead of a sextic. We may thus expect, and shall in fact find, that equation (6) is easily soluble.

We have

$$\Phi(p) = \frac{1 + \frac{1 - m^2}{m^2}p^2}{1 + 2p + \frac{1 + m^2}{m^2}p^2 + \frac{p^3}{m^2}} = \frac{1 + \frac{1 - m^2}{m^2}p^2}{(1 + p)\left(1 + p + \frac{1}{m^2}p^2\right)}$$

$$= \frac{1}{1 + p} - \frac{p}{1 + p + \frac{1}{m^2}p^2} = \frac{1}{1 + p} - \frac{m^2 p}{(p + \frac{1}{2}m^2)^2 + m^2(1 - \frac{1}{4}m^2)}$$

The solution of (6) is thus the sum of two elementary standard forms, which may be found in any textbook on operational calculus. Reverting to the time variable t, we get

$$V_e = 1 - e^{-a_1 t} - G\,e^{-a_2 t}\sin \omega t \qquad \ldots \qquad (7)$$

where

$$a_1 = \frac{\omega_1}{2m}$$

$$a_2 = \tfrac{1}{4}m\omega_1$$

$$G = \frac{m}{\sqrt{1 - \frac{1}{4}m^2}}$$

$$\omega = \frac{\omega_1}{2}\sqrt{1 - \tfrac{1}{4}m^2}.$$

Equation (7) may be compared with Tucker's empirical equation (21) : it will be found to be identical, except that he has not evaluated G.

If numerical values are inserted in equation (7) corresponding to the measured result given in Tucker's Fig. 5 (Curve 1), it will be found that the agreement is not very good : in particular the calculated curve shows about 10 per cent overshoot against the measured 3 per cent. Tucker states that the Q value of his inductors was 100. It may be that this value is not high enough to justify the neglect of the inductor losses ; in this analysis the only resistive elements considered are the terminations. Again it may be that in the measurement the pass-band was not sufficiently small (compared to the mid-frequency) ; the ratio n was 0.037.

One's physical instinct suggests that both the inductor losses and the pass-band were in fact negligible, but it is difficult to think of any other cause of the discrepancy.

BOLOMETERS FOR V.H.F. POWER MEASUREMENT*

By *E. M. Hickin, Grad.I.E.E.*

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

SUMMARY.—The increasing use of decimetre and centimetre wavelengths has necessitated some changes in techniques for measuring power. The application of the bolometer method to the measurement of small h.f. powers is described. In this method the power is dissipated in a resistance having a large temperature coefficient (an " indicator ") which forms one arm of a Wheatstone bridge. By direct-current power substitution the indicator may be calibrated and then one measurement of resistance will give the power in the load.

Some details are given of indicators and circuits to deal with powers from a few microwatts to a few watts at frequencies up to 10,000 Mc/s. The limitations of the method and possible sources of error are discussed.

CONTENTS

1. Introduction

THE increasing use of decimetre and centimetre wavelengths introduced a new problem in the measurement of small powers, such as are available at the output of signal generators. The valve voltmeter, often used for this type of measurement at lower frequencies, had reached its limit for use without calibration at the working frequency, and load lamps were neither convenient nor sensitive enough for the small powers involved.

In order to increase the sensitivity and accuracy of measurement of the power in a lamp a property other than its light output can be used. As soon as any power is dissipated in the filament the temperature rises until the radiation and conduction losses equal the power input. This rise in temperature will also cause a change of resistance. If the circuit is so arranged that the resistance of the lamp can be measured then an indication of power will be obtained long before the filament has reached incandescence. Fig. 1 shows the increase in sensitivity obtainable.

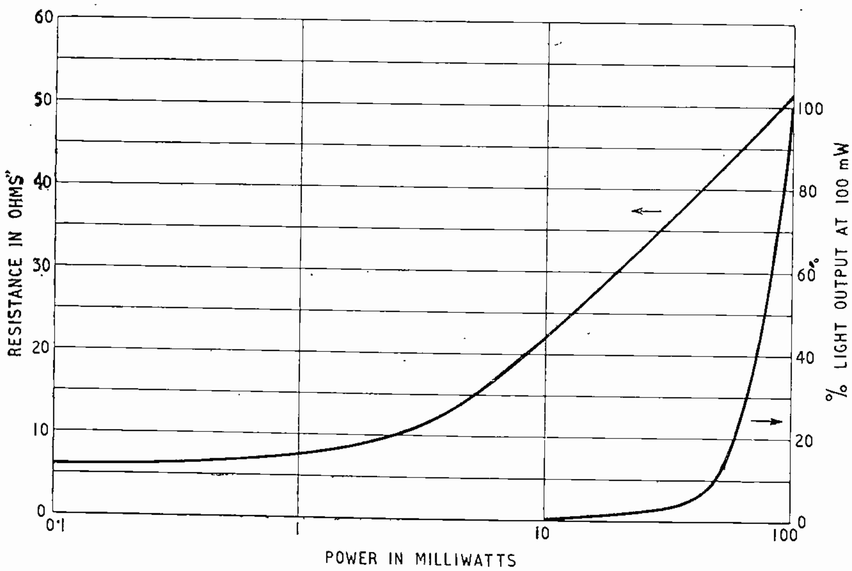


Fig. 1. *Resistance and light output of a tungsten lamp are shown here as functions of the power input. Large resistance changes are obtained well below incandescence.*

The use of this property is by no means new. It was first used to measure heat radiation before the thermopile was developed and it is from this that the name bolometer (Greek: Ray-meter) was derived. Tissot, in 1904, described its use for measuring radio-frequency currents, but the thermocouple superseded it. The recent revival in the use of the bolometer has been entirely concerned with the measurement of total power and not of current, and the circuit arrangements

* MS. accepted by the Editor, March 1946.

have, therefore, been somewhat different.

2. Circuits

One method of coupling a load lamp to an oscillator is by placing it across an open line which is itself coupled to the oscillator. This system can be used with slight modification for bolometer measurements as shown in Fig. 2, where a capacitance-shorting bridge

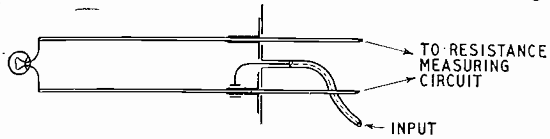


Fig. 2. *A load line can be coupled to an oscillator through an open-wire line.*

is used to enable d.c. leads from the indicator to be taken to a resistance measuring device. A circuit of this type has been used at about 1,000 Mc/s for measuring oscillator outputs and cable attenuations, but the open wire circuit is not so desirable as a concentric system on account of the radiation losses and liability to interference.

Fig. 3 shows a number of circuits for various frequencies; (*a*) and (*b*) are "half-wave" circuits, i.e., the indicator forms a load at one end of the line, with a moveable short-circuiting bridge at the other end and an adjustable tapping point for injecting the input. A capacitance break in the outer conductor enables the necessary d.c. connections to be made. These circuits have been designed for use with a low-impedance indicator (i.e., one which has an impedance equal to or lower than the characteristic impedance of the circuit) and when at higher frequencies the lead length between the filament and the short circuit at the end of the line becomes too great a second bridge must be inserted as in Fig. 3(*c*).

For the most accurate measurement the circuit losses must be reduced to a minimum and for the higher frequencies the sliding contact bridges are not suitable. When the frequency is high enough to enable a waveguide of reasonable dimensions to be used a better type of bridge can be embodied. This is the "non-contact" type shown in Fig. 3(*d*) and is designed to produce so great an impedance discontinuity that the wave is totally reflected before reaching the contact region. Waveguide circuits of the type shown in Fig. 3(*d*) and (*e*) have, with suitable guide and piston dimensions, been used at frequencies greater than 10,000 Mc/s.

3. Indicators

In the circuit shown in Fig. 2 a flashlamp bulb, preferably uncapped, can be used but for frequencies above 600 Mc/s it is preferable to have a "straight-through" construction in which the filament enters and leaves the bulb at opposite ends. This makes the indicator suitable for forming the inner conductor of a concentric line, or for placing across a waveguide.

An indicator, CV95, specially developed for this work is shown in Fig. 4. For ease of construction the filament is first mounted on a mica frame and then sealed into a bulb, and evacuated. It has a 0.01-mm tungsten filament 8 mm in length. As can be seen from Fig. 5, the cold resistance is about 6 ohms and the maximum power which it can dissipate is 120 mW. While higher powers will not cause an immediate burn out, the evaporation of the filament will cause a drift in calibration if this rating is exceeded for long periods.

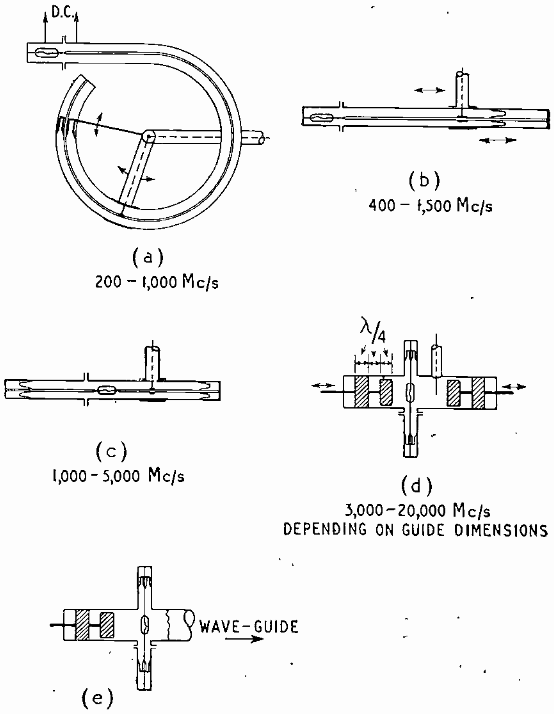


Fig. 3. *Bolometer circuits for various frequency ranges.*

The rating of any given filament can be increased by filling the bulb with an inert gas. The increased conduction loss from the filament will keep the temperature rise down and in this way powers of several watts can be dissipated by the CV95 filament. Fig. 6 shows the result of argon and hydrogen filling at various pressures (thermal conductivities, Argon 0.00004, hydrogen 0.0003 at 0° C).

To reduce circulating current losses to a minimum the characteristic impedance of the bolometer circuit should equal that of the input line. Similarly the indicator impedance should also equal that of the incoming line, e.g. 75 ohms; but if, as with the CV95, this

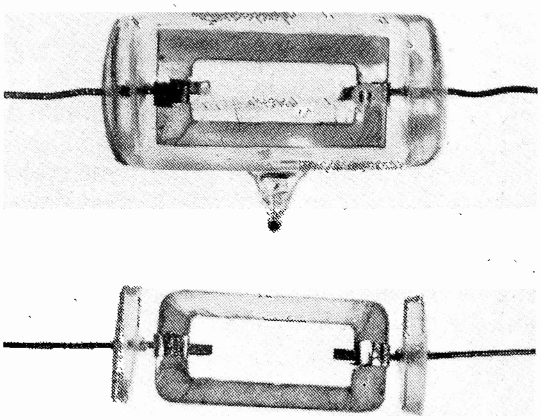


Fig. 4. *CV95 (R3/10) indicator showing construction.*

cannot be achieved it should be made as nearly as possible equal in order to reduce the effect of circuit losses. When a small power is being measured the impedance of the indicator can be increased by adding power from an independent source. If 2-kc/s a.f. power is used the galvanometer is easily decoupled to prevent damage. The a.f. power input can be adjusted to give the temperature, and hence the resistance, required and the r.f. power measured by the substitution method described in Sect. 5 below; i.e., by measuring the change in d.c. power required to rebalance the bridge when the r.f. is removed. The presence of the a.f. power does not affect the result. In Fig. 7 is given the result of measuring the output of an oscillator of constant power (fed through a length of attenuating cable) by a bolometer whose indicator impedance can be varied in the manner described. With no "preheating" the bolometer indicates about 3 mW. at a resistance of 15 ohms. As the resistance is progressively increased by the addition of a.f. power, and the circuit readjusted, the indicated r.f. power also increases, until at 60 ohms about 6 mW is reached. A standing wave detector in the input to the bolometer shows that this effect is not due to mismatching and can therefore be attributed to the circuit losses.

A preferable system for measuring small powers is to have an indicator whose cold impedance is nearer the desired value. One way of obtaining this is by using finer wire; this will also have the advantage of increased sensitivity due to lower thermal capacity. Tungsten cannot easily be drawn below 0.01 mm diameter but platinum can be made with very small diameters by using Wollaston* wire. This consists of a platinum wire coated to some ten times its own diameter with silver. The composite wire is drawn as fine as convenient and the silver is then etched off, leaving the platinum. Wires of 0.003-mm platinum made in this way have been used and an 8-mm length gives a "cold" resistance of about 120 ohms compared with the 6 ohms of the 0.01-mm tungsten.

Higher impedances can also be obtained by using carbon filaments. A 0.06-mm carbon filament of 8-mm length has a cold resistance of 150 ohms dropping to about 90 ohms for an input of 1.5 watts. In addition iron,* by virtue of its permeability,

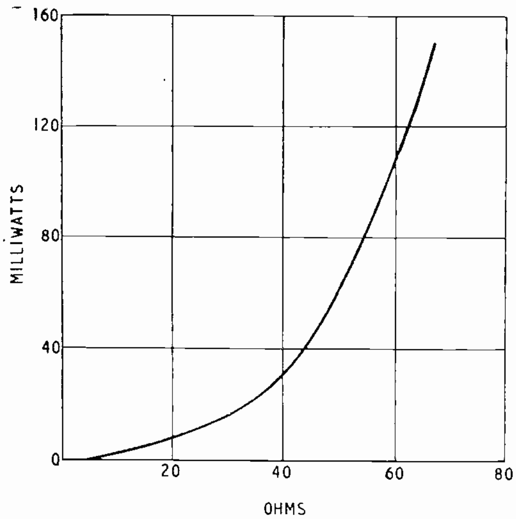


Fig. 5. *Characteristic of indicator type CV95.*

has a higher impedance than non-magnetic metals as the skin effect is more pronounced.

The result of preheating some of these filaments as described above is also shown in Fig. 7.

* The author would like to acknowledge the assistance given by Dr. Chaston (Johnson Matthey Research Dept.) and Mr. D. W. Chappel (N.P.L.) in obtaining Wollaston and 0.01-mm iron wire.

4. Calibration

Calibrations may be made in several ways. If the powers to be measured are greater than a few milliwatts a power-resistance curve may be plotted on d.c. (Fig. 5) and then, using a Wheatstone bridge with low current as shown in Fig. 8(a), the resistance

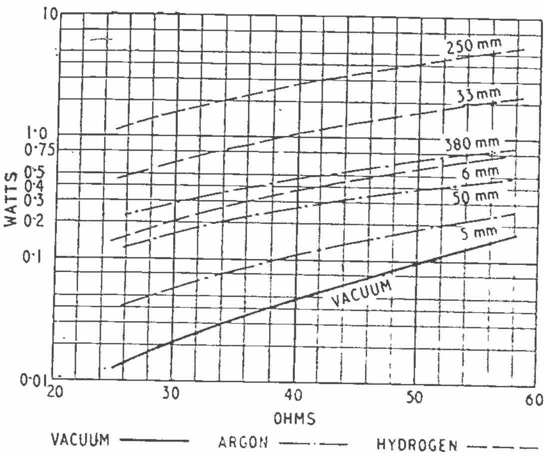


Fig. 6. *Indicator characteristics for various gas pressures (0.01 mm tungsten filament.)*

may be measured and hence the r.f. power derived. The reason for not using this method for powers below 1 mW is that the "cold" resistance of the indicator is a function of ambient temperature and calibration will not therefore be reliable unless this is carefully controlled or unless the temperature rises due to r.f. are large compared with local fluctuations. If a CV95 has been calibrated at say 15° C. a rise of only 4° C can give an apparent reading of 100 μW. By placing an identical indicator in the opposite bridge arm compensation for slow changes in ambient temperature can be obtained but the system is not recommended.

The bridge current must also be small so that the d.c. power introduced does not upset the reading. If

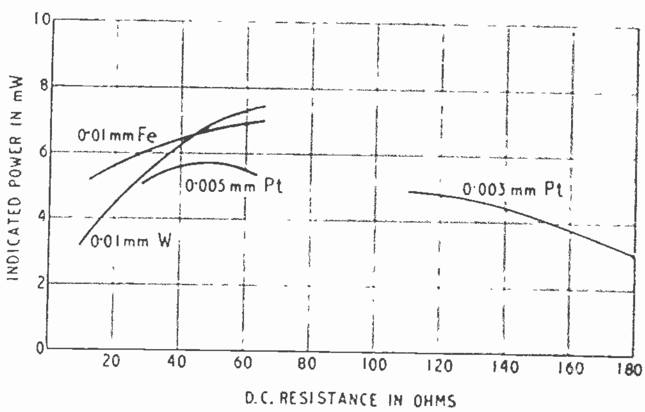


Fig. 7. *The effect of "pre-heating" on the power indication is shown.*

the total bridge current is 0.1 mA the lower limit of power for 1 per cent error is 10 μW when $R_1 = 10R_2$.

When smaller powers have to be measured it is necessary to calibrate the indicator for each reading. This can be simply done by the circuit of Fig. 8(b). The bridge is balanced in the usual way with the r.f. applied and with some arbitrary current I_1 flowing into the bridge. Then the r.f. power is removed and the total bridge current increased until the bridge rebalances. Let the new current be I_2. Since balance has been obtained the indicator resistance, and hence the power in it, must be the same. The difference between the two d.c. powers in the indicator will give the r.f. power.

This power may be obtained in the following way. If I_1 and I_2 are bridge currents (as measured) and i_1 and i_2 the corresponding indicator currents, then :

$$i_1 = I_1\left(\frac{R_1 + R_2}{r + \frac{rR_1}{R_2} + R_1 + R_2}\right) = I_1 \frac{R_2}{r + R_2}$$

similarly $i_2 = I_2 \dfrac{R_2}{r + R_2}$

$$\text{R.F. Power} = i_2^2 R - i_1^2 R$$

$$= (I_2^2 - I_1^2)\left(\frac{R_2}{r + R_2}\right)^2 r$$

$$= (I_2 + I_1)(I_2 - I_1)\left(\frac{R_2}{r + R_2}\right)^2 r$$

Since $\left(\dfrac{R_2}{r + R_2}\right)^2 r$ will be a constant for a number of readings the sum and difference of two currents is all that will be required. In this way powers down to about 10 μW can be measured.

Another method of measuring small powers has been described elsewhere* ; the circuit

* "Radio Measurements in the Decimetre and Centimetre Wavebands," by Clayton, Houldin, Lamont and Willshaw, *Journ. Instn. Elec. Engn.* Pt. III, March 1946.

is shown in Fig. 8(c). A variable high resistor R_4, a microammeter and a switch are added in parallel with the bridge. The bridge is balanced with the switch open before applying the r.f. power. After the application of the r.f. power the switch is closed and R_4 adjusted. The shunting effect will reduce the power supplied to the bridge, and R_4 is reduced until balance is obtained. As in the method of Fig. 8(b) the r.f. power will be the change in d.c. power in the indicator. It can be shown that this power is given by

$$P = r\left(\frac{R_2}{r+R_2}\right)^2 \frac{R_3}{R+R_3} \cdot I_4 \left\{2I_2 - I_4\frac{R_3+2R}{R_3+R}\right\}$$

where $R = r\dfrac{R_1+R_2}{r+R_2}$, the total bridge resistance.

In the simple case where $r = R_1 = R_2 = R$

$$P = \frac{R}{4}\frac{R_2}{R+R_2}\left[2\,I_2 I_4 - \frac{I_4{}^2}{2}\frac{R_3+2R}{R_3+R}\right]$$

and if $I_2 \gg I_4$ and R_3 is made $\gg R$,

$P = \dfrac{I_2 I_4 R}{2}$, that is to say $P \propto I_4$ and the microammeter gives a linear indication of power.

This method is very useful for the measurement of powers of the order of 10 μW where I_4 will be of the order of a few microamperes.

Two other methods which can be used for rough measurements in order to reduce calculations to a minimum are to calibrate the out-of-balance current of the bridge in terms of power, or else to measure the voltage across the indicator when it is fed from a battery in series with a high resistance. These methods are useful as output indicators when setting up oscillators or amplifiers.

5. Precautions in Use

While the bolometer method is simple and straightforward there are certain possibilities of errors which must be borne in mind.

1. As has been mentioned in Sect. 3 above there can be a substantial error due to circuit losses if the impedance of the indicator is too low or too high and if insufficient care is taken with the circuit design. This error can be prevented by correct choice of indicator, by preheating, or by applying a correction which can be derived from consideration of Sect. 3. For measurement of small powers sliding contacts should be avoided wherever possible.

2. When the wavelength is comparable with the filament length the distribution of radio-frequency current in the filament will not be uniform. With the CV95 this effect should not be significant at frequencies up to about 5,000 Mc/s. The magnitude and sign of this error will depend on the slope of the power-resistance curve.

