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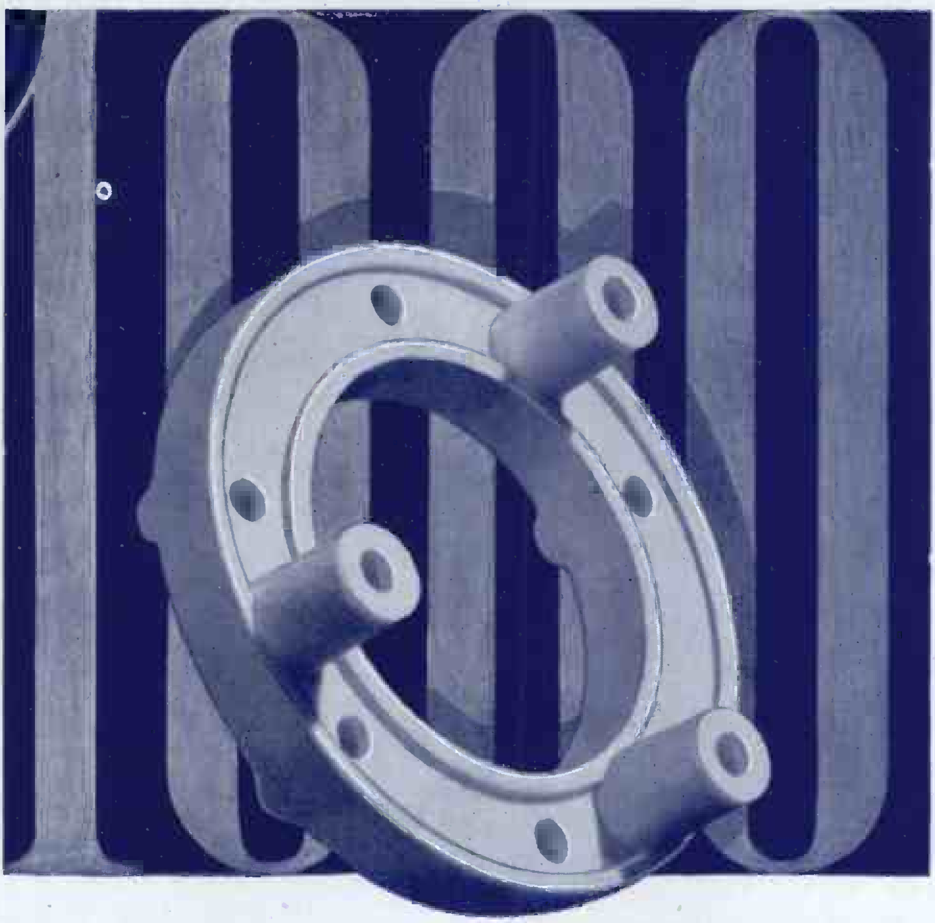


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VOL. XXII JANUARY, 1945 No. 256

EDITORIAL

Coupling Coefficient of Tuned Circuits

IN our February, 1944, Editorial we discussed the calculation of coupling coefficients and gave a number of related numerical examples. In the review of a recently published text-book in this issue (page 14) we refer to the fact that, in a diagram showing five different methods of coupling, the value given for k is obviously wrong in every case.

The object of this note is to show how the coupling coefficients for all the ordinary methods of coupling can be expressed in a simple and unified manner. The formulae given are all obtainable by the methods of the February Editorial.

In the diagrams the cross-hatched elements are all of the same kind, i.e., either all inductors or all capacitors, the plain elements being of the other kind.

Depending on whether they are inductors or capacitors X_1, X_2 and X_m represent either L_1, L_2 and L_m or $\frac{1}{C_1}$, $\frac{1}{C_2}$ and $\frac{1}{C_m}$; the frequency need not be brought in since it cancels out.

In Fig. 1

$$k = \frac{X_m}{\sqrt{(X_1 + X_m)(X_2 + X_m)}}$$

$$= \frac{1}{\sqrt{\left(1 + \frac{X_1}{X_m}\right)\left(1 + \frac{X_2}{X_m}\right)}}$$

If $X_1 = X_2 = X$

then $k = \frac{X_m}{X + X_m} = \frac{L_m}{L + L_m}$ or $\frac{C}{C + C_m}$

In Fig. 2

$$k = \frac{\sqrt{X_1 X_2}}{\sqrt{(X_1 + X_m)(X_2 + X_m)}}$$

$$= \frac{1}{\sqrt{\left(1 + \frac{X_m}{X_1}\right)\left(1 + \frac{X_m}{X_2}\right)}}$$

If $X_1 = X_2 = X$

then $k = \frac{X}{X + X_m} = \frac{L}{L + L_m}$ or $\frac{C_m}{C + C_m}$

It is assumed that the circuits are tuned to the same frequency and it is important

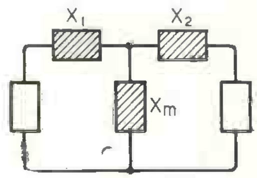

Fig. 1.

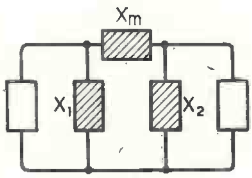

Fig. 2.

to note exactly what this means. When tuning the separate circuits, the coupling elements must be included in the circuit. This applies also to Fig. 2 where X_1, X_2 and X_m must be left connected to the circuit being tuned. Except when $X_1 = X_2$ the two side circuits of Fig. 2 containing only X_1 or X_2 are not of the same frequency.

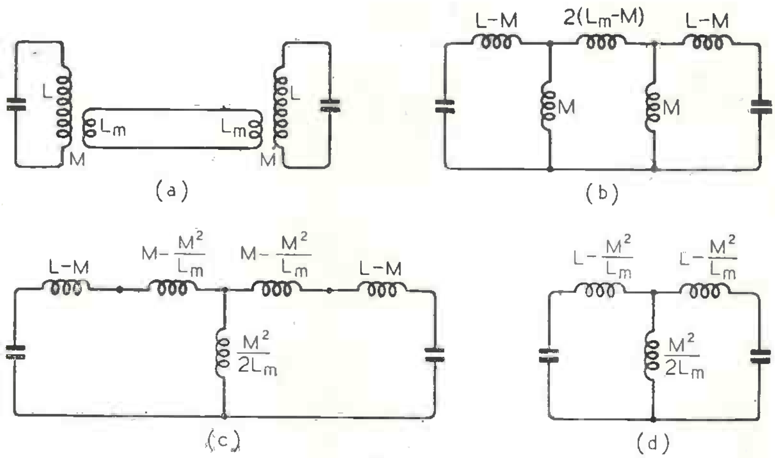

Fig. 3.

Other more complex methods of coupling can always be reduced to the above; thus Fig. 3(a) shows one of the methods given in the text-book referred to above. This can be replaced by Fig. 3(b) in which M is made a common part of the coupled circuits. Replacing the mesh or Π by the equivalent star or T, Fig. 3(c) is obtained, which reduces to Fig. 3(d), similar to Fig. 1, and we have

$$k = \frac{M^2/2L_m}{L - \dfrac{M^2}{L_m} + \dfrac{M^2}{2L_m}} = \frac{M^2}{2LL_m - M^2}$$

We thus see that although Fig. 3(a) appears to bear no resemblance to Fig. 1 it is a simple matter to reduce it in two steps to Fig. 3(d) which is identical with Fig. 1.

G. W. O. H.

EFFECT OF A SPHERICAL SCREEN UPON AN INDUCTOR*

By C. F. Davidson and J. C. Simmonds

Introduction

IN high-frequency engineering it is frequently necessary to screen an inductor from external fields or, alternatively, to screen other components from the field of the inductor. The required screening is usually obtained by enclosing the inductor in a metal box, and it is obvious that this will affect the properties of the inductor. In fact, it is easily seen that the presence of the screen will result in a decrease of inductance and an increase of resistance. It is necessary, in many instances, to estimate the magnitude of the changes brought about by the screen, and it is for this reason the problem of an inductor enclosed in a spherical screen is of practical importance. A spherical screen may be regarded as a good approximation to screens normally in use, as has been shown by H. Kaden. Kaden has considered the screening of inductors at some length and has given formulae† for the effect of the screen upon the inductance and resistance of the inductor, based upon the assumption that the inductor can be replaced by a magnetic dipole of the same magnetic moment. Although this assumption will no doubt be well justified in most practical cases this is not invariably so, and in this paper expressions are developed, based upon the assumption that the inductor may be replaced by a number of circular loops, which give the effect of the screen when it is not necessarily large compared with the dimensions of the inductor.

* MS. accepted by the Editor, October, 1944.

† *Zeits. für Hochfreq. Tech.*, Sept., 1932, p. 92. *E.N.T.*, July, 1933, p. 277. See also *Wireless Engineer* Editorial, March 1934.

The rationalized M.K.S. system of units is used in this paper.

The Eddy Currents in the Spherical Screen

The inductor is assumed to consist of a number of circular loops, centre the origin, lying in the XOY-plane and surrounded by a screen formed by a thin conducting sheet at $r = a$, using spherical co-ordinates as shown in Fig. 1. As a result, the eddy currents induced in the screen will flow in circles parallel to the loops of the inductor and will have only a ϕ-component. It will now be assumed that the dimensions of the inductor and screen are small compared with the wavelength corresponding to the frequency of operation. In these circumstances, the magnetic vector potential $\mathbf{A}$ of the eddy currents must satisfy the equation :—

$$\text{curl}\,\text{curl}\,\mathbf{A} = 0 \quad \quad (1)$$

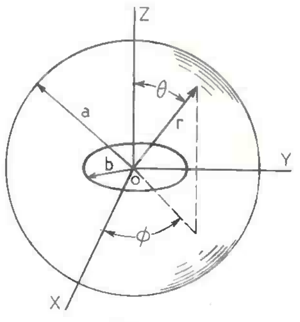

Fig. 1.

Since this magnetic vector potential will have only a ϕ-component, independent of the ϕ-co-ordinate because of circular symmetry, it follows that A_ϕ satisfies the equation :—

$$\frac{\partial^2 A_\phi}{\partial r^2} + \frac{2}{r}\frac{\partial A_\phi}{\partial \theta} + \frac{1}{r^2}\frac{\partial}{\partial \theta}\left\{\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(A_\phi \sin\theta)\right\} = 0 \quad \quad (2)$$

which has the normal solution, finite for all values of θ :—

$$A_\phi = \sum_{n=1}^{\infty}\left\{C_n r^n P_n^1(\cos\theta) + D_n r^{-n-1} P_n^1(\cos\theta)\right\} \quad \quad (3)$$

where C_n and D_n are constants and $P_n^1(\cos\theta)$ is the associated Legendre polynomial of order n. Now the magnetic vector potential must be finite at both the origin and at infinity and must be continuous at the screen. Therefore it follows that inside the screen :—

$$A_{\phi i} = \sum_{n=1}^{\infty} C_n \left(\frac{r}{a}\right)^n P_n^1(\cos\theta) \quad \quad (4)$$

whilst outside the screen :—

$$A_{\phi 0} = \sum_{n=1}^{\infty} C_n \left(\frac{a}{r}\right)^{n+1} P_n^1(\cos\theta) \quad \quad (5)$$

Consider the element of screen shown in Fig. 2, in which i_ϕ is the current density per unit width. Denoting the magnetic intensity due to a current I by $\mathbf{H}$ then

$$\oint \mathbf{H} \cdot d\mathbf{S} = I \quad \quad (6)$$

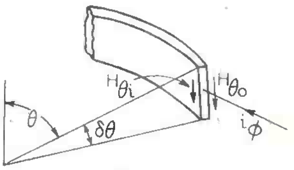

Fig. 2.

the integral being evaluated round a closed contour surrounding I. Applying equation (6) to the element under consideration it is seen that :—

$$i_\phi = (H_{\theta 0} - H_{\theta i})_{r=a} \quad \quad (7)$$

where H_θ is the "θ" component of the magnetic intensity.

Now,

$$\mu\mathbf{H} = \text{curl}\,\mathbf{A} \quad \quad (8)$$

whence :—

$$H_{\theta i} = \frac{1}{\mu}\sum_{n=1}^{\infty} - C_n \frac{(n+1)}{r}\left(\frac{r}{a}\right)^n P_n^1(\cos\theta) \quad \quad (9)$$

$$H_{\theta 0} = \frac{1}{\mu}\sum_{n=1}^{\infty} C_n \frac{n}{r}\left(\frac{r}{a}\right)^{-n-1} P_n^1(\cos\theta) \quad \quad (10)$$

It is therefore seen that :—

$$i_\phi = \frac{1}{\mu a}\sum_{1=n}^{\infty}(2n+1)C_n P_n^1(\cos\theta) \quad \quad (11)$$

Magnetic Vector Potential of the Inductor

First assume that the inductor consists of but a single turn of radius "b," and, following the method given by W. R. Smythe,* assume that the loop is a narrow band at $\theta = \frac{\pi}{2}$ on the surface of a sphere of radius "b." Further, assume that the current is zero on the surface of the sphere except on the narrow band. Now the current density on the sphere may be expanded in the form :—

$$i_\phi = \sum_{n=1}^{\infty} L_n P_n^1(\cos\theta) \quad \quad (12)$$

where L_n is a constant. To determine L_n multiply equation (12) by $P_m^1(\cos\theta)\sin\theta$ and integrate from $\theta = 0$ to π. It then follows from equations (5) and (11) that for N loops

* "Static and Dynamic Electricity," p. 270.

and values of $r > b$, the vector potential is given by :—

$$A_\phi = \frac{\mu IN}{2} \sum_{n=1}^{\infty} \frac{1}{n(n+1)} \left(\frac{b}{r}\right)^{n+1} P_n^1(0) P_n^1(\cos\theta) \qquad (13)$$

Relationship between the Eddy Currents and the Magnetic Vector Potentials

Let the surface resistivity of the material of the screen be R_s and let A_ϕ and A_ϕ' denote the magnetic vector potentials of the eddy currents and the N loops respectively, then the following relation holds on the surface of the sphere :—

$$\frac{d}{dt}\left(A_\phi + A_\phi'\right) = - R_s i_\phi \qquad (14)$$

a result which may be easily seen with the aid of Stokes' Theorem and equation (8). For harmonic currents $I = Ie^{j\omega t}$ and $C_n = C_n e^{j\omega t}$, thus from equations (4), (11), (12) and (13) it is seen that :—

$$j\frac{\mu\omega IN}{2} \frac{P_n^1(0)}{n(n+1)} \left(\frac{b}{a}\right)^{n+1} + j\omega C_n = -\frac{R_s}{\mu a}(2n+1) C_n \qquad (15)$$

Hence,

$$C_n = \frac{-j\dfrac{\mu\omega INP_n^1(0)}{2n(n+1)} \cdot \left(\dfrac{b}{a}\right)^{n+1}}{\dfrac{(2n+1)}{\mu a} R_s + j\omega} e^{j\omega t} \qquad (16)$$

The Effective Inductance and Resistance of the Inductor

The flux due to the eddy currents induces an e.m.f. in the loops given by :—

$$+E = -\frac{Nd\Phi}{dt} = -2\pi bN \left.\frac{dA_{\phi i}}{dt}\right|_{r=b,\ \theta=\frac{\pi}{2}} \qquad (17)$$

From equations (4) and (16) it follows that :—

$$E = -\pi\mu bN^2 I\omega^2 \sum_{n=1}^{\infty} \frac{P_n^1(0)^2 \left(\dfrac{b}{a}\right)^{2n+1}}{n(n+1)\left\{\dfrac{(2n+1)}{\mu a} R_s + j\omega\right\}} e^{j\omega t} \qquad (18)$$

Hence, in order to maintain the current I flowing in the loops, the presence of the screen necessitates an additional e.m.f. $-E$ being applied to the terminals of the loops. The impedance coupled into the loops is therefore given by :—

$$\delta R + j\delta X = -\frac{E}{I} = \pi\mu bN^2\omega^2 \sum_{n=1}^{\infty} \frac{P_n^1(0)^2 \left(\dfrac{b}{a}\right)^{2n+1}}{n(n+1)\left\{\dfrac{(2n+1)}{\mu a} R_s + j\omega\right\}}$$

$$= \pi N^2 R_s \sum_{n=1}^{\infty} \left(\frac{b}{a}\right)^{2(n+1)} \frac{(2n+1)}{n(n+1)} \frac{P_n^1(0)^2}{\left\{1 + \dfrac{R_s^2(2n+1)^2}{(\mu a\omega)^2}\right\}}$$

$$- j\omega\pi\mu bN^2 \sum_{n=1}^{\infty} \left(\frac{b}{a}\right)^{2n+1} \frac{P_n^1(0)^2}{\left\{1 + \dfrac{R_s^2(2n+1)^2}{(\mu a\omega)^2}\right\}} \qquad (19)$$

The increase in the inductor resistance due to the presence of the screen is thus :—

$$\delta R = \pi N^2 R_s \sum_{n=1}^{\infty} \left(\frac{b}{a}\right)^{2(n+1)} \frac{2n+1}{n(n+1)} \frac{P_n^1(0)^2}{\left\{1 + \dfrac{R_s^2(2n+1)^2}{(\mu a\omega)^2}\right\}} \qquad (20)$$

and the decrease in the inductance is :—

$$\delta L = \pi\mu bN^2 \sum_{n=1}^{\infty} \left(\frac{b}{a}\right)^{2n+1} \frac{P_n^1(0)^2}{n(n+1)\left\{1 + \dfrac{R_s^2(2n+1)^2}{(\mu a\omega)^2}\right\}} \qquad (21)$$

If the radius " b " of the loop is made very small the inductor tends to a magnetic dipole and equations (20) and (21) reduce to :—

$$\delta R = \frac{3\pi N^2 R_s}{2}\left(\frac{b}{a}\right)^4 \qquad (22)$$

and $$\delta L = \frac{\pi\mu b N^2}{2}\left(\frac{b}{a}\right)^3, \qquad (23)$$

on neglecting $\left(\frac{3R_s}{\mu a\omega}\right)^2$ in comparison with unity, results which have been given by Kaden.

For metal screens at radio frequencies, it will be found on summing the above series that for values of $\left(\frac{b}{a}\right)$ as large as 0.9 it is only necessary to take values of n up to 31 in order to secure a result accurate to within 0.1 per cent. For smaller values of $\left(\frac{b}{a}\right)$ the series will be more rapidly convergent and correspondingly fewer terms will be needed for the same degree of accuracy. It thus follows that the quantity $\frac{R_s^2(2n+1)^2}{(\mu a\omega)^2}$ can be neglected in comparison with unity providing $\left(\frac{b}{a}\right)$ is not greater than about 0.9. Hence,

$$\delta R = \pi N^2 R_s \sum_{n=1}^{\infty}\left(\frac{b}{a}\right)^{2(n+1)}\frac{2n+1}{n(n+1)}P_n^1(0)^2 \qquad (24)$$

$$\delta L = \pi\mu b N^2 \sum_{n=1}^{\infty}\left(\frac{b}{a}\right)^{2n+1}\frac{P_n^1(0)^2}{n(n+1)} \qquad (25)$$

Equations (24) and (25) may be written in the form :—

$$\delta R = \pi N^2 R_s\left(\frac{b}{a}\right)^4 F_1\left(\frac{b}{a}\right) \qquad (26)$$

$$\delta L = \pi\mu b N^2\left(\frac{b}{a}\right)^3 F_2\left(\frac{b}{a}\right) \qquad (27)$$

where

$$F_1\left(\frac{b}{a}\right) = \sum_{n=1}^{\infty}\left(\frac{b}{a}\right)^{2(n+1)} \cdot \frac{2n+1}{n(n+1)}P_n^1(0)^2\left(\frac{a}{b}\right)^{+4} \qquad (28)$$

$$F_2\left(\frac{b}{a}\right) = \sum_{n=1}^{\infty}\left(\frac{b}{a}\right)^{2n+1}\frac{P_n^1(0)^2}{n(n+1)}\left(\frac{a}{b}\right)^{+3} \qquad (29)$$

Graphs of the functions $F_1\left(\frac{b}{a}\right)$ and $F_2\left(\frac{b}{a}\right)$ are shown in Fig. 3 for values of $\left(\frac{b}{a}\right)$ up to 0.9.

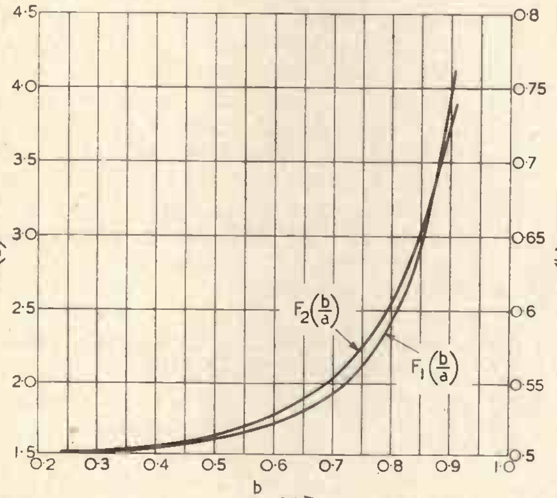

Fig. 3.

Conclusions

The change in impedance of an inductor, consisting of almost coincident circular loops, due to the presence of a circular screen has been calculated, and curves given which enable the increase in resistance and decrease in inductance to be computed relatively easily. From the curves given it is seen that when the ratio of the diameter of the loops to the diameter of the sphere is not greater than about 0.5 much simpler expressions may be used with an error of only a few per cent. These simpler expressions have previously been given by Kaden and, in effect, assume that the inductor may be replaced by a magnetic dipole of the same magnetic moment.

Although in this paper the inductor has been assumed to consist of almost coincident circular loops, the method could be applied to the more general case in which the loops are spaced along the "z" axis. However, when this is carried through in general terms the expressions involved become rather unwieldy, although the analysis is still simple, and for this reason are not included.

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SENSITIVITY CALIBRATION OF RECEIVERS *

A Radiation Method for Wavelengths Below 10 Metres

By J. S. McPetrie, D.Sc., Ph.D., M.I.E.E., W. E. Perry, B.Sc., L. H. Ford, M.Sc., A.M.I.E.E.

(Radio Department, National Physical Laboratory)

ABSTRACT.—The paper describes a radiation method of calibrating the sensitivity of short-wave receivers in the wavelength range 0.5 to 10 metres in terms of the field strength at the aerial necessary to give an output signal which is just detectable through the background noise of the receiver. Three methods of general application are given, by which apparatus may be disposed so that the field at a receiving aerial, due to the current in a transmitting aerial, can readily be calculated. Transmitters which have been used for calibrating receivers are described.

1. Introduction

THE sensitivity of a radio receiving set may be expressed in a number of ways, and that used influences the method adopted for its measurement. One form in which the sensitivity may be expressed is the signal, having a stated percentage modulation, required at the input terminals in order to obtain a standard audio-frequency power output. The method of measurement involves the use of a signal generator, and can be carried out in the laboratory. The information which this expression conveys is, however, incomplete, because the weakest signal for satisfactory reception cannot be derived from it, since the noise produced by the set itself has not been taken into account. This difficulty may be overcome by relating the output to the set noise, and the sensitivity is then expressed as the input signal necessary to give an output either equal to, or a specified number of decibels greater than the noise of the set. The method of test remains substantially unchanged.

The user of a receiving set, however, is often more interested in the field strength at the aerial, in microvolts per metre, necessary to give a specified output, rather than the microvolts at the input terminals which would give that output. At wavelengths greater than a few metres the measurement of sensitivity in this form might be somewhat difficult, but at the shorter wavelengths it is relatively simple. This is because at wavelengths of a few metres and below, the laws of propagation of radio waves are such that a known field can be readily obtained, and because easily specified aerial systems, e.g. the half-wavelength dipole, become of manageable dimensions.

The paper describes the methods which have been used at the National Physical Laboratory for measuring the field strength which, with 100 per cent. audio-frequency modulation, is necessary to give an output just detectable through the background noise in receivers covering the wavelength range 0.5 to 10 metres.

* MS accepted by the Editor, November, 1944.