3. If the power being measured is amplitude modulated at a low frequency then the resistance of the indicator will pulsate in sympathy with the modulation. Although the pulsation in the bridge current can be smoothed out so that the bridge measures mean resistance, owing to the curvature of

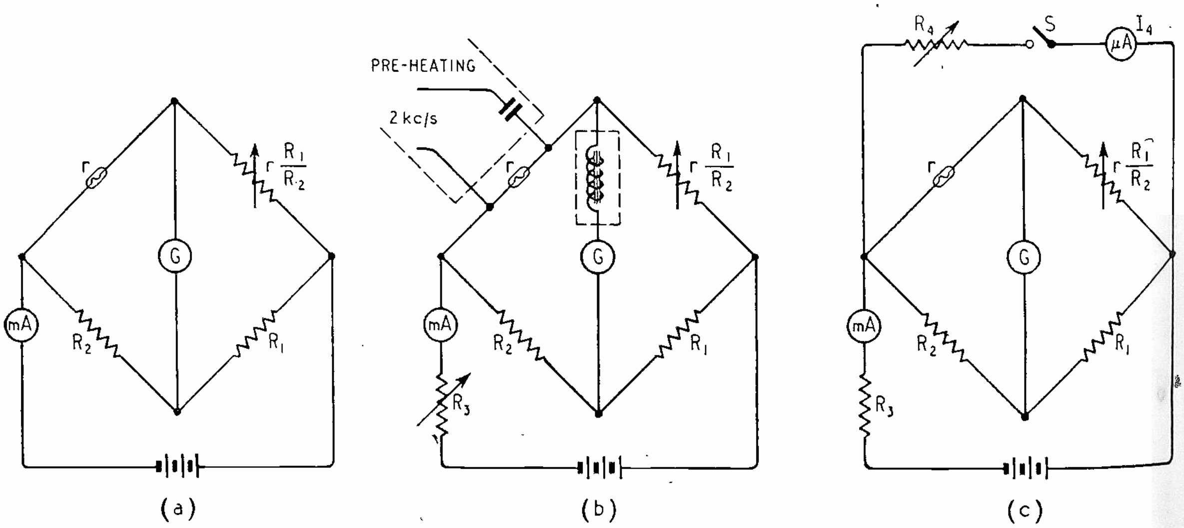


Fig. 8. *Methods of calibrating bolometers for different orders of power.*

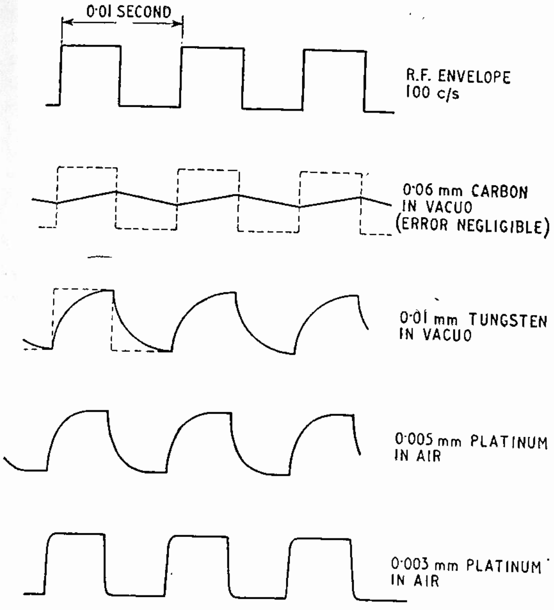


Fig. 9. *Pulsation of resistance with amplitude modulation of carrier.*

the power-resistance relationship, if the pulsation is large the mean resistance will not correspond to the mean power shown by the d.c. calibration. The effect is quite noticeable with the CV95 on short pulses of 50 c/s repetition rate, but soon becomes negligible at higher frequencies of repetition. The time of rise and fall of resistance with pulses of r.f. can be measured by passing a steady current through the indicator and amplifying the voltage pulses generated across it. When these are viewed on a cathode-ray tube the decay time for a CV95 with some 30-mW input has been measured and is about 0·025 second; for 0·005 and 0·003 mm platinum (in air) the times are 0·006 and 0·002 second respectively. Fig. 9 shows the type of picture obtained with various filaments, and it will be seen that the error is least with the filament of highest thermal capacity.

4. It should be mentioned that when thick filaments are used the heat distribution can be non-uniform radially due to skin effect. This effect will be more noticeable when the filament is of a low heat conductivity.

5. Conclusion

Provided proper account is taken of its limitations the bolometer is a valuable tool for power measurement at centimetre and decimetre wavelengths, especially in the range from 100 mW to a few microwatts. The frequency limit has not yet been reached; and for powers of 10 μW and above at frequencies up to 10,000 Mc/s it has provided a good estimate of absolute power and an accurate method for relative measurements.

The work described in this paper was carried out to meet needs arising in various research and development programmes undertaken on behalf of the Admiralty. The author is indebted to the Board of Admiralty for permission to publish this paper.

CORRESPONDENCE

Permeability of Dust Cores

To the Editor, "Wireless Engineer."

SIR,—In the June 1946, issue of *Wireless Engineer*, Burgess gives a formula (cited below) for the computation of the effective permeability μ of a dust core composed of ferro-magnetic particles having an inherent permeability μ_0 and a fractional concentration (by volume) of p. This inspired an investigation under certain hypothetical conditions with the following results.

Hypothesis I. Assuming the iron grains to be identical cubes with corresponding faces parallel, uniformly distributed, and perfectly aligned in rows in three perpendicular directions, I have shown (Appendix A) that for flux perpendicular to the cube faces the effective permeability of the aggregate core is:

$$\mu = 1 + \frac{p}{\frac{\mu_0}{\mu_0 - 1} - \sqrt[3]{p}} \qquad \ldots \quad \ldots \quad (1)$$

whence, if $\mu_0 >> 1$

$$\mu = 1 + \frac{p}{1 - \sqrt[3]{p}} \qquad \ldots \quad \ldots \quad (2)$$

This alignment of cubical grains was proposed by Howe, *Wireless Engineer*, January 1933.

Hypothesis II. Assuming the iron grains to be identical cubes with corresponding faces parallel, uniformly distributed but with *random* alignment, I have shown (Appendix B) that:

$$\mu = 1 + \frac{p}{\frac{\mu_0}{\mu_0 - 1} - p} \qquad \ldots \quad \ldots \quad (3)$$

whence, if $\mu_0 >> 1$

$$\mu_{max} = 1 + \frac{p}{1 - p} \qquad \ldots \quad \ldots \quad (4)$$

Hypothesis III. Assuming the iron grains to be identical spheres uniformly distributed, Burgess gives the value:

$$\mu = 1 + \frac{3p}{\frac{\mu_0 + 2}{\mu_0 - 1} - p} \qquad \ldots \quad \ldots \quad (5)$$

whence, if $\mu_0 >> 3$

$$\mu_{max} = 1 + \frac{3p}{1 - p} \qquad \ldots \quad \ldots \quad (6)$$

The equations (1), (3), and (5) all satisfy the boundary conditions, namely:

If $p = 0$ (no iron) $\mu = 1$
If $p = 1$ (all iron) $\mu = \mu_0$
If $\mu_0 = 1$ $\mu = 1$
If $\mu_0 = \infty$ equations (2), (4), and (6) are obtained.

Assuming sufficiently high values of μ_0 so that equations (2), (4), and (6) are valid, the following table gives the values of μ_{max} attainable with varying concentrations p.

P	Hypothesis I Aligned Cubes (Howe)	Hypothesis II Random Cubes (Lamson)	Hypothesis III Spheres (Burgess)	Legg & Given $u_0 = 220$
0.01	1.013	1.010	1.030	1.055
0.02	1.027	1.020	1.061	1.114
0.05	1.079	1.053	1.158	1.310
0.10	1.187	1.111	1.333	1.715
0.20	1.482	1.250	1.750	2.941
0.50	3.424	2.000	4.000	16.83
0.60	4.831	2.500	5.500	25.44
0.70	7.244	3.333	8.000	43.62
*0.74	8.749	3.846	9.538	54.12
0.80	12.16	5.000		74.81
0.90	27.09	10.00		128.3
0.92	34.56	12.50		142.9
0.94	47.05	16.67		159.2
0.96	72.03	25.00		177.3
0.98	147.0	50.00		197.5

* This is the maximum concentration to which spheres may be packed in space.

For any specific value of p, spheres give higher values of μ_{max} than cubical grains of the same volume. Both of the ratios

$$\frac{\mu \text{ (spheres)}}{\mu \text{ (random cubes)}} \text{ and } \frac{\mu \text{ (aligned cubes)}}{\mu \text{ (random cubes)}}$$

increase progressively with p, while the ratio

$$\mu \text{ (spheres)} / \mu \text{ (aligned cubes)}$$

reaches a maximum of about 1.2 with an iron concentration of about 0.30.

All three hypotheses are based on the assumption that the flux through the medium is in the form of parallel straight lines. In II and III this means that the induction B is the same at every point in the medium. In Hypothesis I the ratio of the cross section of the flux which passes partly in iron to the total flux cross section is $p^{2/3}$, while the induction of the flux which passes wholly in the non-magnetic binder is $1 + \left(\frac{1}{\mu_0} - 1\right) \sqrt[3]{p}$ times the induction in the iron grains. If $\mu_0 >> 1$ this factor becomes $1 - \sqrt[3]{p}$ and independent of μ_0.

In the *Bell System Technical Journal* for July 1940, Legg and Given state a purely empirical equation:

$$\log \mu = p \log \mu_0 \qquad \ldots \qquad \ldots \qquad (7)$$

which holds over a wide range of p. They describe a molybdenum permalloy powder of assorted grain sizes, 98 per cent being less than 100 microns in diameter (mean diameter 42 microns, r.m.s. diameter 50 microns). Assigning their value of 220 for μ_0 the effective permeabilities given in the last column of the table are obtained.

The very definite excess of empirical results over any of the three hypotheses is, I believe, due to the fact that actual flux lines in the core material are not straight and parallel. We may picture the iron grains as "sucking in" some of the flux in their immediate vicinity so that the induction in the iron grains (and at points in the binder material between two adjacent grains along the major axis of the flux) exceeds the induction at points in the binder between adjacent grains on a line perpendicular to the flux axis. This assumption would raise the values obtained by each of the three hypothetical equations and would become more influential as the concentration p is increased. This explanation is analogous to the analysis of conductivity and lines of current flow in a medium of low conductivity impregnated with particles of higher conductivity.

Cambridge, Massachusetts, U.S.A. H. W. LAMSON.

Appendix A

Derivation of Equation (1)

Let s equal the edge dimension of each iron cube. With the alignment specified, each iron cube would occupy a cubical "assigned space," having an edge dimension w and sides parallel to those of the iron cube. The iron cube is centralized in its assigned space so that it is surrounded on all six faces by laminae of binder material of thickness: $\frac{1}{2}(w-s)$.

Computing the reluctance between opposite faces of this assigned space, there are two flux paths.

Path A, Flux all in binder material

Length of path	w
Cross section of path	$w^2 - s^2$
Permeability	$= 1$
Reluctance	$w/(w^2 - s^2)$

Path B, Flux partly in iron and partly in binder

B1 Through Iron	Length of path	s
	Cross section	s^2
	Permeability	μ_0
	Reluctance	$\frac{1}{\mu_0 s}$
B2 Through Binder	Length of path	$w-s$
	Cross section	s^2
	Permeability	1
	Reluctance	$\frac{w-s}{s^2}$

Since B1 and B2 are in series, the total reluctance of the B path is

$$\frac{s + \mu_0(w-s)}{\mu_0 s^2}$$

Since Paths A and B are in parallel, the total reluctance of the assigned cube of space (a unit in the assembly of any desired core dimensions) becomes

$$\frac{w[s + \mu_0(w-s)]}{w^2 s + w^3 \mu_0 - w^2 \mu_0 s + s^3(\mu_0 - 1)}$$

Assuming the assigned space to be homogeneous,

Length of flux path	w
Cross section	w^2
Effective permeability	μ
Total reluctance	$1/\mu w$

Equating these two values and solving

$$\mu = \frac{\mu_0 + (\mu_0 - 1)(s^3/w^3 - s/w)}{\mu_0 - (\mu_0 - 1)\, s/w}$$

Then introducing the fractional concentration by volume

$$p = s^3/w^3$$

gives Equation (1).

Appendix B

Derivation of Equation (3)

With uniform but random distribution of the iron grains, any flux line of a given substantial length would traverse the same number of grains.

Consider any tube of flux through the medium of length d and infinitesimal cross section Δ.

Total volume of tube $v_t = \Delta d$

Volume of iron in tube v_i

Whence $p = v_i/v_t$

Length of flux path in iron $= v_i/\Delta$

Length of flux path in binder $= d - v_i/\Delta = (v_t - v_i)/\Delta$

Then the total reluctance to tube of flux will be

$$\frac{v_i}{\mu_0 \Delta^2} + \frac{v_t - v_i}{\Delta^2} = \frac{v_i + \mu_0 (v_t - v_i)}{\mu_0 \Delta^2}$$

Considered as a homogeneous tube of effective permeability μ, the reluctance would be

$$d/\mu\Delta = v_t/\mu\Delta^2$$

Equating these two values and solving

$$\mu = \frac{\mu_0 v_t}{v_i + \mu_0(v_t - v_i)}$$

Introducing p from above leads to Equation (3).

To the Editor, "Wireless Engineer"

SIR,—There has been some discussion of the permeability of iron-dust cores following my paper in the June 1946 issue of *Wireless Engineer* on the "Iron-Cored Loop Receiving Aerial."

The formula derived in the Editorial of January 1933 for the effective permeability of a core of ordered uniform cubical particles was

$$\mu = \frac{\alpha^2\mu_0 + (1 - \alpha^2)}{\mu_0 - \alpha(\mu_0 - 1)}$$

where $\alpha^3 = p$ is the relative volume of the iron. Although this tends to the same form as that for spherical particles when p approaches unity, it has the defect that for zero iron content it gives $\mu = 1/\mu_0$ instead of unity, and for this reason I did not refer to it in my paper.

At large iron densities the usual formula of the Clausius-Mosotti type (equations 1 and 2 of my paper) gives values of μ appreciably smaller than those measured (cf. Legg and Given, *B.S.T.J.*, Vol. 19, p. 385, 1940). This discrepancy may be due to :—

(i) the particles not being spherical,

(ii) the particles being non-uniform in size so that the smaller ones can fit in the spaces between the larger ones,

(iii) the assumption of an unmodified field in the insulator not being valid.

Regarding the latter point, Leigh Page (*Phys. Rev.*, Vol. 60, p. 675, 1941) has postulated that the field in the insulator is reduced to an extent proportional to the magnetic moment of the particles. This effect is determined by a parameter η which increases from zero to unity as the iron content increases. Page thus found

$$\mu = 1 + \frac{3p(\mu_0 - 1)}{3 + (1 - p)(1 - \eta)(\mu_0 - 1)}$$

and by assuming $\eta = 0.96p^{\frac{1}{3}}$ he obtained very close agreement with the experimental data of Legg and Given ; the unmodified formula ($\eta = 0$) gives values of μ some five times too small at $p = 0.7$.

It is of interest to note that Page's formula can be written in the form

$$\frac{\mu - 1}{\mu + c} = p\,\frac{\mu_0 - 1}{\mu_0 + c}$$

where $$c = \frac{2 + \eta}{1 - \eta}$$

which is reminiscent of the Clausius-Mosotti formula in which $c = 2$.

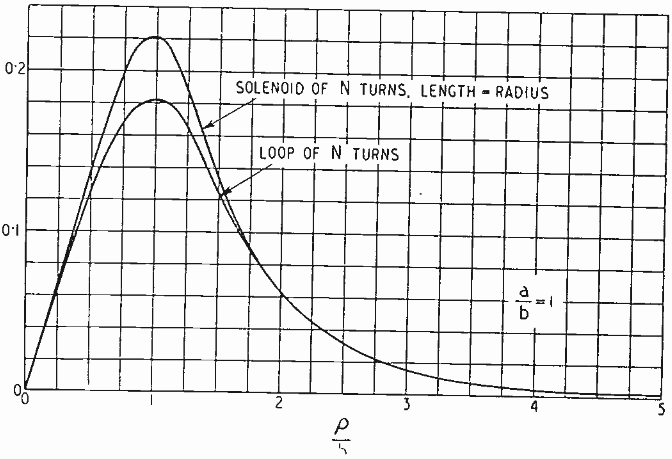
R. E. BURGESS.
National Physical Laboratory,
Teddington.

Power Loss in Electromagnetic Screens

The Editor, "Wireless Engineer."

Sir,—The formula derived by Mr. C. A. Siocos in your correspondence columns of July last for the eddy current density in a plane sheet, provides for this quantity to be calculated where the energizing inductor has finite length. In order to estimate the error on a calculation which assumed the use of a bunched winding, the eddy current density was evaluated using the formula derived by Mr. Siocos for the case of a solenoid of N turns and carrying a current of I amperes. The length of the latter coil was taken as being equal to the radius and the centre of the coil was considered as being at a distance from the sheet equal to the coil radius. For this case, using the notation of our original article, "Power Loss in Electromagnetic Screens"*,

$$\frac{a}{b} = 1.$$



The current distribution in the sheet is shown in the figure, both for the case of a loop of N turns and for a solenoid of N turns having the above proportions and it will be seen that the density of the screen eddy current at a radius equal to that of the coil is about 1.2 times that which occurs when a loop of N turns is employed. At other radii this ratio

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**Wireless Engineer*, Jan. 1946, p. 8.

becomes less, tending closely to unity for values of ρ/b less than 0.5 or greater than 1.5.

Using the method of the original article, the increase in the resistance of the energizing coil due to Screen No. 2 of Table I of that article was calculated for a solenoid of 55 turns, radius 1 inch, axial length 1 inch and centre of solenoid 1 inch from the plane of the screening wires (i.e. $a/b = 1$). The increase in resistance is found to be 0.207 ohm, while the calculated resistance increase due to a 55 turn loop is 0.166 ohm. It is to be expected, of course, that the ratio between these two values will be somewhat less than $(1.2)^2$.

The agreement between values calculated by the two methods will become better as the ratio of a/b increases but, as the formula derived by Mr. Siocos is no more difficult to use than that originally given, it would be preferable to use the former formula when the energizing inductor is in the form of a solenoid.

C. F. Davidson,
R. C. Looser,
J. C. Simmonds.
London, S.E.5.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

576 948.—Traffic control system, say for an aerodrome, in which microphones are spaced out along the runways and light-up individual gas-discharge tubes grouped in the control room.

Standard Telephones and Cables, Ltd., E. M. S. McWhirter, R. H. Dunn, C. H. Chambers, F. W. Warden and S. S. Hill. Application date 3rd March 1944.

577 080.—Adjustable pick-up device for tracing and locating buried conductors, and for depth-determination.

V. Planer and F. E. Planer. Application date 9th February, 1944.

DIRECTIONAL WIRELESS

576 357.—Direction-finding system, free from polarization errors, comprising a quadrilateral arrangement of four pairs of crossed-loops, each adjusted in phase-quadrature, and coupled to a radio goniometer.

N. F. S. Hecht. Application date (for a secret patent) 3rd November, 1936. *Published 9th March,* 1946.

576 415.—Aerial and reflector system for radiating a blind-landing beam which gives the pilot a distinctive signal to enable him to check his vertical bearing at any instant.

H. M. Dowsett. Application date 4th February, 1942.

576 442.—Aerial and reflector system whereby the distribution of the field-strength within a solid angle gradation can be varied, say for local television purposes, for short-wave working from an aeroplane to ground.

H. M. Dowsett. Application date 27th January, 1941.

576 444.—Elliptical system of reflectors, designed to take the place of the usual feed-line for conveying short-wave energy to a radiating aerial, and so saving copper and dielectric losses.

H. M. Dowsett. Application date 18th April, 1941.

576 555.—Receiver coupled to directive and omni-directional aerials to give a clear-cut "inverse-cardioid" response on a cathode-ray indicator.

N. F. S. Hecht. Application date (for a secret patent) 19th March, 1938. *Published 13th March,* 1946.

576 825.—Reflector and dipole for radiating a hollow beam having a constant radius of maximum electric stress.

H. M. Dowsett. Application date 13th June, 1940.

576 826.—Reflector and dipole for securing a desired concentration of field-strength at a given focus.

H. M. Dowsett. Application date 5th July, 1940.

576 828.—Dipole type of aerial for receiving centimetre waves which have been radiated in the form of a beam having rotational symmetry.

H. M. Dowsett. Application date 22nd August, 1941.

576 941.—Aerial and reflector radiating two concentric conical beams, in order to reduce the time required to spot a target by radiolocation.

H. M. Dowsett. Application date 24th September, 1940.

577 002.—Radio gear for controlling the flight of a bomb fitted with movable ailerons.

B. Thomson. Application date 2nd May, 1940.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

576 358.—Receiver in which double resonator circuits are employed to counterbalance unwanted "noise" or interference with desired signals.

N. F. S. Hecht. Application date (for a secret patent), 13th April, 1938. *Published 13th March,* 1946.

576 469.—Two inter-coupled pentode transitrons for generating square-shaped pulses of a given periodicity at a definite interval after the receipt of a triggering impulse.

The General Electric Co. Ltd. and E. C. Cherry. Application date 23rd October, 1941.

576 672.—Receiver provided with a frequency-discriminating circuit of the rectifier type for offsetting the effect of slight or casual variations in tuning.

The General Electric Co., Ltd. and A. S. Gladwin. Application date 3rd March, 1944.

576 768.—Superhet i.f. transformer, formed with recesses to house the coils, and provided with movable powdered-iron cores to adjust the coupling between the coils.

The British Thomson-Houston Co., Ltd. Convention date (U.S.A.) 5th June, 1943.

576 785.—Permeability tuner in which the powdered-iron core is formed with longitudinal grooves to simulate the effect of a taper, whilst allowing tilt-free movement.

Marconi's W.T. Co., Ltd. (assignees of W. E. Newman). Convention date (U.S.A.) 24th March, 1943.

577 168.—Amplifier circuit, including a velocity modulating tube, in which the impedance presented to the electron beam is made equal to the reciprocal of the mutual conductance of the tube, to improve the signal-to-noise ratio.

C. S. Bull. Application date 11th April, 1941.

577 173.—Mixing circuit, say for a superhet receiver, in which an electron discharge device having a hollow resonator is made to function as a diode rectifier.

C. S. Bull. Application date 21st May and 21st November, 1941.

577 181.—Preparation and composition of a silicon crystal rectifier, containing stabilizing elements of aluminium or beryllium, for use as a mixer in a superhet receiver.

The General Electric Co., Ltd., D. E. Jones, C. E. Ransley, J. W. Ryde and S. V. Williams. Application dates 20th August and 18th October, 1941.

577 191.—System of automatic volume control in a telegraphic receiver, designed to prevent undue strain on the insulation resistance of components of normal quality (addition to 557 225).

Creed and Co., Ltd. and F. P. Mason. Application date 5th January, 1944.

577 201.—Mains-eliminator unit in which the l.t. supply is derived from the h.t. voltage through a mechanical vibrator and a step-down transformer.

The General Electric Co., Ltd., and L. C. Stenning. Application date 19th June, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

576 622.—Scanning a transparent record, such as a photographic negative, through the medium of a phosphorescent surface for facsimile transmission.

P. D. Zurian. Application date 8th February, 1943.

577 019.—Synchronizing system, suitable for television, in which the regulating-voltage is derived from the frequency-difference in the first stage of the operation, and from the phase-difference in the final or finer stages of adjustment.

"Patelhold" Patentverwertungs, etc., A.G. Convention date (Switzerland) 11th June, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

576 460.—Power oscillation-generator having a sliding coil in the anode circuit to provide a variable coupling with the tank inductance, so as to match the valve to the load.

Radio Transmission Equipment Ltd., L. Grinstead and K. A. Zandstra. Application date 19th September 1944.

576 656.—Transmitting telegraphic or facsimile signals through a frequency-converting keying-device which is operated instantaneously through a balanced-diode circuit.

F. B. Dehn (communicated by Press Wireless Inc.). Application date 4th September, 1943.

576 685.—Keying circuit for controlling the Morse signal flashes generated by a high-pressure metal-vapour lamp (addition to 508 241.)

The General Electric Co., Ltd., V. J. Francis and E. R. Thomas. Application date 17th March, 1939.

576 719.—Bridge circuit for stabilizing the operation of an oscillation-generator of the polarized vibrating-blade type, used in carrier-wave signalling.

Cie pour la Fabrication des Compteurs and Materiel d'Usines a Gaz. Convention date (France) 11th February, 1941.

576 780.—Reactance-control device for frequency-modulation arranged in the cathode circuit of a valve, and utilizing negative reaction to vary the transconductance of the valve.

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

577 152.—Construction of composite cable, capable of transmitting mechanical power, and of providing a carrier-wave communication or remote-control channel.

Communications Patents, Ltd., and C. H. Leech. Application date 6th March, 1944.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

576 790.—Systems of pulsed signalling, say for interlocking party-lines on a wired networks, or for supervisory of remote control (addition to 514 991.)

Standard Telephones and Cables, Ltd., E. A. H. Bowsher and H. M. M. D'Assis-Fonseca. Application date 31st March, 1944.

576 804.—Circuit for receiving pulsed signals wherein the impact of the pulse flashes a gas-discharge valve momentarily, thus operating a stepping relay, whilst the cessation of the pulse again flashes the valve to restore all relays.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corporation.) Application date 22nd May, 1944.

576 845.—Pulsed signalling system for remote control, say over a radio link, wherein the duration of a transmitted pulse controls the generation of a series of pulses at the receiving end.

L. H. Drysdale and M. Squires. Application date 8th November, 1943.

577 068.—Cathode-ray tube in which two scanning beams are traversed at different speeds over a common screen, in order to change the time-scale of high-speed events, say for transmitting radio-location data over land-lines.
Marconi's W.T. Co., Ltd., and S. W. H. W. Falloon. Application date 5th October, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

576 127.—Gradation of the operating potentials applied to the cathode, reflector, and resonator of a discharge tube of the rhumbatron type.
B. J. Mayo. Application date 8th August, 1941.

576 128.—Supporting and anchoring device for the indirectly-heated cathode of a thermionic valve.
The M-O Valve Co. Ltd., E. G. Rowe and J. A. Smyth. Application date 23rd September, 1942.

576 151.—Process for stabilizing the reaction to heat of a tensioned filament, say of the hair-pin type, of a thermionic valve.
The M-O Valve Co. Ltd., D. H. Donaldson and R. O. Jenkins. Application date 22nd January, 1942.

576 369.—Electron-focusing system, comprising permanently-magnetized and apertured electrodes, particularly for an electron microscope.
The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 31st March, 1943.

576 414.—Electrode arrangement and assembly of a photo-electric cell incorporating heat-resisting baffles of mica, rendered opaque to infra-red rays by pre-firing in hydrogen.
Electrical Research Products Inc. Convention date (U.S.A.) 25th May, 1940.

575 485.—Tuning a magnetron oscillator by the bodily movement of an auxiliary element which is located inside the resonant cavity and is controlled by an externally-heated bi-metallic strip.
" Patelhold " Patentverwertungs, etc. A.G. Convention date (Switzerland) 13th November, 1942.

576 575.—Valve-holder wherein a series of recesses co-operate with a split ring, which is locked in position by lugs engaging with the recesses.
Carr Fastener Co., Ltd., and G. Wagstaff. Application date 20th March, 1944.

576 581.— Valve - holder having axially - spaced abutments which are engaged, above and below, by locking members.
Carr Fastener Co., Ltd., and G. Wagstaff. Application date 27th March, 1944.

576 749.—Mounting the filament of an electron discharge tube on a mandrel of plastic material which is subsequently destroyed by heat.
Westinghouse Electric International Co. Convention date (U.S.A.) 24th April, 1943.

576 883.—Construction of valve-seal designed to prevent the cement from entering the re-entrant " well " and so reducing the insulation-resistance between the electrode leads.
The M-O Valve Co. Ltd. and C. W. Cosgrove. Application date 23rd February, 1944.

577 005.—Velocity-modulating tube in which the " bunching " gap is screened so as to reduce the intensity of the field below that of the second or " working " gap.
Standard Telephones and Cables, Ltd. and J. H. Fremlin. Application date 2nd August, 1940.

577 037.—Oscillation-generator comprising an annular resonator of dumb-bell cross-section, with a continuous transverse gap through which electrons pass radially towards an outer reflecting electrode.
L. F. Broadway. Application date 14th January, 1941.

577 070.—Means for holding a piece of alkaline-earth activating-material inside the helix of a thermionic cathode.
The General Electric Co., Ltd. and B. N. Clack. Application date 18th March, 1942.

577 085.—Arrangement of the field-magnets in a magnetron type of valve to permit of angular adjustment and to facilitate valve-replacement.
D. Jackson and Pye, Ltd. Application date 20th March, 1944.

577 105.—Valve-holder provided with insulating sockets which can " float " to the extent necessary to allow for manufacturing tolerances.
British Solenoids, Ltd. and S. J. Tyrrell. Application date 6th September, 1943.

577 149.—Metal-cased electron discharge tube designed to facilitate the process of evacuation during manufacture.
Marconi's W.T. Co., Ltd. (assignees of C. Herzog). Convention date (U.S.A.) 28th November, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

576 508.—Electro-mechanical selective relay, with centrifugal action, for remote control purposes.
Compania para la Fabricacion de Contadores, etc., and P. Viteau. Application date 2nd March, 1944.

576 631.—Preventing the deterioration of insulation through corona discharges by the use of a coating of coal pulverized to a colloidal fineness.
Westinghouse Electric International Co. Convention date (U.S.A.) 3rd December, 1942.

576 791.—Inductor element suitable for the high-frequency heat-treatment of gear-wheels and like articles formed with re-entrant surfaces.
Standard Telephones and Cables, Ltd. (assignees of V. W. Shannon). Convention date (U.S.A.) 5th April, 1943.

576 817.—Four-pole magnetizing device, arranged to produce two flux-paths at right-angles, for the testing of metal-work for cracks.
The Equipment and Engineering Co., Ltd. and H. B. Swift. Application date 1st September, 1944.

576 903.—Series-parallel arrangement of resistances and reactances coupled to a cathode-ray tube for measuring impedances.
Standard Telephones and Cables, Ltd. (assignees of P. S. Christaldi). Convention date (U.S.A.) 8th June, 1943.

577 022.—Method of cutting and assembling the component parts of a longer-than-normal composite piezo-electric crystal-oscillator.
The Brush Development Co. (assignees of F. Massa). Convention date (U.S.A.) 8th August, 1942.

ABSTRACTS AND REFERENCES

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The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to the World List practice.

ACOUSTICS AND AUDIO FREQUENCIES

534.1 **3157**

Approximate Methods for the Study of Sound Sources.—P. G. Bordoni. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 225–226.) Abstract of a paper in *Acta Pont. Acad. Sci., Vatican City*, 1944, Vol. 8, No. 8, pp. 61–66.

534.121.1 **3158**

The Fundamental Frequency of Vibration of Rectangular Wood and Plywood Plates.—R. F. S. Hearmon. (*Proc. phys. Soc.*, 1st July 1946, Vol. 58, No. 328, p. 487.) Discussion of 1145 of May.

534.13 **3159**

Radiation Characteristics of a Rigid Sphere Having an Oscillating Shell.—P. G. Bordoni. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 226–227.) Abstract of a paper from *Commentationes Pont. Acad. Sci., Vatican City*, 1944, Vol. 8, No. 18, pp. 505–525. The shell subtends an angle of π/2 at the centre. Analysis shows that the device can (*a*) radiate an acoustic power that remains almost constant with changing frequency provided the radius of the sphere is less than a third of the wavelength; for higher frequencies the power slowly decreases: (*b*) produce along its axis an acoustic pressure increasing with frequency until it amounts to twice its initial value.

534.13 : 621.396.611.1 **3160**

The Equivalent Circuit of a Spherical Vibrator.—G. Sacerdote. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 28–33.) A theoretical analysis of the specific acoustic impedance of a spherical vibrator of order *n*. The equivalent circuit consists of a ladder network with series capacitors and shunt inductors (with values in harmonic progression) terminated in a pure resistance.

534.43 : 621.395.613.32 **3161**

Carbon Phonograph Pickup.—A. B. Kaufman & E. N. Kaufman. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 162..168.) A description of the preliminary design of a pickup based on the carbon-microphone principle.

534.844/.845 **3162**

Absorption and Scattering by Sound-Absorbent Cylinders.—R. K. Cook & P. Chrzanowski. (*Bur. Stand. J. Res.*, April 1946, Vol. 36, No. 4, pp. 393–410.) Expressions are developed for a normally incident wave, the surface of the cylinder having an assumed normal acoustic impedance. The theory predicts, and measurements in a reverberation room confirm, that cylinders may have coefficients greater than unity. Reverberation-room statistics are also developed for spherical absorbers.

534.88 **3163**

Echo Depth Sounder for Shallow Water.—G. B. Shaw. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 88–92.) A review of requirements, with a technical description of the Submarine Signal Co. model 788A precision ultrasonic depth recorder suitable for hydrographic surveying. Recording range 75 ft, which can be set to cover any part of a total depth range from 3 ft to 250 ft. Accuracy ± 3 inches up to 50 ft, ± 6 inches for 50–125 ft and 1% for 125–250 ft. Compensating controls are provided for draft, squat, tide, elevation, and sound velocity. Magnetostriction transducers are used at 21.5 kc/s. The transmitter is excited by an unusual capacitor-discharge system. Circuit diagrams of the driver and receiver are given.

534.88 : 534.321.9 **3164**

The "Sonicator".—(*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 752..793.) A horn-type loudspeaker unit at the focus of a parabolic reflector emits sound pulses of 100-μs duration once a second. The echoes are received on a crystal microphone near the focus of the reflector, amplified, and used to operate a neon light revolving once a second behind a transparent disk. The position of the flash on the disk gives the distance of the target, the direction is obtained by rotation of the reflector to give the maximum echo. The range is 550 ft down to 5 ft. An invention by L. Gould.

621.395.61 **3165**
Mechanical Impedance and the Classification of Microphones.—P. G. Bordoni. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 218–224.) The distinction between pressure, gradient, and velocity microphones is indicated in relation to their mechanical characteristics, and, in particular, the effect of the surrounding air on the mechanical impedance of a diaphragm is considered.

621.395.61 **3166**
Meet the Microphone.—H. J. Seitz. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 28..74.) A brief review of the characteristics and special uses of modern microphones of the condenser, crystal, and ribbon types.

621.395.625.3 **3167**
Theoretical Response from a Magnetic-Wire Record.—M. Camras. (*Proc. Inst. Radio Engrs, W. & E.*, Aug. 1946, Vol. 34, No. 8, pp. 597–602.) "This paper considers the effect of magnetic properties of a record wire on the output level and frequency response of a magnetic recording system. The amount of magnetic energy that can be stored at each wavelength determines the voltage output to be expected from a given translating head. Frequency response for a typical record wire is calculated according to derived relations, and compared with experimental data."

621.395.645.3 **3168**
Cathode Follower for Power Amplifier.—Stevens. (*See* 3206.)

621.396.615.029.3 **3169**
Audio Oscillators.—J. C. Hoadley. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 38–40, 98.) Two types of RC or Wien-bridge oscillators are described, one using variable C and the other variable R for controlling the frequency. Circuit diagrams and constructional details are given.

621.396.667 **3170**
Tone Control Circuits.—L. A. Wortman. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 763, 781.) Five simple resistance-capacitance circuits are given.

786.6 : 621.383 **3171**
Photoelectric Tone Generator.—Greenlee. (*See* 3391.)

AERIALS AND TRANSMISSION LINES

621.392 **3172**
Study of the Diffraction and Reflection of Guided Waves.—J. Ortusi. (*Ann. Radioélect.*, Oct. 1945, Vol. 1, No. 2, pp. 87–133.) A theoretical and experimental study of a plane H_{01} wave in a rectangular guide. The introduction defines the coefficients of reflection and transmission and the characteristic impedances. The analogy between a guide carrying a H_{01} wave and a lightly damped transmission line is indicated.

The thermocouple apparatus used for measuring the field intensity in the guide, and the methods of measuring wavelength and the coefficients of reflection at an obstacle in the guide are described.

The impedance and reflection coefficient of a wire across the guide are calculated.

The theoretical treatment of diffraction is based on Kottler's presentation of Huyghens' principle (*Ann. Phys.*, 1923, p. 456). The following cases are analysed: opening in a rectangular guide, sectoral horn, and a cylindrical mirror. Experimental investigation of the diffraction and reflection at the opening of a guide is described, and it is concluded that only for large apertures (a and $b > 2\lambda$) are Kottler's formulae of good accuracy.

The effect of a change of dielectric in a guide is analysed, and its application to the measurement of dielectric constant and damping coefficient is described.

Obstacles in the form of a conducting disk with a small hole, a wire, and a change of curvature of the wave are considered in detail, using the impedance representation in conjunction with reflection and transmission coefficients.

Corrections are given in *Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, p. 276.

621.392 **3173**
The Theory and Experimental Behaviour of Right-Angled Junctions in Rectangular-Section Wave Guides.—J. T. Allanson, R. Cooper & T. G. Cowling. **The Experimental Behaviour of the Coaxial Line Stub.**—J. Lamb. (*J. Instn elect. Engrs*, Part I, Aug. 1946, Vol. 93, No. 68, pp. 359–360.) Long summary of 2133 & 2134 of August.

621.392 **3174**
Ideas on Waveguides.—Y. Rocard. (*Rev. tech. Comp. franç. Thomson-Houston*, April 1946, No. 5, pp. 5–19.) An elementary survey of the velocity and field relations in a waveguide, and of the various modes of propagation. Reference is made to filters, mode separators, mode converters, detectors, diaphragms, and horns.

621.392 **3175**
The Relation between Nodal Positions and Standing Wave Ratio in a Composite Transmission System.—E. Feenberg. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 530–532.) "Reflection generally occurs at a lossless transition region joining two uniform lossless lines. If the output line feeds into a matched load (no reflection) a standing wave ratio η_0 different from unity exists on the input side of the transition region. If the output line is terminated by a movable short circuit, a relation exists between the nodal positions on opposite sides of the transition section. The relation can be used to determine η_0 thus dispensing with the need for a calibrated detecting system to measure this quantity."

621.392 **3176**
Transmission Line Phenomena at Audio and Radio Frequencies.—H. Clark. (*Trans. S. Afr. Inst. elect. Engrs*, June 1946, Vol. 37, No. 6, pp. 149–158. Discussion, pp. 158–162.) An introduction to the theory of transmission lines based on the conception that free electrons in a conductor behave as the molecules of a gas, having random velocities when the conductor is isolated, but acquiring an additional drift velocity when a polarizing e.m.f. is applied.

621.392 : [534 + 535 3177
Extension of the Characteristic-Impedance Concept to Acoustics, Optics, and to the Theory of Vibrating Strings.—Bedeau. *(See 3262.)*

621.392 : 621.317.33.029.64 3178
The Use of the Impedance Concept as Applied to Wave Guides.—G. Williams & H. C. Bolton. (*Phil. Mag.*, Dec. 1945, Vol. 36, No. 263, pp. 862–873.) The analogy between lines and waveguides is used to derive a waveguide method for the measurement of properties of dielectrics at centimetre wavelengths. Expressions corresponding to the *R*, *G*, *L*, and *C* of a line system are given for both *H* and *E* waves, and the method for dielectric measurement is first illustrated by reference to a coaxial line. Applying the impedance concept leads to an expression for the dielectric constant in terms of the wavelength in air, the cut-off wavelength of the guide, and the wavelength in the dielectric-filled guide. The latter is obtained from probe measurements of the wave pattern in the guide, and gives experimental results in agreement with those given by other methods.

[621.392.2 + 621.396.44] : 551.574.7 3179
The Effect of Sleet on the Propagation of Carrier Waves along High-Voltage Transmission Lines.—Wertli. *(See 3416.)*

[621.392.21 : 621.315.1 + 621.396.664] : 621.396.712 3180
The Design and Use of Radio-Frequency Open-Wire Transmission Lines and Switchgear for Broadcasting Systems.—F. C. McLean & F. D. Bolt. (*J. Instn elect. Engrs*, Part I, Aug. 1946, Vol. 93, No. 68, pp. 362–364.) Long summary of 2139 of August.

621.392.5 3181
Simplified Treatment of Some Main Points in the Theory of Quadripoles.—Guerbilsky. *(See 3202.)*

[621.396.44 + 621.398] : 621.315.052.63 3182
Carrier-Current Communication over High-Voltage Transmission Lines.—Hancess. *(See 3417.)*

621.396.67 3183
Radiation Resistance of Loaded Antennas.—R. C. Raymond & W. Webb. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 114.) Experimental determinations have been made of driving-point impedances for antennas with various forms of metallic and dielectric loading. Resistances at resonance are compared with resistances calculated by the Poynting-vector method for assumed current distributions. For a given distribution the resistance is a function of only the length of the antenna in wavelengths. Measured current distributions fall between the curves for uniform and for sinusoidal distribution.

Abstract of an Amer. Phys. Soc. paper.

621.396.67 3184
Determination of the Electric Intensity near an Aerial Cage.—J. C. Simmonds. (*Phil. Mag.*, Nov. 1945, Vol. 36, No. 262, pp. 758–770.) Two methods are developed which enable the charge distribution and hence the electric intensity and corona voltage of an aerial cage to be determined. In the first, easily calculated up to a 6-wire cage only, the wires are assumed to be of diameter small compared with the distance apart, the charge distribution being evaluated in a determinant form. The other method is applicable when the cage is formed from a large number of wires, the distances apart being small compared with the cage diameter. Measurements on rubber-sheet models checked by the first method to within 5%, and were then used to confirm the second method.

621.396.67 3185
Simple Transmission Formula.—G. W. O. H. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, pp. 235–236.) Discussion of the treatment by Friis (2282 of August) of the ratio of received power to transmitted power in terms of the "effective areas" of the aerials.

621.396.674 3186
Advantages of a Low-Impedance Loop for Broadcast Reception.—F. Bedeau. (*Rev. tech. Comp. franç. Thomson-Houston*, Jan. 1944, No. 1, pp. 59–71.) Comparison of the fields from electric and magnetic radiators of interference shows that a receiving aerial should be of the loop type to give the best signal/interference ratio. The reduction of antenna effect by balancing or screening the loop is essential for the best performance, and a single-turn loop, coupled by a suitable transformer to the input circuit of the receiver is the system recommended. The pick-up factor (*hauteur d'entrée*) is analysed for this system, and typical measured values in the bands 150–300 kc/s and 600–1 500 kc/s are given. See also 3187 (Vladimir).

621.396.674 3187
Low Impedance Loop Antenna for Broadcast Receivers.—L. O. Vladimir. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 100–103.) Low-impedance loops are easier to make and are less affected by age and humidity than the corresponding high-impedance loops. An account of the design of associated transformers is given, and curves show the conditions for maximum gain.

621.396.677 3188
A Generalised Radiation Formula for Horizontal Rhombic Aerials : Part 2.—H. Cafferata. (*Marconi Rev.*, April/June 1946, Vol. 9, No. 81, pp. 64–69.) Continuation of 1456 of June. The reflection factor of an imperfectly conducting earth and the general radiation formula for a perfect earth are derived, and the general equation for radiation from the array is set out. To be concluded.

621.396.677 3189
Dual-Rocket Antenna Characteristics. — G. Hendrickson. (*Radio, N.Y.*, July 1946, Vol. 30, No. 7, pp. 14–15.) Rocket antennas are described. They are longitudinally slotted cylinders, and the potential difference is applied across the slot. The radiation is similar to that from a large number of coaxial loops stacked one above the other. The radiation patterns and power gains are given for single and double rockets, and for an array of two double-rocket antennas. For the latter it is 7.5 db.

621.396.677 3190
Polar Diagrams : Experiments with a Half-Wavelength Receiving Aerial and a V-Type Wire-Netting Reflector.—J. S. McPetrie, L. H. Ford & J. A. Saxton. (*Alta Frequenza*, March/June 1945, Vol. 14, Nos. 1/2, pp. 119–122.) Long summary in Italian of 2612 of 1945.

621.396.677 : 621.398 3191
A Simple Method of Controlling the Beam Antenna.—E. Harris. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 60, 62.) A Wheatstone-bridge relay-operating circuit for the remote control of a rotating array.

621.315.052.63 + 621.317.083.7 3192
Télétransmissions par Ondes Porteuses dans les Réseaux de Transport d'Energie à Haute Tension. [Book Review]—A. Chevallier. Dunod, Paris, 111 pp., 124 fig. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, p. 259.) Deals with the protection of h.v. networks by means of superposed h.f. currents.

CIRCUITS

518.5 : 621.3 3193
Computation Problems in Circuit Design.—Baker. (*See* 3365.)

621.314.2.029.5 : 621.396.621.54 3194
Two-Frequency I.F. Transformers.—Thompson. (*See* 3430.)

621.314.6 3195
A Note on Empirical Laws for Non-Linear Circuit Elements and Rectifiers.—D. B. Corbyn. (*Beama J.*, July 1946, Vol. 53, No. 109, pp. 245–252.) A theoretical treatment leads to the deduction of specific parameters analogous to specific resistance or conductance. It is shown that limitations are imposed on the values which the index n (of the current/voltage law) may take for either symmetrically or asymmetrically conducting elements such as rectifiers, and that n cannot in general be treated as a continuous variable.

621.318.7 + 537.228.1 3196
Piezo-Electric Crystals and Their Use in Electrical Wave Filters.—P. Scherrer & B. Matthias. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 316–322.) Crystals of potassium and ammonium phosphate can be used with advantage in lattice band-pass filters for 10–100 kc/s. They can be artificially grown, they are more stable than Rochelle salt and give wider bandwidths than quartz crystals. The piezoelectric effect is explained using a mechanical model, and the insertion-loss characteristic of a filter using potassium phosphate crystals is graphed.

621.392 3197
Balancing System.—P. D. Andrews. (*Radio, N.Y.*, July 1946, Vol. 30, No. 7, p. 16.) A circuit is described for connecting a push-pull source to an unbalanced load. The primary feature is a special capacitor having two ganged variable sections built so that the series value of capacitance remains constant. Summary of U.S. patent 2 380 389.

621.392.091 3198
Simplified Method of Plotting Attenuation Curves.—L. S. Biberman. (*Radio, N.Y.*, July 1946, Vol. 30, No. 7, pp. 12–13.) Attenuation characteristics of many circuits plot as straight lines and circular arcs on semi-log paper. Illustrations are given.

621.392.4 3199
Link-Coupled Coil Design.—S. Sabaroff. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 16–19, 45.) Analysis of a design procedure, assuming resistive loads. A nomogram is given.

621.392.43 3200
New Method of Impedance Matching in Radio-Frequency Circuits.—G. Guanella. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 327–329.) Description of a transformer method depending on double-winding of coils, which can be used for impedance matching and for coupling symmetrical and unsymmetrical circuits. The matching remains substantially independent of frequency over a relatively wide range of the u.h.f. region.