2. General Description of Radiation Method for Receiver Calibration

The principle underlying the method of test is that of obtaining a known field at the receiver from a knowledge of the transmitter aerial current and the laws of propagation between transmitter and receiver, and then adjusting this field by a calibrated attenuator at the transmitter to obtain the desired receiver output. By applying the attenuator at the transmitter the receiver may be calibrated in the condition in which it will normally be used. This is an advantage over the alternative possibility of inserting an attenuator between the receiving aerial and the receiver.

When determining the sensitivity of a receiving set, the transmitter is set up and coupled through a piston attenuator and a suitable length of twin flexible lead to a half-wavelength dipole aerial. In each limb of the aerial, immediately adjacent to the input loads, a non-contact type thermo-junction with straight through heater is connected, by which the aerial current can be measured. The transmitted carrier wave is modulated by a signal of 1,000 c/s and the modulation depth used is normally 100 per cent. The receiver with its aerial, usually a half-wave dipole, is set up at such a distance away that the field at its aerial can be readily calculated. The signal received with no attenuation at the transmitter is, in general, considerably greater than the noise level of the set; the observer, by a simple code of signals, then instructs an assistant at the transmitter to reduce the radiated power by means of the piston attenuator until the required condition is obtained. This is either when the observer judges the signal to be of equal intensity to the noise, or when the signal is just detectable through the background noise. Numerous experiments showed that the latter condition could be repeated at different times and with different observers to an accuracy of ± 2 db., and that it corresponds to a signal strength about 3 db. less than that required for signal equal to noise, on the range of receivers tested. Observations are made of the initial aerial current with the corresponding piston attenuator reading, and of the attenuator reading when the desired condition is obtained at the receiver. The initial field strength is then calculated from the appropriate formula, and the final field strength derived from it and the known attenuation introduced during the calibration.

3. Three Methods of Obtaining a Calculable Field Strength

The method of calibration described above depends on the possibility of obtaining a field at the receiver aerial which can be calculated from a knowledge of the aerial current at the transmitter and the arrangement of the apparatus. Three ways of producing such fields have been employed for receiver calibration, two of which are applicable at all the wavelengths under consideration, while the third is only suitable for use at wavelengths below about 1 metre.

A.—Field proportional to I/D^2.

The use of horizontally polarised waves for the calibration of field-stregth measuring sets has been described in previous publications[1, 2]. A simple formula can be used to calculate the field at a distance from a transmitter of known power.

If H_T, H_R be the heights of the half-wavelength transmitting and receiving aerials respectively, I the aerial current and D the distance between the aerials, then

$$\text{field at receiving aerial} = \frac{240\,\pi H_T H_R I}{\lambda D^2}\ \text{v/m},$$

when the lengths are measured in metres and the currents in amperes. This formula applies for wavelengths less than about 20 metres with aerial heights of more than about 0.1λ, provided that the distance between transmitter and receiver is great enough for the reflected ray to be at grazing incidence, i.e., the reflection coefficient may be taken as -1.

The method is convenient with values of H_T and H_R of between 1 and 2 metres, and of D between 40 and 200 metres. If the aerial heights are much less than one metre, the uncertainty in their measurement, if the ground is at all rough, becomes serious, while if D is too small the reflection coefficient of the ground can no longer be taken as -1, and the formula is inaccurate. The major limits on aerial height and on D are those of practical convenience.

B.—Direct and reflected rays in phase

Limitations of space, or the need for a stronger field may sometimes render a shorter separation than 40 metres desirable between transmitter and receiver. Another arrangement may then be adopted, in which the aerials are so disposed that the receiving aerial is situated where the direct and reflected rays from the transmitter are in phase. Fig. 1 shows diagrammatically the aerial

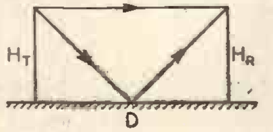


Fig. 1.

TABLE I

λ (metres)	H (metres)	n	$D = \frac{4H^2}{(2n-1)\lambda} - \frac{(2n-1)\lambda}{4}$ (metres)
10	5.6	1	10
5	2.8	1	5
2	2	1	7.5
0.5	2	1	31.9
0.5	2	2	10.3
0.5	2	3	5.77
0.5	2	4	3.69

arrangements. The transmitting and receiving aerials are of heights H_T and H_R respectively, and are distant D apart. Since at these wavelengths over the probable range of values of ground conductivity the phase change on reflection is within a few degrees of 180 deg., irrespective of the angle of incidence, the reflected ray is in phase with the direct ray when the path difference is $\lambda/2$, $3\lambda/2$ .... $(2n - 1)\,\lambda/2$, where n is any integer. It is usually possible and convenient to make $H_T = H_R = H$, when:—

$$\sqrt{D^2 + 4H^2} - D = (2n - 1)\,\lambda/2,$$

whence

$$D = \frac{4H^2}{(2n - 1)\lambda} - \frac{(2n - 1)\,\lambda}{4}$$

Values of D and H which satisfy this relationship are shown for various wavelengths and values of n in Table I. It will be seen that the method becomes inconvenient for values of λ greater than 2 metres and that at the shorter wavelengths it will often be preferable to use one of the higher values of n.

When the above relationship is satisfied the field due to the direct ray, is given by $E = 60\,I/D$, and that due to the indirect ray is given by

$$60IG/\sqrt{D^2 + 4H^2},$$

where G is the magnitude of the reflection coefficient of the

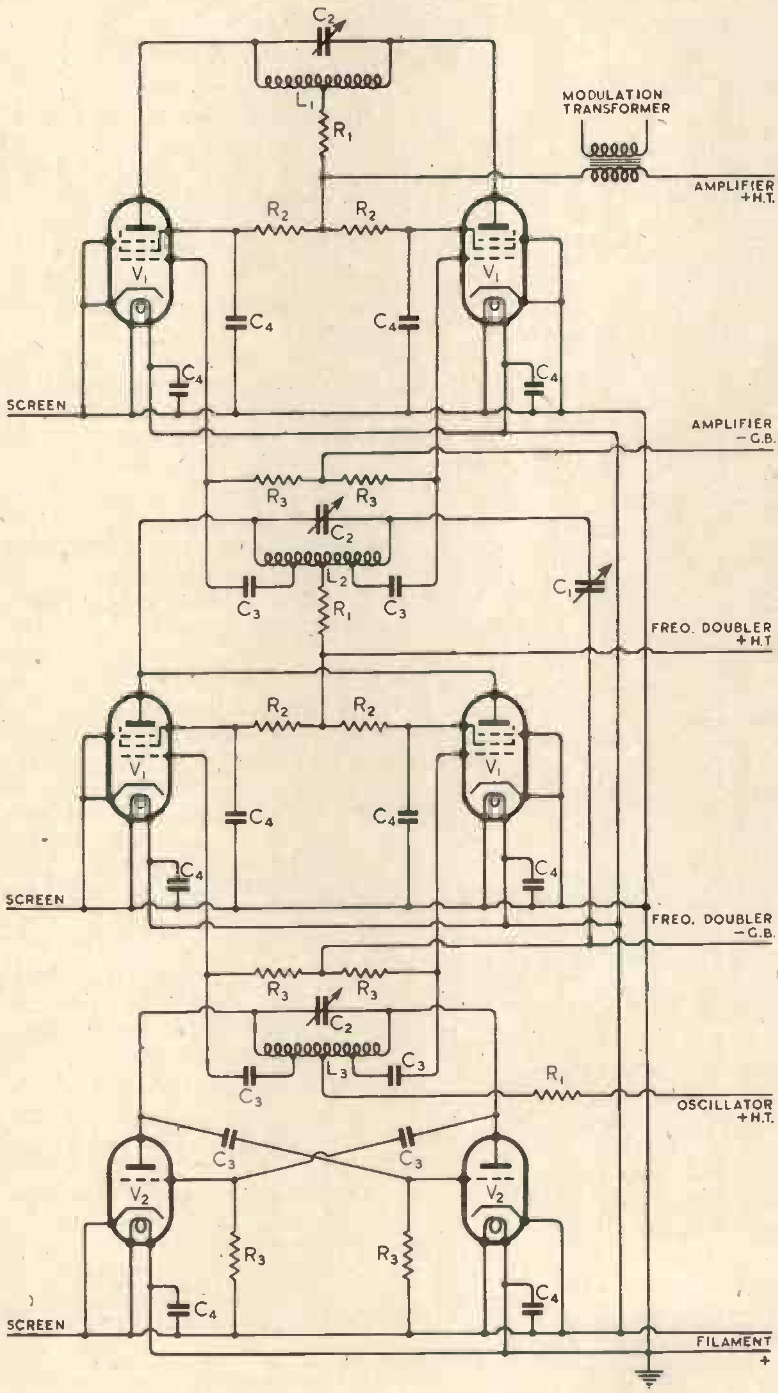


Fig. 2. *Transmitter circuit diagram.* R_1, 1000 *ohms;* R_2, 250,000 *ohms;* R_3, 20,000 *ohms;* C_1, *variable,* 25$\mu\mu F$ *max.;* C_2, *variable,* 50$\mu\mu F$ *max;* C_3, *ceramic,* 40$\mu\mu F$ *for* 1.5–3 *metres,* 80$\mu\mu F$ *for* 6–12 *metres;* C_4, *fixed mica,* 0.1μF *approx;* V_1 *acorn pentode;* V_2 *acorn triode.*

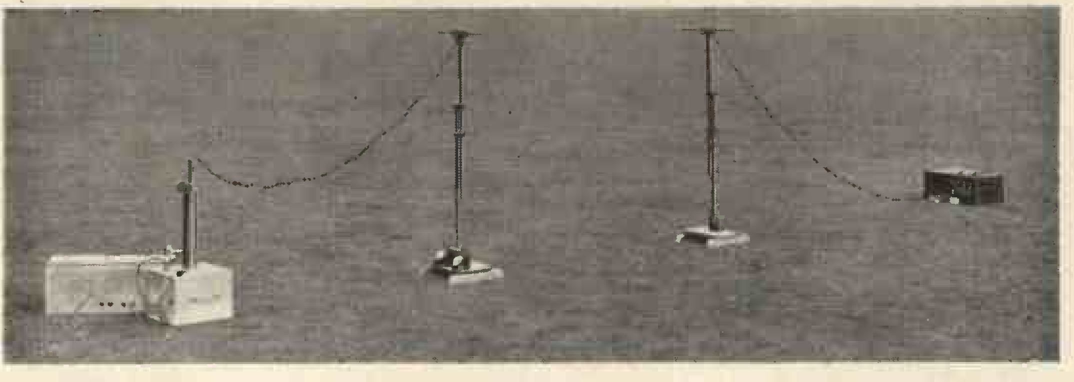
ground; this can be obtained from a knowledge of the constants of the ground. This knowledge often only needs to be very approximate, since by a suitable choice of n the reflected ray can be made considerably weaker than the direct ray. For example, if $\lambda = 1$ metre and $H = 1.75$ metre, a suitable value for D is 1.2 metre ($n = 3$); under these conditions the reflected ray will be incident at an angle of 19 deg., and its path will be 3.7 metres long. The value of the dielectric constant* of the ground will almost certainly fall within the range $K = 5$ to $K = 30$, for which values the magnitudes of the reflection coefficient are 0.4 and 0.7 respectively at this angle of incidence. Thus, if K is assumed to be 5, the calculated field at the receiving aerial will be $60\,I/1.2 + 0.4 \times 60\,I/3.7 = 56.5\,I$, whereas, if K is taken as 30, the calculated field will be $60/1.2 + 0.7 \times 60\,I/3.7 = 61.3\,I$. The difference between these two values is less than 1 db., so that if some reasonable value, such as $K = 15$, is assumed for the dielectric constant of the ground, no serious error is likely to arise from uncertainty as to its exact value.

When this method is used to establish a known field, the appropriate aerial heights and distance of separation should be calculated from the formula and the apparatus arranged accordingly. With the aerials correctly sited the field at the receiving aerial is not a maximum with respect to the distance between aerials, although the direct and reflected rays are in phase. This is because a small displacement of the receiving aerial in the direction of the transmitter causes the signal due to the direct ray to increase by more than the change in phase of the reflected ray causes the signal due to the combined rays to decrease. It is not satisfactory, therefore, to move the receiver towards the transmitter until a maximum signal is observed and to assume that the direct and reflected rays are then in phase.

* The reflection coefficient of the ground depends on both its dielectric constant and its conductivity. The contribution made by the latter varies inversely with the frequency, and is only likely to be applicable at the longer wavelengths in the range under consideration. For simplicity, it has been ignored in the example given, since its inclusion would not invalidate the argument.

C.—Field proportional to I/D.

The method of obtaining a calculable field at a receiving aerial, described in the preceding section, can be modified and simplified at wavelengths below about one metre by using small separations between aerials combined with large heights of aerial. Under these conditions the reflected ray can be neglected and the free space condition assumed, in which the field strength is given by $60\ I/D$. It is then possible to conduct the calibration in a laboratory instead of on an open site, provided that the space available is sufficiently great to ensure that no reflecting surface is close to either aerial compared with the distance between them. This condition becomes progressively more easy to attain as the wavelength is reduced, since the dimensions of the room, in terms of wavelength become greater. The space needed is, moreover, not as great as might at first sight appear, since the dielectric constant of the material forming the walls of a room is likely to be low, and the reflection coefficient consequently not more than about 0.3.



Chopped oscillator and receiver set up for calibration, using Method 2. $H_T = H_R = 1.5$ metres; $D = 2.25$ metres; $\lambda = 1$ metre.

D.—Comparison of the three methods.

A series of measurements was undertaken to ensure that the three methods described above gave consistent results. The field corresponding to a considerable variety of conditions was computed by the appropriate formula and determined for each condition with a field-strength measuring set. The ratio between the calculated field and that indicated by the field-strength measuring set was computed for each observation. The distance between transmitting and receiving aerials used in these tests varied over the wide range of 1.2 to 90 metres, and the values of field strengths lay between 0.6 and 0.001 volt per metre. The results are given in Table II.

The results in Series B were computed assuming a value of 10 for the dielectric constant of the ground and using published curves[3] to obtain the value of G, the reflection coefficient. The results in Series C were taken in a laboratory about 8 metres long by 5 metres wide and 6 metres high; the aerials were placed symmetrically in the middle of the room parallel to the 5-metre side, so that the reflection from the nearest wall was a minimum, owing to the shape of the polar diagrams of the aerials. It will be seen that even in the first experiment with aerial heights and separation of about 2 metres, for which the path of the reflected ray via the floor was not very great compared with that of the direct ray, the formula $60\,I/D$ could be safely applied, owing to the low reflection of the concrete floor.

The readings of the attenuators of the field-strength measuring set were known to be liable to errors of up to ± 1 db. The table shows that individual results of each series are within about ± 1.5 db. of the mean of the series, and that the mean of the results of each series differ from one another by less than 1 db. This proves conclusively that all three methods of obtaining a calculable field are equally reliable if proper precautions are taken.

4. Description of Apparatus

A number of transmitters giving a power output of about 100 milliwatts have been constructed for calibrating receivers, using the methods described above. They individually cover the wavelength ranges 0.8 to 1.1, 1.0 to 1.6, 1.5 to 3, 3 to 6, and 6 to 12 metres. The circuit diagram is shown in Fig. 2, and the general arrangement in Figs. 3 and 4. Each transmitter consists of a push-pull oscillator feeding a frequency doubler, and a push-pull amplifier. Acorn valves are used throughout; those in the oscillator are triodes and the remainder pentodes. The three stages are carefully screened from one another. Modulation is applied to the anode supply of the amplifier stage through a screened transformer. The audio frequency for modulation is supplied from a beat frequency oscillator, and the

TABLE II

λ = 1 metre. Transmitter aerial current 10 mA.

Distance between Aerials (metres)	Height of Aerials (metres)	Calculated Field (Volts/metre)	Ratio of calculated to measured field	Mean Ratio of Series
Series A. Formula $E = 240\,\pi H^2 I/\lambda D^2$				
90	1.75	0.00285	1.0	1.05
90	1.5	0.0021	1.05	
90	1.1	0.00115	1.15	
60	1.1	0.00255	0.9	
40	1.1	0.0057	1.05	
Series B. Formula $E = 60\,I/D + 60IG/\sqrt{D^2 + 4H^2}$				
12.0 (Path diff. $\lambda/2$)	1.75	0.088	0.95	0.95
3.33 (,, ,, $3\lambda/2$)	1.75	0.255	0.95	
1.20 (,, ,, $5\lambda/2$)	1.75	0.59	1.05	
8.75 (,, ,, $\lambda/2$)	1.5	0.12	0.95	
4.6 (,, ,, $\lambda/2$)	1.1	0.225	0.9	
Series C. Formula $E = 60\,I/D$				
1.95	2	0.31	1.05	1.0
1.75	3	0.345	0.95	
1.25	2.8	0.48	1.0	

voltage required for 100 per cent. modulation was determined initially by viewing the received signal on a cathode-ray oscillograph. In these circumstances no frequency modulation was apparent when the transmission was received in a narrow-band superheterodyne receiver.

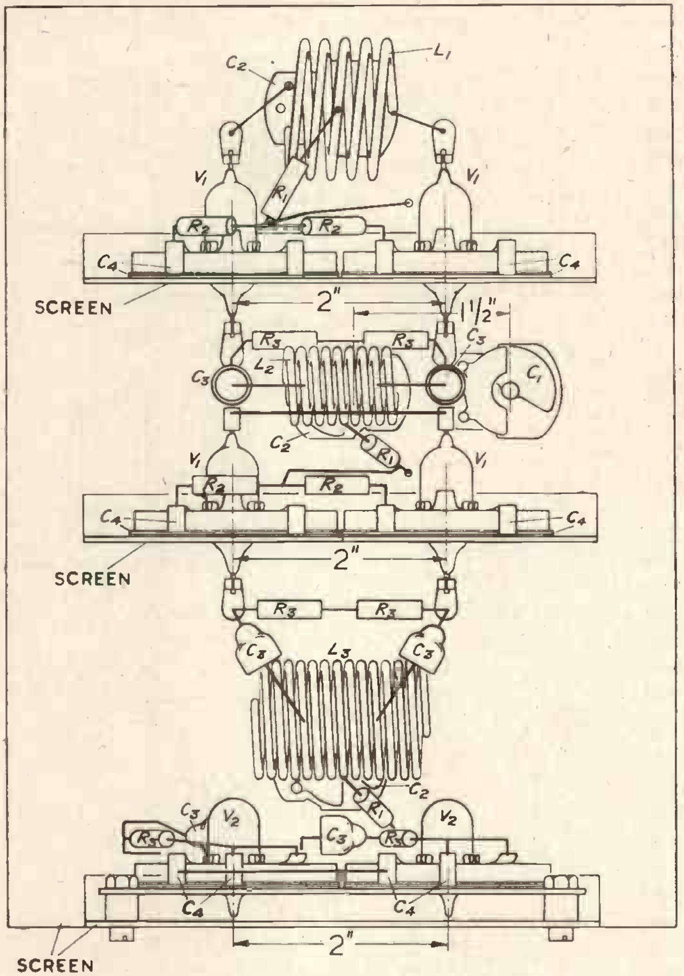


Fig. 3. *Elevation of transmitter.*

The transmitter is fitted in a screened box, which also contains both dry batteries for the H.T. supplies and accumulators for the filament supplies. An inductive type piston attenuator, to which the aerial is connected through a length of twin flexible lead, is fixed in one side of the box in correct position to couple with the coil of the amplifier. The attenuator gives approximately 1 db. for every 2 mm. travel, and its calibration is linear over about 50 db. Movement of the piston to obtain further attenuation beyond this value shows erratic effects, as the radiation from the box becomes appreciable compared with that from the aerial.

At wavelengths below about 1 metre it was not found possible to construct a satisfactory transmitter of this type. Instead, a simple oscillator has been used and the anode supply of this oscillator was chopped with equal on and off periods and 1,000 c/s recurrence. The use of this system raises the problem of what value of carrier wave, sine-wave modulated 100 per cent., is the equivalent of the chopped signal.

When a carrier wave has imposed on it a 100 per cent. sine-wave modulation, the energy in the two side bands is 50 per cent. of that in the carrier. When the modulation is square wave instead of sine wave, there is an infinite number of side bands and, with equal on and off periods, the energy in these side bands is equal to that in the carrier, 80 per cent. of the side-band power being in the two fundamental side bands. The conditions are summarised in Table III below.

The field strength at the receiver is determined by the carrier power, while the audio signal is determined by the side-band power. If, therefore, the minimum signal detectable above noise is measured using square-wave modulation and all side bands are assumed to be effective, in order to obtain the same side-band

TABLE III

Modulation	Total Power	Carrier Power	Total Side-Band Power	Power in Fundamental Side Bands
100 per cent. sine-wave	1.5	1.0	0.5	0.5
Square wave equal on and off	1.0	0.5	0.5	0.4

power when using 100 per cent. sine-wave modulation, the carrier power required would have to equal the total power with square-wave modulation. When carrying out a receiver calibration, the aerial current is measured when the oscillator is in the chopped condition, and this aerial current is interpreted as that corresponding to the carrier wave which, when 100 per cent. sine-wave modulated, would give the same signal at the receiver. Since a small proportion of the energy in the chopped condition will give rise to a supersonic signal, the above assumption may give rise to an error of about 1 db., with the chopped signal appearing weaker than a 100 per cent. sine-wave modulated signal.

Experiments using a chopped signal and a 100 per cent. sine-wave modulated signal at the same wavelength show reasonable agreement if this assumption is used. The consistency with which different observers, or the same observer at different times, estimate the attainment of the condition when the signal is first detectable through the noise of the receiver is, however, noticeably less with a chopped, than with a sine-wave modulated signal.

5. Discussion

The radiation method of calibrating short-wave receivers in terms of the field strength at the aerial necessary to give an output signal equal to the set noise has been extensively used and has proved satisfactory. It has the advantage of giving the user of the set the information he most requires, the value of the weakest signal he can detect with certainty, and although the accuracy of $\pm$ 2 db. may seem at first sight low, it is ample for all ordinary purposes. Moreover, the whole receiving system is calibrated in exactly the conditions in which it will be used in practice, which is not generally the case when other methods of calibration are used.

A number of precautions are necessary. The range of attenuation which can be used with safety at the transmitter is limited. With a little experience this presents no danger since the observer will at once realise if the signal is behaving abnormally with increasing attenuation. The limited range of attenuation possible makes it necessary to choose a suitable value of initial field, which gives a readable aerial current at the transmitter and which does not require excessive attenuation. Although the 50 db. attenuation available with the apparatus described could be increased by more elaborate screening of the transmitter, there will always be a limit to the total attenuation possible without error. This means that the choice of the three possible methods of obtaining the known field will be partly determined by the sensitivity of the receiver under test. The final set-up of the apparatus

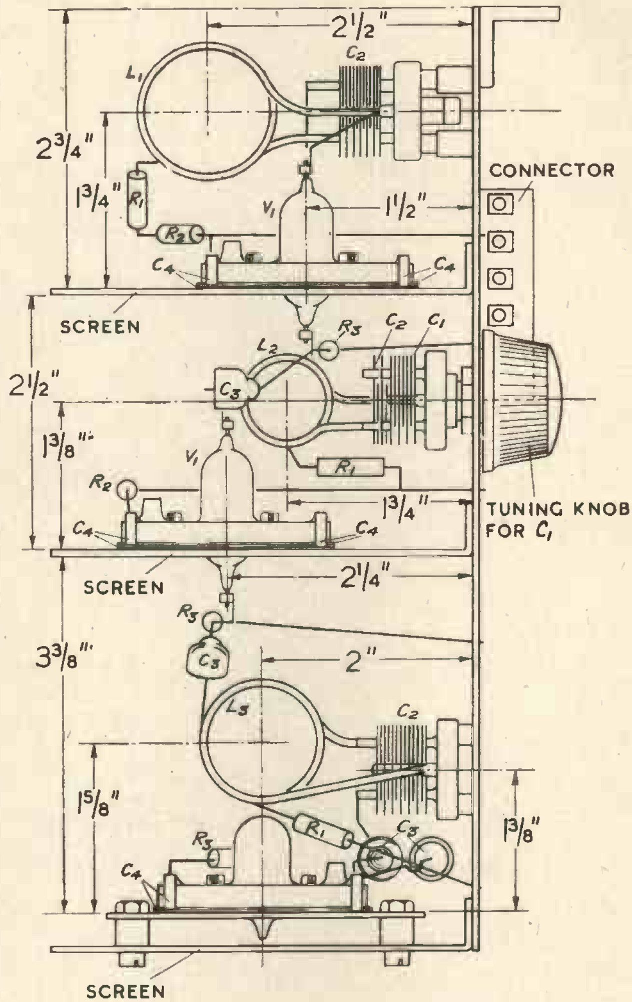


Fig. 4. *Side elevation of transmitter.*

adopted must, of course, be such that the appropriate formula for calculating the field can be applied without fear of error; and the absolute accuracy is ultimately dependent on the assumption that the thermojunction readings of aerial current are reliable.

The disadvantages of the radiation method are that two observers, one at the transmitter and one at the receiver, are required, and that a suitable site, which must be free from spurious signals producing noise, such as car ignition systems, may not readily be available.

6. Acknowledgments

The work described above was carried out as part of the programme of the Radio Research Board, to whom this paper was first circulated in August, 1942. It is now published by permission of the Department of Scientific and Industrial Research.

The methods of calibration described in the paper have been developed and improved over a considerable period, and the thanks of the authors are due to Messrs. B. J. Byrne, R. G. Chalmers, J. A. Lane and R. Oliver, for their assistance in various stages of the work, and in the application of the technique described to the testing of large numbers of special radio receivers.

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CORRESPONDENCE

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

Reform of Electrical Units

To the Editor, "Wireless Engineer"

SIR,—In his excellent plea for simplification of electrical units in the November issue, J. J. Durack writes "Practical units are too cumbersome for use in theory so at least two systems must remain until the practical system dies of senile decay." As all our resistance and inductance boxes, condensers and meters are calibrated in ohms, henrys, farads, volts, amperes or watts, or their multiples or sub-multiples, the event predicted by Mr. Durack is unlikely to occur for many generations. But is it true to say that practical units are too cumbersome for use in theory? An exhaustive study of the subject by G. A. Campbell (A Definitive System of Units, *Bulletin Nat. Res. Council*, 1933, No. 93, p. 48) justifies the opposite view.

By employing only units in common use, viz., the ampere, coulomb, volt, ohm, henry, farad, metre, kilogramme, second, joule, watt, which are realities to the student, and the corresponding unit of magnetic flux, viz., the volt-second, for which the name weber has been proposed, we obtain, as in the following Table, a system of equations which is simple and easily committed to memory.

The practical units are such that for air κ and μ have the numerical values 8.86×10^{-12} and 1.256×10^{-6} respectively, or, putting the units in evidence, 8.86 micromicrofarads per metre and 1.256 microhenrys per metre; for other substances the values are equal to the above multiplied by the specific inductive capacitance and specific permeability respectively.

Mr. Durack has dealt with the 4π aspect of the

	Maxwell's equations
(amperes/sq. metre $\mathbf{J} = \gamma\mathbf{E}$ (volts/metre)	
(coulombs/sq. metre) $\mathbf{D} = \kappa\mathbf{E}$ (volts/metre)	curl $\mathbf{H} = \dot{\mathbf{D}} + \mathbf{J}$
(webers/sq. metre) $\mathbf{B} = \mu\mathbf{H}$ (amperes/metre)	$-$ curl $\mathbf{E} = \dot{\mathbf{B}}$

Velocity of propagation of electro-magnetic waves .. .. .. $= 1/\sqrt{\kappa\mu}$ metres/second

Energy of electric field .. $= \frac{1}{2}\kappa E^2$ joules/cu. metre

Energy of magnetic field $= \frac{1}{2}\mu H^2$ joules/cu. metre

Poynting flux .. .. $\mathbf{S} = (\mathbf{E} \times \mathbf{H})$ watts/sq. metre

Force between electric charges Q, Q' coulombs .. .. $= \dfrac{QQ'}{4\pi\kappa r^2}$ newtons*

Force between magnetic poles Φ, Φ' webers .. .. $= \dfrac{\Phi\Phi'}{4\pi\mu r^2}$ newtons

* The newton is the force which gives to a mass of 1 kg. an acceleration of 1 metre per sec. per sec.

subject so well that there seems nothing to add to his remarks. In conclusion I venture to claim that universal adoption of the practical units, as proposed by G. Giorgi and G. A. Campbell, would benefit students and physicists as well as engineers.

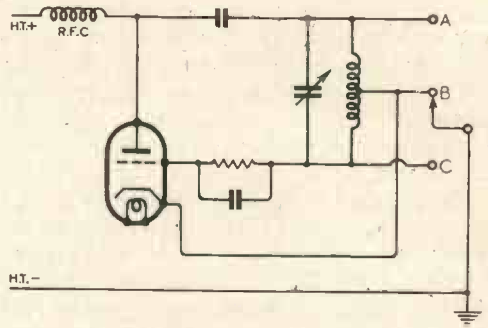
P. VIGOUREUX.

"Cathode-Coupled Oscillators"

To the Editor, "Wireless Engineer"

SIR,—In his article in the November issue, F. Butler gives the circuit of an earthed-grid oscillator (Fig. 3) for which he claims several advantages. The circuit, however, is only that of a tapped-coil Hartley.

Comparing my Figure, according to whether A, B, or C is earthed, the oscillator becomes a cathode-tap, earthed-cathode, or earthed-grid Hartley respectively. Since no other point of the circuit is at earth potential, this connection can have no effect on the operation. Furthermore, in



a cathode-tap Hartley, one side of the tuned circuit is earthed, and a reactance modulator can be connected across the entire tuned circuit.

M. FELIX.

London, S.E.19.

BOOK REVIEWS

Radio Receivers and Transmitters

By S. W. AMOS and F. W. KELLAWAY. Pp. 281 + x with 150 Figs. Chapman & Hall, 37–39, Essex St., Strand, London, W.C.2. Price 21s.

This book is intended to provide a bridge joining pure science and applied radio. It is not designed for the beginner, and an elementary knowledge of radio, electricity, and mathematics is assumed. It is pointed out in the preface that Amos is responsible for the radio engineering and Kellaway for the mathematics; they are both Honours B.Sc. graduates and the result of their joint effort is very satisfactory. One should not be misled by the title into assuming that such things as the propagation of radio waves are not dealt with. It is a book that can be unreservedly recommended to any serious student of the subject. The ten chapters are entitled: introduction; inductance; capacitance; resonant circuits; propagation and aerials; valves, a.f. amplification and detection; output stage, etc.; r.f. and i.f. amplification; oscillators, superheterodynes, television; transmitters, etc. There are eight appendices dealing with mathematical details. It is almost impossible in the first edition of a book of this type to attain perfection in the matter of symbols and nomenclature, but generally speaking the authors have reached a high standard. They confuse the abbreviations of milli and mega, using mc/s when they mean Mc/s; they misuse the plural and speak of 0.2 mms. and 0.15 cms.; they ring the changes between capacity and capacitance on the same page; they write mV but ma: they over-aspirate Reinartz by writing it Rheinhartz* on several occasions, and on p. 157 they confuse both in text and figure the vibrating reed with the pin by which the cone of the loudspeaker is fixed to it. A more serious matter is Fig. 116, where five methods of coupling are shown and the alleged value of the coupling coefficient is given for each; it is true that in the text on the next page it mentions that they are only approximate, but they are all obviously wrong, and it would have been very much better to have given the correct values. A student who had had one lesson on the subject would know that in the simplest case, $k = \frac{L_m}{L + L_m}$ and not $\frac{L_m}{L}$ as stated. This is a serious blot on an otherwise excellent textbook. The authors depart from the recommendations of the British Standards Institution when they refer to a circuit being capacitative instead of capacitive which is in keeping with resistive and inductive; it is true that a person may be inducted to an office and later incapacitated, but these things do not happen in electric circuits.

G. W. O. H.

* Twenty years ago wireless magazines contained numerous references to the Reinartz circuit; then in 1928 Palmer's "Wireless Principles and Practice" called it the Reinhartz circuit; now the authors call it the Rheinhartz circuit. Fortunately the process cannot go much further.

Elementary Statistics

By H. LEVY and E. E. PREIDEL. Pp. 184 + vii, with 29 Figs. T. Nelson and Sons, Parkside Works, Edinburgh, 9. Price 5s.

During this war quality control has proved of immense value in saving man-hours, and it is probable that many have used it with only a hazy idea of its fundamental principles. There will now be no excuse for ignorance, and the authors of "Elementary Statistics" deserve the thanks of all those who have to employ statistics in solving their problems. The book is written in a very lucid style, and is a pleasure to read for its own sake.

There are fifteen chapters, averaging about ten pages each, and every development is liberally illustrated by examples, answers to which are given at the end of the book with the index. A point which will appeal to engineers is that most of the theorems are developed from a particular example, and generalisation follows later. This is the reverse of the mathematician's normal approach to a problem. The first seven chapters call for a knowledge of algebra little higher than that of matriculation standard, and the remainder do not require a very wide knowledge of calculus.

Chapters 1 and 2 are mainly introductory and concerned with definition of terms. Chapters 3 and 4 deal with the best or average value for a set of measurements and the scattering or deviation of measurements about this value. Frequency of selection, the binomial distribution and size of sampling are the subjects of Chapter 5. There is a misprint on page 44, the expression for $N \ldots (N-r+1)/r!$ should be $N!/(N-r)!r!$. The term "size of sample" may confuse some and could better be called "size of sampling." The basis of the next chapter is the relation between the size of sampling and the accuracy of the conclusion to be drawn from the results. Chapter 7 takes a series of pairs of related measurements and shows how to draw the best line or curve giving least deviations for all the points. Measurement of trends of related readings having no unique relationship (for example, the heights and weights of people), the coefficient of correlation and its meaning are discussed in the eighth chapter. This is elaborated in Chapter 10 where the point is made that the coefficient of correlation has significance only in cases where some relationship between the readings is known to exist. Chapter 9 is a preliminary one on Probability, obviously leading up to Chapters 12 and 13 on Gauss's Law of Error, its properties and the distribution of errors about the mean. The eleventh chapter is in the nature of a diversion and deals with approximations to the exponential function and Stirling's approximate expression for $n!$ Here the brackets connected with the square root sign may be missed, the approximate expression for $n!$ (p. 127) is better written $e^{-n}n^n\sqrt{(2\pi n)}$. Chapter 14 outlines the basic principles of quality control, and the last is devoted to the limitations of normal statistical analysis, pointing out that a system of component parts each with a Gaussian Law of failure produces a quite different composite law of failure. A list of formulae would be a valuable finale to the book.

Radio engineers having either no knowledge of, or only a superficial acquaintance with, statistics will want to add this excellent five shillingsworth to their bookshelves.

K. R. S.

Radio Technique

By A. G. Mills. Pp. 170 + viii, with 301 Figs. Chapman & Hall, 37-39, Essex Street, Strand, London, W.C.2. Price 12s. 6d.

The author, who is an instructor at Battersea Polytechnic, states that his object is to present a complete, yet concise, collection of material not hitherto gathered together in one volume, paying special attention to the necessity for presentation in a straightforward manner and with a minimum of mathematics. He does not say why he chose the title "radio technique" which does not seem very appropriate for such a book. As the whole field from Ohm's law to pulse generators and squegging oscillators, including cathode-ray tubes and "Q" bars, is covered in 164 pages, very little space can be devoted to any one thing. For example, "the valve as a maintainer of oscillations," including eight diagrams of connections, is disposed of in two and a half pages. A more suitable title would have been "A smattering of radio" for the conciseness and the avoidance of mathematics and of explanation have been carried to such an extreme that one would hesitate to recommend the book to any serious student of the subject. It contains numerous mistakes. On p. 6 we are told that if a piece of platinoid wire connected across the terminals of a battery were shortened, "with each successive shortening it would get hotter. Alternatively, a piece of iron wire would eventually fuse if similarly shortened," but no explanation of the difference is given. Lower down on the same page "it follows that $\frac{EI \times 10^7}{4.2 \times 10^7}$ is equal to .24 calories, or $EI \times .24$ calories per second," which suggests that the author is somewhat at sea when trying to explain these fundamental principles. On p. 35 it is stated that "the Kelvin electrostatic voltmeter is usually enclosed in a glass cabinet in order to shield it from the electrostatic effect of any stray external charges." Something is wrong with the last line on p. 114 and the first line on p. 115. Fig. 39 shows a moving-iron instrument that could not possibly work, Fig. 50 shows a damped oscillation of a weird type, Fig. 84 shows an arrangement presumably for maintaining the screening grid at the H.T. potential and not at earth potential as stated, Figs. 157 and 158 are both obviously quite wrong. In the last sentence in the book we are told that "a trace is swept across the screen which *flys* back"—which fly's back ?

Books giving a smattering of a subject have their uses, but to write them successfully the author must have very much more than a smattering of the subject.

G. W. O. H.

The Simple Calculation of Electrical Transients

By G. W. Carter. Pp. 120 + viii, with 74 Figs. Cambridge University Press, 200, Euston Road, London, N.W.1. Price 8s. 6d.

This is essentially a mathematical book for engineers, emphasising as it does the importance of mathematics as a tool in the solution of many electrical problems, and illustrating each important step with a numerical example. The style is conversational but it is not carried to such lengths as to irritate the technical reader. Its level is about equal to that of the engineering degree standard of mathematics, but the presentation is clear and could be followed by those whose calculus is up to Higher School Certificate standard. To the radio engineer concerned only with sinusoidal voltage and current waveforms the book will have little appeal; those whose work includes an analytical examination of pulse generator and amplifier circuits, rectifier operation, etc., will welcome the book. There are seven chapters, five appendices and a useful bibliography of standard works on Heaviside's Operational methods.

Chapter I is introductory, defining the linear lumped impedances to which the analysis applies, and drawing attention to the correspondence between the Steinmetz function, $j2\pi f$, and the Heaviside Operator, p. Chapter II deals with transient conditions in the simplest RC circuit; the exponential form of voltage and current waveshape is derived from the integrating operator Q. The possibilities and pitfalls in regarding Q as a purely algebraic function and its relation to the Heaviside differentiating operator, p, are fully discussed, and a set of rules is formulated for the solution of first order differential equations. To the reader versed in the heuristic method and the particular and complementary solutions, the change-over to p and its relationship to Q discussed in Chapter III may be bewildering, and the author could with advantage draw attention to the fact that on page 18 $f(t)$ represents the particular and $f(o)$ the complementary solution. The danger of the use of the Heaviside operator, p, without full understanding of its function is well brought out here. The rest of the chapter is devoted to differential equations of higher order than the first, standard forms of the Heaviside operator, and the partial fractionalisation of complicated expressions containing p into standard forms. Chapter IV on the impulse excitation of circuits starts with the Heaviside unit function and shows how it may be used to build up a given shape of impulse. The implication at the bottom of page 41 that the mechanical rectifier passes reverse current and therefore simplifies the analysis is rather puzzling, and the reader is left rather abruptly "in mid air" at the bottom of page 47. The close connection between the operator p in the transient state and the function $j2\pi f$ in the steady state is used in Chapter V to show how particular problems can be greatly simplified. Circuits involving the solution of differential equations of the second and third order are examined in Chapter VI, which uses as practical examples the conditions of resonance, damping, self oscillation and motor speed control. Chapter VII is devoted entirely to practical examples such as the interruption of A.C. current, an earthing fault on a three-wire system, a lightning surge, six-phase rectification and the propagation of a surge voltage in alternator windings.

The five appendices deal with standard forms of the operator, p, the binomial theorem, trigonometrical formulae, derivatives and integrals, and the solution and properties of algebraic equations; by far the most important is the first, standard forms of the operator. The book can be thoroughly recommended to those radio engineers who have occasion to analyse non-sinusoidally excited circuits.

K. R. S.

"Radio Technology"

It is regretted the title of this book, by B. F. Weller, was misprinted in the review in last month's issue.

British Institution of Radio Engineers

THE meeting of the London Section of the Brit. I.R.E., to be held at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, at 6 o'clock on January 17th, will take the form of a discussion on "Television Standards."

L. Grinstead will give a paper on "Radio-Frequency Heating" at the Brit. I.R.E. Midlands Section meeting at the University of Birmingham (Latin Theatre), Edmund Street, Birmingham, at 6 o'clock on January 25th.

Marconi College

A. W. LADNER, who has been Principal of the Marconi School of Wireless Communication for many years, retired on December 31st. He had been in the service of the Marconi Company for 32 years and had filled the post of Superintendent of Instruction for 24 years. Mr. Ladner will continue to act in an advisory capacity. His place as College Principal has been taken by N. C. Stamford, who was previously with the Company and has since been on the Electrical Engineering teaching staff at Manchester University.

Dr. K. R. Sturley, who has been Assistant Principal of the College since 1940, is also leaving. He has been appointed to the new post of head of the engineering training department of the B.B.C.

Institution of Electrical Engineers

DR. R. L. SMITH-ROSE will open a discussion on "Frequency Allocation for Long-Distance-Communication Channels" at a meeting of the Radio Section of the Institution of Electrical Engineers to be held at Savoy Place, London, W.C.2, at 5.30 on January 16th.

A discussion on "High-Frequency Heating" will be opened by H. Wood and J. F. Capper at a meeting of the North-Western Centre Radio Group to be held at the Engineers' Club, Albert Square, Manchester, at 6 o'clock on January 26th.

Institution of Electronics

A MEETING of the North-West Branch of the Institution will be held at 7.30 on Friday, February 2nd, at the Reynolds Hall, College of Technology, Manchester, when D. Besso and H. Brown will give a lecture on "Neon Stroboscopic Lamps," with special reference to lamps of the cold-cathode type. The lecture will be followed by a demonstration.

Non-members may obtain tickets on application to L. F. Berry, 14, Heywood Avenue, Austerlands, Oldham, Lancs.

The Television Society

A JOINT meeting of the Television Society and the Radio Section of the I.E.E. will be held at Savoy Place, London, W.C.2, at 5.30, on January 24th, when D. G. Fink, of our U.S. contemporary *Electronics*, will deliver a paper on "American Television Broadcasting Practice, 1927–1944." Tickets of admission for non-members of the Society can be obtained on application to the Lecture Secretary, G. Parr, 68, Compton Road, Winchmore Hill, London, N.21.

A Note on
ELECTRONIC NEGATIVE RESISTORS*

By J. R. Tillman, Ph.D., A.R.C.S.

Introduction

IN 1935 Herold[1] summarised clearly the available knowledge of the fundamental properties of negative resistors. In classifying the known types of these resistors he acknowledged the distinction, already made by earlier workers, between voltage- and current-control, and showed how phenomena established for one class could be converted to analogous phenomena for the other. (Where the d.c. or static characteristic of the device is obtainable, or its equivalent deducible, the term voltage-controlled is used if there is a unique current for any given applied voltage, and current-controlled if there is a unique voltage for any given applied current). He drew attention to possible figures of merit for negative resistors and, in pointing out that these resistors are not the complete reverse of positive resistors, to the misleading, but well established, words " negative resistance."

Electronic devices of the voltage-controlled type have received most attention in more recent investigations, largely because they have a considerable number of useful applications as negative resistors, e.g., as driving circuits for oscillators. But the published data for these electronic " negative resistors " are still incomplete or inaccurate in several respects. Modified dynatrons and modified transitrons have received little attention; the negative resistor produced by suitably coupling the input and output circuits of a highly degenerated amplifier has been neglected outside the U.S.A., and the erroneous impressions given by Chakravarti have remained uncorrected. This note is intended to clarify some aspects of the subject and to draw attention to those others on which further work is needed. The results of some measurements left incomplete in 1941, on the negative resistance of dynatrons and transitrons are given and are followed by some data for the degenerated amplifier with input and output coupled together. The subsequent discussion deals also with other properties of these negative resistors. Stress is laid throughout on the degree of stability of the characteristics. The criteria suggested for goodness factors apply only to voltage-controlled negative resistors; but a study of Herold's paper will show how they can be converted for use with the other class.

* MS. accepted by the Editor, October, 1944.

1. Negative Resistance of the Dynatron

(a) Factors affecting Stability

The dynatron depends for its long term stability of negative resistance, $-R_N$, on the stabilities (i) of the coefficient of secondary emission of the inner wall of the anode and (ii) of the cathode emission. Few measurements have been made on this stability, although the dynatron has been widely used with fair satisfaction. Provision is usually made, however, in practice, for the readjustment of one or more electrode potentials, in order that, in effect, some particular value of R_N can be maintained.

The variations of R_N with changes of power supply voltage are the main factors determining the short period stability; results of measurements made of these variations are now given. Those of another investigator, which are not confirmed, are briefly discussed.

(b) Measurements of Negative Resistance

The valve most thoroughly investigated was the S4VB, a now obsolete tetrode, which has for many years proved very suitable for use as a dynatron in oscillators. When one sample was connected as shown in Fig. 1(a), the results shown in Fig. 2* were obtained. The measurements were made with an a.c. (800 c/s) bridge, the a.c. voltage applied to the dynatron never exceeding one. Other samples gave similar results,

* Both Fig. 2 and Fig. 4 show only one curve for each of the variables V_H, V_{G1}, V_{G2}, etc., i.e., each curve relates to only one set of fixed values of the voltages applied to the other electrodes. Other sets of values, not too far removed from these, were tried and found to give curves of similar shapes.

though the minimum values found with $V_{G1} = -1.5$ ranged between 25,000 and 60,000 ohms. A few measurements made on

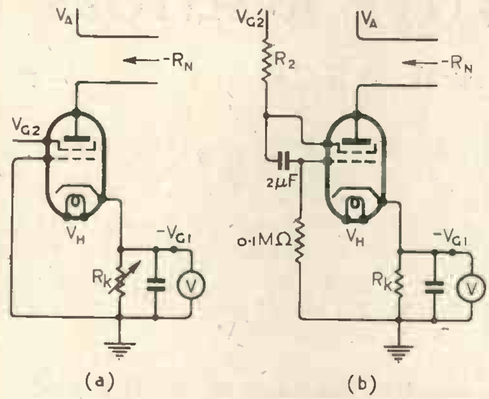


Fig. 1. *The dynatron.* (*a*) *Normal,* (*b*) *Modified.*

the SP41, the SP210 and the V257 (all with the suppressor grid, G_3, strapped to the screen grid, G_2) gave similar qualitative results.

Chakravarti has made several statements about the variation of R_N of a dynatron with changes of supply voltages. Thus[2] " . . . it can be said (*of the SG*215) that the variation of a.c. resistance of a new tube at a given frequency is negligible up to a 4 per cent. change in plate voltage, a 4.6 per cent. change in filament current (I_f) and 3.3 per cent. change in screen grid voltage, and that the variation for an old tube is similar . . ." If V_A and V_{G2} are obtained from a common supply, V_{G1} being fixed or obtained from a cathode resistor, it is admittedly possible to adjust these two voltages so that a small change in the overall voltage of the common supply has very little effect on the value of R_N ; it is another matter, however, to imply, as does Chakravarti, that R_N is, in general, independent of V_A and V_{G2}. That he should not have noted any worthwhile change of R_N with a change of I_f of 4.6 per cent. (presumably measured to 0.1 per cent.) is even more surprising ; some measure of the accuracy of this author's work may be gauged from the fact that both the V257 and the SP210 (valves similar in most respects to the SG215) show changes of R_N of about 3 per cent. for this change of I_f.