621.392.43 3201
Electric Filters built up from Choke Coils and Condensers for Frequencies up to 60 kc/s.—K. Ehrat. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 329–330.) Mentions points to be observed when using powdered-iron cores, and gives attenuation curves for filters to pass 0–1 000 c/s and 2.8–3.2 kc/s.

621.392.5 3202
Simplified Treatment of Some Main Points in the Theory of Quadripoles.—A. Guerbilsky. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 191–207.) The fundamental theorems of network theory are stated, and it is shown that, in general, three parameters determine any quadripole, while two are sufficient for a symmetrical quadripole.

Symmetrical quadripoles and the implications of Bartlett's theorem are discussed. Particular attention is devoted to the treatment in terms of lattice networks and their properties. An account of the asymmetrical quadripole is given, and its equivalence to a symmetrical quadripole followed by an ideal transformer is demonstrated.

Appendices deal respectively with transmission lines, the mid-band iterative impedance of a narrow-band-pass filter, and the approximate calculation of the propagation constant.

621.394./395].645.3 3203
Radio Design Worksheet No. 50.—Note on Analysis of Push-Pull Amplifiers with Negative Feedback.—(*Radio, N.Y.*, July 1946, Vol. 30, No. 7, p. 20.)

621.394/.397].645.22 3204
Transient Response of Tuned-Circuit Cascades.—D. G. Tucker. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, pp. 250–258.) The response of an amplifier with N circuits, each with the same resonant frequency ω_0, to a pulse of carrier frequency ω is evaluated by repeated application of Duhamel's integral. When $\omega = \omega_0$ the envelope of the output pulse is found in terms of a series equivalent to the incomplete gamma function; when $\omega \neq \omega_0$ only the last (Nth) term of the series gives the envelope. "A comparison of the responses of tuned-circuit cascades with those of underived band-pass filters shows that for equal component qualities in the two cases, two tuned circuits in cascade are approximately equivalent, for pulse transmission applications, to a single-section band-pass filter using 50 per cent more components."

621.395/.397].645 : 621.396.619 3205
Carrier-Frequency Amplifiers.—C. C. Eaglesfield. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, pp. 258–259.) An amendment to 1474 of June (Eaglesfield), suggested by van der Pol, concerning the influence of a linear 4-terminal network on a carrier with small amplitude or frequency modulation.

621.395.645.3 3206
Cathode Follower for Power Amplifier.—C. Stevens. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 52–54 . . 80.) Constructional details of an a.f. amplifier with a cathode-follower push-pull output stage.

621.396.24.029.63 3207
Development Work in the Decimetre Wave Field.—Schüpbach & de Quervain. (*See* 3361.)

621.396.611 3208
Average Frequency Stability [with deformation] **of Cavity Resonators.**—K. F. Niessen. (*Physica, 's Grav.*, Feb. 1942, Vol. 9, No. 2, pp. 145–157. In German.) For simplicity only deformations of a tensional form are considered. The axis of symmetry of the applied deformations is always chosen to be along one or other of the three principal axes of the cavity. One or two of these three deformations transform the original fundamental frequency to that of the deformed cavity while the other(s) lead to a higher frequency. The three new resulting frequencies are averaged. The frequency stabilities of the sphere and of the cube are very little different if the deformations satisfy the condition of constant surface area. The above is valid when only the linear terms in the frequency variation are taken into account. See also 3209 and 3210 below (Niessen).

621.396.611 3209
On the Frequency Stability of Certain Cavity Resonators in an Electric Circuit.—K. F. Niessen. (*Physica, 's Grav.*, June 1942, Vol. 9, No. 6, pp. 539–546. In German.) In deriving the frequency stability of cavities it is necessary to consider, in addition to the absolute value of the frequency variation, the average of such values when several deformations are possible. A comparison of the cube and the sphere is in favour of the former (about twice as good) for the case of expansion in one of the three mutually perpendicular dimensions when the other two dimensions contract so as to preserve constant surface area. The same applies for a contraction in one dimension instead of an expansion. On the basis of these calculations it is supposed that in general the cube exhibits the least frequency deviation when the two cavities are subjected to small irregular deformations. See also 3208 and 3210 (Niessen).

621.396.611 3210
Practical Remarks on the Frequency Stabilization of Spherical Cavity Resonators.—K. F. Niessen. (*Physica, 's Grav.*, July 1942, Vol. 9, No. 7, pp. 768–772. In German.) In order to reduce the frequency variations due to the expansion produced by the heating of the walls of a cavity resonator it is recommended that (*a*) the sphere be clamped between two diametrically applied supports whose spacing does not change with temperature; the electric dipoles must be radial at the supports: (*b*) the sphere be clamped in a ring whose diameter is independent of temperature and the electric dipoles be arranged diametrically in the plane of the ring and in a radial direction. See also 3208 and 3209 (Niessen).

621.396.611.1 3211
Characteristic Oscillations of Solid Conductors and Electromagnetic Cavities.—P. Nicolas. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 181–190.) The periodic oscillations of a solid body or of a cavity are studied for the case of any shape. It is shown that there are preferred modes of oscillation which lead to particularly simple relations between the fields and currents. There is generally no geometrical relationship between the current distributions corresponding to two different characteristic modes. In general, on any surface, there are no preferred coordinates which lead to simplified relations between the fields and currents. The current distributions corresponding to free oscillations are closely connected with the characteristic modes. When a hollow resonator or a solid conductor is used it is almost always in the vicinity of one of its frequencies of free oscillation. It can be assumed that one of the characteristic modes of distribution preponderates and that the properties mentioned apply to the whole current-system in practice. All these results have been obtained by starting from the reciprocity theorem of electromagnetism.

621.396.611.1 : 534.13 3212
The Equivalent Circuit of a Spherical Vibrator.—Sacerdote. (*See* 3160.)

621.396.611.1.017 3213
***D* and Q.**—R. F. Field. (*Gen. Radio Exp.*, May 1946, Vol. 20, No. 12, pp. 5–8.) Expressions for power losses in a reactor are given in terms of the storage factor Q or its reciprocal D, the dissipation factor. Exclusive use of the latter is recommended, particularly where more than one source of loss is present.

621.396.615 3214
Synchronization and Frequency Division.—N. Carrara. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 134–160. With English, French and German summaries.) A general theoretical treatment of a resonant circuit connected to a two-terminal negative-resistance element. The condition for oscillation is established, and the system is classified as real or complex according as the discriminant of the second-order differential equation for the system is positive or negative. The synchronization and frequency-division characteristics of these types are separately considered, and the optimum conditions of operation are deduced. Oscillograms of the synchronizing process in a "real" oscillator are given.

621.396.615.029.63 3215
Composite Tank Circuit for U.H.F.—P. L. Bargellini. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 115–119.) A description of circuits, each comprising a resonant transmission line inside a resonant cavity, for use with negative-grid triodes. The arrangement gives a greater maximum frequency of oscillation, greater stability, and greater ease of coupling to the load than is obtained with an ordinary transmission-line circuit. For an earlier paper by the same author dealing with the same material see *Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 161–174.

621.396.615.1 3216
Oscillator Power Relations.—R. E. Burgess. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, pp. 237–240.) "The amplitude and power relations are derived for a class of valve-maintained oscillators in which the source of power can be represented as a negative-conductance element which has a characteristic limited by a term proportional to a higher odd-power of the voltage. The analysis is based on the classical work of E. V. Appleton and B. van der Pol. The coupling conditions for obtaining the maximum output power from such a source are deduced and shown to differ fundamentally from the impedance-match conditions appropriate

to linear systems. It is shown that the intrinsic oscillatory-circuit losses are purely parasitic in the transfer of power to an external load-circuit, and there is no question of a resistance match.

"The response of such an oscillator circuit to a small external e.m.f. having a frequency different from the oscillation frequency is considered. It is found that the circuit effectively has a positive conductance which is proportional to the excess negative conductance producing oscillation."

621.396.615[.11 + .17 **3217**

Low-Frequency Oscillator using an Artificial Electric Line.—M. Federici. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 175–182. With English, French and German summaries.) A low-pass line having 100 sections (40 mH series, 10^4 $\mu\mu$F shunt) with a cut-off frequency of 16 kc/s is used as the feedback element of a triode circuit. The fundamental frequency of oscillation is 250 or 500 c/s according as the coupling transformer gives a phase shift of 0 or π. Oscillographic analysis of the waveform shows appreciable harmonic content. A four-section lattice network (130 mH series, 0.5 μF shunt) having a markedly non-linear phase/frequency characteristic shows that synchronization between the various constituent frequencies need not occur, *e.g.* in a typical case frequencies of 247 and 1 400 c/s were present. The oscillator can therefore be used to produce complex waveforms for special purposes.

621.396.615.11 **3218**

Two-Phase Resistance-Capacitance Oscillator.—G. B. Madella. (*Alta Frequenza*, March/June 1945, Vol. 14, Nos. 1/2, pp. 5–10. With English, French and German summaries.) The circuit uses a single-phase RC oscillator with a phase-shifter mechanically linked with the frequency control of the oscillator to give constant shift at all frequencies. It has the advantage of greater frequency stability and simplicity compared with the beat-frequency oscillator but does not provide such a wide frequency range. The model described has a range of 60–300 c/s, and a range of 8 : 1 should be possible by the use of a larger variable capacitor. The distortion of the output voltage is less than 2%.

621.396.615.17 **3219**

Wave Shaping Circuits.—S. Fishman. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 761, 793.) Simple explanation of the action of diode and triode limiters used as square-wave generators.

621.396.615.17 : [621.317.755 + 621.397.331.2 **3220**

Current Oscillator for Television Sweep.—G. C. Sziklai. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 120–123.) The inadequacies of previous saw-tooth current oscillators for magnetic deflexion are reviewed, and the basic principles of the requirement are outlined. A circuit is described, with circuit diagrams, which gives a sweep of excellent linearity with adequate amplitude to give full deflexion in a 12-inch 38-degree kinescope. Specifications of the oscillator transformer and dual filament choke are given.

621.396.619 **3221**

Class B Modulator Design.—R. M. W. Grant. (*Marconi Rev.*, April/June 1946, Vol. 9, No. 81, pp. 70–87.) A theoretical discussion of the design of the output filter generally used with high-power class-B modulators.

621.396.621.029.64 **3222**

Low Noise Microwave Video Receiver Design.—Zable. (*See* 3407.)

621.396.645 **3223**

Design of Broad Band I.F. Amplifiers.—R. F. Baum. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 519–529.) A treatment of the problem for stagger-tuned stages, each consisting of a single tuned circuit, with an extension to the case of stages containing two magnetically coupled circuits. "It is found that the figures of merit (Q_n) of the individual circuits should be related to the Q of a reference circuit according to :

$$Q/Q_n = \sin\left[(2m+1)\pi/2t\right] \cdot \frac{\omega_0}{\omega_{0n}},$$
$$m = 0, 1, 2, \ldots (t-1).$$

Then, by proper tuning, either an oscillatory or a monotonic response may be obtained. The relative band width BW/f_0 and the gain tolerance d_0 within the band determines the value of Q. The minimum number of stages for a given minimum attenuation in the cut-off region depends only on the gain tolerance and on the desired kind of response. Gain maxima (attenuation minima) appear at frequency deviations $\Delta f_n^{\min}$ from middle-band frequency f_0 given by :

$$2\Delta f_n^{\min}/BW = \cos\left[(2m+1)\pi/2t\right].$$

Their location depends only on the number of stages The resonance deviations Δf_{0n} of the tuned circuits are proportional to $\Delta f_n^{\min}$ with a proportionality factor F dependent on t and d_0. The circuit impedances are calculated from a prescribed gain or from the maximum attainable gain. A formula for the maximum gain band-width product is derived."

621.396.662.2 **3224**

Tracking Permeability-Tuned Circuits.—A. W. Simon. (*Electronics*, Sept. 1946, Vol. 19, No. 9, p. 138.) A brief account of the theory, with worked-out examples.

621.396.662.34 : 621.396.611.21 **3225**

Generalised Curves for the Design of the Two-Crystal Bandpass Filter.—J. D. Brailsford. (*Marconi Rev.*, April/June 1946, Vol. 9, No. 81, pp. 40–63.) Development of a design technique. The curves give the transmission loss of the filter used as an inter-valve coupling. The effect of crystal mismatching is taken into account, and a note is included on the use of mechanically coupled crystals.

621.396.665 **3226**

Surgeless Volume Expander.—A. N. Butz, Jr. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 140, 142.) Description of a circuit which balances out anode-current surges without recourse to push-pull operation.

621.396.667 **3227**

Tone Control Circuits.—Wortman. (*See* 3170.)

621.397.813 **3228**

Theoretical Investigation of the Distortion of Television Signals in Valve Circuits.—J. Huber. (*Schweiz. Arch. angew. Wiss. Tech.*, April 1945. Vol. 11, No. 4, pp. 115–127.) Conclusion of 901 of April.

GENERAL PHYSICS

53.081 **3229**

A Discussion on Units and Standards.—(*See* 3341.)

531.3 **3230**

On the Process of Establishment of Oscillatory Systems with One Degree of Freedom.—V. V. Kasakevitch. (*C.R. Acad. Sci. U.R.S.S.*, 10th Dec. 1945, Vol. 49, No. 7, pp. 486–489. In French.)

535.1 **3231**

Change of Frequency of a Light Wave by the Variation of Its Optical Path.—T. L. Ho & W. S. Lung. (*Nature, Lond.*, 13th July 1946, Vol. 158, No. 4002, p. 63.) A formula is derived and applied to various types of waves; application to material waves gives confirmation of the relation $E = h\nu$, and represents one type of energy change for photons. A more generalized formula is proposed which represents a second type of energy change, and which also explains the effect on frequency of a doubly refracting medium.

535.215+621.383 **3232**

Influence of Polarized Light on the Falling-Off Effect of the Limiting Potential of Einstein's Photoelectric Law.—E. Marx. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 523–529.)

535.34 **3233**

Nuclear Electric Quadrupole Moment and the Radiofrequency Spectra of Homonuclear Diatomic Molecules.—B. T. Feld. (*Phys. Rev.*, 1st/15th July 1946, Vol 70, Nos. 1/2, p. 112.) Abstract of an Amer. Phys. Soc. paper.

535.343.4+621.396.11.029.64+538.569.4 **3234**

The Absorption of Microwaves by Gases.—W. D. Hershberger. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 495–500.) The full paper, of which an abstract was noted in 1336 of May. Fourteen gases including ammonia, dimethyl ether, various amines, and alkyl halides have shown strong absorptions at microwavelengths. Measurements of the absorption coefficient and permittivity of these at 1.25 cm wavelength and atmospheric temperature and pressure are given. The frequencies for maximum absorption are derived from absorption/pressure curves. Data on the absorption of several gas mixtures are given, and possible molecular mechanisms are discussed. See also 3235, 3236, 3238, and back references.

535.343.4+621.396.11.029.64 **3235**

Expected Absorption in the Microwave Region by Water Vapour and Similar Molecules.—R. M. Hainer, G. W. King & P. C. Cross. (*Phys. Rev.*, 1st/15th July, Vol. 70, Nos. 1/2, pp. 108–109.) "To predict microwave absorption it is necessary to determine all possible transitions [up to $J\sim12$] between asymmetric rotor levels about one wave number apart. . . . Exact values of the energies and transition probabilities of H_2O were calculated and the position and intensity of absorption in the microwave region determined." The work has been extended to D_2O, HDO, H_2S, H_2Se, D_2Se. See also 3234.

Abstract of an Amer. Phys. Soc. paper.

535.343.4+621.317.011.5+621.396.11.029.64] : 546.171.1 **3236**

The Inversion Spectrum of Ammonia.—W. E. Good. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 539.) The strong absorption band of NH_3 at 0.8 cm^{-1} has been resolved into 28 sharp, widely separated lines, using a variable-frequency continuous-wave source. A graph of the frequencies and intensities of the lines is given, and the empirical expression for the frequencies compared with previous theoretical and experimental results. The lines were observed at about 0.1 mm Hg pressure by inserting the gas in a waveguide between a frequency-modulated source and detectors connected to a cathode-ray display. A hyperfine structure is resolved at about 10^{-2} mm Hg pressure. For an abstract of an Amer. Phys. Soc. paper based on this work see *Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 109. See also 2622 of September (Bleaney & Penrose), and back reference.

535.343.4+621.317.1.011.5 +621.396.11.029.64] : 546.171.1 **3237**

Ammonia Spectrum in the 1 cm Wavelength Region.—B. Bleaney & R. P. Penrose. The cross reference to this paper given in 2536 of September as "*See* 2662" should read "*See* 2622".

535.343.4+621.396.11.029.64] : 546.171.1 **3238**

Resolution and Pressure Broadening of the Ammonia Spectrum Near One-cm Wave-Length.—C. H. Townes. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 109.) Twelve lines were resolved and examined in the band 22.840–25.046 kMc/s at pressures less than 1 mm Hg. Detailed examination of one line yielded a collision frequency of 1.7×10^8 sec^{-1}. See also 3236 and back references.

Abstract of an Amer. Phys. Soc. paper.

535.343.4 : 535.61–15 : 546.212.02 **3239**

The Infra-Red Spectrum of Heavy Water.—F. P. Dickey & H. H. Nielsen. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 109.) Abstract of an Amer. Phys. Soc. paper.

535.376 **3240**

Cathodo-Luminescence: Part 1—Growth and Decay Processes; Part 2—Current Saturation and Voltage Effects; Part 3—Discussion of Results.—J. W. Strange & S. T. Henderson. (*Proc. phys. Soc.*, 1st July 1946, Vol. 58, No. 328, pp. 369–383, 383–391 & 392–401.) Experimental results show that processes of exponential form occur widely in growth and decay of light output from inorganic phosphors. The simple theory relating to monomolecular or random-type processes fails to account for the complexity of the results. There is no definite evidence in favour of bimolecular decay, though non-exponential processes are found to be present in the growth at low current densities and in the decay at long times after excitation.

Measurements have been made of the light output from phosphors under steady electron beams at constant voltage and varying current density, and "current saturation" has been found to vary greatly in extent for different materials. Similarly the change of light output with varying voltage at constant current density shows different characteristics for different phosphors, but without the expected variation on changing the current density.

The interpretation of the experimental results is inadequate due to insufficient knowledge of electron absorption in phosphors. There is some evidence of a new type of voltage absorption law.

536.4+536.5 3241
A New Form of Chart for Determining Temperatures in Bodies of Regular Shape during Heating or Cooling.—A. J. Ede. (*Phil. Mag.*, Dec. 1945, Vol. 36, No. 263, pp. 845–851.)

537.122 : [537.212+538.12 3242
On a Free Electron Gas in Static Magnetic and Electric Fields.—J. Lindhard. (*Ark. Mat. Astr. Fys.*, 26th Aug. 1946, Vol. 33, Part 1, Section A, No. 4, 17 pp. In English.) A theoretical paper.

537.221 3243
Contact Potential Difference in Crystal Rectifiers.—Meyerhof. (*See* 3465.)

537.228.1 3244
Forced Vibrations of Piezoelectric Crystals.—H. Ekstein. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, pp. 76–84.) "The vibrations of anisotropic bodies under the influence of sinusoidally variable volume forces and boundary stresses are investigated. The displacement components are represented as sums of a system of "zero-order" solutions which solve approximately the free-vibration problem. By using Betti's theorem, the problem is reduced to a system of inhomogeneous linear equations which, for the free-body case, further reduces to the homogeneous system derived in an earlier paper. If the external forces are piezoelectric, the forces are no longer given explicitly because the electrical field distribution is known only if Maxwell's equations are solved simultaneously. However, if the pertinent piezoelectric constants are small, the field can be calculated approximately as if the crystal were not vibrating. The solutions can then be obtained by the above method, and the electric reaction of the crystal upon the driving system can be determined. As an example, forced vibrations of thin quartz plates between parallel electrodes are discussed."

For previous work by the author see 523 & 3645 of 1945.

537.533.72 + 621.385.833 3245
The Variation of Resolution with Voltage in the Magnetic Electron Microscope.—V. E. Cosslett. (*Proc. phys. Soc.*, 1st July 1946, Vol. 58, No. 328, pp. 443–455.) A theoretical consideration of spherical and chromatic aberrations, diffraction error, and total error. The calculations indicate that there are definite optimum conditions of operation for a given lens.

537.56 : 621.396.11 3246
Conduction and Dispersion of Ionized Gases at High Frequencies.—H. Margenau. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 508–513.) "The distribution in energy of electrons in a high frequency electromagnetic field is derived by kinetic theory methods. By use of the distribution law, the current density and hence the (complex) conductivity are calculated as functions of electron density, pressure, and frequency of the field. The real part of the conductivity has a maximum for gas pressures, or frequencies, such that the mean free time of an electron is approximately equal to the period of the field. From the conductivity, the dielectric constant of the medium, its index of refraction, and its extinction coefficient are deduced. The results are applicable in microwave researches and in ionosphere problems."

538 3247
Unipolar Magnetic Charges (Poles).—F. Ehrenhaft. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 114.) Abstract of an Amer. Phys. Soc. paper.

538.114 3248
Magneto-Resistance and Domain Theory.—R. M. Bozorth. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 106.) "Changes in resistivity at saturation in longitudinal and transverse fields have been measured for alloys containing 40–100% nickel, and these are compared with the changes due to tension."

Abstract of an Amer. Phys. Soc. paper.

538.12 3249
A New General Theory of the [magnetic] **Coercive Field.**—L. Néel. (*C.R. Acad. Sci., Paris*, 22nd July 1946, Vol. 223, No. 4, pp. 198–199.)

538.14 3250
Magnetic Domain Patterns on Silicon-Iron Crystals.—H. J. Williams. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 106.) Abstract of an Amer. Phys. Soc. paper.

538.247 3251
The Demagnetizing Factors for Ellipsoids.—E. C. Stoner. (*Phil. Mag.*, Dec. 1945, Vol. 36, No. 263, pp. 803–821.)

538.3 : 530.12 3252
Relative Nature of Electromagnetic Radiation.—H.-P. Soh, M.-H. Wang & S.-C. Kiang. (*Nature, Lond.*, 15th June 1946, Vol. 157, No. 3998, p. 809.)

538.32 : 621.385.832 3253
An Analysis of Electromagnetic Forces.—A. Gronner. (*Elect. Engng, N.Y.*, June 1946, Vol. 65, No. 6, pp. 300–302.) A letter commenting on 587 of March (Tripp) explaining the forces between electrons in parallel motion in terms of relativity theory. See also 2547 of September (Burgess: G.W.O.H.)

538.652 3254
The Effect of Transverse Magnetic Field on the Longitudinal Joule Magnetostriction Effect in Nickel.—O. P. Sharma. (*Indian J. Phys.*, Oct. 1945, Vol. 19, No. 5, pp. 202–209.) The effect predicted by Williams (*Phys. Rev.*, 1912, Vol. 34, p. 289), that a transverse field would produce an additional change in length of a longitudinally magnetized rod is confirmed experimentally.