(*c*) *A Modified Dynatron*

Since a secondary property of the tetrode dynatron is its positive value of

$$\left(\frac{dI_{G2}}{dV_A}\right)_{V_{G1},\ V_{G2}\ \text{const.}}$$

it is possible by suitably coupling G_1 to G_2 and inserting a resistive load in their common circuit (see Fig. 1(b)) to reduce R_N. When V_A is increased causing I_A to reduce, I_{G2} is increased and V_{G2} and V_{G1} are both lowered. The decrease in V_{G1} reduces the total cathode current and therefore causes an additional decrease of I_A. Because the initial tendency for I_{G2} to rise is largely offset by the decrease occurring when V_{G1} falls, the additional reduction in I_A is severely limited, as was found experimentally (see curves *B* of Fig. 2(a) and (c), obtained with $R_2 = 1000\Omega$). If the G_1-G_2 circuit load is simply a resistance, the increased voltage required to supply the G_2 circuit would, had it been applied directly to G_2, have produced most of the reduction

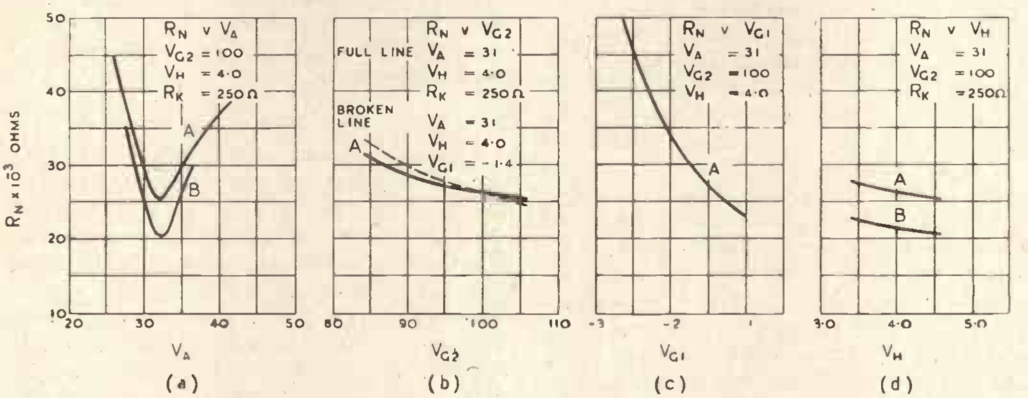


Fig. 2. *The negative resistance of the dynatron* (*S4VB*) (*a*) *Normal* (*see Fig.* 1(*a*)), (*b*) *Modified* (*see Fig.* 1(*b*)), *with* $R_2 = 1000\Omega$.

obtained in R_N. It seems clear that variations in R_N with changes of supply voltages are as pronounced for the modified dynatron as for the prototype.

2. Negative Resistance of the Transitron

(*a*) *Factors affecting Stability*

The long term stability of negative resistance of the transitron depends almost entirely on the stabilities of the cathode emission and of the geometry of the valve; it should be high for a well constructed valve whose cathode emission is adequately maintained for long periods (e.g. AC/S2 Pen, SP41, EF50). The variation of the coefficient of secondary emission of the anode, and even that of G_2, such as occurs over long periods of use of a valve, may play a small part. The secondary electrons, though returning to the electrode from which they originated, have a small influence on the electric field in the neighbourhood of G_3, which determines the distribution of the primary electrons between G_2 and A. As with the dynatron, the short period stability is largely a function of the variation of supply voltages.

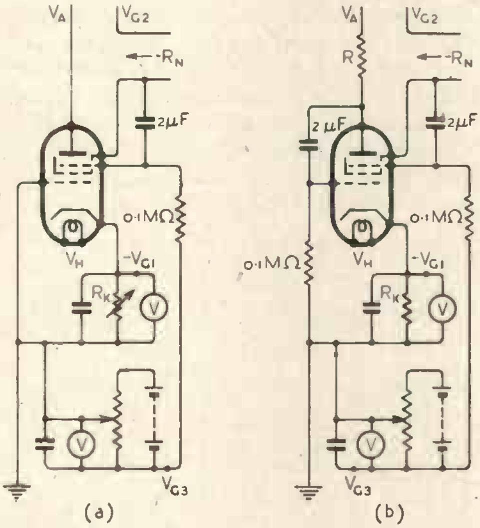


Fig. 3. *The transitron.* (*a*) *Normal,* (*b*) *One application of Patent No.* 533241.

(*b*) *Measurements of Negative Resistance*

Measurements were made on the SP41, connected as shown in Fig. 3(a), with a bridge similar to that used for the measurements on the dynatron. Fig. 4 shows the results obtained for one valve (full lines). Tests on two other samples gave similar results.

Chakravarti[2] and Pinciroli[3] have made measurements on other valves. The former, without giving any precise data, states that the variation of R_N is negligible with small (5 per cent.) changes of supply voltage. The latter shows curves for the EF6 which agree qualitatively with those of Fig. 4; the conditions he used when V_{G2} was varied involved a fixed value of V_{G1} (a more fundamental but often less practical condition than the use of a cathode bias resistor) and accounts for the value of R_N he obtained being fairly constant with increase of V_{G2} above a certain value, below which, however, it rose much as in the left-hand side of Fig. 4(c). Pinciroli gives no data for the variation of R_N with changes of heater voltage.

(*c*) *Modified Transitrons*

During the above measurements on the SP41, it was noted that the value of R_N was reduced if the large capacitor connected across the cathode resistor was removed; a set of measurements was made with this changed condition. The results are included in Fig. 4 (dotted lines). This effect, the explanation of which is given in the Appendix, is peculiar because the removal of such a capacitor is normally associated with degeneration and an improvement in stability.

British Patent No. 533 241, with which the name of Herold is associated, claims that by the application of feedback to G_1, R_N of a transitron can be reduced. One method is shown in Fig. 3(b); others differ in the methods of applying the necessary voltages to the electrodes. Tests made on the SP41 used above showed the validity of the claim. Thus with $R = 1000\Omega$, $V_A = 31$, $V_{G2} = 108$ and $V_{G3} = -6.5$, R_N was 2000Ω. The changes in this value of R_N when V_H was decreased from 4.0 to 3.5 volts and increased from 4.0 to 4.5 volts were + 18 per cent. and − 10 per cent. respectively. Changes in the voltages applied to the other electrodes had effects similar to those shown in Fig. 4.

Pinciroli[3] describes several modifications (other than the use of a series or shunt resistor) which give control of R_N even when all the electrode potentials are fixed (preferably at those values which give maximum stability of R_N with small changes of these voltages). Of these, only one, almost identical with the above application of Herold's patent (compare Pinciroli's Fig. 8(c) with Fig. 3(b) here) gave any reduction in R_N. With it, Pinciroli obtained a value of R_N of 500 ohms, only one-seventh of that of the original.

3. Amplifier with Input and Output Circuits Coupled

The amplifier with input and output circuits coupled is commonly used as a negative resistance in the form of a driving circuit for oscillators. With some forms of amplifier the stability of R_N (with changes of supply voltages and ageing of valves) is poor. Thus consider the amplifier of Fig. 5, the switch S being in position 1. The gain of the amplifier, μ, is $g^2R_1R_2$ over the range of frequency for which the inter-electrode capacitances are negligible, provided the various coupling condensers are sufficiently large, where R_1 and R_2 are the *net* anode loads of the two stages and g is the mutual conductance of either valve (assumed to be identical). Then the negative resistance measured between terminals A and $B \simeq \frac{R_{PF}}{\mu}$ assuming $R_{PF} \gg R_{L2}$ and $R_{a1} \gg R_N$. $\delta R_N/R_N$ is therefore $\simeq -2\,\delta g/g$.

However, with the switch thrown to position 2, the stability improves. The overall gain is reduced to M, where $M = \frac{\mu'}{1+\mu'\beta}$, μ' being $g^2R_1R_2/(1+gR_K)$ and differing from μ because the method of applying overall feedback necessarily involves some local series negative feedback in the circuit of V_1, and $\beta = \frac{R_K}{R_K + R_{NF}}$. R_N is now increased to $\frac{R_{PF}}{M-1}$. It is easy to show that, assuming $gR_K \simeq 1$ (as it normally is for H.F. pentodes correctly used),

$$\frac{\delta R_N}{R_N} \simeq -\frac{3}{2\mu'\beta}\cdot\frac{\delta g}{g} \simeq -\frac{3}{\mu\beta}\cdot\frac{\delta g}{g}$$

Hence the stability of R_N, after negative feedback has been applied, is $2\mu\beta/3$ times better than before. Thus the short term stability, largely a function of the change of g with changes of supply voltage, is calculable; for the relationship between the mutual conductance of a modern amplifying valve, used with cathode bias as in Fig. 5, and supply voltages can be expressed, over the normal working range, by

$$\frac{\delta g}{g} \simeq K_1\frac{\delta V_{g2}}{V_{g2}} + K_2\frac{\delta V_H}{V_H}$$

where K_1 is about 0.5 and K_2, during, say, the first 10,000 hours of life of the valve, is $\not> 0.3$. If V_{g2} is less than the overall supply voltage, V_B, and is obtained from it by means of a series resistor R_{g2}, $\frac{\delta V_{g2}}{V_{g2}}$ will be $< \frac{\delta V_B}{V_B}$. The long term stability, besides containing the term $-\frac{3}{\mu\beta}\cdot\frac{\delta g}{g}$ where δg is the change of g with ageing of the valves, contains the terms

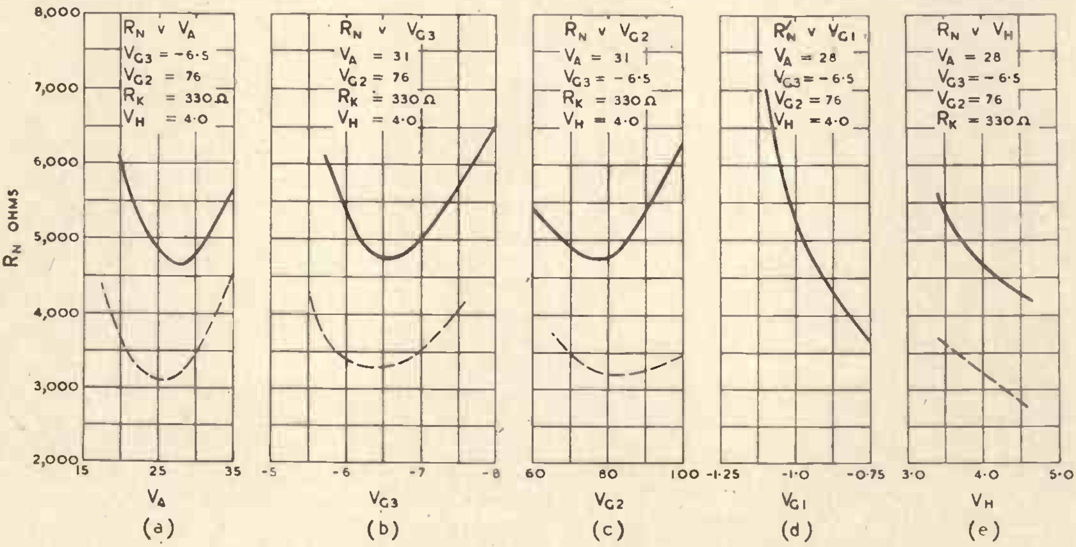


Fig. 4. *The negative resistance of the transitron (SP41).*

$-\frac{\delta\beta}{\beta}$, which is $\simeq \frac{\delta R_{NF}}{R_{NF}} - \frac{\delta R_K}{R_K}$, and $\frac{\delta R_{PF}}{R_{PF}}$. If wire-wound resistors, or others of comparable stability, are used for R_K, R_{NF} and R_{PF}, these terms can be ignored.

A negative resistor of this type, suitable for use at frequencies up to 20 kc/s, can conveniently use the EF36 valve. μ is easily made 2500 (no inductance L, is needed). By making $R_{NF}/R_K \simeq 100$, high stability of R_N is obtained; the rate of change of R_N is then not greater than one-tenth that of the supply voltage.

For use at higher frequencies, the SP41, EF50 or RL7 should preferably be used. The following values of components apply if the maximum frequency is to be 1 Mc/s. If no inductance compensation is used, i.e. $L = 0$ (see Fig. 5), R_{L1} should be about 2000 ohms and R_{L2} in parallel with $R_{NF} + R_K$ equivalent to about 5000 ohms* giving $\mu \simeq 400$. R_{NF}/R_K can now be about 40, giving good stability for R_N. If some inductance compensation is used, say $L = 0.2$ mH, R_{L1} can be increased to 4000 ohms, thereby increasing μ and the stability of R_N twofold. For use at frequencies above 1 Mc/s the anode loads must be reduced progressively, but the amplifier can have more stages or consist of two or more amplifiers (each with its own negative feedback applied), connected in cascade.

Brunetti and Greenough[4] have investigated this type of negative resistor experimentally in detail.

Their two stage amplifier used a 6J7 and a 6L6 valve (the use of such a high-anode-current valve as the 6L6 seems unnecessary however); they showed that it was possible to give R_N any value between 1 ohm and ∞. The stability was that to be expected from the above analysis for values of $R_N > 100$ ohms, becoming poorer, due to effects ignored above, e.g. the shunting of R_{L2} by R_{PF}, as R_N was reduced. Terman, Buss, Hewlett and Cahill[5] have also drawn attention to this very stable form of negative resistor.

Any of the particular examples of this device given above are many times more stable than the amplifier described by Chakravarti, and used by him to judge, unfavourably, this type of negative resistor.

* It is permissible to make this value $> R_{L1}$ because the capacitance shunting it is less than that shunting R_{L1}.

4. Comparison of the Properties of the Three Types of Negative Resistor

(a) *Range of Values Obtained and Methods of Controlling R_N*

Each type of resistor can be made to give, without difficulty, any value of $R_N > 100{,}000$ ohms. The minimum value obtainable, however, differs from one type to another. In the case of the dynatron, it is limited by the rate of change of the secondary emission coefficient with change of primary voltage and by the magnitude of the cathode current. For the S4VB with a cathode current of about 6 mA, it is $\not< 20{,}000\ \Omega$. A small "battery" H.F. pentode (tetrode connected) would probably not give a value $< 50{,}000\ \Omega$; on the other hand a large output valve might well give a value as low as $5{,}000\ \Omega$. R_N is best controlled by change of V_{G1} (via the cathode bias resistor if used).

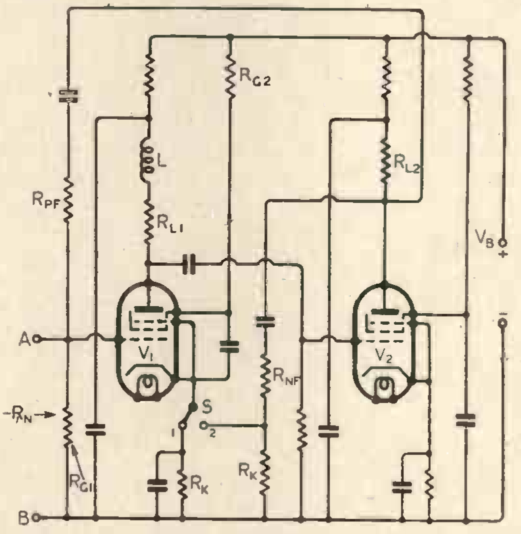


Fig. 5. *Amplifier with input and output circuits coupled.*

A high slope H.F. pentode used as a transitron, with a cathode current of about 4 mA, has a minimum value of R_N of about $4{,}000\ \Omega$. A valve such as the V872,† in which $\frac{dI_A}{dV_{G3}}$ and hence $\frac{dI_{G2}}{dV_{G3}}$ has deliberately been made relatively large, and some output pentodes will give considerably lower values. R_N is best controlled by change of V_{G1} or as suggested by Pinciroli[3]. Herold's modifica-

† Thus with $V_{G2} = 85$, $V_{G1} = -1.5$, $V_A = 25$ and $V_{G3} = -1$, R_N is about 800Ω for this valve, the cathode current being about 5 mA.

tion to the normal transitron allows of smaller values of R_N being obtained, e.g. 500 Ω.

The third type of negative resistor has been shown by Brunetti and Greenough to be capable of values as low as 1Ω. R_N is best controlled by R_{PF}.

When, as is usual, negative resistors are used in alternating current circuits, their values of resistance can be transformed in the same way as are those of positive resistors, the practical limitations being very little more severe. This method of extending the range of values of R_N is to be preferred to that of adding (either in series or parallel) a positive resistor, for the latter method results in loss of stability. The series addition has been used by Chakravarti[6] to reduce a value of R_N of 50,000 Ω to one of 1,000 Ω; a 2 per cent. variation in R_N then meant a 100 per cent. change in the net value of his combination. Moreover because none of the original devices is purely resistive in nature, (see Section 4(d)), the phase angle of the combination of a negative and a positive resistor in series, is greater than that of the original "negative resistor"; for it is easy to show that when such a device, considered as a negative resistance, $-R_N$, in parallel with a capacitance, C, has placed in series with it a resistor of value R_P, the equivalent parallel resistor (R') — capacitor (C') combination is given by

$$\frac{R'}{1 + \omega^2 C'^2 R'^2} = R_P - \frac{R_N}{1 + \omega^2 C^2 R_N^2}$$

and

$$\frac{C'R'^2}{1 + \omega^2 C'^2 R'^2} = \frac{CR_N^2}{1 + \omega^2 C^2 R_N^2}$$

where $\frac{\omega}{2\pi}$ is the frequency being used.

If now both $\omega^2 C^2 R^2$ and $\omega^2 C'^2 R'^2$ are $\ll 1$, $R' = R_P - R_N$ (the obvious result) and $C' = \left(\frac{R_N}{R'}\right)^2 C$, i.e. the angle of the overall impedance is $\frac{R_N}{R_N - R_P}$ times that of the negative resistor. Herold[1] has already given this result; because it deserves more prominence than it has so far received, the calculation has been given rather more fully here. Another detrimental effect resulting from the addition of a series positive resistor has been noted by Brunetti[7]. The parallel addition also gives an impedance whose angle is greater than that of the original negative resistor.

(b) Stability of the Value of R_N

The relative stabilities of the three types for changes of supply voltages are seen by comparing Figs. 2 and 4 and the data given by Brunetti and Greenough. The third type is obviously superior to the other two, though, if the voltages applied to the electrodes have certain values and a cathode bias resistor is used, even the dynatron or transitron can be made to give a value of R_N which is substantially independent of small changes of these voltages (those of the heater voltage being excepted).

R_N of the third type of negative resistor is little affected by sample-to-sample change of valve, a feature not shared by the other two.

(c) Linearity of the Negative Resistor

The linearity of R_N with respect to applied voltage, V_0, differs, both qualitatively and quantitatively, from one type to another. The dynatron and transitron are both linear to say 1 per cent. if the applied voltage is kept small (possibly up to 1 volt for the transitron* and up to several volts for the dynatron). As the applied voltage is increased the linearity deteriorates, gradually at first, and then more and more rapidly. The third device can be made extremely linear for small inputs; the greater $\mu\beta$ (the practical limit is normally considerably $< \mu$ however), the more exact the linearity. This linearity is well maintained up to a certain value of applied voltage, but once this critical value is exceeded, the linearity deteriorates rapidly.

It is misleading to judge (as Chakravarti[2] has done) the usefulness of a negative resistor as a linear device merely from considerations of the maximum voltage V_M that can be applied without the non-linearity exceeding some particular value. A better comparison would be based on the values of V_M^2/R_N, if only because with the aid of a $1:n$ transformer, $V_M \rightarrow nV_M$ and $R_N \rightarrow n^2 R_N$, giving the same value of V_M^2/R_N. No importance attaches to a precise value of V_M^2/R_N unaccompanied by equally precise data for the non-linearity present; but it would seem that values up to the order of 0.003 watt are possible for all three types with non-linearity $\not> 5$ per cent.; no investigation of this point has been made, however.

* Much less for a valve having a short suppressor grid base such as the V872 mentioned earlier.

(d) Capacitance, C, of the "Negative Resistor"

The reactive components of the dynatron and transitron are, at frequencies up to at least several megacycles/sec, capacitive; the effects of the finite electron transit time and of the inductance of the electrode leads become important only at higher frequencies. The "cold" capacitance between the anode A and all the other electrodes is a good approximation to the dynamic capacitance of the valve used as a dynatron (being about 7 $\mu\mu$F in the case of either the S4VB or SP41) and that between $G_2 + G_3$ and all the other electrodes a fair approximation in the case of the transitron (being about 20 $\mu\mu$F for either the AC/S2 Pen or SP41). Francini[8] has investigated the value of C of the transitron in some detail; he found, as might be expected, that the value was much smaller for acorn valves than for more conventional types. The third type of negative resistor can, if the amplifier introduces little or no phase shift, have a much smaller reactive component, of which the main contribution comes from the input capacitance, C_I, of the amplifier. If G_2 of V_1 is coupled to K via a large valued capacitor (as shown in Fig. 5), C_I can, because nearly all the grid capacitance of the valve is included in the feedback loop, be as low as 2 $\mu\mu$F. If, however, G_2 is coupled to earth, $C_{G1/G2}$ falls outside the loop and appears directly in C_I, whose minimum value is now about 6 $\mu\mu$F. The contribution to C made by the output capacitance C_0 of the amplifier is small; for although C_0 is many times the anode capacitance of the second valve by reason of the application of parallel negative feedback, its effect is small provided $1/R_{PF}$ is much smaller than the output conductance of the amplifier (which is many times $\left\{\frac{1}{R_{L2}} + \frac{1}{R_{NF} + R_K}\right\}$ for the same reason). In most practical cases this contribution to C is < 0.1 $\mu\mu$F.

If the amplifier introduces a large phase shift (thereby showing it to be incorrectly designed for the present purposes) another appreciable reactive component will be present.

The important criterion in this connection is, however, rarely that of the smallness of C, but more often that of CR_N. Herold[1] considered $\frac{1}{\omega CR_N}$ to be one figure of merit for devices of the voltage controlled type. The superiority of the third device is then clearly seen; and the transitron is not inferior to the dynatron.

The stability of C with changes of supply voltages has received little or no attention. Baker's[9] measurements on the change of dynamic anode capacitance of a triode are valuable, but the valve was not functioning as a dynatron during the measurements. When data are available, the smallness of $R_N\delta C$ should be taken as the criterion of goodness of the device, rather than that of δC, where δC is the change of C for some given change of supply voltage. While the transitron may be expected to give a value of δC greater than that given by the dynatron, its value of $R_N\delta C$ may well be no larger.* The third type of device should give much smaller values, both of δC and $R_N\delta C$.

(e) Range of Frequency over which the Negative Resistors can be used

Both the dynatron and transitron have been used at frequencies from zero up to several Mc/s, but their performance at the higher frequencies has not been fully investigated. The highest frequency at which the third type retains its audio frequency properties is set largely by the maintenance of the gain, μ, with increasing frequency. A two-stage amplifier of the type shown in Fig. 5 using high-slope H.F. pentodes and suitable inductance compensation will maintain a value of μ of 100 to within 30 per cent. for frequencies up to 5 Mc/s. Then with $\beta = 1/10$, values of R_N as low as 500 ohms with good stability are easily possible. The lowest useful frequency is set by the maximum practical values of the various coupling condensers.

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* Experiment shows that for an oscillator using an inductor of $Q \simeq 120$, a tuning capacitor of about 1500 $\mu\mu$F and a dynatron so adjusted that oscillation was only just maintained at the lowest value of heater voltage, V_H, used (R_N being then about 150,000 ohms), the change of frequency accompanying a 10 per cent. change of V_H corresponded to $\delta C = 0.01$ $\mu\mu$F, 0.02 $\mu\mu$F or 0.035 $\mu\mu$F, according to whether the valve used was respectively the S4VB, the AC/S2 Pen or the SP41 (G_3 strapped to G_2 for the pentodes).

With a resonant circuit of similar properties used in a transitron oscillator, similarly adjusted ($R_N \simeq 15{,}000$ ohms), the equivalent δC was 0.06 $\mu\mu$F for the AC/S2 Pen and 0.17 $\mu\mu$F for the SP41. Unfortunately this experiment does not allow of definite conclusions being drawn regarding δC, because a considerable proportion of the frequency changes noted may have been due to changes of harmonic content accompanying changes of R_N.

5. Conclusions

While the dynatron and transitron still have their uses, only the negative feedback amplifier, with input and output circuits coupled, should be used for precision negative resistors. The advantages of this type over the other two include the relative independence of R_N of changes of both supply voltages and valves, lower minimum value of R_N without recourse to measures which greatly reduce stability, lower valued susceptance and better linearity. Its disadvantages, the use of two (more if it is to be suitable for use at very high frequencies) valves instead of one and unsuitability at and near zero frequency are for this, and many other purposes, unimportant.