539.3 3255
Impedance Representation of Tangential Boundary Conditions.—G. D. Camp. (*Phys. Rev.*, 1st/15th May, 1946, Vol. 69, Nos. 9/10, pp. 501–502.) The tensor formulation of an elastic system is given, and the method applied to the tangential impedance for the plane boundary of a viscous fluid.

548.0 : 547.476.3–162 3256
Structure and Thermal Properties of Crystals: Part 6—The Role of Hydrogen Bonds in Rochelle Salt.—A. R. Ubbelohde & I. Woodward. (*Proc. roy. Soc. A*, 5th April 1946, Vol. 185, No. 1003, pp. 448–465.)

621.317.39 : 535.34 3257
The Measurement of Nuclear Spin, Magnetic Moment, and Hyperfine Structure Separation by a Microwave Frequency-Modulation Method.—Roberts, Beers & Hill. (*See* 3347.)

621.317.39.029.64 : 537.312.62 : 546.815–1 3258

Superconductivity of Lead at 3-Cm Wave-Length.—F. Bitter, J. B. Garrison, J. Halpern, E. Maxwell, J. C. Slater & C. F. Square. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, pp. 97–98.) Outline of experiments and equipment used at a wavelength of 3.2 cm. The lead sample was in the form of a resonant cavity, the Q of which was measured by taking resonance curves using the variable-frequency signal from a medium-wave generator mixed with the output from a stabilized klystron as the signal source. "The best indications . . . indicate a conductivity at 4° K of 10^6 times as great as at room temperature . . ." The values of Q measured were of the order of 10^6.

621.384 3259

The Stability of Synchrotron Orbits.—Dennison & Berlin. (*See* 3440.)

621.384 3260

The Racetrack : a Proposed Modification of the Synchrotron.—H. R. Crane. **The Stability of Orbits in the Racetrack.**—D. M. Dennison & T. H. Berlin. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 542 & 542–543.)

621.385.82 3261

High-Frequency Discharge as an Ion Source.—P. C. Thonemann. (*Nature, Lond.*, 13th July 1946, Vol. 158, No. 4002, p. 61.) A 10-mA current of positive hydrogen ions has been drawn from an h.f. discharge and focused into a beam by a direct potential difference of 20 kV. Use of a magnetic field may increase the current.

621.392 : [534+535 3262

Extension of the Characteristic-Impedance Concept to Acoustics, Optics, and to the Theory of Vibrating Strings.—F. Bedeau. (*Rev. tech. Comp. franç. Thomson-Houston*, April 1946, No. 5, pp. 21–30.) A generalized treatment of characteristic impedance Z arrived at independently of Schelkunoff's work (1740 of 1938). The Z for a longitudinal sound wave is given by $\sqrt{\rho E}$ (ρ = density of medium, E = elasticity), and, for a transverse sound wave, as for a vibrating string, by $\sqrt{\mu\tau}$ (μ = mass per unit length, τ = tension). In e.m.u. the characteristic impedance and velocity of waves in a transparent medium are equal. The application of these concepts to acoustical and optical problems is illustrated.

621.395.822 : 621.315.59 3263

Electrical Contact Noise.—M. H. Greenblatt, P. H. Miller, Jr., & L. I. Schiff. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 113.) A theory is given of the low-frequency noise observed in biased electrical contacts involving semiconductors, based on diffusion of impurities between semiconductor and interface region where large electric fields exist. Preliminary experiments give confirmation of the theory on variation of noise power with frequency, back-bias current, and temperature.

Abstract of an Amer. Phys. Soc. paper.

621.396.029.64 3264

Elementary Physics of Ultra-Short Waves.—P. Grivet. (*Onde élect.*, April & May 1946, Vol. 26, Nos. 229 & 230, pp. 135–148 & 188–203.) A survey of the special characteristics of centimetre waves and of the theory of their generation by triode and velocity-modulated valves, with detailed description of typical valves. The second section gives a general account of guided waves and of horn types of radiator. Appendices give more detail of the theory of electron beams, of dielectric losses, and of attenuation. In particular, a development of guided-wave phenomena in terms of the interference patterns arising from reflections from the walls of the guide is given. Bibliography of 55 items.

621.396.611 3265

Electromagnetic Field in Cavity Resonators.—M. Abele. (*Alta Frequenza*, March/June 1945, Vol. 14, Nos. 1/2, pp. 96–116. With English, French and German summaries.) A general analysis of the field inside cavities bounded by surfaces of revolution, neglecting dielectric and ohmic losses. Only those cases are considered in which no meridian plane is a nodal plane both for the electric and for the magnetic field. The location of the points of zero electric field is indicated, and enables the qualitative configuration of the field to be rapidly determined. The theory is applied to the behaviour of a toric and of an almost cylindrical cavity at their fundamental modes.

621.396.822+537.525.5] : 621.385 3266

Noise and Oscillations in Hot-Cathode Arcs.—J. D. Cobine & C. J. Gallagher. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 113.) Positive ions oscillate in two regions of the discharge, the plasma, and the potential minimum at the cathode; the disturbances appear as voltage variations between the electrodes. "Plasma" oscillations are usually below 400 kc/s and "cathode" oscillations about 700 kc/s. Random noise depends on current, increasing rapidly as Townsend discharge changes into an arc. Noise voltage was investigated under various conditions by a probe technique. See also 3267.

Abstract of an Amer. Phys. Soc. paper.

621.396.822 + 537.525.5] : 621.385 3267

Effect of Magnetic Field on Noise and Oscillations in Hot-Cathode Arcs.—C. J. Gallagher & J. D. Cobine. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 113.) Oscillations in gas discharges discussed in 3266 above are affected by a magnetic field transverse to the normal flow of currents. Oscillations are transmitted to the electrodes by electrons velocity-modulated by the plasma oscillations. A critical value of field suppresses oscillation and reduces noise to a minimum. Higher values give increased noise above 1 Mc/s.

Abstract of an Amer. Phys. Soc. paper.

621.396.822 3268

Statistical Analysis of Spontaneous Electrical Fluctuations.—Fürth & MacDonald. (*See* 3411.)

53 : 621.38 3269

Traité de Physique Électronique. [Book Review] —L. Chrétien. E. Chiron, Paris, 368 pp. (*Onde élect.*, June 1946, Vol. 26, No. 231, p. 17A.) "The fundamentals..in popular form..Nothing essential is sacrificed."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 : 621.396.822 3270

Cosmic Radiations at 5 Metres Wave-Length.—J. S. Hey, J. W. Phillips & S. J. Parsons. (*Nature, Lond.*, 9th March 1946, Vol. 157, No. 3984, pp. 296–297.) The intensity distribution of cosmic-noise power-flux at 64 Mc/s was measured with a radio receiver using a Yagi aerial system providing a beam width to half power of $\pm$ 6° in elevation and $\pm$ 15° in bearing. The results are presented in the form of a contour map. The contours are roughly symmetrical with respect to the galactic equator. The main source is in the direction of the galactic centre, a second peak is at R.A.2030 hr, Dec. + 35° in Cygnus. The intensity in the first peak is given as 13.2×10^{-21} $\Delta\nu$ $\Delta\omega$ W/sq. inch where $\Delta\nu$ = bandwidth in c/s and $\Delta\omega$ = solid angle in steradians.

523.16 : 621.396.822 **3271**

Interstellar Origin of Cosmic Radiation at Radio-Frequencies.—J. L. Greenstein, L. G. Henyey & P. C. Keenan. (*Nature, Lond.*, 15th June 1946, Vol. 157, No. 3998, pp. 805–806.) Measurements of the intensity of cosmic electromagnetic radiation (see 1823/1826 of July and back references, and 3270 above) show good agreement with computed values based on the theory of radiation arising from free-free transitions by electrons in the field of protons, using the accepted figures for the number of protons and electrons.

523.165 : 523.3 **3272**

A Lunar Effect on Cosmic Rays?—A. Duperier. (*Nature, Lond.*, 9th March 1946, Vol. 157, No. 3984, p. 296.) Harmonic analysis of average solar daily inequalities reveals the existence of a semi-diurnal variation, nearly opposite in phase to the semi-diurnal barometric oscillation. It is deduced that the moon may, by altering the height of the meson-producing layer, affect the intensity of cosmic rays at ground level.

523.165 **3273**

Solar and Sidereal Diurnal Variations of Cosmic Rays.—A. Duperier. (*Nature, Lond.*, 10th Aug. 1946, Vol. 158, No. 4006, p. 196.) Analysis of observations over the last 3 years indicates a seasonal change in the intensity of cosmic radiation. The variation of the time of maximum intensity may also be taken as evidence of a sidereal variation. The maximum and minimum values of the solar variation, 0.77% and 0.06% respectively, may be correlated with the change of solar zenith distance. It is suggested that part of the cosmic radiation may originate in the sun and part in the galaxy.

523.165 **3274**

The East-West Asymmetry of Cosmic Radiation at a Geomagnetic Latitude of 28°31′ and an Estimation of the Difference of the Exponents of the Absorption Law for the Polar and the Equatorial Regions.—F. Oster, S. L. Ch'u & L-Y. Lü. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 531.)

523.7 **3275**

General Magnetic Field of the Sun.—T. G. Cowling. (*Nature, Lond.*, 6th July 1946, Vol. 158, No. 4001, p. 31.) Abstract of a paper in *Mon. Not. R. astr. Soc.*, surveying the various theories. The view that the material in the far interior of the sun is capable of permanent magnetization is considered worthy of further investigation.

523.74 "1942.02/.03" **3276**

Solar Eruption of February-March, 1942.—B. Edlén. (*Nature, Lond.*, 9th March 1946, Vol. 157, No. 3984, p. 297.) Reminder of the decreased cosmic-ray intensity, and the increased intensity of the 5694 Å line, produced on this occasion.

523.78 : [551.51.053.5 + 621.396.11 **3277**

The Solar Eclipse of 1945 and the Propagation of Radio Waves.—R. L. Smith-Rose. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 37–38.) Long summary in Italian of 1831 of July.

551.51.053 **3278**

Meteorology of the Lower Stratosphere.—G. M. B. Dobson, with A. W. Brewer & B. M. Cwilong. (*Proc. roy. Soc. A*, 12th Feb. 1946, Vol. 185, No. 1001, pp. 144–175.) Methods of measuring the amounts of water vapour, carbon dioxide, and ozone in the upper atmosphere are described, and the meteorological conditions at these levels discussed. Bakerian Lecture.

551.51.053.5 **3279**

Detection of Rapidly Moving Ionospheric Clouds.—H. W. Wells, J. M. Watts & D. E. George. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 540–541.) Observations were made during the magnetic storm of 25th–26th March 1946 with a new panoramic recording technique that enables the frequency range 1.5–20 Mc/s to be swept in a time adjustable from 5 to 30 seconds. The ionospheric clouds were observed to move in from 800–900 km down to 300–400 km at a rate of 1–2 km/s, and sometimes to move out again at a similar rate. "The principal effects of influx of the clouds are: (1) sudden changes in *F*-layer ionization; (2) rapid changes in *F*-layer heights indicating turbulence which is often progressive from high to low heights and from high to low frequencies; (3) rapid fluctuations of echoes at the lower frequencies with occasional temporary disappearance indicating high absorption."

The clouds are provisionally attributed to corpuscular ionization during magnetic disturbances, indicating a corpuscular contribution to *F*-layer ionization.

An inaccurate account of these observations was noted in 2889 of October.

551.51.053.5 **3280**

Geophysics of the Ionosphere.—J. W. Cox. (*Nature, Lond.*, 10th Aug. 1946, Vol. 158, No. 4006, pp. 189–191.) Report of a discussion at the Royal Astronomical Society. Appleton surveyed the present state of knowledge of the ionosphere layers and pointed out some of the outstanding problems. Mumford spoke on reciprocity of transmission and reception. Kirke described experiments on lateral deviation between Daventry and New Delhi, and also asked that attenuation on long routes and the influence of the gyromagnetic frequency should be further studied. Cox described the wartime work of the (British) Inter-Service Ionospheric Bureau. Hey spoke on solar noise and scatter bursts. Massey spoke on the processes of recombination and attachment.

551.51.053.5 : 523.746 **3281**

The Ionosphere as a Measure of Solar Activity.—M. L. Phillips. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 119.) Critical frequencies (f^0) of regular ionospheric layers vary as $f^0 = F_1(t) + F_2(t)S$ where t is time of day and S the sunspot number. Where ionospheric trends are well established, observations of critical frequency may be used to determine an ionospheric "sunspot number". Using F_2 layer observations around local noon, the ionospheric "sunspot number" probably presents a more precise index of solar activity than the ordinary sunspot number.

Abstract of an Amer. Phys. Soc. paper.

LOCATION AND AIDS TO NAVIGATION

534.88 3282
Echo Depth Sounder for Shallow Water.—Shaw. (*See* 3163.)

534.88 : 534.321.9 3283
The "Sonicator".—(*See* 3164.)

621.396.677.1 3284
The Mutual Perturbations of Two Loop Direction Finders.—F. Penin. (*Onde élect.*, March 1946, Vol. 26, No. 228, pp. 101–106.) It is shown that the minimum separation between two direction finders for freedom from errors within a given standard depends on the diameter of the loops, their type of winding, and effective *Q* values. In particular, it is shown that separation of two or three metres is adequate for the types of direction finder mounted in aircraft.

621.396.9 3285
Radar.—E. G. Schneider. (*Proc. Inst. Radio Engrs, W. & E.*, Aug. 1946, Vol. 34, No. 8, pp. 528–578.) A comprehensive survey of the principles, problems, and techniques.

621.396.9 3286
The Scientific Principles of Radiolocation.—E. V. Appleton. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 230–232.) A long summary in Italian of 3777 of 1945.

621.396.9 3287
An Introduction to Hyperbolic Navigation, with Particular Reference to Loran.—J. A. Pierce. (*J. Instn elect. Engrs*, Part III, July 1946, Vol. 93, No. 24, pp. 243–250.) "Hyperbolic navigation is achieved when synchronized signals, having a known velocity of propagation, are transmitted from at least three known points, and when the relative times of arrival of these signals are known and measured by a navigator." For Loran, pulse transmitters, (frequency 1.70–2.00 Mc/s) synchronized by ground-wave (Standard Loran) or sky-wave (SS Loran), are at the known points.

The accuracy of Standard Loran is about 500 yards at short distances and about 1 mile in the ground-wave service area, 700 miles by day, 500 miles by night over sea. For sky-wave working at night the error is 1½–8 miles for ranges of 300–1400 miles. In SS Loran the minimum average error of fix is 0.9 nautical miles due to variations in ionosphere heights. Low Frequency Loran, at present under development, should have day or night range of at least 1 000 miles, but with lower accuracy than Standard Loran.

Summary and I.E.E. discussion of an I.R.E. paper.

621.396.9 3288
The Loran System.—(*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 48–52.) Long summary in Italian of 605 of March.

621.396.9 3289
The Civil Application of Radar.—E. G. Bowen. (*Proc. Instn Radio Engrs, Aust.*, June 1946, Vol. 7, No. 6, pp. 4–10.) A short account of applications to civil aviation, marine navigation, surveying, and meteorology. An airborne distance indicator is described for measuring range from an airport, with 2% accuracy up to 120 miles at 8 000 ft flying height. A multiple track radar range (MTR) under development uses the Gee principle (see 3916 of 1945—Harley) but with ground transmitters 5–10 miles apart. An aircraft located to ± 20 yd relative to two radar beacons 200 miles apart can be used for the photographic surveying of an area of about 200 000 square miles. The importance to the meteorologist of scatter from raindrops is mentioned. For two previous lectures see 1854 of July and 2907 of October.

621.396.9 (44) 3290
On French Contributions to the Technique of Electromagnetic Detection [of objects].—M. Ponte. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, pp. 171–180.) Historical survey of radiolocation developments in France by the C.S.F. (Compagnie Générale de T.S.F.) and the S.F.R. (Société Française Radioélectrique).

In 1935 c.w. obstacle detectors on wavelengths of 80 cm and 16 cm were fitted to ships and installed at harbours giving ranges of about 5 km on ship targets.

In 1936–38 higher power magnetrons and pulse modulation technique were developed: peak power 10 W at λ 16 cm with 6-μs pulses.

Later developments included increase of power to 4 kW on λ 16 cm, use of 1-μs pulses, superheterodyne receivers with c.r. indication, and horn radiators. A system installed at Toulon in 1942 gave ranges up to 25 km on large ships with an accuracy of 25 m in range and 2–3° in azimuth. Systems on λ 3 m with a peak power of 25 kW were also developed. The paper contains 18 photographs of the systems described

621.396.9 : 621.396.932 3291
Radio Aids for Ships.—(*Nature, Lond.*, 25th May 1946, Vol. 157, No. 3995, p. 689; *Engineering, Lond.*, 10th May 1946, Vol. 161, No. 4191, pp. 451–452.) International meeting, with demonstrations of war-time devices and their peace-time applications. See also *Engineer, Lond.*, 7th June 1946, Vol. 181, No. 4717, p. 527 for a fuller description of one of the new models.

621.396.9 : 621.396.932 3292
The Electronic Navigator.—T. Grover & E. C. Kluender. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 30..39.) Technical description of a 10-cm wavelength merchant-ship surface-search and navigational radar with range 200 yards, or less in favourable conditions, to 30 miles. P.p.i. display is used, and bearings are indicated by a selsyn unit.

621.396.91 3293
Static [atmospherics] **Direction Finder.**—H. L. Knowles. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 546.) An apparatus developed for the U.S. Army Signal Corps. It consists of the usual crossed-loop aerials feeding twin amplifiers, with c.r. tube display, the orientation of the trace giving the azimuth of the incoming signal The method of determining the position of the storm area by synchronized observations at three stations is discussed. Abstract of an Amer. Phys. Soc. paper.

621.396.931/.933].22.029.5 3294
Better Direction Finder.—E. D. Padgett. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 750..805.) Description of the Simon Radioguide, and its U.S. military version SCR-503-A. For a previous account see 1545 of June.

621.396.933 3295
All-Weather Flying.—G.T.M. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 84–87.) A general review

of available radio aids, giving an account of the state of progress towards their adoption for civil flying in the U.S.

621.396.933 **3296**
Aviation Radio.—Newstead. (*See* 3425.)

621.396.933.23 **3297**
Blind Approach Systems.—D. Brice. (*Aeroplane*, 9th Feb. 1945, Vol. 68, No. 1759, pp. 165–167.) A general description of the Standard Beam Approach and American Radio Range systems.

621.396.9 **3298**
Introduzione alla Radiotelemetria. [Book Review] —U. Tiberio. Editore Rivista Marittima Roma, 1946, 277 pp., 137 figs., 300 lire. (*Wireless Engr*, Sept. 1946, Vol. 23, No. 276, p. 259: *Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 62–64.) Introduction to radar.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **3299**
A Multiple High-Vacuum Valve.—R. I. Garrod. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, p. 191.) Design details of a valve to permit the simultaneous or independent exhaustion of four separate vacuum sections.

533.5 **3300**
Leaking and Controlling Small Quantities of Gas.—A. S. Husbands. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, pp. 190–191.) A method of control of the gas pressure in discharge tubes using a fixed inlet leak (a porous Steatite pellet), and a variable needle-type valve in the exhausting tube.

535.37 **3301**
Effect of Absorption on Decay of Infra-Red Sensitive Phosphors.—R. T. Ellickson & W. L. Parker. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 534.)

535.371.07 : 537.531 **3302**
Microsecond Phosphorescent Decay Periods of X-Ray Fluorescent Screens.—F. Marshall. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 114.) Abstract of an Amer. Phys. Soc. paper.

535.376 **3303**
Cathodo-Luminescence: Part I—Growth and Decay Processes: Part 2—Current Saturation and Voltage Effects: Part 3—Discussion of Results.—Strange & Henderson. (*See* 3240.)

537.226 **3304**
Dielectric Properties of Dipolar Solids.—H. Fröhlich. (*Proc. roy. Soc. A*, 5th April 1946, Vol. 185, No. 1003, pp. 399–414.) " A quantitative theory of the dielectric properties of crystalline solids consisting of dipolar long-chain molecules is developed (one dipole per molecule). In these solids the dipoles are concentrated in dipolar planes. In the ground state the dipolar planes have a permanent polarization, but usually the polarizations of successive planes have opposite directions. The static dielectric constant rises with increasing temperature up to a critical temperature T_0 and then decreases. At T_0 the substance has a phase transition of the second kind. Comparison with experiments by Muller on a solid ketone leads to good agreement.

" For chains with an even number of C-atoms metastable states with a permanent polarization are predicted, and a method to reach these states is discussed.

" The interaction between dipoles plays a predominant role at temperatures below T_0. It is shown that Lorentz's or Onsager's methods are invalid in this temperature range."

539.23 : 546.74 **3305**
Resistivity of Thin Nickel Films at Low Temperatures.—A. van Itterbeek & L. De Greve. (*Nature, Lond.*, 20th July 1946, Vol. 158, No. 4003, pp. 100–101.) As films thicker than 40 mμ cool towards liquid helium temperatures, the resistance passes through a minimum, the temperature at which this minimum occurs being higher the more nearly the thickness approaches to 40 mμ.

539.234 : 535.87 **3306**
Thermally Evaporated Anti-Reflexion Films.—S. Bateson & A. J. Bachmeier. (*Nature, Lond.*, 27th July 1946, Vol. 158, No. 4004, pp. 133–134.) The hardness of magnesium-fluoride films on glass is improved by vacuum-baking in preference to air-baking, and depends on the type of source and the degassing procedure. It is not affected by length of baking time. Soft coatings are caused by " soft fluoride ", *i.e.* low-velocity molecules, and may be eliminated by use of faster pumps and special pellet sources. A similar effect is observed when coating on two surfaces. See also 2598 of September (Bannon).

541.64 + 679.5] : 05 **3307**
Journal of Polymer Science.—(*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, p. 475.) Publication of new journal of high-polymer research.

546.23 **3308**
Volume, Internal Energy, and Entropy of Amorphous and Crystalline Selenium.—G. Borelius & K. A. Paulson. (*Ark. Mat. Astr. Fys.*, 26th Aug. 1946, Vol. 33, Part 1, Section A, No. 7, 16 pp. In English.) The values of these quantities and their differences ΔV, ΔU, ΔS, for the two forms of selenium are calculated from new determinations of the thermal expansion α and the heat capacity C. There are no real pre-melting phenomena in selenium, and in the glassy state (below 300°K) α and C have nearly the same values for the amorphous and crystalline forms; it is therefore concluded that " the values of ΔV, ΔU and ΔS obtained in the range of the supercooled liquid from 300 to 494°K are only dependent on the arrangement of the atoms in the liquid, which, at each temperature, attains a state of instable equilibrium." These difference values should be of use for testing theories of the structure of the liquid state. For previous work see 3637 & 3638 of 1945 (Borelius *et al.* & Weibull).