More data are required to complete the characteristics of the three devices. In particular, further information is required regarding the accompanying reactive component.

Acknowledgment

The author wishes to thank the Engineer-in-Chief, G.P.O., for permission to publish this note.

APPENDIX

Explanation of the effect found when the condenser, bypassing the cathode resistor of a transitron, is removed.

Let $\dfrac{dI_K}{dV_{G1}} = g'$ and $\left(\dfrac{dV_{G2}}{dV_{G1}}\right)_{I_K \text{ const.}} = -\mu'$. For the SP 41 used as a transitron with $I_K = 5$ mA, $g' \simeq 4$ mA/V and $\mu' \simeq 80$. Further, suppose that when the voltages applied to the various electrodes are V_{G1}, V_{G2}, V_{G3} and V_A as shown in Fig. 3(a), the total cathode current is shared so that $I_{G2} = \rho I_K$ and $I_A = (1 - \rho)\, I_K$. Suppose V_{G2} is increased by δV_{G2} during part of an alternating current cycle. Then I_K will increase by $I_K = \delta V_{G2} \,.\, g'/\mu'$ if V_{G1} is kept constant, i.e. R_K is suitably bypassed. At the same time V_{G3} rises by δV_{G2} and the current will be shared differently between I_{G2} and I_A. Suppose G_2 now receives ρ' of the whole. I_{G2} will be $\rho'(I_K + \delta I_K)$, i.e., δI_{G2} will be $(\rho' - \rho)\, I_K + \rho' \delta I_K$. This must be negative for a transitron.

If R_K were not bypassed the increase of V_{G2} would cause I_K to increase by ΔI_K given by

$$\Delta I_K = \delta V_{G2} \,.\, g'/\mu' - \Delta I_K\, R_K \,.\, g'$$

i.e. $\Delta I_K\,(1 + R_K g') = \delta V_{G2}\, g'/\mu' \quad \therefore\ \Delta I_K < \delta I_K.$

Since $\dfrac{\Delta I_K \,.\, R_K}{\delta V_{G2}} = \dfrac{g' \,.\, R_K}{\mu'} \,.\, \dfrac{1}{(1 + R_K g')}$ which is $< 1/\mu'$, the rise in the cathode voltage, $\Delta I_K \,.\, R_K$, must be small compared with δV_{G2} and the net increase in V_{G2} and V_{G3} (with respect to the cathode). is very nearly as much as before.

$\therefore\quad \Delta I_{G2}$, the new increase in I_{G2}, will be

$$\simeq \rho'(I_K + \Delta I_K) - \rho I_K$$
$$\simeq (\rho' - \rho) I_K + \rho' \Delta I_K$$

$\therefore\quad \Delta I_{G2} < \delta I_{G2}$, but since δI_{G2} is negative

$$|\Delta I_{G2}| > |\delta I_{G2}| \quad \text{and} \quad \therefore \left|\frac{\delta V_{G2}}{\Delta I_{G2}}\right| < \left|\frac{\delta V_{G2}}{\delta I_{G2}}\right|$$

as was found experimentally.

REFERENCES

[1] Herold, *Proc. I.R.E.*, Vol. 23, p. 1201 (1935).
[2] Chakravarti, *Phil. Mag.*, Vol. 30, p. 294 (1940).
[3] Pinciroli, *Alta. Freq.*, Vol. 10, p. 644 (1941).
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[5] Terman, Buss, Hewlett and Cahill, *Proc. I.R.E.*, Vol. 27, p. 649 (1939).
[6] Chakravarti, *Phil. Mag.*, Vol. 23, p. 897 (1937).
[7] Brunetti, *Proc. I.R.E.*, Vol. 27, p. 93 (1939).
[8] Francini, *Alta. Freq.*, Vol. 10, p. 661 (1941).
[9] Baker, *Journ. I.E.E.*, Vol. 73, p. 196 (1933).

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

563 351.—Construction and mounting of the stylus used for cutting home-made gramophone records.

Philco Radio and Television Corporation (assignees of I. L. Stephan). Convention date (U.S.A.) 7th January, 1942.

563 595.—Two-part microphone wherein undesired local background noise is balanced out, leaving the transmitted signal free of such interference.

F. C. Beekley. Convention date (U.S.A.) 26th December, 1941.

DIRECTIONAL WIRELESS

563 007.—Aerial system for transmitting a clear-cut navigational course, by means of overlapping beams, with a minimum of undesired reflection and re-radiation.

Standard Telephones and Cables Ltd. (assignees of A. Alford). Convention date (U.S.A.) 7th November, 1939.

563 075.—Aerial system, comprising four units set at the corners of a square, for radiating four separate navigational courses from a beacon station.

Standard Telephones and Cables Ltd. (assignees of A. Alford). Convention date (U.S.A.) 19th October, 1939.

563 076.—Short-wave beacon installation in which the carrier frequency is deliberately wobbled in order to prevent the course indications from being blurred by local reflection or re-radiation.

Standard Telephones and Cables Ltd. (assignees of A. Alford). Convention date (U.S.A.) 11th October, 1939.

563 393.—Radio marker beacon with an aerial system comprising two arrays arranged to project a vertically-directive beam.

Standard Telephones and Cables Ltd. (assignees of

A. G. Kandoian). *Convention date* (*U.S.A.*) *25th March*, 1942.

563 493.—Folded-wire directional aerial, the reception sensitivity of which, in a given plane, increases uniformly with angular deviation over a given sweep.

E. C. Cork. Application date 23rd September, 1940.

563 522.—Utilising the skin effect in a high-mu nickel-iron alloy to indicate the direction of the Earth's, or any other, magnetic field, say for navigational purposes.

H. Hughes and Son Ltd.; E. P. Harrison; and A. J. Hughes. Application date 29th April, 1943.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

562 990.—Compensating for the effect of temperature variations on the gain-control filter circuits used in a carrier-wave signalling system employing an A.G.C. pilot frequency.

Automatic Telephone and Electric Co. Ltd.; P. E. Cowley; and E. C. Walls. Application date 20th January, 1943.

562 993.—Increasing the selectivity and signal-to-noise ratio, in a receiver for frequency-modulated signals, by utilising a locked-in harmonic generator.

Marconi's W.T. Co. Ltd. (*assignees of G. L. Beers*). *Convention date* (*U.S.A.*) *12th February*, 1942.

563 034.—Combination of a limiter with A.V.C., particularly for preventing the overloading of a receiver when used for inter-communication between aircraft flying in close formation.

Standard Telephones and Cables Ltd.; J. D. Holland; and D. D. Robinson. Application date 22nd January, 1943.

563 146.—Tuned R.F. couplings of the transmission-line type, adjustable over a wide frequency range.

Hazeltine Corporation (*assignees of L. R. Malling*). *Convention date* (*U.S.A.*) *3rd March*, 1942.

563 197.—L-shaped chassis construction to facilitate the mass production of compact mobile wireless sets.

Standard Telephones and Cables Ltd. and G. Newton. Application date 28th January, 1943.

563 220.—Control unit for stabilising the operation of thermonic valve circuits against fortuitous fluctuations in the supply voltages.

Standard Telephones and Cables Ltd. and M. M. Levy. Application date 29th January, 1943.

563 222.—Means for deriving variable grid-biasing voltages from a fluctuating voltage supply in order to stabilise the operation of valve oscillators or amplifiers fed from that supply.

Standard Telephones and Cables Ltd. and M. M. Levy. Application date 29th January, 1943.

563 377.—Assembly of condenser vanes and inductances arranged to give four wave-band changes in one complete rotation, without using a contact-closing switch.

Marconi Instruments Ltd. and E. Garthwaite. Application date 7th January, 1943.

563 464.—Back-coupled valve oscillator in which negative feed-back automatically comes into action in order to stabilise the amplitude of the output.

A. D. Blumlein. Application date 17th June, 1940.

563 463.—Short-wave resonator, or tuning device, comprising a substantially flat plate or inductance, which is slotted to support a variable condenser and other circuit elements.

W. S. Percival. Application dates 25th April and 1st October, 1940.

563 468.—Resonator or tuning device comprising a ring-shaped inductance with a peripheral slot to take the rotary vane of a condenser.

A. Landmann. Application date 28th April, 1942.

563 490.—Receiving circuit adapted to detect either frequency-modulated or amplitude-modulated signals, at will, by the operation of a single switch.

Marconi's W.T. Co., Ltd. (*assignees of W. D. Houghton*). *Convention date* (*U.S.A.*) *10th February*, 1942.

563 520.—Coupling network designed to handle the different frequency ranges required in a receiver adapted to detect, at will, either frequency- or amplitude-modulated signals.

Marconi's W.T. Co. Ltd. (*assignees of G. Mountjoy*). *Convention date* (*U.S.A.*) *7th January*, 1941.

563 564.—Interference-eliminating system in which the signals plus disturbance are fed to a main and to an auxiliary receiver, the interference alone being fed from the latter back to the main receiver in anti-phase.

H. B. Rubin. Convention date (*U.S.A.*) *3rd December*, 1941.

563 686.—Receiving system for phase- or frequency-modulated centimetre waves, wherein the incoming energy is diffracted by a slotted plate, and one or more detecting dipoles are placed at points of maximum field strength in the resulting wave pattern.

Marconi's W.T. Co. Ltd. (*assignees of W. R. Ferris*). *Convention date* (*U.S.A.*) *30th January*, 1942.

563 689.—High-frequency reactive network which can be used as a transformer to allow tight coupling to be applied without prejudicial results due to stray capacitance.

C. S. Bull. Application date 20th February, 1943.

563 692.—Construction of powdered-iron inductance coils having a diameter of not more than one-quarter of an inch, a length of less than half-an-inch, and a *Q* value of at least 100.

E. K. Cole Ltd. and C. E. White. Application date 2nd April, 1943.

563 696.—Amplifier with non-linear negative feed-back for reducing the band-width and for selecting the strongest of a complex of frequencies, and locking on to it.

Western Electric Co. Inc. Convention date (*U.S.A.*) *16th May*, 1942.

563 786.—Short-wave tuning system comprising coarse, fine, and trimming controls, wherein the fine calibration is independent of the setting of the coarse control.

A. C. Cossor Ltd.; A. H. A. Wynn; and L. H. Bedford. Application date 26th February, 1943.

563 788.—Arrangement of tuning circuit with ganged condensers to give a coarse, an independent fine, and a trimming control.

A. C. Cossor Ltd; A. H. A. Wynn; and L. H. Bedford. Application date 26th February, 1943.

563 951.—Device for mounting a tubular inductance or condenser element on the chassis of a wireless set.

Marconi's W.T. Co. Ltd. (assignees of L. G. Ketcham). Convention date (U.S.A.) 28th February, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

563 569.—Saw-tooth oscillation generator in which a two-grid amplifier is operated as a blocking oscillator and a control voltage is applied to one of the grids to linearise the sweep voltage.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 27th January, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

563 205.—Phase-control coupling between a pair of valves operating as a frequency-modulated oscillator.

Marconi's W.T. Co. Ltd. (assignees of G. L. Usselman). Convention date (U.S.A.) 27th April, 1942.

563 237.—Measuring and monitoring the relation of the C.W. frequency to the signal amplitude in frequency-modulated systems.

Marconi's W.T. Co. Ltd. (assignees of R. A. Braden). Convention date (U.S.A.) 27th February, 1942.

563 385.—Multi-vibrator for generating square-shaped modulating impulses for radio telegraphy.

H. S. Molyneux-Ffennell and Vacuum-Science Products Ltd. Application date 5th February, 1943.

563 417.—Transmission line loaded with elements which provide a negative impedance effect within a predetermined band of frequencies.

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

563 698.—Circuit arrangement designed to operate a relay when oscillations of a given amplitude occur at a certain point, e.g., in plotting the polar diagram of a transmitting aerial.

The British Thomson-Houston Co. Ltd. and J. Dyson. Application date 30th April, 1943.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

562 986.—Relay responsive to C.W. pulses transmitted over a power supply, or like network, for signalling or remote-control purposes.

Automatic Telephone and Electric Co. Ltd., and P. N. Roseby. Application date 19th January, 1943.

563 218.—Generating coded pulses of carrier current for transmission over electric-supply networks, for signalling or remote-control purposes.

Automatic Telephone and Electric Co. Ltd.; P. N. Roseby; and J. F. Mackenzie. Application date 21st January, 1943.

563 471.—Secret signalling system for subdividing the message into frequency bands which are then shuffled or scrambled.

"Patelhold" Patentverwertungs, etc., Akt. Convention date (Switzerland) 10th May, 1941.

563 620.—Selective circuit, particularly for the tone frequencies used in multiplex telegraph systems, comprising a limiter valve which feeds a detector valve through a resonant circuit.

S. Y. White. Convention date (U.S.A.) 1st April, 1942.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

563 113.—Controlling the operation of secondary-emission oscillation generators in which the primary electron stream passes through an aperture in the anode under the control of a variable magnetic field.

Standard Telephones and Cables Ltd. (assignees of A. M. Skellett). Convention date (U.S.A.) 23rd October, 1941.

563 234.—Construction and mounting of the grids of electron-discharge devices, particularly when made of metal having a high melting point.

Standard Telephones and Cables Ltd. (assignees of H. van Sant). Convention date (U.S.A.) 7th April, 1942.

563 446.—Supporting member, frictionally held against the internal walls of an electron discharge tube, for carrying one or other of the electrodes.

The M-O Valve Co. Ltd.; J. A. Smyth and L. R. E. Windsor. Application date 9th April, 1943.

563 561.—Electron beam amplifier of the double-anode type in which a control voltage is developed across the anodes to compensate automatically for variations in the operating characteristic of the tube.

H. Ziebolz. Convention dates (U.S.A.) 4th November, 1941 *and 17th March,* 1942.

563 623.—Oxide-coated cathode with a core containing reducing agents which serve to minimise undesired cooling due to radiation.

Marconi's W.T. Co. Ltd. (assignees of E. G. Widell). Convention date (U.S.A.) 3rd October, 1941.

563 729.—Magnetic deflecting device for varying the direction or focus of the electron stream in a cathode-ray tube.

Cinema-Television Ltd. and L. G. Wyatt. Application date 23rd February, 1943.

563 767.—Construction of a discharge device of the "crater lamp" type for translating electric signals into light or other radiation.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 12th February, 1942.

563 776.—Method of welding the glass parts of a vacuum tube and of mounting and spacing the electrodes.

Standard Telephones and Cables Ltd. (assignees of C. V. Litton). Convention date (U.S.A.) 12th May, 1942.

563 817.—Cathode-ray tube in which a conductive surface is placed outside the glass envelope, near the fluorescent screen, in order to control the focusing of the electron stream.

A. C. Cossor Ltd. and L. A. Woodbridge. Application date 26th February, 1943.

SUBSIDIARY APPARATUS AND MATERIALS

563 002.—"Anti-static" screening system for a multi-cylinder internal-combustion engine, as used in aircraft.

E. L. W. Byrne (communicated by Titeflex Metal Hose Co.). Application date 8th April, 1943.

563 139.—Method of resiliently mounting a piezo-electric crystal so that it oscillates under tension.
Marconi's W.T. Co. Ltd. (assignees of S. A. Bokovy). Convention date (U.S.A.) 5th July, 1941.

563 156.—Rotary commutator device for generating a high-tension current from a low-tension source.
E. G. Greville and H. W. Grover. Application date 20th April, 1943.

563 203.—Construction and processing of resistance elements comprising a carbon coating on a ceramic surface.
Sangamo Weston Ltd. Convention date (U.S.A.) 1st July, 1942.

563 338.—Selenium type rectifier in which the sensitive coating contains oxygen compounds of the halogen group of elements.
O. K. Kolb and O. F. C. Stockel. Application date 3rd September, 1943.

563 362.—Blanks for a dry-contact rectifier in which peripheral slots are formed to engage with a central assembly rod.
Standard Telephones and Cables Ltd., and A. M. Searle. Application date 4th February, 1943.

563 407.—Tubular condenser in which the interleaved foils are spirally wound about two rigid members set parallel to the axis.
A. C. Cossor Ltd. and A. le Boutillier. Application date 8th February, 1943.

563 421.—Pentode valve arranged as a transitron oscillator, wherein degenerative feedback comes into play for any harmonics of the fundamental frequency.
A. C. Cossor Ltd. and A. H. A. Wynn. Application date 8th February, 1943.

563 422.—Insulation safeguard for the extremities of the interleaved foils of a spirally-wound condenser (divided out of No. 563 407).
A. C. Cossor Ltd. and A. le Boutillier. Application date 8th February, 1943.

563 424.—Photo-electric apparatus for amplifying the response of sensitive measuring instruments.
The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 22nd January, 1942.

563 456.—Construction of condenser of the interleaved or "sheet stack" type, suitable for heavy duty at radio frequencies.
Dubilier Condenser Co. (1925) Ltd. (communicated by W. Dubilier). Application date 29th April, 1943.

563 469.—Balanced-bridge arrangement for measuring the near approach of an aircraft to the ground, as determined by the change in impedance of an aerial carried by the craft.
The General Electric Co. Ltd. and D. M. Heller. Application date 6th May, 1942.

563 486.—Two-valve combination with negative back-coupling, giving the frequency-impedance characteristic of a series-resonant circuit, and serving to eliminate or measure the harmonic content of an oscillation generator.
A. C. Cossor Ltd. and A. H. A. Wynn. Application date 8th February, 1943.

563 511.—Manufacture and processing of electric switch and like contacts from pressed and sintered silver and copper powder.
Mallory Metallurgical Products Ltd. Convention date (U.S.A.) 25th February, 1942.

563 517.—Construction of inductances having cores of wound magnetic stip material.
W. M. Pannell and Pye Ltd. Application date 9th March, 1943.

563 529.—Vibrator device for deriving a stable high-tension voltage from a low-tension source that may be subject to voltage fluctuations.
A. H. Stevens (communicated by Electronic Laboratories Inc.). Application date 26th November, 1942.

563 537.—Arrangement of a glow-discharge tube for "time-marking" an oscillograph record.
A. C. Cossor Ltd. and A. N. Melchior. Application date 15th February, 1943.

563 659.—Variable magnetic coupling controlled by the indicator needle of a meter for stabilising, say, the output of an oscillation generator whilst the frequency is varied.
Standard Telephones and Cables Ltd. and M. M. Levy. Application date 29th January, 1943.

563 774.—Stack of photo-electric cells designed to measure the ultra-violet or infra-red content of any source of light.
Sangamo Weston Ltd. Convention date (U.S.A.) 16th April, 1942.

563 794.—Multivibrator circuit with a sensitive control of the change over from equal alternate operation of the two valves, to a unilateral operation of one or other of them.
Ferranti Ltd. and H. Wood. Application date 8th April, 1943.

563 822.—Arrangement and assembly of a rectifier unit comprising a stack of plates designed to handle large currents with minimum generation of heat.
Standard Telephones and Cables Ltd. (assignees of C. A. Kotterman). Convention date (U.S.A.) 18th June, 1942.

563 952.—Variable-impedance choke with an armature which is rotatable about an axis to vary the reluctance of the magnetic circuit.
A. Reyrolle and Co .Ltd ; J. W. Bayles ; and A. T. Robertson. Application date 1st March, 1943.

564 077.—Leak-proof terminal post for alkaline-type accumulators.
Britannia Batteries Ltd. ; R. M. Blomfield ; and F. E. Burt. Application date 28th April, 1943.

564 164.—Short-wave filter network incorporating in each half-section a metal-coated tube of dielectric acting as a length of transmission line.
Marconi Instruments Ltd. and C. F. Brocklesby. Application date 11th March, 1943.

564 203.—Terminal block for selecting any one of a number of circuits, say, the different voltage-supply contacts on a tapped choke coil.
The British Thomson-Houston Co. Ltd. and W. S. Adams. Application date 3rd February, 1943.

Errata.—The number of a Specification was incorrectly quoted in the "Aerials and Aerial Systems" section of Wireless Patents in the July 1944 issue. *For* 559 424, *read* 559 423.

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ABSTRACTS AND REFERENCES

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Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title, while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

PROPAGATION OF WAVES

1. ELECTROMAGNETIC WAVES IN METAL TUBES FILLED LONGITUDINALLY WITH TWO DIELECTRICS.—L. Pincherle. (*Phys. Review*, 1st/15th Sept. 1944, Vol. 66, No. 5/6, pp. 118–130.)

Author's summary :—" The propagation of e-m waves is investigated : (1) in a rectangular metal tube half-filled longitudinally with a dielectric ; (2) in a cylindrical dielectric guide of radius a, surrounded by a coaxial metal tube of radius b. In (1) the waves are of the longitudinal-section type ; for high frequencies they are confined to the medium of higher dielectric constant. The problem is discussed also with the model of the criss-cross component waves.

" In (2) the waves are linear combinations of E and H waves. The case of axial symmetry is considered, in which there are simple E and H waves. For E_0 a critical wavelength exists, depending only on the dimensions of the inner dielectric and on the dielectric constants, below which the system behaves more or less as a dielectric guide in free space, and above which as an ordinary hollow tube. For H_0 this critical wavelength depends also on the ratio b/a. The case in which the external medium has a higher dielectric constant is also briefly investigated " : for high frequencies the waves are then confined to the space between the two cylinders : " this represents a new kind of guide, limited on the outside by the metal of the tube, and on the inside by the medium of smaller dielectric constant."

It is mentioned that " in the frequency region in which hollow tubes are used, almost all dielectrics are absorbing . . . The solution of the fundamental equations would then require the use of Bessel functions of complex argument, a cumbersome procedure, as complete tables of these functions are not available. The introduction of a conductivity does not, however, lead to any important change in the features of the phenomenon, except those already known for ordinary hollow tubes."

2. QUESTIONS AND RESULTS OF IONOSPHERIC RESEARCH [Survey].—J. Zenneck. (*Naturwiss.*, 11th Dec. 1942; Vol. 30, No. 50/51, pp. 739–745.)

True and apparent heights (Pekeris : Rydbeck : Rawer : Booker & Seaton) : temperatures (Penndorf : Harang : Vegard & Tönsberg : Appleton : Pekeris) : ionospheric research and solar physics (Eyfrig, Goubau, Netzer, & Zenneck : Beckmann, Wenzel, & Vilbig : Kiepenheuer) : fade-outs (Mögel : Dellinger : Berkner & Wells : also Richter, ref. " 17 ", for a connection between these phenomena and fluctuations of the brightness and size of the tails of comets).

3. CARNEGIE INSTITUTION OF WASHINGTON : ANNUAL REPORT OF THE DIRECTOR OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM.—J. A. Fleming & O. H. Gish. (Reprinted from *Year Book No. 39*, for 1939/40, pp. 55–112 : issued 13th Dec. 1940.) A summary was referred to in 2058 of 1941 ; for later reports *see* 2274 of 1942, 2068 of 1943, and 1128 of 1944. For a note on the 1942/3 *Year Book* see *Nature*, 2nd Sept. 1944, p. 308.

ABSTRACTS AND REFERENCES INDEX.

THE subject and author index to the abstracts and references published during 1944 will be issued separately in February. It will occupy some forty pages and cost 2s. 8d., including postage. As supplies will be limited, early application for copies should be made to the Publishers.

4. On the Explanation of the Stratospheric Temperature.—F. Möller. (*Naturwiss.*, 12th March 1943, Vol. 31, No. 11/13, p. 148.)

For previous work *see* 637 & 3188 of 1942. " Hitherto it has been impossible to give a reason for the differing heights and temperatures of the tropopause (at tropics, 18 km, −90° : at medium latitudes, 10 km, −50°). R. Emden's radiation-equilibrium theory leads to much too low temperatures (−140°), if the spectral absorption coefficients of the water vapour are taken into account even approximately. Besides, the radiating action of the water vapour, and the consequent speed of cooling, must be vanishingly small at heights above 12 km. For régimes at heights of 18 km and more, other absorbers must therefore be predominant. An excellent absorber for wavelengths 13–16μ is present in the atmosphere in the form of carbon dioxide. In spite of its low partial pressure of 0.3 mb, CO_2 absorbs almost totally at these wavelengths, and a radiation upwards is therefore impossible. It begins to be effective above 10 km, and at about 20 km (that is, in the higher tropopause regions) it assumes considerable values.

" But CO_2 is mingled with the air in equal quantities in all geographical latitudes and at all heights, so that differences in radiation between different latitudes are not present. For the same 13–16μ wavelengths, however, the ozone existing at great heights (20–40 km) has a strong absorption band, by which the radiating activity of the CO_2 in the lower layers is screened from space. Only at points where the ozone content is reduced can the CO_2 radiate strongly. This is the case in the tropics, where the ozone content is only about two-thirds of its value in medium latitudes. The low temperature of the tropical tropopause may thus be attributed to the increased power of radiation enjoyed by the CO_2 there. In medium latitudes there is a lot of ozone present, the CO_2 radiation is small, and the tropopause temperature correspondingly high. In the polar regions the winter ozone content is very small, the stratosphere extremely cold ; whereas in the summer specially large ozone values are accompanied by specially high tropopause temperatures.

" An explanation of the various tropopause temperatures thus seems to be possible by this interplay of CO_2 and O_3, and the chain ' solar u.v. radiation–ozone quantity–CO_2 radiation–stratospheric temperature–atmospheric pressure at ground level ' offers a physically credible relation for cosmic and solar influences on the weather."

5. Tropopause Studies to aid Long-Range Weather Forecasting.—H. Arctowski. (*Journ. Franklin Inst.*, Sept. 1944, Vol. 234, No. 3, p. 274 : summary, from *Heating and Ventilating*, Vol. 39.) For previous work *see* 3387 of 1944.

6. Links between the Calendar and Meteorological Events [Survey & Deductions : the Rôle of Research on " Singularities " (in the Yearly Temperature Curves, etc.) in Meteorology & Climatology].—H. Flohn. (*Naturwiss.*, 27th Nov. 1942, Vol. 30, No. 48/49, pp. 718–728.)

7. Spacing Ratio of Atmospheric Streets [with Application to Weather Forecasting].—S. N. Sen & V. Ganesan. (*Sci. & Culture* [Calcutta], July 1944, Vol. 10, No. 1, pp. 54–56.) For a preliminary note *see* April issue, Vol. 9, No. 10, pp. 453–455.

8. " Einführung in die Physik der Atmosphäre " [Vols. I & II (Statics & Thermodynamics : Meteorological Aerodynamics) : Book Review].—P. Raethjen. (*Naturwiss.*, 18th June 1943, Vol. 31, No. 25/26, p. 304.) A review of Vol. I was referred to in 3196 of 1942.

9. An Overlooked Effect in Gas Kinetics.—K. Clusius & L. Waldmann. (*Naturwiss.*, 13th Nov. 1942, Vol. 30, No. 46/47, p. 711.)

" The new effect [easily demonstrated] is closely connected with the phenomenon of thermal diffusion and represents, in a certain sense, the converse of this. In thermal diffusion the temperature drop produces in a previously homogeneous gas mixture a drop in the relative concentrations. In the new effect the concentration drop of the diffusing gases produces a temperature gradient in the previously isothermal system."

10. On Hydrodynamic Eddy Laws [and Their Generalisation and Some Consequences].—H. Ertel. (*Physik. Zeitschr.*, 15th Dec. 1942, Vol. 43, No. 23/24, pp. 526–529.)

11. Supersaturation in the Spontaneous Nucleus-Formation in Water Vapour [Experimental Investigation].—A. Sander & G. Damköhler. (*Naturwiss.*, 24th Sept. 1943, Vol. 31, No. 39/40, pp. 460–465.)

12. Hard and Soft Cosmic Rays during Magnetic Storms [Report on Dahlem Observations].—W. Kölhorster. (*Physik. Zeitschr.*, 15th Jan. 1943, Vol. 44, No. 1/2, p. 48.)

Measurements, during the unusually violent magnetic storm of 1st March, 1941, of the hard vertical rays (meson component, filtered through 10 cms of lead) and the soft (expressed as the difference between the total, unscreened vertical rays and the hard component), and comparisons with the magnetic data from Potsdam, showed that the soft component was completely unaffected by the storm. This striking result led to the examination of the records of six other storms between January, 1940, and July, 1941 : these were less violent, but the general result was the same.

" Since the soft component consists chiefly of comparatively low-energy rays, mostly of electrons, and yet according to these observations is not deflected magnetically, it must have originated in the near neighbourhood of the place of observation, and can only proceed from a primary radiation which is independent of field effects—for otherwise it would, as a secondary, follow the fluctuations of its primary. As primaries for the soft component, therefore, the likely choice would be photons, particles which are undeflected either because they are uncharged or because of their extremely high energy.

" On the other hand the hard component (*i.e.*, the mesons) is dependent on the field. According to our modern ideas these rays are likewise secondary rays, formed in the atmosphere in the last 10–30 km above the ground. They are therefore, and also because of their large mass, not likely to be much affected by fluctuations in the earth's magnetism, so that their changes represent only the fluctuations of the primary cosmic radiation in space. Since saturation has to be considered, it is possible to draw conclusions as to the behaviour of the primary cosmic rays of space in the neighbourhood of the earth's orbit, from observations of the hard component during magnetic storms."

13. MASS-DETERMINATION OF THE IONISING PARTICLES RECORDED IN PHOTOGRAPHIC PLATES EXPOSED TO COSMIC RAYS [at High Altitudes].—B. Choudhuri. (*Indian Journ. of Phys.*, Feb. 1944, Vol. 18, No. 1, pp. 57–70.)

14. LAW AND CHANCE IN GEOPHYSICS [Address to Prussian Academy of Sciences: with Special Attention to the Writer's "Generalised Error-Propagation Law" for the Treatment of Geophysical Time-Functions, as a Substitute for Probability-Theory Methods].—J. Bartels. (*Naturwiss.*, 10th Sept. 1943, Vol. 31, No. 37/38, pp. 421–435.)

15. MODERN EVIDENCES FOR DIFFERENTIAL MOVEMENT OF CERTAIN POINTS ON THE EARTH'S SURFACE: II.—H. T. Stetson. (*Science*, 11th Aug. 1944, Vol. 100, No. 2589, pp. 113–117.)

16. A SOLAR HALO PHENOMENON [Discussion of Mock Sun Displays].—D. E. Blackwell & J. C. W. De la Bere. (*Nature*, 14th Oct. 1944, Vol. 154, No. 3911, p. 491.)

The writers conclude: "It is evident that knowledge of atmospheric optics is still in an elementary state, and that many more careful (preferably photographic) observations are required . . ."

17. ON THE TEMPERATURE OF THE SOLAR REVERSING LAYER [5000° K & 4500° K for Disc & Limb, respectively, calculated by Formulae deduced from Theory of Band-Line Intensities: with a Discussion of M. G. Adam's Conclusions].—K. N. Rao. (*Indian Journ. of Phys.*, Feb. 1944, Vol. 18, No. 1, pp. 23–30.)

18. CONTINUOUS ABSORPTION COEFFICIENT OF THE NEGATIVE HYDROGEN ION. — Henrich. (*Nature*, 28th Oct. 1944, Vol. 154, No. 3913, p. 554: summary only.)

"Considerably reduces the discrepancy between theory and observation in the relation between effective temperature and colour temperature in the visual region of stellar spectra, and establishes on a firm basis the hypothesis that the negative hydrogen ion is an important contributor to opacity in stellar atmospheres."

19. NEW MOLECULAR ABSORPTION LINES SHOWING CHARACTERISTICS CLOSELY SIMILAR TO ATOMIC LINES [Probable Origin in Solid Particles responsible for General Absorption in Interstellar Space: Need for Laboratory Investigations].—E. C. Beale. (*Nature*, 2nd Sept. 1944, Vol. 154, No. 3905, p. 306, r-h column.) In a report of a Roy. Soc. of Canada meeting.

20. ACTIVATION OF NITROGEN AT LIQUID-AIR TEMPERATURE.—S. S. Joshi & A. Purushotham. (*Current Science* [Bangalore], June 1944, Vol. 13, No. 6, p. 155.)

21. ELECTRICAL PROPERTIES OF INDIAN SOILS AT MEDIUM BROADCAST FREQUENCIES [Measurements on Soil Samples from Different Places near All-India Radio Stations: Calculation of Service Areas: Calculation of Aerial h/λ for Fading-Free Reception].—S. M. F. Rahman & F. Muhi. (*Indian Journ. of Phys.*, Feb. 1944, Vol. 18, No. 1, pp. 31–37.)

"The conductivity was observed to increase with both frequency and moisture content; but the rate of increase with moisture was very great while that with frequency was small. The effective dielectric constant was found to decrease with frequency and to increase with moisture content. . ."

22. ON THE THEORY OF THE DOPPLER EFFECT AND ABERRATION—E. Rüchardt. (*Physik. Zeitschr.*, 15th Dec. 1942, Vol. 43, No. 23/24, pp. 525–526.)

This theory is usually derived by somewhat complicated calculations, whereby the important fact does not emerge clearly that all that is needed is the so-called time-dilatation as the single deduction from the Lorentz transformations. The writer gives an elementary treatment for sound and for light. For the latter he obtains the complete expression $\nu = \nu_0(1 + v/c)/\sqrt{1 - v^2/c^2}$ and the aberration equation

$$\cos\delta = (\cos\delta_0 + v/c)/\{1 + (v/c)\cos\delta_0\}$$

where δ and δ_0 are the angles between the direction of motion and the source/observer direction, measured in the observer's and in the source's system respectively. For Perrine's recent work on the Doppler effect *see* 3391 of 1944.

23. A MEASUREMENT OF THE VELOCITY OF LIGHT IN WATER [by the Method dealt with in 3244 of 1941, improved].—R. A. Houstoun. (*Proc. Roy. Soc. Edinburgh*, Sec. A, 1943/4, Vol. 62, Part 1, pp. 58–63.)

"The results are a verification of the formula for the group velocity of light for water. Hitherto it has been verified only for carbon disulphide, and that not accurately . . ." The writer mentions: "It is comparatively easy to oscillate the crystal and produce bands, but it is much more difficult to ensure that the oscillations are pure enough to make the quartz act as an intermittent grating. Indeed it is so easy to produce bands, that I think they may be useful as a means of measuring electrical wavelength. The deviation of the first order, it is true, is only 32′ for Hg green when $\lambda = 283$ cm, but for $\lambda = 10$ cm it would be 7°."

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

24. PERSISTENCE OF LUMINOSITY IN AIR [Appearance of Luminous Clouds as Sequel to Arc Extinction: Possible Explanation of the Stability of Ball Lightning].—J. J. O'Doherty. (*Nature*, 9th Sept. 1944, Vol. 154, No. 3906, p. 339.)

25. NEW MECHANICAL HEIGHT-COMPUTER FOR RADIO-SONDE OBSERVATIONS.—W. E. K. Middleton. (*Nature*, 2nd Sept. 1944, Vol. 154, No. 3905, p. 306, r-h column.) In a report of a Roy. Soc. of Canada meeting.

PROPERTIES OF CIRCUITS

26. RESONANCE IN QUARTER-WAVE LINES [Editorial prompted by Collie's Paper, 3155 of 1944: Consideration of Same Problem from Viewpoint of Student familiar with Ordinary

Telephone Transmission Formulae].—G. W. O. H: Collie. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, pp. 509–511.)

27. The Quarter-Wave Step-Up Transformer.—H. Salinger. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 553–556.)

"In the arrangement of Fig. 1, the load Z_L is assumed to have a high impedance and a capacitive phase. Formulas and graphs are presented for determining the correct length and tapping point on the line. If the step-up ratio is high, a simple formula, $\Delta = 2\sqrt{2}\, gZ_0 / \{(\pi/2) - bZ_0\}$, can be derived for the band-width of the system."

28. High-Frequency Cable with Varying Characteristic Impedance. — E. Keutner. (*E.T.Z.*, 21st Oct. 1943, Vol. 64, No. 41/42, p. 564.) Another summary was dealt with in 2512 of 1944.

29. Single- and Double-Stub Impedance Matching.—Wing & Eisenstein. (*See* 44.)

30. The Application of Filter Theory to the Design of Reactance Networks [illustrated by Examples of Design of Impedance-Matching Networks (such as might be used for Aerial/Feeder Matching) and of Coupling Units for Video Amplifiers].—A. V. Eastman. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 538–546.)

Filter theory is now so well known to most radio engineers that "its application to the design of impedance networks should appreciably simplify the procedure".

31. Fluctuation Phenomena as Limits of Amplification and Reception [Survey, with 18 Literature References].—W. Kleen. (*E.T.Z.*, 9th Sept. 1943, Vol. 64, No. 35/36, pp. 473–478.)

This is the full paper, a summary of which was dealt with in 3109 of 1944. The separate investigations there mentioned ("as regards aerial noise, only experimental results are available, whereas for circuit and valve noises quantitative relations which agree with experimental results are given") lead to a final formula (eqn. 12) for the "limiting sensitivity" of an amplifier or a receiver, defined as the energy (power per c/s) which must be applied to the circuit in order to produce equality of signal and noise. In this connection, it is convenient to express energy in the small unit $kT_0 = 4 \times 10^{-21}$ watt-second, and the equation for "limiting sensitivity," applicable to different aerials provided that for each one the optimum coupling is assumed, becomes: $E = kT_0[T_A/T_0 + (2\, R_{eq}/R + 2\sqrt{(R_{eq}/R)^2 + R_{eq}/R})]$. The curve of Fig. 8 shows the calculated variation of the sum in the round brackets, $f(R_{eq}/R)$, as a function of the ratio of the equivalent grid-noise-resistance R_{eq} to the circuit resistance R. A long paragraph on p. 477, r-h column, discusses the application of the results to problems of telegraphy and music transmissions.

Throughout the paper many simplifications have been made and subsidiary effects without fundamental importance have been neglected. "Technically, there are many further problems of interest: for instance, the various influences of feedback, non-optimum aerial coupling, aeria reactive and loss resistances, secondary electrons, and electron transit-times in the valves. Further, the limiting sensitivity of mixing circuits and the effect of non-linear circuit components have not been considered. . ." For previous work *see*, for example, 2689 & 2708 (end) of 1941.

32. Cathode-Coupled Oscillators [and a Discussion of a Two-Valve Network permitting the Maintenance of Sustained Oscillations in a Parallel-Resonant *LC* Circuit without the Necessity for Coil Tappings or Retroaction Windings: and the Development of Selective Amplifiers].—F. Butler. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, pp. 521–526.)

Introduction: equivalent circuits of valve amplifiers: theory of the inverted (earthed-grid) amplifier: its conversion to an earthed-grid oscillator: theory of the cathode-coupled amplifier (driving power to inverted amplifier supplied by cathode-follower stage: "the resulting 2-valve circuit becomes almost identical with the cathode-coupled amplifier, of which practical details have already been published": Schmitt, 666 of 1942 and back references. "So far as the writer is aware, no complete treatment of this circuit has been given, though the appropriate analysis has been suggested and the equivalent circuit derived: Debski, 344 of 1943"): the cathode-coupled oscillator (and its five main advantages: *e.g.* alteration of frequency range made by inductance changes, using single-pole switch: light loading on main tuned circuit: etc.): quartz-crystal stabilisation: development of a selective amplifier with off-resonance attenuation greater than that given by conventional amplifiers.

33. "Thermionic Valve Circuits: Second Edition, Enlarged" [Book Reviews].—E. Williams. (*Nature*, 7th Oct. 1944, Vol. 154, No. 3910, p. 446: *Electrician*, 20th Oct. 1944, Vol. 133, No. 3464, p. 354.)

34. Calculation with Matrices [as applied to Four-Terminal-Network Theory, etc: Elementary Treatment]. — H. Rossmüller. (*E.T.Z.*, 21st Oct. 1943, Vol. 64, No. 41/42, pp. 555–561.)

35. Transformation Matrices in Electrical Engineering.—R. E. Vowels. (*Journ. Inst. Eng. Australia*, June 1944, Vol. 16, No. 6, pp. 97–104.)

TRANSMISSION

36. The Effect of Electric Forces in the Density-Modulated Electron Ray [Influence of Space-Charge Forces in Velocity-Modulated Beams of High Current-Density].—F. Borgnis & E. Ledinegg. (*Naturwiss.*, 13th Aug. 1943, Vol. 31, No. 33/34, p. 392.) Preliminary note on the work dealt with in 784 of 1944.

37. Frequency and Phase Modulation [and Some Still-Existing Confusion].—Hund. (*See* 39.)

38. Cathode-Coupled Oscillators.—Butler. (*See* 32.)

RECEPTION

39. FREQUENCY AND PHASE MODULATION [and Some Still-Existing Confusion].—A. Hund. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 572–573.)

The difficulties discussed may be illustrated by the following quotation: "Only for a condition for which $\Delta F/f = \Delta\theta$ would both types of discriminator produce the same result at the output of the receiver. It is true that a simple correcting network . . . will translate properly into faithful a.f. recovery when a frequency discriminator is combined with such a correcting network or when a phase discriminator is employed with a suitable corrector. However, when both frequency and phase modulation are present, distortion will occur since the change-over by a corrector from a frequency discriminator to a phase discriminator will now cause partially wrong a.f. emphasis for received f.m. waves and de-emphasis for received p.m. waves, since in the first case parasitic p.m. and in the latter case parasitic f.m. is not translated properly . . ." Slide-rule and rubber-strip models for p.m. and f.m. respectively illustrate the great difference between variations in Ω and in θ even in the simple case of the sinusoidal wave-train expressed by $I_t = I \sin(\Omega t + \theta)$. Practical conclusions as to the design of r.f. and i.f. networks are drawn at the end of the letter.

40. SOME NOTES ON SUPER-REGENERATION, WITH PARTICULAR EMPHASIS ON ITS POSSIBILITIES FOR FREQUENCY MODULATION.—H. P. Kalmus. (*Proc. I.R.E.*, Oct. 1944, Vol. 32, No. 10, pp. 591–600.)

Principles of operation of super-regeneration (and a method of measuring very small voltages: 128, below: coherency and incoherency: super-regenerative detection and impulse-noise suppression: sensitivity and selectivity). Signal/noise ratio considerations in super-regenerative circuits. Application of super-regeneration to frequency modulation (and the s-r stage as f.m. demodulator and as f.m. amplifier). Receiver design.

Both the receivers described are for 45 Mc/s signals. In the second one, however (Fig. 15, for wider-band f.m.) the s-r valve is worked at 75 Mc/s (oscillator at 30 Mc/s) and the type 9002 valve easily produces a quench frequency of 200 kc/s, which fulfils the requirement, for distortion-free demodulation, that the q.f. should be higher than the maximum deviation. The s-r valve produces a band spectrum which is heterodyned in the second mixer and transposed to an 8.3 Mc/s spectrum. One single band is selected: as it passes a combined amplifier–limiter it is demodulated in a double-diode (or a space-charge) discriminator. It is mentioned that with a s-r stage as amplifier the space-charge discriminator (U.S. Patent 2 233 706) works remarkably well, owing to the good limiting action of the s-r stage, which removes most of the impulse noise.

41. FLUCTUATION PHENOMENA AS LIMITS OF AMPLIFICATION AND RECEPTION.—Kleen. (*See* 31.)

42. "UNITIZED" RADIO - CHASSIS DESIGN [developed by the Harvey Machine Company: *see* 338 & 1573 of 1944 & Back References].—S. Morrison, J. Nowak, & G. B. Green. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 521–525.)

"Though 'unitized' construction is primarily a mechanical development, certainly no compromise in quality need be accepted in the electrical performance of the unit. Indeed, an electrical advance has been scored in the improved use of shielding and the unique arrangement of parts which 'unitizing' permits . . ." Apart from the more usual applications, the principle has been extended experimentally to a 35-watt transmitter and to various control devices, such as recording-and-actuating thermometers, humidistats, and barometers, gas calorimeters, etc.

AERIALS AND AERIAL SYSTEMS

43. RESONANCE IN QUARTER-WAVE LINES [Editorial prompted by Collie's Paper].—G. W. O. H. (*See* 26.)

44. SINGLE- AND DOUBLE-STUB IMPEDANCE MATCHING.—A. H. Wing & J. Eisenstein. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, pp. 615–622.)

Formulae determining the position and length of a single matching stub for any load impedance or any standing-wave voltage distribution are derived, neglecting losses in the matching sections. Conditions for minimum length of stub and minimum distance between load and stub are specified. Although the single stub is extremely simple in its application, it has certain disadvantages: it is not always convenient to provide an adjustment in the stub-position (especially in coaxial cables) and an open stub may not easily be lengthened. On the other hand, with a double closed stub the position of the stubs and the spacing between them are fixed in any given installation, the two adjustments being the lengths of the two stubs. For this arrangement, expressions for the lengths of stubs and distance between them are derived for any possible combination of load and distance between stubs. A double-stub tuner with any fixed distance between stubs cannot match all loads to the feeder, and the limits are specified.

The optimum location, on the feeder, of the double-stub tuner is discussed. A graphical method employing a circle diagram for computing the lengths and position of the stubs is explained. The graphical determination of the stub lengths is facilitated by auxiliary circular loci, which also indicate the range of admittances over which an impedance match can be effected.

45. CIRCULAR LOOP ANTENNAS AT ULTRA-HIGH FREQUENCIES [Investigation of Radiation Characteristics of Single-Turn Circular Loops at Wavelengths of the order of the Loop Dimensions: Expressions for Distant Field Intensity in Plane of Loop & on Axis].—J. B. Sherman. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 534–537.)

Sinusoidal current distribution is assumed, giving ideal characteristics from which those of various actual loops may be expected to depart according to existing attenuation and phase-shift. The sections are headed:—Introduction (references to existing work): formulation and solution of the field integral: reduction to low-frequency case: effect of open-circuiting the loop: radiation patterns (for loops of circumference λ, 2λ, and 3λ) : field on the axis of the loop : experimental results (on 150 cm wave) : a circular non-resonant antenna (" rather hypothetical, except that it may represent a portion of an actual structure " : solution of same form as that of resonant loop : omnidirectional in plane of loop).

46. LOOP ANTENNAS WITH UNIFORM CURRENT.—D. Foster. (*Proc. I.R.E.*, Oct. 1944, Vol. 32, No. 10, pp. 603–607.)

This paper, but with its mathematical analysis less compressed, was read at the 1937 I.R.E.–U.R.S.I. meeting. An application of its ideas to commercial purposes was described in Alford & Kandoian's " Ultra-High-Frequency Loop Antennas " (3011 of 1940).

Author's summary :—" The properties of a circular loop carrying uniform current are calculated for loops of any size relative to the wavelength. The radiation resistance and the greatest directivity pass through a series of maxima and minima as the frequency is increased. At frequencies below that for which one wavelength is contained in the circumference, the directivity graph is nearly independent of frequency. As the frequency is increased, additional lobes appear, the principal lobe tending to point more nearly in the direction normal to the loop. The paper includes a note on other loops, and a mathematical appendix dealing with certain integrals involving Bessel functions."

47. THEORY AND PERFORMANCE OF CORNER REFLECTORS FOR AERIALS, *and* THE MEASURED PERFORMANCE OF HORIZONTAL DIPOLE TRANSMITTING ARRAYS.—E. B. Moullin : H. Page. (*Electrician*, 3rd Nov. 1944, Vol. 133, No. 3466, p. 408 : pp. 408–409 : summaries of I.E.E. papers.)

48. NEW DEVICES AID RAPID COMMUNICATION IN FORESTS [including the " PD " (" Plumber's Delight ") Aerial].—Forest Service Laboratories. (*Journ. Franklin Inst.*, Aug. 1942, Vol. 234, No. 2, pp. 205–206.) For this aerial *see* 3256 of 1942.

49. THE DESIGN OF DIRECTIONAL AERIAL ARRAYS [with Special Application to Equi-Signal Beams].—Cooper & Green. (*See* 67.)

50. THE EFFECT OF RADIATION ON THE VIBRATIONS OF A CIRCULAR DIAPHRAGM.—Lax. (*See* 70.)

51. DISCUSSION ON " THE PRINCIPLE OF RECIPROCITY IN ANTENNA THEORY " [Neiman, 1935 of 1944].—D. O. North: M. S. Neiman. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 556–558.)