549.514.1 **3309**
Elastic Deficiency and Color of Natural Smoky Quartz.—C. Frondel. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 543–544.) An account of experiments on the effect of various types of radiation on the elastic properties of quartz indicated by changes in the frequency of piezoelectric oscillation. The radiation produces an exponential fall in frequency to a saturation value, accompanied by a smoky coloration proportional to the change in frequency. Natural smoky quartz possesses a similar elastic deficiency which can be removed, together with the coloration, by baking. The effect,

which is of the order of 0.01% of frequency, may be repeated reversibly by successive irradiation and baking. These results are relevant to the ascription of the origin of smoky quartz to natural radioactive radiation, but the effects of the artificial and presumed natural radiation differ in some respects. For instance natural smoky specimens have much maller elastic deficiency in relation to the coloraion than those irradiated artificially.

549.514.1 — 3310
The Breaking up of Single Crystals of Quartz.—). D'Eustachio & S. B. Brody. (*Phys. Rev.*, st/15th March 1946, Vol. 69, Nos. 5/6, p. 256.) Quartz wafers prepared by etching from wafers 5–100 μ thick are found no longer to be single rystals when they become thinner than 25 μ. Abstract of an Amer. Phys. Soc. paper.

549.514.1 3311
Thermal Recrystallization of Quartz.—D. D'Eusachio & S. Greenwald. (*Phys. Rev.*, 1st/15th May 946, Vol. 69, Nos. 9/10, pp. 532–533.) A further eport on quartz wafers, 25–30 μ thick, which, hough prepared from single crystals, are no longer ingle crystals themselves. The wafers are polyrystalline, neighbouring crystals being disoriented y one or two degrees. The single crystalline contion may be recovered by heating, and return to e polycrystalline state occurs if the specimen is ent a number of times round a cylindrical rod. For previous work see 3310 above (D'Eustachio & rody).

9.514.1 3312
Preparation of Synthetic Quartz.—N. Wooster & . A. Wooster. (*Nature, Lond.*, 9th March 1946, ol. 157, No. 3984, p. 297.) Spezia's method has en confirmed but found unsuitable for industrial oduction. In a new method, perfect but small ystals are produced by heating fused silica in a ution of sodium metasilicate.

1.314.2 : 621.395 : 621.316.974 3313
The Magnetic Screening of Telephone Transmers.—Nucci. (*See* 3429.)

1.314.632 : 546.289 3314
The Photo-Diode and Photo-Peak Characteristics Germanium.—S. Benzer. (*Phys. Rev.*, 1st/15th y 1946, Vol. 70, Nos. 1/2, p. 105.) When tain germanium crystals are touched with a tal point, the saturation current depends on the mination level and temperature. The maximum oto-effect occurs at about 1.3 μ, while for white it the sensitivity is several mA/lumen. The k in the current/voltage characteristic may be inated by raising the temperature or level of mination sufficiently; this behaviour is reverle, and may be applied in the design of a trigger to-cell.
bstract of an Amer. Phys. Soc. paper.

.315.58.029.54/.64 3315
he Electrical Properties of Salt-Water Solutions the Frequency Range 1-4 000 Mc/s.—R. per. (*J. Instn elect. Engrs*, Part I, Aug. 1946, . 93, No. 68, p. 358.) Long summary of 1880 uly.

.315.59 3316
he Energy of Impurity Levels in Semi-Conors.—B. Serin. (*Phys. Rev.*, 1st/15th July 1946, 70, Nos. 1/2, p. 104.) Abstract of an Amer. s. Soc. paper.

621.315.61 + 537.226 3317
Dielectrics in Theory and Application.—(*Nature, Lond.*, 27th July 1946, Vol. 158, No. 4004, pp. 121–124.) A report of discussions at meetings of the Royal Institute of Chemistry with the Institute of Physics, and of the Faraday Society. The former surveyed the fields of physical theory, chemical preparation and industrial applications; the latter dealt with surveys and original papers on the present state and immediate trends of physical-chemical and physical research. Two important contributions were concerned with the theory of the internal field of dielectrics, and with advances in h.f. dielectric measurements.

621.315.612 3318
Ceramic Dielectrics.—D. C. Swanson. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 546.) A study of the dielectric properties of certain ceramic alloys having dielectric constants of several thousand and resistivities of 10^{6}–10^{15} Ω . cm. The materials show marked changes in electrical properties with change of temperature and applied voltage. Proper choice of the alloys will give almost any desired electrical property.
Abstract of an Amer. Phys. Soc. paper.

621.315.612.4 3319
Dielectric Constants of Some Titanates.—P. R. Coursey & K. G. Brand. (*Nature, Lond.*, 9th March 1946, Vol. 157, No. 3984, pp. 297–298.) Addition of metallic titanates to a ceramic mix raises the permittivity to peak values as high as 44 000 at a temperature which is characteristic of the material. Solid solutions of two or more titanates exhibit similar properties, a mixture of two showing a linear relation between composition and the temperature of peak permittivity. Capacitors with positive or negative temperature coefficients of capacitance may be constructed with these dielectrics.

621.315.618.2.015.5 : 621.3.029.64 3320
Lowering of Electrical Breakdown Field Strength at Microwave Frequencies due to Externally-Applied Magnetic Field.—D. Q. Posin. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 541.) Studies of 3-cm microwave breakdown of air gaps in a waveguide reveal the following effects. (1) A gap on the verge of sparking can be made to spark over by the approach of a permanent magnet. (2) A magnet with small pole face may produce a 20% decrease in the breakdown field strength. (3) A magnet moved rapidly near the gap may lower the breakdown field strength by a factor of 2 or more. (4) No effect is produced by a magnetic field at right angles to the microwave electric vector. (5) Effects (2) and (3) are much diminished when broadface magnets are used. Various possible explanations of the effects are mentioned, but none appears entirely adequate.

621.316.842 + 621.315.553 3321
Resistance Materials for Standard Resistors.—A. Schulze. (*Arch. tech. Messen*, April 1940, No. 106, pp. T46–48.) Survey of electrical, thermal, and mechanical properties of manganin, isabellin (Cu-Mn alloy with Al) and novokonstant (Cu-Mn alloy with Al, Fe). Recommended technique for the construction of standard-resistance windings is described.

621.319.7 : 621.385 3322
Potentiograms and Electron Trajectories in Electrostatic Fields.—A. Pinciroli & M. Panetti.

Alta Frequenza, March/June 1945, Vol. 14, Nos. 1/2, pp. 81–95. With English, French and German summaries.) A general review of methods for plotting electrostatic fields is given. The electrolytic tank is considered in detail, with an examination of the sources of error. Experimental results for structures typical of valve electrode systems are described.

621.357.7 : 546.97 **3323**

Purification of Rhodium Plating Baths.—(*J. Franklin Inst.*, July 1946, Vol. 242, No. 1, pp. 64–65.) A note from the National Bureau of Standards on the impurities in rhodium phosphate plating baths that cause imperfect coatings. The addition of potassium ferrocyanide will precipitate the impurities which can then be filtered out.

621.793 : 546.74 **3324**

Nickel Plating on Steel by Chemical Reduction.—(*J. Franklin Inst.*, July 1946, Vol. 242, No. 1, p. 64.) A short note from the National Bureau of Standards. " The deposition is brought about by the chemical reduction of a solution of a nickel salt with hypophosphites. The reaction is catalyzed by steel and nickel, and deposition of nickel occurs only on the surfaces of these metals."

621.396.6 (213) **3325**

Deterioration of Radio Equipment in Damp Tropical Climates and Some Measures of Prevention.—Healy. (*See* 3502.)

666.3 + 621.315.612 **3326**

The Scientific Basis of Modern Applications of Ceramic Raw Materials.—W. Steger. (*Chalmers tekn. Högsk. Handl.*, 1944, No. 32, 23 pp. In German.) A brief survey of the composition and properties of ceramics in use for technical applications, with some indication of process of manufacture. The materials considered are :—(1) Systems with one component : silicic acid, aluminium oxide, alkaline earth oxides, other highly refractory oxides, titanium dioxide ; (2) Binary systems : silicic acid–aluminium oxide, silicic acid–alkaline earth oxides, other simple silicates, non-silicate oxide systems ; (3) Ternary systems : silicic acid–aluminium oxide –alkali oxides, silicic acid–aluminium oxide-alkaline earth oxides.

666.3 **3327**

The Evolution of Ceramic Technique in the Laboratories of the Compagnie Générale de Télégraphie sans Fil (C.S.F.). C.S.F. Processes for the Preparation of High Precision Ceramics.—F. Violet & R. Lecuir. (*Ann. Radioélect.*, Oct. 1945 & Jan. 1946, Vol. 1, Nos 2 & 3, pp. 152–159 & 242–255.)

MATHEMATICS

512.37 **3328**

Approximating Formulae.—W. Luchsinger. (*Brown Boveri Rev.*, July 1945, Vol. 32, No. 7, pp. 238–242.) Simple explanation of methods of fitting algebraic curves to experimentally determined data.

517.432 **3329**

The Steady-State Operational Calculus.—D. L. Waidelich : N. F. Riordan. (*Proc. Inst. Radio Engrs, W. & E.*, Aug. 1946, Vol. 34, No. 8, pp. 579–580.) Discussion of 1276 of May (Waidelich).

517.942 **3330**

On Stokes Functions.—P. G. Bordoni. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, p. 227.) Abstract of a paper from *Commentationes Pont. Acad. Sci., Vatican City*, 1945, Vol. 9, No. 3, pp. 87–113, which includes tables and graphs of the 1st, 2nd and 3rd order functions useful in acoustical problems.

518.2 **3331**

Integration of $\sin^2 x\ dx/x$.—S. M. Christian. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, p. 546.) Notice of the preparation of table of values of the definite integral, from 0 to x. Typical values are given for x in the range 0.5 to 11.

Abstract of an Amer. Phys. Soc. paper.

518.3 **3332**

Nomograph Construction : Part 2—Charts with Complicating Factors or Constants.—F. Shunaman. (*Radio Craft*, July 1946, Vol. 17, No. 10, pp. 690..719.) For part 1 see 2830 of October.

518.5 **3333**

An Improved Slide Rule for the Addition of Squares.—B. H. Dawson. (*Science*, 5th July 1946, Vol. 104, No. 2688, p. 18.) A modification of Morrell's method (2616 of September) using a pair of scales instead of a single scale. See also 2956 of October (Dempster).

518.61 **3334**

On a New Method of Approximate Integration of Second Order Differential Equations.—F. Rabinovitch. (*Ann. Radioélect.*, Oct. 1945, Vol. 1, No. 2, pp. 134–151.) " This method, based on extrapolation, is a generalized extension of Adams' method for equations of the first order. It embraces as particular cases most of the classical methods of approximate integration, notably Störmer's. The new method is applied to the equation $d^2x/dt^2 = f(x) \sin t$ occurring in the study of the motion of a particle in an oscillating field of force. Formulae for approximate integration, and estimates of the resulting errors are given.

" The treatment concludes with a comparison of the new method and Störmer's for some numerical cases related to the problem of electron motion in a non-uniform h.f. field."

Corrections are given in *Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, p. 276.

519.283 : 53.08 **3335**

Experimental Data and ' Sufficient ' Accuracy.—H. A. Hughes. (*Nature, Lond.*, 6th July 1946, Vol. 158, No. 4001, p. 29.) Using the formula $\alpha = 0.6745\sqrt{[\Sigma(x_n - M)^2/n(n-1)]}$ to obtain the most probable error α of the arithmetic mean of a series of n distance-measurements $x_1 \ldots x_n$, it was found that at least 7 observations were necessary to get M to within 2% in one case. 10 was regarded as a safer minimum in general.

519.283 : 621.318.572 **3336**

On the Statistical Treatment of Counting Experiments in Nuclear Physics.—N. Hole. (*Ark. Mat. Astr. Fys.*, 30th Aug. 1946, Vol. 33, Part 2, Section A, No. 11, 11 pp. In English.) Formulae are developed for the statistical distribution of the time intervals between impulses observed on counting apparatus, and the influence of the recovery time (" resolving power ") of the counter is considered theoretically. The case of a pair of counters in cascade is also treated.

51 (075) : 62 **3337**

Engineering Mathematics. [Book Review]—H. Sohon. Van Nostrand Co., New York, 1944. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, p. 536.) The book " is intended to strengthen the student in algebra and to provide him with certain mathematical tools which depend on the calculus." See also 2236 of August.

51(075) : 621.396 3338

Basic Mathematics for Radio Students. [Book Review]—F. M. Colebrook. Iliffe, London, 270 pp., 10s. 6d. (*Nature, Lond.*, 24th Aug. 1946, Vol. 158, No. 4008, p. 254; *R.S.G.B. Bull.*, Sept. 1946, Vol. 22, No. 3, p. 45; *Elect. Rev., Lond.*, 26th July 1946, Vol. 139, No. 3583, p. 144.) "[The author] has rendered a valuable service to students and engineers alike . . ." ". . . a substantial gap in the literature for teaching potential engineers has been filled."

518.2 : 016 3339

An Index of Mathematical Tables. [Book Review]—A. Fletcher, J. C. P. Miller & L. Rosenhead. Scientific Computing Service, London, 451 pp., 75s. (*Elect. Rev., Lond.*, 6th Sept. 1946, Vol. 139, No. 3589, p. 388. *Proc. phys. Soc.*, 1st July 1946, Vol. 58, No. 328, pp. 491–492.) Aim is to provide "a working tool for the working scientist in a wide variety of investigations".

519.2(075.8) 3340

Elementary Statistics. [Book Review]—H. Levy & E. E. Preidel. Ronald Press Co., New York, 1945, 184 pp., $2.25. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 535–536.) ". . . an introduction to more advanced tex s, and, as such, should contribute to the growing use of statistical methods."

MEASUREMENTS AND TEST GEAR

53.081 3341

A Discussion on Units and Standards.—(*Proc. roy. Soc. A*, 9th July 1946, Vol. 186, No. 1005, pp. 149–217.) A symposium of short papers by staff of the National Physical Laboratory, on units and standards studied at the Laboratory. Each paper gives the main technical details and a short history.

621.316.842 + 621.315.553 3342

Resistance Materials for Standard Resistors.—Schulze. (*See* 3321.)

621.317.083.7 3343

Telemetering Equipments for the Transmission of Any Desired Measurements over Long Distances.—F. Jaggi. (*Brown Boveri Rev.*, April 1945, Vol. 32, No. 4, pp. 147–148.) A short account of a system using a variable audio frequency for remote indication.

621.317.1.011.5 + 621.396.11.029.64 + 535.343.4] : 546.171.1 3344

The Inversion Spectrum of Ammonia.—Good. (*See* 3236.)

621.317.333.4 3345

Two Methods of Localising Cable Faults.—J. M. Allan. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 70–72.) A modification of the Varley test which nullifies the disturbing effects of varying induced currents, and a method of testing when no good wire is available.

621.317.334/.335] : 621.315.2 3346

Measurement of Inductance and Capacitance of Conductors and Cables.—O. Naumann. (*Arch. tech. Messen*, June 1940, No. 108, pp. T63–65.) Survey of d.c. methods of measurement (Thomson comparison method, "shared charge" method, Sauty bridge), and of l.f. methods (Wheatstone bridge, Maxwell bridge, Geyger's compensation circuit, Wien and Wien-Wagner bridge and its derivatives, Felten and Guilleaume's impedance bridge).

621.317.39 : 535.34 3347

The Measurement of Nuclear Spin, Magnetic Moment, and Hyperfine Structure Separation by a Microwave Frequency-Modulation Method.—A. Roberts, Y. Beers & A. G. Hill. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 112.) Abstract of an Amer. Phys. Soc. paper.

621.317.39.029.64 : 537.312.62 : 546.815–1 3348

Superconductivity of Lead at 3-Cm Wave-Length.—Bitter, Garrison, Halpern, Maxwell, Slater & Square. (*See* 3258.)

621.317.4 3349

Some Uses of the Magnetic Potentiometer for the Determination of Magnetization Curves upon Open-Circuited Specimens.—T. A. Margerison & W. Sucksmith. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, pp. 182–184.)

621.317.71/.72] : 621.314.632 3350

Moving Coil Rectifier Instruments for A.C. Measurements: Part 1—Equivalent Circuit Diagram and Temperature Errors: Part 2—Frequency Error, Back-Current Error, Ageing Error and Waveform Error.—K. Maier. (*Arch. tech. Messen*, May & June 1940, Nos. 107 & 108, pp. T57 & T69–70.)

621.317.7 3351

Electrical Measuring Instruments.—F. E. J. Ockenden & D. C. Gall. (*J. Instn elect. Engrs*, Part I, Aug. 1946, Vol. 93, No. 68, pp. 348–354.) A review of progress during the past decade, discussing the design and construction of industrial instruments and the wide applications of electrical and electronic instruments to scientific measurement.

621.317.725 3352

An Electrostatic Generating Voltmeter for Measurement of Very Small E.M.Fs.—S. A. Scherbatskoy & R. E. Fearon. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 96.) Short notes describing a null instrument having good long-term zero-stability and "nearly complete immunity to mechanical or thermal abuse". Ionization currents of as low as 10^{-19} ampere "or better" can be measured.

621.317.75.087.5 : 522.5 3353

On the Registration of the Exact Time of Each Exposure by Cinematographic Photography.—K. G. Malmquist, H. Norinder & W. Stoffregen. (*Ark. Mat. Astr. Fys.*, 26th Aug. 1946, Vol. 33, Part 1, Section B, No. 3, 7 pp. In English.) The exact time of exposure of film is measured by means of a double c.r. tube. The method is of use for solar eclipse observations.

621.317.761 3354

A Standard-Frequency Generator for High-Precision Measurements.—M. Boella. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 183–194. With English, French, and German summaries.) A laboratory equipment based on a quartz oscillator at 100 kc/s giving a series of over 55 000 single standard frequencies between 10 kc/s and 30 Mc/s. The interval in this range varies from 3 kc/s at the high-frequency end to 2 c/s at the low end. With an interpolating low-frequency meter the measurement of a radio frequency can be carried out to a precision not less than 10^4 times that of the interpolator.

621.317.79 3355
Constructing a Grid Dip Meter.—H. Burgess. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 50–51.) Constructional details of a test instrument comprising a variable-frequency oscillator with a mixer tube, and with a milliammeter connected in its grid lead. It can be used as a simple signal generator or frequency meter.

621.317.79 : 621.385.1 3356
Tube Checker Modernizer.—H. A. Foster. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 753 . . . 803.) Constructional details of an additional panel which may be added to an existing valve tester to make it suitable for testing modern valves.

621.317.79 : 621.396.621 3357
Output Systems of Signal Generators.—A. Peterson. (*Gen. Radio Exp.*, June 1946, Vol. 21, No. 1, pp. 1–8.) Discussion of errors in measurement, particularly at frequencies of 5–30 Mc/s, due to the form of the output circuit and lead. Four arrangements are considered analytically in which the line is either (*a*) matched at both ends, (*b*) matched at the generator end, (*c*) matched at the load end, or (*d*) unmatched. The output e.m.f. and impedance are presented in graphical form as a function of frequency.

621.317.79 : 621.396.621 3358
The Transigenerator.—R. E. Altomare. (*Radio Craft*, July 1946, Vol. 17, No. 10, pp. 686 . . 722.) Constructional details of a simple transitron signal generator for the range 160 kc/s–8 Mc/s.

621.392 3359
The Relation between Nodal Positions and Standing Wave Ratio in a Composite Transmission System.—Feenberg. (*See* 3175.)

621.392 : 621.317.33.029.64 3360
The Use of the Impedance Concept as Applied to Wave Guides.—Williams & Bolton. (*See* 3178.)

621.396.24.029.63 3361
Development Work in the Decimetre Wave Field.—R. Schüpbach & A. de Quervain. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 292–295.) A general discussion of measurement techniques and screening, and a description of cavity-resonator couplings. Curves are given for a filter consisting of two inductively coupled resonators which are damped to give a *Q* of 350 and a coupling factor of 0.51%.

621.396.611.21 : 529.786 3362
A Quartz Clock.—Booth. (*See* 3388.)

621.396.611.21 : 621.396.615 3363
A 100 kc/s Quartz Frequency Sub-Standard and Harmonic Generator.—E. W. Nield. (*R.S.G.B. Bull.*, Sept. 1946, Vol. 22, No. 3, pp. 39–40.) An LC circuit tuned to the resonant frequency of the crystal is placed in series with the latter; this arrangement effectively cancels stray reactances which might otherwise impair stability. A 50% change of supply voltage produces a fundamental frequency change of only a fraction of a cycle per second.

621.397.79 : 621.396.621 3364
Tracer Plus Power Supply.—W. H. Watkins. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 756 . . 791.) Wiring diagram and constructional details of an equipment suitable for servicing tests at r.f., i.f. and a.f. on radio receivers and sound equipment.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

518.5 : 621.3 3365
Computation Problems in Circuit Design.—G. T. Baker. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 58–63.) The fundamental processes of computation, when numbers are expressed on the binary scale, may be represented physically by the action of a simple two-position relay. Circuits are given which perform these operations, with extension to the decimal scale. The technique is illustrated by an application to time-measurement problems.

621.317.083.7 3366
Telemetering Equipments for the Transmission of Any Desired Measurements over Long Distances.—Jaggi. (*See* 3343.)

621.317.39 : 537.221 : 544.8 : 669.018 3367
Sorting Alloys.—N. F. Agnew. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 124–125.) Short description, with a circuit diagram, of a device for the non-destructive identification of alloys. A piece of standard metal is rubbed against the metal to be tested, and the resulting triboelectric voltage is measured. The instrument is calibrated by reference to materials of known composition.

621.317.39 : 620.172.222 3368
The Electrical Measurement of Strain.—S. C. Redshaw. (*J. R. aero. Soc.*, Aug. 1946, Vol. 50, No. 428, pp. 568–602. Discussion, pp. 603–612.) Description of strain gauges in which mechanical strains produce variations in electrical parameters. Resistance-type gauges consisting of fine wire mounted on slips of paper cemented to specimens under test are found to be of most general use.

621.317.39 : 621.753.3 3369
Capacitive Micrometer.—R. W. Dayton & G. M. Foley. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 106–111.) The principle used is that the change in capacitance between an electrode and the specimen examined is used to change the frequency of an oscillator, and hence, by means of a discriminator following a frequency converter and amplifier, to produce a proportional voltage for driving an indicator. Circuit diagrams of two such devices are given, and applications to the measurement of lathe-spindle movement and to dilatometers, manometers, roughness gauges, and hardness testers are described briefly. Design considerations and limits to the technique are discussed. Performance characteristics of typical instruments are given in tables. See also 2991 of October (Hayman), and 3370 below (Foley).