With particular reference to North's proposed " noise factor " and " absolute sensitivity " (1656 & 2337 of 1942) and to the effect of even a little terrestrial reflection on the correlation between the radiation field of an aerial and its response to passing Poynting vectors ; including the problem of the elliptically polarised waves often radiated in non-optimum directions by practical aerials, and the proposal of the term " free-space directivity ", associated with the function $D^2(\Omega, \phi)$. Neiman replies on p. 558.

52. THE COUPLING RESISTANCE OF FEEDERS AND COMPONENTS FOR AERIAL INSTALLATIONS [with Special Reference to Community Aerials : the Quantity as a Measure of Screening Action : Methods of Measurement].—K. Thalmeyer. (*E.T.Z.*, 21st Oct. 1943, Vol. 64, No. 41/42, p. 568.) A short discussion prompted by V.D.E. Rule 0856/X.42 : *cf.* W. Wild, *ibid.*, 1943, p. 440.

53. ELECTRICAL PROPERTIES OF INDIAN SOILS AT MEDIUM BROADCAST FREQUENCIES [and Calculation of Aerial Heights for Reduced Sky-Wave].—Rahman & Muhi. (*See* 21.)

54. " HOCHSPANNUNGSPROBLEME BEI GROSSSENDER-ANTENNEN " [High-Voltage Problems concerning the Aerials of High-Power Stations : Notice of Booklet].—W. Peters. (*E.T.Z.*, 9th Sept. 1943, Vol. 64, No. 35/36, p. 494.)

For an extract *see* pp. 485–487 ; it includes curves showing the variation of end and base potentials (for various types of aerial) with the relative height h/λ, for various values of characteristic impedance ; and curves showing the glow-discharge, brush-discharge, and breakdown potentials (in air, between point electrodes with varying gap-lengths) at 50 c/s and at 150 kc/s. It discusses the formation of corona on wires and masts ; the distortion of fields around insulators by dust particles, moisture, and surface roughness ; a new improved design of back-stay insulator (Fig. 4) ; mast-foot insulators ; and similar subjects.

55. STAINLESS STEEL TUBES FOR SUBMARINE AERIAL MASTS : NEW METHOD CUTS PRODUCTION TIME BY ABOUT 15%.—Babcock & Wilcox Tube Company. (*Sci. News Letter*, 5th Aug. 1944, Vol. 46, No. 6, p. 94.)

VALVES AND THERMIONICS

56. THE SIGNAL CONVERTER AND ITS APPLICATION TO TELEVISION.—Nagy. (*See* 107.)

57. DEFLECTED ELECTRON BEAMS [Continuation of Correspondence referred to in 3865 of 1944 and Back References].—J. H. O. Harries : S. Rodda. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, p. 528.)

58. ON FIELD AND CHARGE DISTRIBUTIONS IN PLASMAS [Approximate Theory throwing light on Large Number of Processes in the Grid Control of Plasmas].—W. O. Schumann. (*Naturwiss.*, 26th Feb. 1943, Vol. 31, No. 9/10, pp. 115–117.)

" Further deductions, in particular regarding the range of validity of the equations, the effect of ionisation, of the main electrodes, and of the instability of the discharge, follow in a later paper." For other work *see* 1944 of 1944 and back references ; also 680 of 1942 and 2980 of 1943, and 59, below.

59. TRANSIT-TIME OSCILLATIONS, SELF-EXCITATION, AND DENSITY AND CURRENT FLUCTUATIONS IN THE PASSAGE OF ELECTRONS THROUGH A SPACE WITH CONSTANT POSITIVE DENSITY OF CHARGES [Continuation of Plasma Analysis dealt with in 2685 of 1941].—W. O. Schumann. (*Naturwiss.*, 12th March 1943, Vol. 31, No. 11/13, pp. 140–143.) *See* also 58, above.

60. SECONDARY-ELECTRON OUTPUT: A COMPREHENSIVE SURVEY OF WORK ON THE INFLUENCE OF FIELD-EMISSION ON THE SECONDARY-ELECTRON OUTPUT.—F. Trey. (*Physik. Zeitschr.*, 15th Jan. 1943, Vol. 44, No. 1/2, pp. 38–47.) With particular attention to Russian researches, not dealt with in Bruining's monograph (111 of 1944).

61. ON THE DEPENDENCE ON ANGLE OF THE SECONDARY-ELECTRON EMISSION FROM INSULATORS [Supplement to the Work dealt with in 3432 of 1941: the "Jump" Effect & the Importance of Space-Charge Action].—H. Daene & H. Salow. (*Physik. Zeitschr.*, 15th Aug. 1943, Vol. 44, No. 13, pp. 302–303.)

62. ON THE INTERPRETATION OF THE OBSERVATIONS ON MELTING TUNGSTEN SINGLE-CRYSTAL WIRES REPORTED BY I. N. STRANSKI & R. SUHRMANN [787 of 1943, on Fused "Pintsch" Filaments].—J. Leonhardt: Stranski & Suhrmann. (*Naturwiss.*, 12th March 1943, Vol. 31, No. 11/13, pp. 139–140: Reply on p. 140.)

63. THE PLANNING OF A GLASSWORKING DEPARTMENT.—R. L. Breadner & C. H. Simms. (*Journ. of Scient. Instr.*, Oct. 1944, Vol. 21, No. 10, pp. 169–173.) From the G.E.C. Laboratories.

DIRECTIONAL WIRELESS

64. CIRCULAR LOOP ANTENNAS AT ULTRA-HIGH FREQUENCIES.—Sherman. (*See* 45.)

65. LOOP ANTENNAS WITH UNIFORM CURRENT.—Foster. (*See* 46.)

66. ELECTRONIC AVIATION [Peace-Time Applications of Military Developments].—V. Zeluff. (*Scient. American*, June 1944, Vol. 170, No. 6, pp. 256–258.)

67. THE DESIGN OF DIRECTIONAL AERIAL ARRAYS.—V. J. Cooper & E. Green. (*Marconi Review*, Oct./Dec. 1944, No. 75, pp. 2–16: to be contd.)

Authors' summary:—"This article demonstrates a method of designing an array to give a theoretically exact polar curve of field strength to any preconceived law. The method presupposes that the mathematical equation of the polar curve desired is known or can be determined. It is then shown that from a Fourier analysis of the known form of the curve the physical arrangement of the array can be specified completely. In practice, where the size and extent of an array has an economical limit, approximations can be made, and the methods used to obtain these approximations are illustrated by the design of typical aerials, with particular reference to equi-signal beams for navigation purposes," where the presence of subsidiary loops of radiation may introduce false courses, so that it is necessary to determine what conditions must be fulfilled in order that only the specified number of radiation loops may exist.

68. THE MARCONATOR [Aircraft Navigational Aid containing Single-Needle Visual Indicator ("Switched Cardioid" Reception, with Electronic Switching), Amplitude Indicator, Master Cursor, Relative-Bearing, True-Bearing, & Drift Scales, Gyro-Magnetic Distant-Reading-Compass Repeater Motor, Adjustable Quadrantal-Error Compensator, and Loop-Drive Mechanism].—J. H. Moon. (*Marconi Review*, Oct./Dec. 1944, No. 75, pp. 17–24.)

"Incorporates in one unit [about 7" × 7" × 4½"] the several measuring instruments normally used to determine a w/t bearing. These instruments are coordinated in such a manner that a True Bearing may be read directly from a single cursor without recourse to calibration charts or need for any calculations whatever. This manipulative simplification—as compared with current methods—enables even those new to direction finding to obtain more speedy and reliable w/t bearings [*cf.* table on p. 22] which, incidentally, are automatically corrected for 'sense'"; it considerably enhances the scope of the current apparatus, so that "such operations as Straight-Track Homing, Flying on a Back Bearing, and the determination of Wind Velocities become comparatively simple matters. . ."

ACOUSTICS AND AUDIO-FREQUENCIES

69. THE ACTION OF A DIRECT-RADIATOR LOUDSPEAKER WITH A NON-LINEAR CONE-SUSPENSION SYSTEM.—H. F. Olson. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 1–4.)

Author's summary:—"During the past few years a number of mathematical investigators have directed their efforts towards the solution of differential equations with variable coefficients (*see* Friedrichs & Stoker [3020 of 1944]: this paper includes an extensive bibliography). These analyses are useful in explaining some of the phenomena which occur in electroacoustic vibrating systems with non-linear elements.

"In particular, this mathematics may be useful to explain the various phenomena exhibited by a direct-radiator loudspeaker with a non-linear cone-suspension [as, especially, in small table models and "personal" receivers]. One of the effects is a jump phenomenon in the response/frequency characteristic. Another effect is the production of harmonics and subharmonics."

70. THE EFFECT OF RADIATION ON THE VIBRATIONS OF A CIRCULAR DIAPHRAGM [Analysis of Free & Forced Vibrations of Clamped Plate with a Fluid on One Side].—M. Lax. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 5–13.)

"The procedures developed in this paper can be extended or applied in several ways: (i) Radiation impedances can be obtained for modes with nodal diameters: (ii) membranes, strings, and antennas may be handled in a similar manner (in particular, eqns. 4.7 and 5.3 apply to membranes as well as plates if $u_n(r)$ is regarded as the nth mode of a membrane): and (iii) the radiation impedances can be used to solve transient problems by making use of the Laplace or Fourier transforms." The assumptions of incompressibility and spherical radiation, made by Lamb (1920), are dropped in this treatment.

71. A NUMERICAL METHOD IN THE THEORY OF VIBRATING BODIES ["Thoroughly Practical" & Speedy Method, within the Frame of

Southwell's Relaxation Technique but with Advantages: Determination of Lowest, Second, & Higher Modes: Forced Vibrations: etc.].—A. Vazsonyi. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, pp. 598–606.)

72. A THEOREM ON DIRECTIVITY PATTERNS.—R. Clark Jones & L. A. MacColl. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 101: summary only.) From the Bell Telephone Laboratories.

73. THE DIPOLE MICROPHONE [and Its Application to a Wearable, Close-Talking Microphone with Strong Discrimination against Ambient Noise: Calculations of Various Characteristics, and Comparison with Experiment].—B. Olney, F. H. Slaymaker, & W. F. Meeker. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 102: summary only.)

74. SOUND-WAVE FIELDS WITHIN CAVITIES [as used in the Calibration of Microphones & Receivers: Solutions of Wave Equation in form of Fourier–Bessel Expansions: Comparison with Experiment].—R. K. Cook. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 102: summary only.)

75. INSTANTANEOUS RECORDING [Demand & Scope: History of Development: Acetate Discs: Development of Shellac Plastics in India (including the Addition of Metallic Soaps, giving Reduced Surface Noise & Better Keeping Qualities): etc.].—N. Bannerjee. (*Sci. & Culture* [Calcutta], July 1944, Vol. 10, No. 1, pp. 42–45.)

76. A BROADCAST-STUDIO CONTROL CONSOLE [designed specially for Comfort & Convenience of Operator, Pleasing Appearance, and Complete Accessibility for Maintenance & Repair].—R. H. DeLany. (*Proc. I.R.E.*, Oct. 1944, Vol. 32, No. 10, pp. 600–603.)

77. ON VOWEL-RESONANCE DATA [Note on Continuation of Previous Work].—T. von Tarnóczy. (*Naturwiss.*, 29th Jan. 1943, Vol. 31, No. 5/6, p. 66.)

78. INVERTED SPEECH [and Its Phonetics]: PART I—SPEECH PRODUCTION IN GENERAL.—A. W. Ladner. (*Marconi Review*, Oct./Dec. 1944, No. 75, pp. 34–36.)

Part II will deal with the relationship of inverted speech to ordinary articulatory sounds, and outline a theory as to why certain of the results occur. Although it is possible to enunciate "quite a proportion of inverted sounds, by far the larger proportion of articulatory sounds cannot be acquired by the average individual. In consequence, we cannot really consider inverted speech to be a new language capable of being learned and taught. To all intents and purposes, therefore, it may be regarded as a privacy system in itself, provided the receiving system contains no means of even partial reinversion. It should be pointed out here that partial reinversion is often sufficient to enable the brain to reconstruct the original context."

79. A WIDE-RANGE ADJUSTABLE ACOUSTIC IMPEDANCE [of Calculable Values: using Three Telescoping Tubes: Theory, and Comparison with Experiment].—W. F. Meeker & F. H. Slaymaker. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 102: summary only.)

80. EAR AND CLOSED-COUPLER ACOUSTIC IMPEDANCE [Adaptation of Flanders Method of Impedance Measurement (1932 Abstracts, p. 589, l-h col.) to Measurement of Ear Impedance].—G. S. Cook & P. Chrzanowski. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 102: summary only.)

81. ACOUSTICAL AMPLIFICATION BY HEARING AIDS [Apparatus & Procedure for Tests: Results on Six Types of Instrument].—P. E. Sabine. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 38–44.)

"The data presented do not by any means cover all the information that is desirable in evaluating the merits of a particular hearing aid. They do, however, present a fairly simple method of measuring the acoustical gain ... The method is essentially that which Romanow [743 & 1377 of 1942] has called a 'coupler calibration', without imposing the somewhat difficult condition of setting up a 'free field'."

82. PRACTICAL HEARING-AID MEASUREMENTS [in Production, and Their Basis in Standard Laboratory Tests: including Descriptions of the Artificial Voice, Body, Ear, & Mastoid (for Bone-Conduction Receivers): Specially Effective Frequency Generating & Detecting Equipment (136 of 1942)].—R. W. Carlisle & A. B. Mundel. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 45–51.) For a correction *see* October issue, No. 2, p. 125.

83. ACOUSTIC FILTRATION AND HEARING AIDS [Experimental Study of the Variations of the Acoustic "Line" between Hearing-Aid Receiver & Drum, and Their Effects on the Quality of the Transmission: with Mathematical Analysis of the Phenomena involved].—F. M. Grossman & C. T. Molloy. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 52–59.)

84. THE BAFFLE EFFECT OF THE HUMAN BODY ON THE RESPONSE OF A HEARING AID, *and* PRESSURE AND FIELD RESPONSE OF THE EAR IN HEARING-AID PERFORMANCE DETERMINATION.—W. W. Hanson: C. J. LeBel. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 60–62: pp. 63–67.) Two of a group of studies with the object of "putting hearing-aid fitting on a more scientific basis."

85. ANATOMICAL CHANGES RESPONSIBLE FOR BLAST DEAFNESS, AND THE PREVENTION OF SUCH DAMAGE TO THE EAR.—S. R. Guild. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 68–70.)

86. THE REHABILITATION SERVICE FOR THE HARD OF HEARING, AT DESHON GENERAL HOSPITAL, BUTLER, PENNSYLVANIA.—E. H. Truex, Jr. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 71–74.)

87. EVIDENCE FOR THE EXISTENCE OF PERIPHERAL AUDITORY MASKING.—K. Lowy. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 98: summary only.)

88. AIR- AND BONE-CONDUCTION AUDIO-TESTING ASSEMBLY [avoiding Use of Sound-Proofed Booth, and eliminating Errors common in Present Techniques].—N. A. Watson. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 98 : summary only.)

89. THE RÔLE OF THE COLLEGE AND UNIVERSITY HEARING CLINIC.—Miriam D. Pauls. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 98–99 : summary only.)

90. ANALYSES OF TONES OF WIND INSTRUMENTS AND OF RESONATING STRINGS [including an Investigation of the Effect of the Extra Wires of the Viola d'Amore].—F. A. Saunders. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 101 : summary only.)

91. SOME PROBLEMS FOR POST-WAR MUSICAL ACOUSTICS [Velocity of Sound within Wind Instruments for Various Ambient Conditions, Criterion of Standard Pitch for Wind Bands, New Instruments, More Practical Sound Analyser, etc.].—R. W. Young. (*Journ. Acous. Soc. Am.*, Oct. 1944, Vol. 16, No. 2, pp. 103–107.)

92. THE "CLANG" [or "Wolf"] TONE OF THE PIANOFORTE.—A. F. Knoblaugh. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 102 : summary only.)

93. THE REFLECTION OF SOUND DUE TO A CHANGE IN CROSS-SECTION OF A CIRCULAR TUBE [Reflection & Transmission Coefficients determined by calculating the Exact Pressure Distribution in Vicinity of Discontinuity, without Any Assumption that Dimensions of Latter are Very Small or Very Large compared to Wavelength].—J. Miles. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 14–19.)

"The concepts of 'transverse' modes of propagation (in addition to the usual plane wave) seem to have lain dormant until the event of increased interest in the parallel, but more complicated, electromagnetic problems in wave-guides."

94. PROPAGATION OF SOUND IN LINED DUCTS [Approximate Methods of Treatment for Cases where Application of Morse's Results is Too Laborious].—C. T. Molloy. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 31–37.)

95. ON THE THEORY OF THE DOPPLER EFFECT AND ABERRATION.—Rüchardt. (*See* 22.)

96. A PRECISION METHOD FOR THE DETERMINATION OF THE VELOCITY OF SOUND IN AIR [at University of California, Los Angeles].—R. W. Leonard. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 101 : summary only.) "Since it is unnecessary for the operator to enter the room during or immediately previous to making the measurements, temperature gradients and turbulence are at a minimum."

97. SUPERSONIC TRANSMISSION AT OBLIQUE INCIDENCE THROUGH A SOLID PLATE IN WATER, *and* A REVIEW OF SUPERSONIC METHODS FOR MEASURING ELASTIC AND DISSIPATIVE PROPERTIES OF SOLIDS.—J. B. Smyth & R. B. Lindsay : S. Siegel. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, pp. 20–25 : pp. 26–30.)

98. CURVED QUARTZ CRYSTALS AS SUPERSONIC GENERATORS.—L. W. Labaw. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 100 : summary only.) *Cf.* Lyon & others, 3907 of 1944.

99. ELASTIC CONSTANTS OF DIAMOND [New Method of Measurement, based on Generation of Continuously Varying Supersonic Frequencies by Suitably Cut & Silvered Quartz or Tourmalin Wedge].—S. Bhagavantam & J. Bhimasenachar. (*Nature*, 28th Oct. 1944, Vol. 154, No. 3913, p. 546.)

100. RAPID DETERMINATION OF ELASTIC CONSTANTS OF GLASS AND OTHER TRANSPARENT SUBSTANCES [and perhaps Opaque & Anisotropic Bodies : a New Supersonic-Diffraction Technique].—Szymanowski. (*See* 121.)

101. EFFECTS OF SUPERSONIC WAVES ON YEAST.—H. von Euler & B. Skarzynski. (*Naturwiss.*, 13th Aug. 1943, Vol. 31, No. 33/34, p. 389.)

PHOTOTELEGRAPHY AND TELEVISION

102. PICTURE DEFINITION [Paper at British Kinematograph Society's Symposium].—L. H. Bedford. (*Journ. Television Soc.*, June 1944, Vol. 4, No. 2, pp. 37–40.)

Cf. 2250 of 1944. Inadequacy of usual television formula : saturated definition : the case of interlaced scanning : resolution chart (visual acuity) : frequency requirements (with comparison of four television service standards and a cinematograph standard, leading to the conclusion that the best television service obtainable economically in terms of present-day technique is one having 500 lines net, interlaced, giving saturation definition at a viewing-angle of 1/8.1. The frequency band for which this is an optimum is 3.26 Mc/s, obtainable on the existing carrier frequency by the vestigial-sideband technique).

103. THE TELEVISION CONTROVERSY.—E. F. McDonald, Jr. (*Scient. American*, July 1944, Vol. 171, No. 1, pp. 27–28.) Views of the president of Zenith Radio. "I am against pre-war standards or warming over last night's dinner . . ."

104. INDUSTRIAL TELEVISION CAN SERVE TO IMPROVE PROCESS CONTROL.—R. R. Beal. (*Scient. American*, July 1944, Vol. 171, No. 1, pp. 36–37.) As a means of coordinating activities in giant manufacturing plants, and of peering into places and situations inaccessible or extremely hazardous.

105. TELEVISION WITHOUT SCANNING [Craig System, where Each Spot on Photosensitive Screen is allotted a Particular Frequency, and Light Gradations of Each are handled Simultaneously by Continuously Modulating a Single Broadcast Carrier].—P. H. Craig. (*Journ. Television Soc.*, June 1944, Vol. 4, No. 2, pp. 46–47.) Summary of the paper dealt with in 2629 of 1944.

106. Television over the 'Phone [Comments on Report of Washington Demonstration].—(*Electrician*, 3rd Nov. 1944, Vol. 133, No. 3466, p. 389: paragraph only.)

107. The Signal Converter and Its Application to Television [Paper read at Television Society General Meeting].—P. Nagy. (*Journ. Television Soc.*, June 1944, Vol. 4, No. 2, pp. 26–35: Discussion pp. 35–36 and 47.)
An article by Nagy & Goddard was dealt with in 3393 of 1943.

108. On the Effect of the Space Charge on the "Sharpness" of Television Cathode-Ray Tubes.—E. Schwartz. (*Physik. Zeitschr.*, 1st Oct. 1943, Vol. 44, No. 16/17, pp. 348–366.)

The fact that projection-type cathode-ray tubes require larger ray-currents and sharper light-spots than the ordinary directly-viewed tubes would seem to make the effect in question of very special importance in connection with projection-type tubes. In order, however, to obtain a general view of the question, the present theoretical investigation deals with all types of tube.

Author's summary:—"The results may be summed up by saying that at present the space-charge forces have only a small influence on the attainable sharpness of spot in c.r. tubes for television.

"At the first cross-over point or minimum cross-section near the cathode the space-charge forces can be the more completely neglected, the larger the electron-optical ratio and the more the cross-over point lies in the region of high ev-velocity. The sharpness-limiting action of the space charge makes its appearance much earlier in the region of the fluorescent screen, but even here a good reserve is in hand in all important types of tube up to the present. It is no mere accident that the tube of the old 'upright-tube' type of receiver [with sloping mirror] has the most favourable relations and the tube of the 'Unit' receiver [*see* 4598/4603 of 1939 and 1124 of 1940] has the smallest reserve; for the former model, though deriving from an older development, was nevertheless produced in greater technical freedom and without many manufacturing and economic restrictions, whereas the latter was allotted, for economy's sake, a small ray-voltage and a small ray-aperture.

"The conditions for a projecting tube are in no way more critical than for directly-viewed tubes, because the increased power-density in the spot is counterbalanced by a considerable raising of U_A and generally also a slight (and also less important) raising of ρ_0', so that altogether the value of $k = (1/N) \cdot \rho_0'^2 \cdot U_A^{5/2}$, which governs the whole problem, remains within normal limits" [*see* eqn. 10a, p. 356].

"It may be regarded as a piece of luck that the electronic mechanism in the electron-gun system produces a non-constant divergence, so that the ray divergence and the current are so interconnected that $i_A/\rho_0'^2$ in the modulation interval is nearly constant, and the position of the focal plane nearly fixed.

"There are three things which in future developments may give an increased importance to the reduction of sharpness due to the space charge: they are (i) lower anode voltage, especially if combined with raised anode current, (ii) decreased divergence of the ray, and (iii) a divergence independent of the anode current and constant in the modulation interval. Up to just before the war the trend of development gave signs of all these three tendencies; on the other hand, consideration of the above calculations leaves the impression that by purely empirical methods the naturally provided possibilities were quite well utilised. In any case, the remaining possibilities of change along the lines of (i), (ii), and (iii) are no longer very great, and any distinct step in the first direction (lower U_A) would only be made to the exclusion of the other two. The developmental possibilities would soon find, in the relationships expressed in this paper, their natural physical limits."

109. Electron Bombardment in Television Tubes.—I. G. Maloff. (*Journ. Television Soc.*, June 1944, Vol. 4, No. 2, pp. 41–45.)
Already dealt with in 2632 of 1944.

110. On the Dependence on Angle of the Secondary-Electron Emission from Insulators.—Daene & Salow. (*See* 61.)

111. On the Absolute Measurement of the Spectral Sensitivity of Photocells [and Its Difficulty compared with the Measurement of Relative Sensitivity: a Simplified Procedure].—W. Leo. (*Physik. Zeitschr.*, 1st April 1944, Vol. 45, No. 1/2, pp. 46–47.)