621.317.39 : 621.753.3 : 621.941 3370
Testing of Precision-Lathe Spindles.—G. M. Foley. (*Trans. Amer. Soc. mech. Engrs*, Oct. 1945, Vol. 67, No. 7, pp. 553–556.) An account of an application of the equipment described in 3369 above (Dayton & Foley).

621.317.39.083.7 + 621.316.7] : [533.275 + 536.5 3371
Recorder - Controller for Temperature and Humidity.—V. D. Hauck, R. E. Sturm & R. B. Colt. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 96–99.) Temperature is indicated by a temperature-sensitive resistor, and humidity by

neans of a hair hygrometer that controls the position of a contact on a resistor. The recorder (of which a simplified circuit diagram is given) scans eight pairs of remote measuring units every fifteen minutes. The resistors in each unit control a recorder or humidity-control devices through a elf-balancing bridge. A general technical description of the device is given.

21.317.39.087.4 : 533.275 **3372**
Humidity Recording.—P. E. Maier. (*Electronic ndustr.*, July 1946, Vol. 5, No. 7, pp. 70..102.) Description of an equipment for continuously recording the relative humidity of a gas. A dew-point mirror on a copper tube is observed with a hotocell. When no dew is present, relays cause ooling water to flow in the tube and the flow stops when the dew forms. The temperature of the tube herefore hunts, with the dew point as maximum. he temperatures of the pipe and of the gas are neasured with resistance thermometers that are onnected in a circuit arranged to combine the eadings to give the value of the relative humidity n a recording ohmmeter.

21.317.755 : 535.33 : 535.61–15 **3373**
"Instantaneous" Presentation of Infra-Red pectra on a Cathode Ray Screen.—E. F. Daly & G. B. B. M. Sutherland. (*Nature, Lond.*, 27th pril 1946, Vol. 157, No. 3991, p. 547.) The radiaon is interrupted at 15–20 c/s, and falls on a theristor bolometer after passing through the spectroeter. The output of the bolometer bridge is nplified, rectified, and applied to the Y plates. -plate deflexion is associated with the frequency an. See also 3374 below (King, Temple & hompson).

1.317.755 : 535.33 : 535.61–15 **3374**
Infra-Red Recording with the Cathode Ray cilloscope.—J. King, R. B. Temple & H. W. hompson. (*Nature, Lond.*, 10th Aug. 1946, Vol. 8, No. 4006, pp. 196–197.) Brief description of an uipment similar to that used in 3373 above aly & Sutherland).

1.365.5 **3375**
Medium Frequency Power in Industry. H. Fehlmann & V. Widmer. (*Brown Boveri Rev.*, ty 1944, Vol. 31, No. 5, pp. 159–162.) Brief count of the consideration of an induction nace plant, with considerations on the design unipolar generators, for operation in the range 0–10 000 c/s.

.365.92 **3376**
Basic Factors in Dielectric Heating: Part 1.— S. Winlund. (*Elect. World, N.Y.*, 3rd Aug. 46, Vol. 126, No. 5, p. 80.) Formulae, with numeri- examples, relating minimum heating time, nsfer efficiency, and required power, to the ure and thickness of the material to be heated l to generator frequency. First of three articles.

.365.92 **3377**
Dielectric Heating.—A. J. Maddock. (*J. sci. trum.*, Aug. 1946, Vol. 23, No. 8, pp. 165–173.) eneral review of the subject, including an outline he theory and an account of useful applications.

.38 : 6 **3378**
ndustrial Electronics.—(*Engineer, Lond.*, 19th y 1946, Vol. 182, No. 4723, pp. 54–55.) Some mples of thyratron and ignitron control devices wn at the British Thomson-Houston symposium. Particular attention is paid to motor control, voltage regulation, and resistance welding. For another account see *Engineering, Lond.*, 19th July 1946, Vol. 162, No. 4201, p. 68.

621.383 : 621.316.578 : 628.971.6 **3379**
Photoelectric Street Lighting Control.—C. E. Marshall. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 134–136.) Description, with circuit diagrams, of a device for switching the lights according to the local degree of darkness. Features such as proper selection of time delays and operating thresholds are discussed in some detail.

621.385.833 + 537.533.72 **3380**
The Variation of Resolution with Voltage in the Magnetic Electron Microscope.—Cosslett. (*See* 3245.)

621.385.833 + 537.533.72 **3381**
A Study of Distortion in Electron Microscope Projection Lenses.—J. Hillier. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 411–419.) "The origin of distortion . . . is discussed and the serious nature of its effect on the measurement of particle size distributions is pointed out. Methods of measuring distortion are described. By means of first-order theory it is shown to be possible to correct distortion by the use of a two-element projection lens. The degree of correction obtainable is shown to be satisfactory for most practical purposes. A double-gap projection lens polepiece and the correction of distortion obtained with it are described."

621.385.833 + 537.533.72 **3382**
A Zonally Corrected Electron Lens.—D. Gabor. (*Nature, Lond.*, 10th Aug. 1946, Vol. 158, No. 4006, p. 198.) A new type of lens to reduce spherical aberration in an electron microscope, uses a central wire surrounded by several annular electrodes. It is unsuitable as a microscope objective, but may be used to correct objectives. This lens also reduces depth of focus and may be useful for exploring objects in depth.

621.385.833 **3383**
Some Recent Developments in the Field of Electron Microscopy.—R. W. G. Wyckoff. (*Science*, 12th July 1946, Vol. 104, No. 2689, pp. 21–26.) An account of the present position and future possibilities of electron microscopy for the examination of tissues, surface structure, and organisms of interest in bacteriology.

621.385.833 **3384**
Electron Optics and Its Application to the Electron Microscope.—P. Chanson. (*Onde élect.*, March 1946, Vol. 26, No. 228, pp. 95–100.) A description of the general theory, with particular reference to the wave interpretation of high-speed electrons. The author concludes with a short note on the present advanced state of development of this subject in France. In particular, work at the Collège de France is pointing the way to a "proton microscope", with the possibility of magnifications up to 400 000 (see 2659 of September—Magnan, Chanson & Ertaud).

621.385.833 **3385**
Contour Fringes and Asymmetries of Electron Microscope Objectives.—J. Hillier & E. G. Ramberg. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 113.) Abstract of an Amer. Phys. Soc. paper.

621.385.833 3386
Modifications of Specimens in Electron Microscopy.—L. Marton, N. N. Das Gupta & C. Marton. (*Science*, 12th July 1946, Vol. 104, No. 2689, pp. 35–36.) Stresses the necessity for obtaining independent evidence on the stability of specimens under examination.

621.385.833 3387
Frozen-Dried Preparations for the Electron Microscope.—R. W. G. Wyckoff. (*Science*, 12th July 1946, Vol. 104, No. 2689, pp. 36–37.) A method of preparation for obtaining specimens without distortion or shrinkage.

621.396.611.21 : 529.786 3388
A Quartz Clock.—C. F. Booth. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 33–37.) A general description of the principles, with details of equipment being produced by the British Post Office for the Royal Observatory.

621.396.931 3389
New Radio Warning Device tested by Chicago & North Western.—(*Telegr. Teleph. Age*, Aug. 1946, Vol. 64, No. 8, pp. 26, 27.) Note on a new "slow-tone" device, for use on trains, which broadcasts a series of high-pitched notes at four-second intervals, allowing voice communication at the same time.

623.26 : 621.396.9 3390
How Mine Detectors Work.—E. Leslie. (*Radio Craft*, July 1946, Vol. 17, No. 10, pp. 676..721.) General description, with circuit diagrams, of one a.f. mutual-inductance type for detecting metallic mines.

786.6 : 621.383 3391
Photoelectric Tone Generator.—L. E. Greenlee. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 93–95.) An account of the device described in 2668 of September (Campbell & Greenlee).

PROPAGATION OF WAVES

523.78 : [551.51.053.5 + 621.396.11 3392
The Solar Eclipse of 1945 and the Propagation of Radio Waves.—R. L. Smith-Rose. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 37–38.) Long summary in Italian of 1831 of July.

537.56 : 621.396.11 3393
Conduction and Dispersion of Ionized Gases at High Frequencies.—Margenau. (*See* 3246.)

621.396.11 3394
Study of the Propagation of Electromagnetic Waves in Mountains, Valleys, Fiords, etc.—B. Polié. (*Onde élect.*, March 1946, Vol. 26, No. 228, p. 7A.) Abstract of a paper appearing in *T.S.F. Technik*, April 1944, Vol. 33, No. 4, and in *J. Télécomm.*, May 1945, Vol. 7, No. 5, pp. 57–62. Vilbig has suggested that a valley acts as a waveguide, only propagating waves below a critical wavelength. The author has tested the theory with sheet-iron models (scale about 1 : 500) at wavelengths 0.8–4 m. There was a cut-off wavelength equal to twice the valley width except for polarization normal to the valley wall, when there was no cut off, but appreciable attenuation at all wavelengths.

621.396.11 : 551.51.053.5 3395
The Ionosphere and Short-Wave Broadcasting.—T. W. Bennington. (*B.B.C. Quart.*, April 1946, Vol. 1, No. 1, pp. 29–32.) An elementary survey.

621.396.11.029.6 : 546.21–1 3396
The Absorption of One-Half Centimeter Electromagnetic Waves in Oxygen.—R. Beringer. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, pp. 53–57.) "The apparatus employs a [1-cm] klystron oscillator, crystal-rectifier frequency-multiplier, wave guide absorption path, and crystal detector. The measured values [for oxygen and oxygen-nitrogen mixtures] are in agreement with the theory of Van Vleck [unpublished reports] both as regards the absolute value of the absorption . . . and the dependence on pressure." The sharp peak of the absorption curve occurs very close to 0.5 cm wavelength, and at the peak gives rise to attenuations (at normal pressure) of about 67 and 15 db/km for pure oxygen and air respectively.

621.396.11.029.64 : 535.343.4 3397
Expected Absorption in the Microwave Region by Water Vapor and Similar Molecules.—Hainer, King & Cross. (*See* 3235.)

RECEPTION

621.396.619.018.41 3398
Frequency Modulation : Part 3.—Courtillot. (*See* 3420.)

621.396.619.018.41 3399
The Mutual Effect of Two Frequency Modulated Waves in Limiters.—P. Güttinger. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 296–297.) The frequency spectrum is calculated. It is shown that the audio frequency of only one transmitter remains. The audio frequency of the other transmitter and overtones and beat notes of the audio frequencies are absent. The disturbing element consists chiefly of beat notes due to the difference between the carrier frequencies and their harmonics.

621.396.621 + 621.396.61 3400
Inside the Handie-Talkie.—Scott. (*See* 3449).

621.396.621 3401
Some Radio Receiver Design Considerations.—P. P. Di Roberto. (*Alta Frequenza*, Sept./Dec. 1945, Vol. 14, Nos. 3/4, pp. 232–234.) Long summary of a paper in *Boll. Inform. Comp. Gen. Elett.*, April 1945, pp. 8–15.

621.396.621 3402
The Radio News Circuit Page.—(*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 64 . . 71.) For previous parts see 2680 of September.

621.396.621 3403
Radio Data Sheet 337.—(*Radio Craft*, July 1946, Vol. 17, No. 10, p. 691.) Servicing data for Emerson Radio Models 501, 502 and 504.

621.396.621 3404
Radio Data Sheet No. 338.—(*Radio Craft*, Aug. 1946, Vol. 17, No. 11, p. 762.) Servicing data for General Electric Model 250 receiver.

621.396.621 + 621.396.61].029.62 3405
Transmitter-Receiver for Ham Beginners : Part 1.—C. M. Sullivan. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 32 . . 140.) A description of the design and construction of a superregenerative receiver for use in the 144–148-Mc/s band. The audio-frequency section is used as the modulator of the transmitter.

621.396.621 + 621.396.61].029.63 3406
2 700 Mc/s Transceiver.—K. H. (*See* 3458.)

621.396.621.029.64 **3407**
Low Noise Microwave Video Receiver Design.—W. J. Zable. (*Radio, N.Y.*, July 1946, Vol. 30, No. 7, pp. 10 . . 32.) New design factors for a low-noise input circuit comprising a neutralized triode followed by a grounded-grid output tube are discussed. The analysis of a π network suitable for coupling to a crystal mixer is given.

621.396.621.54 **3408**
Practical Radio Course : Part 47.—A. A. Ghirardi. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 46 . . 111.) An account of multigrid mixers and converters. For previous parts see 2684 & 2692 of September and back references.

621.396.622.4.029.64 : 537.228.4 **3409**
Optical Microwave Detector.—P. H. Miller, Jr., & B. Goodman. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 110.) A proposed device in which plane-polarized monochromatic light is modulated in passing through a Kerr cell in a resonant cavity and through an analyser. The spacing of the sidebands so produced about the light frequency may be measured on an interferometer. The instrument is expected to have a sensitivity of 10^{-7} W, but means of improving this to 10^{-12} W are envisaged.
Abstract of an Amer. Phys. Soc. paper.

621.396.645 **3410**
Design of Broad Band I.F. Amplifiers.—Baum. (*See* 3223.)

621.396.822 **3411**
Statistical Analysis of Spontaneous Electrical Fluctuations.—R. Fürth & D. K. C. MacDonald. (*Nature, Lond.*, 15th June 1946, Vol. 157, No. 3998, p. 807.) A recently developed statistical theory of electrical fluctuations such as shot effect has been found to give good agreement with experimental results.

621.397.62 **3412**
Television Receivers.—Monfort. (*See* 3447.)

STATIONS AND COMMUNICATION SYSTEMS

621.396 : 061.5 **3413**
High-Frequency and Communications Engineering.—(*Brown Boveri Rev.*, Jan./Feb. 1945, Vol. 32, Nos. 1/2, pp. 73–77.) A brief review of progress and work of the Brown Boveri Company in 1944 with special mention of stability tests on sets designed for aircraft communication purposes.

621.396.2 **3414**
Mobile Relay Broadcasting.—H. E. Ennes. (*Radio, N.Y.*, July 1946, Vol. 30, No. 7, pp. 17–19, 30.) A pack transmitter is used at the scene of the broadcast. The transmission is picked up by a mobile unit and relayed to the nearest point that is linked to the studio by audio wire line. Detailed descriptions of the various equipments are given.

621.396.43 **3415**
Various Possible Applications for Beam Transmission.—R. Schüpbach. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 288–291.) Graphs give the maximum elevation of the ground permissible for a communication link on 75-cm wavelength, and a radio-telephone link using frequency modulation is described.

621.396.44+621.392.2] : 551.574.7 **3416**
The Effect of Sleet on the Propagation of Carrier Waves along High-Voltage Transmission Lines.—A. Wertli. (*Brown Boveri Rev.*, Nov. 1944, Vol. 31, No. 11, pp. 362–366.) A short account of the experimental recording apparatus used on the Schwägalp-Säntis line together with photographs of the line and a typical record. No results are given.

621.396.44+621.398 **3417**
Carrier-Current Communication over High-Voltage Transmission Lines.—E. Hancess. (*Brown Boveri Rev.*, Oct. 1944, Vol. 31, No. 10, pp. 335–339.) An outline of a system for a 10-kV power line, with a description of the coupling units and protective devices, and a short consideration of the range and efficiency as limited by line noise and climatic conditions.

621.396.619.018.41 **3418**
Frequency Modulation.—P. Besson. (*Onde élect.*, June 1946, Vol. 26, No. 231, pp. 239–256.) Conclusion of 2703 of September. See also 3419 & 3420 below (Matricon : Courtillot).

621.396.619.018.41 **3419**
Frequency Modulation : Parts 1 & 2.—M. Matricon. (*Rev. tech. Comp. franç. Thomson-Houston*, Jan. 1944, No. 1, pp. 5–43.) An elementary survey dealing with general principles and the methods of generation of f.m. waves. For part 3 see 3420 below. See also 3418 above (Besson).

621.396.619.018.41 **3420**
Frequency Modulation : Part 3.—E. P. Courtillot. (*Rev. tech. Comp. franç. Thomson-Houston*, Oct. 1945, No. 4, pp. 3–24.) For parts 1 & 2 see 3419 above. This part deals with reception, including signal/noise ratio and distortion.

621.396.619.16 **3421**
Pulse Modulating System.—W. R. Greer. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 126–131.) Description of equipment similar to that described in 2315 of August (Kelleher) and back references.

621.396.712 **3422**
Studio Equipment : a New Design.—H. D. Ellis. (*B.B.C. Quart.*, April 1946, Vol. 1, No. 1, pp. 21–28.)

621.396.712.004.5 **3423**
Preventive Maintenance for Broadcast Stations.—C. H. Singer. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 33, 54.) A discussion of the facilities required for routine upkeep work, with advice on safety precautions. Third of a series ; for previous parts see 3055 of October and 2709 of September.

621.396.931.029.62 **3424**
A Method of Increasing the Range of V.H.F. Communication Systems by Multi-Carrier Amplitude Modulation.—J. R. Brinkley. (*J. Instn elect. Engrs*, Part 1, Aug. 1946, Vol. 93, No. 68, pp. 360–362.) Summary of 2326 of August.

621.396.933 **3425**
Aviation Radio.—G. Newstead. (*Proc. Instn Radio Engrs, Aust.*, April 1946, Vol. 7, No. 4, pp. 3–19.) A survey of the factors affecting the choice of frequency bands, the spacing of ground stations for communication purposes, navigation aids, and ground station design, with special

reference to Australian conditions. Consideration is given to the effects at various frequencies of atmospherics, precipitation and man-made static, and of the ionosphere. Graphs show the variation of field strength with distance and flying height.

A description is given of the U.S. Civil Aeronautics Administration v.h.f. (120 Mc/s) radio range which provides course indication on a pointer-type instrument with aural quadrant indication by the A-N system.

Problems discussed include operation of transmitters and receivers on sites remote from the airport and reception in proximity to the transmitter.

621.397.7 **3426**

A Plan for Television Studios.—P. Bax. (*B.B.C. Quart.*, July 1946, Vol. 1, No. 2, pp. 47–51.) The present studio arrangement at Alexandra Palace has several serious disadvantages. Improvements in design for a future station are discussed whereby the studios and the associated departments are arranged to form a segment of a circle, thus giving facilities for any subsequent expansion.

SUBSIDIARY APPARATUS

531.787 **3427**

An Accurate Bellows Manometer.—H. G. East & H. Kuhn. (*J. sci. Instrum.*, Aug. 1946, Vol. 23, No. 8, p. 185.) Description of an instrument in which the expansion and contraction of bellows is transmitted to an optical lever. Pressure differences at any absolute value from vacuum up to several atmospheres may be measured with a sensitivity of 5×10^{-4} mm Hg.

621.3.085.22 **3428**

Meter and Instrument Jewels and Pivots.—G. F. Shotter. (*J. Instn elect. Engrs*, Part I, June 1946, Vol. 93, No. 66, pp. 276–278.) Long abstract of paper published in *J. Instn elect. Engrs*, Part II, Feb. 1946, Vol. 93, No. 31. For another abstract see 2738 of 1945.

621.314.2 : 621.395 : 621.316.974 **3429**

The Magnetic Screening of Telephone Transformers.—P. Nucci. (*Alta Frequenza*, March/June 1945, Vol. 14, Nos. 1/2, pp. 11–80. With English, French and German summaries.) Screening for static and for l.f. fields is investigated theoretically for magnetic and non-magnetic materials. The screening effect is substantially independent of the shape and in some cases of the absolute dimensions of the screen; it increases linearly with screen permeability and with its thickness when this is small, and it also increases exponentially with the number of screens. The screening is expressed in terms of p = geometrical thickness/penetration depth. If $p \gg 1$ the screening varies as e^p.

Experiments on single and multiple screens are described with particular reference to disturbing fields from mains transformers. The screening effect follows the theoretical formulae qualitatively but is always smaller, probably due to uncertainty in the initial permeability and to decrease of the permeability with increasing frequency. The latter effect makes copper screens preferable above a certain frequency because of their higher conductivity.

Correction factors to the theoretical formulae are given, enabling the attenuation of a screening system to be calculated with sufficient accuracy. The appendix contains a detailed mathematical treatment of screening applied to spherical, cylindrical, and multiple concentric screens.

621.314.2.029.5 : 621.396.621.54 **3430**

Two-Frequency I.F. Transformers.—R. T. Thompson. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 142..158.) Description of the construction and performance of transformers for use at 455 kc/s and 8.3 Mc/s.

621.314.5 **3431**

Modern Vibratory Power Converters.—L. S. Distin. (*P.O. elect. Engrs' J.*, July 1946, Vol. 39, Part 2, pp. 53–57.) The principles of operation of rectifying and non-rectifying types, with a description of a rectifier type specially developed for Service use.

621.314.6 **3432**

A Note on Empirical Laws for Non-Linear Circuit Elements and Rectifiers.—Corbyn. (*See* 3195.)

621.316.5 **3433**

Circuit Interruption.—R. W. J. Cockram. (*Elect. Rev., Lond.*, 6th Sept. 1946, Vol. 139, No. 3589, pp. 385–388.) A brief history of circuit-breaking techniques and detailed descriptions of two modern developments: (*a*) the micro-break switch; (*b*) a modified form of the conventional tilting mercury switch.

621.318.323.2.042.15 **3434**

Brown Boveri Powdered-Iron Cores for Filter and Tuned Coils in Communications Engineering.—E. Ganz. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, p. 331.) Figure-of-merit Q is graphed against frequency (0–16 kc/s) for various permeabilities of an annular core, and for different numbers of turns.

621.318.323.2.042.15 : 621.396.662.2 **3435**

Coils with Iron Dust Cores.—I. Avanessoff. (*Onde élect.*, April 1946, Vol. 26, No. 229, pp. 149–154.) An analysis of the losses associated with the cores, and a description of methods of measuring the components of these losses. It is shown that the performance and the optimum frequency range for such coils can be calculated from a knowledge of the constructional details of the coil and the magnetic characteristics of the core. Experimental confirmation is given for a typical case.

621.319.51 **3436**

Electrode Evaporation and the Electric Spark.—F. L. Jones. (*Nature, Lond.*, 9th March 1946, Vol. 157, No. 3984, pp. 298–299.) An equation is given which shows that for minimum erosion the electrodes should be composed of a material with the highest boiling point, density, and thermal conductivity. Good agreement with experimental data has been obtained in the case of aero-engine sparking plugs.

621.384 **3437**

The Racetrack: a Proposed Modification of the Synchrotron.—H. R. Crane. **The Stability of Orbits in the Racetrack.**—D. M. Dennison & T. H. Berlin. (*Phys. Rev.*, 1st/15th May 1946, Vol. 69, Nos. 9/10, pp. 542 & 542-543.)

621.384 **3438**

Methods for Betatron or Synchrotron Beam Removal.—E. C. Crittenden, Jr., & W. E. Parkins. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, pp. 444–447.) Two methods are discussed: one uses "a perturbing magnetic field to focus the electrons as they are made to leave the field of the accelerator by means of orbit expansion"; the other "makes use of a pulsed deflecting system where the deflecting field is applied during a time short compared to the period of revolution of the electrons."

621.384 **3439**
Removal of the Electron Beam from the Betatron.—L. S. Skaggs, G. M. Almy, D. W. Kerst & L. H. Lanzl. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 95.)

621.384 **3440**
The Stability of Synchrotron Orbits.—D. M. Dennison & T. H. Berlin. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos 1/2, pp. 58–67.) Approximate solutions are obtained for the equations of motion of electrons in a synchrotron employing a frequency-modulated accelerating voltage. The electron orbits are shown to be stable. A numerical example is given.

621.396.66 **3441**
Broadcast Station Alarm System for Carrier and Program Failures.—R. R. Taylor. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 20 . . 55.) The circuit is given, and precautions to prevent actuation of the relays by momentary surges and so forth are detailed.

621.398 : 621.396.677 **3442**
A Simple Method of Controlling the Beam Antenna.—Harris. (*See* 3191.)

TELEVISION AND PHOTOTELEGRAPHY

621.396.615.17 : [621.317.755 + 621.397.331.2 **3443**
Current Oscillator for Television Sweep.—Sziklai. (*See* 3220.)

621.397 **3444**
First Facsimile Newspaper printed in Air Transport's Cabin.—(*Telegr. Teleph. Age*, Aug. 1946, Vol. 64, No. 8, pp. 12, 14.) Brief description of equipment which gives a reception rate of 500 words/minute, and which can be adapted to transmit and receive flight and weather information from aircraft in flight.

621.397(73) **3445**
Apparatus and Standards for Television Broadcasting in the U.S.A.—D. G. Fink. (*Alta Frequenza*, March 1946, Vol. 15, No. 1, pp. 40–43.) Summarized excerpts in Italian from 3955 of 1945.

621.397.611 : 621.383.8 **3446**
Television Pickup Tubes.—Blanc-Lapierre & Chantereau. (*See* 3472.)

621.397.62 **3447**
Television Receivers.—R. A. Monfort. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 41–44 . . 150.) A discussion of some of the technical features, including aerial design, f.m. sound channels, alignment of the video i.f. amplifier, the differentiating and integrating circuits in the synchronizing stages, and the use of test patterns.

621.397.813 **3448**
Theoretical Investigation of the Distortion of Television Signals in Valve Circuits.—Huber. (*See* 3228.)

TRANSMISSION

621.396.61 + 621.396.621 **3449**
Inside the Handie-Talkie.—R. F. Scott. (*Radio Craft*, July 1946, Vol. 17, No. 10, pp. 684 . . 724.) Description, with circuit diagrams, of the U.S. Army equipment SCR-536.

621.396.61 **3450**
Broadcast Transmitter Designs as Determined by a Market Survey.—M. R. Briggs. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 11–14, 44.) An account of a survey of opinions and preferences of 91 station managers and operators.

621.396.61 **3451**
Special Transmitters for Wireless Broadcasting, Telephony, and Telegraphy.—M. Dick. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 281–287.) Describes the mechanical layout, with the aid of photographs, of 10-kW transportable medium- and short-wave transmitters.

621.396.61 : 621.396.619.018.41 **3452**
Direct F.M. Transmitters.—N. Marchand. (*Communications*, Aug. 1946, Vol. 26, No. 8, pp. 24 . . 54.) A typical transmitter is described consisting of an exciter unit employing a reactance-tube-modulated oscillator, frequency multiplying stages, and r.f. class-C amplifier stages. The oscillator frequency is automatically stabilized by a two-phase motor in conjunction with a crystal. Part 8 of a series; for previous parts see 3105 of October and back references.

621.396.61 : 621.396.99 **3453**
Transmitting Stations for Police Forces and Fire Brigades.—H. Labhardt. (*Brown Boveri Rev.*, March 1945, Vol. 32, No. 3, pp. 105–109.) A non-technical description, with photographs, of the applications of s.w. and u.s.w. equipments.

621.396.61.029.56 **3454**
Flea Power Voice Transmitter.—A. B. Kaufman. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 35 . . 142.) Design and construction of a crystal-controlled single-tube transmitter of small size for operation in the 3-Mc/s region. A pentode is used with suppressor-grid voice modulation.

621.396.61.029.58 **3455**
The "Monobloc" Short-Wave 15-kW Broadcast Transmitters Type TH 1417.—M. Guérineau. (*Rev. tech. Comp. franç. Thomson-Houston*, April 1946, No. 5, pp. 31–36.) Detailed description of the mechanical and electrical design of a transportable and easily erected transmitter. At 95% modulation the harmonic distortion is less than 2% for 50–3 000 c/s and 3.5% for 3 000–5 000 c/s. The noise modulation is 55–60 db below the level corresponding to 80% modulation at 800 c/s. The transmitter can operate on the broadcasting bands of λ 16, 19, 25, 31 and 41 m.

621.396.61 + 621.396.621].029.62 **3456**
Transmitter-Receiver for Ham Beginners: Part 1.—Sullivan. (*See* 3405.)

621.396.61.029.62 **3457**
Crystal Controlled 2-Meter Transmitter.—W. D. Speight. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 36 . . 117.) Design and constructional details. A 7.2-Mc/s crystal is used with one quintupler and two doubler stages feeding the final amplifier.

621.396.61+621.396.621].029.63 3458
2 700 Mc/s Transceiver.—K. H. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 104–105.) A short technical description of a portable (56 lb in two packs) highly directional telephone equipment, including a circuit diagram and sectional drawing of the cavity resonator used with the GL-446 lighthouse tube. Reliable range 30 miles.

621.396.61.029.64 3459
430 Mc/s with a 6F4.—I. Queen. (*Radio Craft*, July 1946, Vol. 17, No. 10, pp. 687 . . 724.) Constructional details of a coaxial-cavity amateur transmitter.

621.396.611.21 : 621.396.615 3460
A 100 kc/s Quartz Frequency Sub-Standard and Harmonic Generator.—Nield. (*See* 3363.)

621.396.619 3461
Modulation : Part 1—Physical Basis [of amplitude and phase modulation].—O. Henkler & R. Otto. (*Arch. tech. Messen*, Sept. 1940, No. 111, pp. T97–98.)

621.396.619 3462
Class B Modulator Design.—Grant. (*See* 3221.)

621.396.619.018.41 3463
Frequency Modulation : Parts 1 & 2.—Matricon. (*See* 3419.)

621.396.645.3 3464
[Short Wave] **Transmitter Output Stage.**—H. D. Hooton. (*Radio Craft*, Aug. 1946, Vol. 17, No. 11, pp. 755–799.) Constructional details of a neutralized push-pull r.f. amplifier designed to work from an exciter delivering 30–100 W.

VALVES AND THERMIONICS

537.221 3465
Contact Potential Difference in Crystal Rectifiers.—W. E. Meyerhof. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 106.) The contact potential of (mainly) silicon-metal point contact rectifiers has been measured (*a*) by variation of d.c. contact resistance as a function of temperature and (*b*) by the Kelvin method where the semiconductor and metal are not in contact. The poor correlation between the results from the two methods "is probably caused by layers on the semiconductor and metal which undergo changes in forming a contact". See also 1282 of May (Meyerhof & Miller).

Abstract of an Amer. Phys. Soc. paper.

621.3.032.21 : 537.585 3466
Positive Ions from Thoriated Tungsten.—G. A. Jarvis. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 106.) The specimen is prepared by heating to above 2 600°K, so as to reduce the thorium dioxide. It is then found "that the temperature dependence of positive thorium ion emission is similar to that for positive ions from pure metals". Simultaneous measurements made with a magnetic analyser on the emission of thorium and tungsten positive ions as a function of temperature yield approximate values for the work functions. The growth of the thorium layer on a filament at 2 000°K has been examined.

Abstract of an Amer. Phys. Soc. paper.

621.3.032.216 : 537.533.8 3467
Secondary Electron Emission from Oxide-Coated Cathodes : Part 2.—M. A. Pomerantz. (*J. Franklin Inst.*, July 1946, Vol. 242, No. 1, pp. 41–61.) Conclusion of 3107 of October. The apparatus and results are described in detail.

It is found that above a critical temperature, near that at which thermionic emission became appreciable, there was a time lag in the decay of the secondary emission after stopping the primary radiation. This is shown to be due to space-charge phenomena (see also 1482 of 1945—Johnson). The average energy of secondary electrons decreases as the target temperature is increased, so that the total energy of secondary emission remains roughly constant or tends to decrease although the total emission current rises. A qualitative explanation is suggested.

621.3.032.216 : 537.533.8 3468
The Temperature Dependence of Secondary Electron Emission from Oxide-Coated Cathodes.—M. A. Pomerantz. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, pp. 33–40.) "Experiments have been performed with three types of apparatus [see 3467 above]. Yield *vs.* energy data reveal values of δ of 4–7 at room temperature with a more or less flat maximum at approximately 1 000 V primary energy." Extrapolation of data suggests yields exceeding 100 at 850°C, but the product of yield and average energy per secondary decreases with increase in temperature. The temperature dependence of the yield is discussed but no satisfactory explanation is found. Yields under pulsed and steady state conditions are in agreement and the secondary emission, except in the presence of certain space charge effects, follows the primary waveform.

621.314.632 : 546.289 3469
The Photo-Diode and Photo-Peak Characteristics in Germanium.—Benzer. (*See* 3314.)

621.319.7 : 621.385 3470
Potentiograms and Electron Trajectories in Electrostatic Fields.—Pinciroli & Panetti. (*See* 3322.)

621.383.8 : 535.61–15 3471
Infrared Image Tube.—G. A. Morton & L. E. Flory. (*Electronics*, Sept. 1946, Vol. 19, No. 9, pp. 112–114.) A description of the R.C.A. 1P25 image converter. Electrons emitted by a photo-electric screen (cathode) sensitive to infra-red light are focused by an electron-lens on to a fluorescent screen of synthetic willemite. The cathode is made by depositing a base layer of silver on the glass of the tube, the layer is "completely oxidized and processed with additional silver, caesium and silver, with an appropriate thermal treatment". Application to various types of infra-red telescope is mentioned. See also 2661 of September and 2346 of August.

621.383.8 : 621.397.611 3472
Television Pickup Tubes.—A. Blanc-Lapierre & J. Chantereau. (*Rev. tech. Comp. franç. Thomson-Houston*, Oct. 1945, No. 4, pp. 25–44.) Description of the principles of operation, construction, and characteristics of the Emitron and Superemitron types of camera. The paper concludes with a brief discussion of the advantages of "slow electron" tubes in which the collector anode is at zero potential.

621.385 3473
Demonstration of a Water-Jet Analogue of the Reflection Klystron.—W. J. Scott. (*Proc. phys.*

Soc., 1st July 1946, Vol. 58, No. 328, pp. 475–476.) The behaviour of the electron beam in the electric field is simulated by a water jet under the influence of the gravitational field. The "bunching" action, as represented by the distribution of water globules, is clearly shown by stroboscopic photographs.

621.385 **3474**

The Construction and Operation of Klystrons.—E. D. Hart. (*R.S.G.B. Bull.*, Sept. 1946, Vol. 22, No. 3, pp. 34–38.) Practical operating adjustments are described in some detail.

621.385 **3475**

Errata : On the Possibility of Purely Electrostatic Focusing in a Velocity Modulation Drift Tube.—P. Guénard. (*Ann. Radioélect.*, Jan. 1946, Vol. 1, No. 3, p. 276.) Corrections to 3878 of 1945.

621.385.1 **3476**

Some Facts concerning the Construction of Brown Boveri Small Tubes.—A. Bertschinger. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 313–315.) A general description.

621.385.16 **3477**

Space Charge in Plane Magnetron.—L. Page & N. I. Adams, Jr. (*Phys. Rev.*, 1st/15th May, 1946, Vol. 69, Nos. 9/10, pp. 492–494.) "The space charge equation for the plane magnetron is solved, the current is obtained as a function of the magnetic field, and the effect of the magnetic field on the distribution of potential and charge is discussed."

621.385.16 **3478**

Space Charge in Cylindrical Magnetron.—L. Page & N. I. Adams, Jr. (*Phys. Rev.*, 1st/15th May, 1946, Vol. 69, Nos. 9/10, pp. 494–500.) The space charge equation is solved for a system of two coaxial cylindrical electrodes, with a uniform axial magnetic field. Three forms of solution are obtained: (1) applicable near the inner electrode (cathode) or weak magnetic fields; (2) applicable at large distances from the cathode; (3) applicable near cut-off. Curves illustrating the results are given.

621.385.16.029.62/.63 **3479**

Split Anode Magnetrons for the 100-800 Megacycle Range.—J. P. Blewett, D. A. Wilbur & L. D. Roberts. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 118.) Cathode back-heating, anode dissipation at high frequencies, and escape of electrons from the anode structure at low frequencies limit the power output. A shielding process permits operation of small glass-enclosed magnetrons at powers greater than 1 kW from 100 to 400 Mc/s. Liquid cooling is used. Powers of 150 W from 350 to 800 Mc/s are obtained by mounting an internal loop in parallel with the external tank circuit.

Abstract of an Amer. Phys. Soc. paper.

621.385.16.029.63 **3480**

Methods of Tuning Multiple-Cavity Magnetrons.—J. B. Nelson. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Now. 1/2, p. 118.) The most successful of several methods tried involves simultaneous variation of inductance and capacitance of all cavities by a single tuning motion. Tuning ranges greater than 1.4 to 1 have been obtained with good efficiency throughout; for example a magnetron tuning from 800 to 1 160 Mc/s delivering over 2 kW c.w. at all frequencies is described.

Abstract of an Amer. Phys. Soc. paper.

621.385.3 **3481**

Sealed-Off Transmitting Tubes and Their Production.—F. Jenny. (*Brown Boveri Rev.*, Sept. 1944, Vol. 31, No. 9, pp. 309–312.) A general description of the materials used and the methods of assembly, with characteristic curves for a 5-kW air-cooled triode.

621.385.3 **3482**

New Manufacturing Techniques for Transmitter Tubes.—M. Matricon & J. Chantereau. **The Standardization of the Components in the Manufacture of C.F.T.H. Transmitting Tubes.**—R. Montagne. **Test Equipment for Materials in the Manufacture of Electronic Tubes.**—A. Laurent. **Continuously Evacuated Demountable Transmitting Tubes.**—M. Matricon. (*Rev. tech. Comp. franç. Thomson-Houston*, April 1945, No. 2, pp. 5–17, 19–22, 23–32 & 33–39.) Another account of the same material by the same authors is given in 490 of February and 1110 of April.

621.385.832 **3483**

The Image Formation in Cathode-Ray Tubes and the Relation of Fluorescent Spot Size and Final Anode Voltage.—G. Liebmann : H. Moss. (*Proc. Inst. Radio Engrs, W. & E.*, Aug. 1946, Vol. 34, No. 8, pp. 580–586.) Long discussion of 3030 of 1945 (Liebmann).

621.396.694 **3484**

The Calculation of Amplifier Valve Characteristics.—G. Liebmann. (*J. Instn elect. Engrs*, Part 1, Aug. 1946, Vol. 93, No. 68, pp. 357–358.) Long summary of 2406 of August.

621.396.822 + 537.525.5] : 621.385 **3485**

Noise and Oscillations in Hot-Cathode Arcs.—Cobine & Gallagher. (*See* 3266.)

621.396.822 + 537.525.5] : 621.385 **3486**

Effect of Magnetic Field on Noise and Oscillations in Hot-Cathode Arcs.—Gallagher & Cobine. (*See* 3267.)

621.396.822 : 621.385 [.12 + .18 **3487**

A High Level Electronic Noise Source.—J. D. Cobine & C. J. Gallagher. (*Phys. Rev.*, 1st/15th July 1946, Vol. 70, Nos. 1/2, p. 119.) Continuous spectrum from low audio frequency to above 5 Mc/s built in form of a gas discharge tube with cylindrical electrode structure. The r.m.s. voltage is substantially flat up to 1 Mc/s and drops 18 db from 1–5 Mc/s.

Abstract of an Amer. Phys. Soc. paper.

MISCELLANEOUS

027 : [5 + 6 **3488**

Science Librarianship.—J. W. Hunt. (*Science*, 23rd Aug. 1946, Vol. 104, No. 2695, pp. 171–173.)

058 : [621.38 + 621.396 **3489**

Electronics Buyers' Guide.—The issue of 15th June 1946 contains (in addition to data on sources of supply) charts and tabulated information on the e.m. spectrum, frequency allocations, sound levels, graphical symbols, and solid-dielectric coaxial cables, and also an index to *Electronics* for 1936–June 1946, and a bibliography of about 500 books on electronic and allied subjects.

347.771 **3490**

Patent Law Reform in Britain.—(*Nature, Lond.*, 6th July 1946, Vol. 158, No. 4001, pp. 1–3.) Editorial on second interim report of the Departmental Committee on the Patent and Design Acts, dealing with the alleged abuse of monopoly rights, the grant of worthless patents, and the legal procedure for the determination of patent rights.

518.3 **3491**

Alignment Chart Construction.—D. C. French. (*Proc. Instn Radio Engrs, Aust.*, June 1946, Vol. 7, No. 6, pp. 11–20.) A non-theoretical explanation.

519.283 : 519.24 **3492**

A Simple Test of Significance.—E. J. Williams : K. K. Schiller. (*Engineering, Lond.*, 24th May & 14th June 1946, Vol. 161, Nos. 4193 & 4196, pp. 496 & 568.) Two letters discussing the test proposed by " A. Mateur " (2427 of August).

621.3 + 537 + 538].081 **3493**

Electrical Units and the MKS System.—H. P. Williams. (*Elect. Comm.*, March 1946, Vol. 23, No. 1, pp. 96–106.) An instructional review.

621.3 **3494**

I.R.E.-U.R.S.I. Convene.—(*Electronic Industr.*, July 1946, Vol. 5, No. 7, pp. 75–77, 96.) Summaries of some of the papers read at the joint meeting held in Washington, D.C., in May 1946.

621.3 **3495**

Electrical Progress and Development.—H. W. Richardson. (*G.E.C. J.*, Feb. 1946, Vol. 14, No. 1, pp. 3–56.) Survey of work at British General Electric Co., including radio and communications, measuring instruments, and batteries.

621.3(07) **3496**

A Note on Electrical Engineers Trained [in U.S. schools] **during the War.**—G. H. Fett. (*Proc. Inst. Radio Engrs, W. & E.*, July 1946, Vol. 34, No. 7, pp. 481–482.)

621.3.027.3 : 016.5 **3497**

High-Voltage Engineering.—(*Brown Boveri Rev.*, Sept./Oct. 1943, Vol. 30, Nos. 9/10, pp. 211–291.) This is a special high-voltage engineering number of the journal, giving 16 papers on the properties of insulators, breakdown phenomena, and h.v. laboratory equipment.

621.3.078 : 621.383 **3498**

Step-Control of a Productive Process. — W. Sommer. (*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 150–154.) Photoelectric device employing a series of filters of varying density for controlling tolerances in mass production processes.

621.3.084(07) **3499**

Education in Instrument Technology. Report of a Discussion held by the Society of Instrument Technology in London on 8 November 1945.—(*J. sci. Instrum.*, July 1946, Vol. 23, No. 7, pp. 161–163.)

621.38 **3500**

Electronics Exhibition.—(*Elect. Rev., Lond.*, 19th July 1946, Vol. 139, No. 3582, pp. 93–94.) A review of the electronic equipment for controlling industrial processes, high-frequency heating, etc., shown at the British Thomson-Houston Co. exhibition. For another account see *Electrician*, 19th July 1946, Vol. 137, No. 3555, pp. 165–167.

621.385 **3501**

Demonstration of a Water-Jet Analogue of the Reflection Klystron.—Scott. (*See* 3473.)

621.396.6 (213) **3502**

Deterioration of Radio Equipment in Damp Tropical Climates and Some Measures of Prevention.—C. P. Healy. (*J. Instn Engrs, Aust.*, April/May 1946, Vol. 18, Nos. 4/5, pp. 73–85.) The nature of moulds, their reproduction, and the preparation of cultures are described. Moulds will grow on almost any organic material, and even on the surface of many inert materials if there is enough organic dust to maintain growth. In such cases the surface may be pitted. A survey of tropical conditions leads to the design of a humidity chamber in which tropical conditions may be simulated. Methods of inoculation of the equipment with mixed mould spores are described. Tests may also be carried out in petri dishes on small specimens and with particular moulds. The effectiveness of various fungicides, when incorporated in waxes, paints, etc., is discussed. The effects of mould on particular parts of equipment (connecting wire, laminated sheet, batteries, etc.) are considered, and methods of prevention or suitable substitutes recommended.

Humidity tests without moulds are outlined, and the effect on individual components considered. Preventive treatments are suggested for transformers, capacitors (paper and mica), ceramics, phenolic mouldings, and sheets. The use of moisture-proof equipment cases is mentioned. See also 809 of March (Collins, Gittoes & Rowed).

621.396.621.004.67 **3503**

Hospitalization for Radios.—O. I. Sprungman. (*Radio News*, Aug. 1946, Vol. 36, No. 2, pp. 45, 151.) Details of a type of insurance under which a yearly premium is paid and servicing is free for the year.

621.396.97 : 7 **3504**

The Search for a Radiophonic Art.—J. Matras. (*Onde élect.*, June 1946, Vol. 26, No. 231, pp. 228–238.) An essay on the aesthetics of broadcasting as a cultural medium, by the chief engineer of the French broadcasting system.

658.311.5 **3505**

The Selection of Engineering Personnel.—F. Holliday. (*J. R. aero. Soc.*, April 1946, Vol. 50, No. 424, pp. 240–261. Discussion pp. 262–274.) A lecture before the Royal Aeronautical Society.

778.142 **3506**

Microfilm.—M. Sollima. (*Rev. tech. Comp. franç. Thomson-Houston*, July 1945, No. 3, pp. 1–20.) A general account, with particular note of cameras and reading apparatus developed by the French Thomson-Houston Company.

519.283 : 62 **3507**

A First Guide to Quality Control for Engineers. [Book Review]—E. H. Sealy. H.M. Stationery Office, London, 1945, 38 pp., 1s. (*Nature, Lond.*, 13th April 1946, Vol. 157, No. 3989, pp. 475–476.) A guide to production engineers in the application of statistical methods of checking and testing in mass production.

551.5(021) **3508**

General Meteorology. [Book Review]—H. R. Byers. McGraw-Hill Book Co., New York, 1944, 645 pp., $5. (*J. appl. Phys.*, June 1946, Vol. 17, No. 6, p. 535.) " . . . recommended to persons interested in modern developments in descriptive and synoptic meteorology."

Correction.—In the October abstracts, for *Physica, Eindhoven* read *Physica, 's Grav.*