Theissing's simplified method (252 of 1936) assumes that the sensitivity of the cell under examination does not lie too far in the ultra-violet region; further, an integration of the product values of the already-known relative sensitivity of the cell and the spectral energy-distribution of the Hefner candle has to be carried out. The calibration of the absolute sensitivity can, however, be simplified still more if the relative spectral sensitivity is first measured in the usual way and the wavelength-independent "comparison" receiver (thermoelement) is only employed to compare the radiation-intensity of one (or several) monochromatic light beams with the total radiation from a Hefner candle, or better still, from a standard incandescent lamp calibrated in watt/cm². For such a measurement neither the surface area of the thermoelement nor its sensitivity data need be known, and the sensitivity-distribution along its receiving surface may be arbitrarily inhomogeneous. The procedure is outlined.

112. Alloy Photocathodes with Absence of Saturation.—W. Hartmann. (*Naturwiss.*, 13th Nov. 1942, Vol. 30, No. 46/47, p. 712.)

From the Fernseh G.m.b.H. laboratories: for previous work *see* 853 of 1944. In investigations on photocathodes of the type [Ag]–Cs_2O, Cs, Ag–Cs, Sb, layers were obtained, under certain conditions, which showed no saturation but rather a photocurrent increasing with the anode voltage, and to a much greater extent than would be expected according to the Schottky effect. For an anode voltage of 3000 v the sensitivity was about three times as great as for 200 v, and reached values of 120–180 μA/lumen. The slope of the current/voltage straight lines was approximately proportional to the incident light flux.

To obtain this result, it was necessary to oxidise the thick, non-transparent silver layer which served as the under-layer, to a definite thickness measured by the consumption of oxygen in the glow discharge; and to employ an amount of antimony of about 1.25×10^{-5} mg/cm². It was also necessary that throughout the cooling of the photosensitive layer after the activation process, during illumination, a field strength of about 1000 v/cm should be maintained at the cathode. The experiments were made in October, 1938, but owing to more urgent work their further development had to be postponed till now.

113. Photocells for High-Frequency Modulated Light.—P. Grivet. (*Ann. de Physique*, Vol. 17, 1942, p. 72 onwards: 84½ pp.)

A long summary is given in *E.T.Z.*, 7th Oct. 1943, Vol. 64, No. 39/40, pp. 538–539. "The writer investigates closely the behaviour of vacuum-type photocells, with filamentary anode in the middle of the tube, to modulated light of frequencies 1 to 10 Mc/s [13 Mc/s is mentioned later on]. Hitherto, vacuum-type cells have chiefly been dealt with in television technique, and there only for frequencies below 2.5 Mc/s. Two interesting types of phenomenon were found; these were investigated and analysed mathematically.

"The two effects are as follows:—(1) A h.f. current in the external circuit of the photocell is not necessarily connected with the attainment of the anode by the electrons; it can occur even in the presence of a counter-voltage: and (2) the existence of the h.f. current (produced by the h.f. modulated light falling on the photocathode) greatly influences the form of the current/voltage characteristic; the characteristic has a sharply marked maximum, before saturation in the space-charge region, which may assume a value nearly double that of the saturation current, and which may be interpreted as a kind of resonance effect between the electrons swinging to-and-fro and the frequency of the modulated light, provided that this frequency is comparable with the electron path-times."

The summary describes the experiments in some detail. The light-source was a capillary discharge tube with external electrodes; various fillings (from helium to cadmium vapour) were used, maximum brightness being obtained at a certain pressure which differed according to the nature of the filling. Striking and burning voltages also differed widely, between 900 and 1200 v. The oscillator was of the writer's own design, with amplitude constant within less than 1% and quartz-controlled frequency constant within 10^{-6}. The depth of light modulation attainable depends on two factors, which are discussed: in descending order of attainable depth the fillings form the series water vapour, helium, neon, mercury vapour; the best results were given by helium.

The voltage for the maximum h.f. sensitivity (mentioned above as "effect 2"), which was 13 v at 13 Mc/s in a particular case quoted, increases if the modulation frequency is decreased, the relation being $N\tau(U) = 0.88$, where $\tau(U)$ is the mean free path of the electrons as a function of the accelerating voltage. The phase alters very rapidly in the region of voltage where the amplitude is at its maximum. "These phenomena depend only on the electron mechanism in the vacuum, and not at all on the coating of the cathode or on coupling with the amplifier." This view was confirmed by the fact that an external magnetic field had not the slightest effect on the photo-current except when it was parallel to the electron paths: a result which the writer explains as analogous to retarding-field valve phenomena. This discussion leads to "effect 1" (above) and its elucidation.

The summary deals briefly at the end with the writer's evolution of a quantitative theory of the effects of h.f. illumination, based on a model formed of two concentric spheres: an equation is given for τ, the time of stay of the electrons between the electrodes.

MEASUREMENTS AND STANDARDS

114. A Measurement of the Velocity of Light in Water [Vibrating-Quartz Method: and a Possible Means of Measuring Ultra-Short Electrical Wavelengths].—Houstoun. (*See* 23.)

115. Testing High-Frequency Cables: a Resonance Line Method for the Measurement of Characteristics in the Decimetre-Wave Range.—F. Jones & R. Sear. (*Wireless Engineer*, Nov. & Dec. 1944, Vol. 21, Nos. 254 & 255, pp. 512–520 and 526: pp. 571–583.)

The "junction effect" due to the inevitable discontinuity at the point of connection of the cable decreases at frequencies above about 150 Mc/s with the necessary use of distributed impedance devices, which enable the discontinuity to be greatly reduced: above about 300 Mc/s, however, it again becomes a main difficulty, since the effect of a given discontinuity increases with frequency. The special techniques for overcoming the difficulty (N.P.L. method using odd multiples of $\lambda/8$: Cartesian-coordinate diagram method) are both too lengthy for routine testing, "as one sample normally requires a minimum test time of three to four hours."

The writers' method involves a testing time of the order of twenty minutes for each sample. It is adapted from the first writer's investigation into the effects of junction discontinuities with "lumped circuit" resonance methods (2019 of 1942), which showed that the effect of a "lumped" inductive reactance in the cable junction is negligible when the junction is situated at a voltage antinode, and that a possible source of error is thus minimised by arranging the cable to be resonant and with a high input resistance. In practice, cable lengths of an integral number of half-wavelengths are used, with the far end open-circuited (thus permitting the cable length to be easily adjusted). The measuring lines employed are of two types, for measuring coaxial and balanced-twin cables. The description of the apparatus includes various practical difficulties (contact troubles, thermocouple habits, etc.) and the manner in which they were overcome. The paper also includes a discussion of the measurement of twin cables with a velocity unbalance.

116. A Standard-Signal Generator for Frequencies up to 300 Mc/s.—R. Otto. (*E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, pp. 512–513: summary only.)

A shorter summary was referred to in 1991 of 1944. Points in the design of this generator include the following: the range (5–300 Mc/s) is covered by 8 coils mounted on a "coil wheel" so arranged that the coil in use lies close to the tuning condenser. A push-pull oscillator is used: part of its output voltage, measured with a diode, serves as the basic voltage for a capacitive voltage-divider. The continuously adjustable voltage is modulated in a pentode (frequencies up to 2.3 Mc/s, only slight frequency-modulation) and taken to an output cable terminated by 100-ohm resistances. Among the advantages of the push-pull connection is the absence, with a symmetrical tuning condenser, of any conveyance of current to the rotor. The voltage division (over a wide range down to 0.1 μV) is performed by a rotary condenser ($1 - 10^{-4}$ pF) as series capacitance combined with a fixed parallel capacitance: the basic voltage is taken to a fixed electrode, to and from which a moving electrode, carrying away the divided voltage, is swung by its spindle: thanks to a cylindrical cover, a logarithmic scale is obtained. The lowest output voltages must not be masked by valve noise, and to prevent this happening a second, ohmic voltage divider of 1 : 100 ratio is connected, for these smallest voltages, after the modulating valve. The very careful screening is mentioned, as well as the blocking of the h.f. tending to enter the screened spaces by way of the heating and anode-supply leads, by means of low-pass filters and other precautions. Various other refinements, such as motor-driven coarse adjustment, with fine adjustment by hand, are mentioned in the summary.

117. A SEMICONDUCTOR-TYPE HIGH-RESISTANCE BOLOMETER.—G. Bauer. (*Physik. Zeitschr.*, 15th Feb. 1943, Vol. 44, No. 3/4, pp. 53–62.)

In a previous paper (134 of 1943) the writer calculated the sensitivity of a high-resistance bolometer, and in particular the sensitivity-limit and its dependence on the various sources of trouble. The results of this calculation are now applied to the special case of a semiconductor-type bolometer and are compared with measured results with such an instrument, which had as its semiconductor a cuprous-oxide film about 0.0017 cm thick, formed by a special process in the central portion of a 0.001 cm-thick strip of copper foil. This foil remained unchanged to form the ends of the whole strip, two of which were combined to make the bolometer: they were from 0.6 to 0.8 cm long and 0.1 cm wide, and at room temperatures gave resistances of about 150 megohms. The design of the instrument is described and illustrated.

Since the resistance/temperature coefficient is negative, and decreases with rising temperature, the optimum region of temperature is lower than in the general case previously calculated. The limit of sensitivity is reached at 326° K and amounts to about 6×10^{-8} watt/cm². Owing to the thickness of the film, this is only about four times better than that given by the metal-type bolometer.

118. DIELECTRIC LOSS OF ENAMELLED WIRE [Simple Method (*e.g.* for Acceptance Tests) giving Reliable Results on Short Lengths: Conductor as One Electrode, Graphite Coating as the Other: Conclusions as to Character of the Enamel can be reached from Capacitance & tan δ Variations with Temperature & Humidity, etc.].—K. Potthoff & R. Müller. (*E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, pp. 503–507.)

119. MEASUREMENT OF THE ELECTRICAL PROPERTIES OF ENAMELLED WIRES [Discussion of the New Standard Test Specification DIN E 46 453, and Description of the Equipment & Technique at the P-T.R: with Literature References].—W. Hetzel. (*E.T.Z.*, 7th Oct. 1943, Vol. 64, No. 39/40, pp. 529–532.)

120. FRICTIONAL DISPERSION OF THE DIELECTRIC CONSTANTS OF ORGANIC LIQUIDS FOR COMPARATIVELY LONG ELECTRIC WAVES.—E. Plötze & P. Mehler. (*Naturwiss.*, 16th July 1943, Vol. 31, No. 29/30, pp. 346–347.) Extension of the work referred to in 703 of 1939.

121. RAPID DETERMINATIONS OF ELASTIC CONSTANTS OF GLASS AND OTHER TRANSPARENT SUBSTANCES [Problem of Increasing Urgency in Research & Production: Superiority of Supersonic-Diffraction Methods: Practical Defects of the Schaefer–Bergmann Technique: an Improved Method].—W. T. Szymanowski. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, p. 627.) Experiments are in progress to extend the method to opaque substances and anisotropic bodies.

122. BRAZILIAN QUARTZ—A STRATEGIC MINERAL.—P. F. Kerr. (*Journ. Franklin Inst.*, Oct. 1942, Vol. 234, No. 4, p. 412: summary, from *Mining & Metallurgy*, Vol. 23.)

123. ORIENTATION OF THE ETCHING FIGURES OF QUARTZ [New Measurements, in the course of Investigations of the Effect of Ultra-Violet Radiations on the Figures].—Choong Shin-Piaw. (*Nature*, 7th Oct. 1944, Vol. 154, No. 3910, p. 464.)

"In contradiction to the observations of previous workers, the three basal heights of the pyramids are by no means parallel to the three directions of the bisectors of the angles of the hexagonal cross-section . . . The pyramids are directed to the mechanical axes rather than to the electric axes of quartz . . ."

124. THE EFFECT OF RADIATION ON THE VIBRATIONS OF A CIRCULAR DIAPHRAGM.—Lax. (*See* 70.)

125. PRODUCTION OF PIEZOELECTRIC CRYSTALS [Enormous War-Time Expansion made possible by Recent Techniques: X-Ray Diffraction (with Geiger–Müller Counter): Frequency Checks during Hand-Finishing: Metal Coatings: Planetary-Type Lapping Machine: etc.].—North American Philips. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, p. 628 & Cover.) From a booklet "How quartz crystals are manufactured".

126. AN EXTENSION OF THE X-RAY GONIOMETER METHOD [of Crystal Investigation]: THE DIFFERENTIAL X-RAY GONIOMETER.—W. Hoffmann. (*Naturwiss.*, 26th Feb. 1943, Vol. 31, No. 9/10, pp. 113–114.)

Of special value in cases where the crystal has no visible surfaces or edges to guide its orientation with respect to the apparatus, when hitherto either the X-ray method had to be abandoned (with all its advantages) or else a complicated determination of orientation by the Laue technique had to be carried out.

127. Note added to "Modulated-Beam Cathode-Ray Phase Meter" [2928 of 1944: Similar Principle used by McLean & Sivian (1931 Abstracts, p. 503), with Thyratron Pulse Circuit acting on the Anode Potential, instead of the "Clipper" Circuit acting on the Intensity Grid Potential].—A. Watton, Jr. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, p. 573.)

128. The Effect of Voltage on an Oscillatory Circuit loaded by a Negative Resistance, and a Derived Method of Measuring Very Small Voltages [*e.g.* 10 Microvolts: using an Oscilloscope].—Kalmus. (In the paper dealt with in 40, above.)

From the equation $\log_e(e_a/e_b) = t_b - t_a$: two known voltages are required, because although $t_b - t_a$ is easy to determine on the oscilloscope screen, it is impossible thus to determine t_b or t_a.

129. The Reading Time of the Wulf Single-Thread Electrometer [for Various Tensions of the Thread: Measurement by Photographic Method: for a Fixed Tension but Arbitrary Sensitivity, the Time is Constant so long as the Calibration Curve is Linear].—J. Schintlmeister & Gertrud Urm. (*Physik. Zeitschr.*, 15th Nov. 1942, Vol. 43, No. 22, pp. 486–488.)

130. Megohm Meter [essentially a Direct-Reading Ohmmeter but incorporating a Valve Voltmeter in order to cover relatively High Resistance Values: for Laboratory & Production Testing: "Several New Features"].—Industrial Instruments. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 156.)

131. Radio-Frequency Bridges [Summary of Chairman's Address to I.E.E. Radio Section].—H. L. Kirke. (*Electrician*, 20th Oct. 1944, Vol. 133, No. 3464, pp. 349–350.)

132. Measurement of Capacitance [of the Order of 1 $\mu\mu$F, at Audio Frequencies (instead of resorting to R.F. Methods) by Modification of the de Sauty Bridge: Method free from Limitations of Hartshorn's Schering-Bridge Technique].—B. K. Sahay. (*Sci. & Culture* [Calcutta], May 1944, Vol. 9, No. 11, pp. 501–502.)

133. Foundations of Electrical Measurement.—L. Hartshorn. (*Nature*, 28th Oct. 1944, Vol. 154, No. 3913, pp. 534–537.) Based on the I.E.E. paper, a summary of which was dealt with in 2663 of 1944.

134. Standardisation of Electrical Quantities: the Modern Trend of Accuracy [with Special Reference to the Future Standardisation of Radio Components & Apparatus in India: Results of a Questionnaire].—J. N. Bhar. (*Sci. & Culture* [Calcutta], May 1944, Vol. 9, No. 11, pp. 462–465.)

135. On the Definition of the Quantities of the Electromagnetic Field and on the Theory of Systems of Measurement [Explanation & Discussion of the 1941 A.E.F. Proposals].—J. Wallot. (*Physik. Zeitschr.*, 15th Jan. 1943, Vol. 44, No. 1/2, pp. 17–31.)

136. Reform of Electrical Units.—J. J. Durack. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, pp. 527–528.)

"We need not expect the practician of the future to take any more kindly to mathematics than he does to-day, but if he acquires an intimate knowledge of the *results* of theory he may safely ignore the methods by which they were obtained.

"This will put a heavy tax on his memory. Is that memory to be unnecessarily burdened with the lopsided formulae that disfigure electrical theory to-day? Will the practical man still have the labour of translating from three different systems of units into the practical system in which he makes all his calculations? The answer is yes, unless a change is made in our electric and magnetic units . . . Gaussian units are generally used in the treatment of Maxwell's electromagnetic theory and, I hold, as modified by Heaviside, should be the only system appearing in the whole theory of electricity and magnetism . . ."

SUBSIDIARY APPARATUS AND MATERIALS

137. A New Coordinate-Recorder System [Substitute for Cathode-Ray Oscillograph].—Lueg. (*E.T.Z.*, 9th Sept. 1943, Vol. 64, No. 35/36, pp. 487–488: long illustrated summary.) A previous summary was dealt with in 169 of 1944.

138. On the Effect of the Space Charge on the "Sharpness" of Television Cathode-Ray Tubes.—Schwartz. (*See* 108.)

139. A Cathode-Ray Oscillograph for Transient and Recurrent Phenomena over a Wide Frequency Range: Type 247.—DuMont Laboratories. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 156.)

140. Cross-Prism Investigation of Fluorescence.—Germann & Woodriff. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, pp. 145–149.)

The method yields a single photograph of the fluorescence spectrum such that a vertical scanning of it gives the variation of light intensity of a given wavelength as a function of the exciting wavelength, while a horizontal scanning gives the spectral energy distribution, as a function of wavelength, for a given frequency of exciting light. "Using a continuous source of ultra-violet radiation, a single exposure thus gives all the information necessary to determine the best frequencies of exciting light to produce a maximum fluorescent light of a given colour or energy distribution."

141. On the Spectral Energy Distribution of the Luminescence of Certain Luminophores [excited by Ultra-Violet Light & by Alpha Particles: especially the Unexpected Difference, in the Blue Region, of the Two Curves of Green-Glowing Zinc-Sulphide–Copper Phosphor].—Korte & Bünnagel. (*Physik Zeitschr.*, 1st Nov. 1942, Vol. 43, No. 21, pp. 437–439.)

142. On the Temperature-Dependence of the Brightness of Crystal Phosphors under Monochromatic Excitation [and the Information which It yields as to the Mechanism of Fluorescence: Measurements on ZnS and Cu-Activated & Self-Activated ZnS CdS, at

Room & Liquid-Air Temperatures].—Schön. (*Naturwiss.*, 2nd April 1943, Vol. 31, No. 14/15, p. 169.)

143. PHOSPHORESCENCE AFTER-GLOW OF SOME ALKALI HALIDES [under X-Ray Irradiation: the Action of Pressure-Treatment in Increasing the After-Glow Period, and Its Interpretation: etc.].—Bose. (*Sci. & Culture* [Calcutta], June 1944, Vol. 9, No. 12, pp. 562–563.)

144. "SCIENTIFIC PAPERS FROM THE YEARS 1886 TO 1932: VOL. 2—PHOSPHORESCENCE: WITH AN INTRODUCTION BY P. LENARD" [Review of German Book].—Wesch (Edited by). (*E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, p. 516.) For original work by Wesch *see* 203 of 1942.

145. DEFLECTED ELECTRON BEAMS [Continuation of Correspondence referred to in 3865 of 1944 and Back References].—Harries: Rodda. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, p. 528.)

146. GROUNDWORK OF THE ELECTRON-OPTICAL THEORY OF A MASS SPECTROMETER.—Marschall. (*Physik. Zeitschr.*, 1st April 1944, Vol. 45, No. 1/2, pp. 1–36.)

147. STATISTICAL ULTRA-MICROMETRY WITH RÖNTGEN, ALPHA, AND NEUTRON RAYS [Comparison with Optical & Electron Microscopy: the Theoretical Basis of the Method, on the "Target-Hit" Theory: Examples of Application].—Zimmer. (*Physik. Zeitschr.*, 1st June 1943, Vol. 44, No. 9/10, pp. 233–243.)

148. A NEW SOURCE FOR IONS [Objections to Existing Sources: Simple Method of obtaining Currents up to 1000 μA with a 1-Watt Input: Electron Stream & Separately Generated Molecular Beam (or Gas Current) cross at Right Angles, Resulting Ions are drawn out by Electric Field].—Heil. (*Zeitschr. f. Phys.*, Vol. 120, 1943, p. 212 onwards: summary in *E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, p. 514.)

149. HIGH-RESOLUTION IMAGE FORMATION WITH THE USE OF ION RAYS: ION SUPER-MICROSCOPY [Difficulties in improving Resolving Power of Electron Microscopes: Shortening of the de Broglie Wavelength by use of Ions: Some Preliminary Results].—Boersch. (*Naturwiss.*, 13th Nov. 1942, Vol. 30, No. 46/47, pp. 711–712.)

150. DESIGN AND APPLICATIONS OF AN ELECTRON-MICROSCOPE ARRANGEMENT [for Ordinary Two-Stage High-Resolution Image Formation, Shadow-Microscope Image Formation, Fresnel Diffraction, Fraunhofer Diffraction (Ordinary & High-Resolution), and Emission Microscopy].—Boersch. (*Physik. Zeitschr.*, 15th Dec. 1942, Vol. 43, No. 23/24, pp. 515–520.)

151. FRESNEL DIFFRACTION IN THE ELECTRON MICROSCOPE [Theoretical Basis (including the Differences between Fresnel & Fraunhofer Diffractions): Experimental Investigation of Fresnel-Diffraction Effects in the case of a Strongly Extrafocal Adjustment].—Boersch. (*Physik. Zeitschr.*, 1st June 1943, Vol. 44, No. 9/10, pp. 202–211.)

Among other points, the writer brings out the importance of these phenomena for demonstrating the wave-nature of the electron, for determining resolving power, for measuring the angular distribution of edge diffraction, and in connection with image distortions in normal image formation. It is shown also that the Fresnel-diffraction effects, in the framework of quantum theory, demand wave-properties of the electron (coherence, phase) that are not required by the Fraunhofer-diffraction phenomena. For previous work on the subject *see* 1736/7 of 1941.

152. EDGE-DIFFRACTION OF ELECTRONS [producing Noticeable Effects in the Dark-Field Image-Formation of (*e.g.*) Crystal Edges: Theory & Experimental Investigation].—Boersch. (*Physik. Zeitschr.*, 15th Jan. 1943, Vol. 44, No. 1/2, pp. 32–38.)

The writer concludes: "Deviations from a *complete* analogy between light and electron edge-waves, shown by an intensity-difference between the electrons scattered to the two sides of the edge of the shadow, cannot be explained on the existing theory of the diffraction of light."

153. DARK-FIELD ILLUMINATION IN ELECTRON MICROSCOPY [Its Advantages, and the Easy Technique of Obtaining It with the R.C.A. Type B Microscope: Examples].—Levy. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, pp. 623–625.)

"Dark-field illumination is frequently used in microscopy, and a number of devices are available to achieve this end. In electron microscopy similar use is not made of dark-field illumination, although it was demonstrated feasible several years ago (von Ardenne's book, 4402 of 1940 [and *see* also 2709 of 1940])."

154. MAGNESIUM-OXIDE CRYSTALS IN THE ELECTRON MICROSCOPE [Formation of Bright-&-Dark Striations, extremely sensitive to Small Changes of Beam Angle, and thus attributed to Crystal-Lattice Interferences].—Kinder. (*Naturwiss.*, 12th March 1943, Vol. 31, No. 11/13, p. 149.)

155. WANDERING STREAKS IN ELECTRON-OPTICAL IMAGES OF SINGLE CRYSTALS, ESPECIALLY OF MOLYBDENUM OXIDE [and the Problem of Their Cause].—Seemann. (*Naturwiss.*, 27th Aug. 1943, Vol. 31, No. 35/36, pp. 415–416.)

156. EQUAL-THICKNESS LINES [of a Crystal] IN THE ELECTRON MICROSCOPE.—Kossel. (*Naturwiss.*, 2nd July 1943, Vol. 31, No. 27/28, pp. 323–324.)

157. THE BEHAVIOUR OF ALUMINIUM IN CRYSTAL-FIGURE ETCHING [Further Development of Work dealt with in 2065 of 1942, on Electron-Microscopic Examination of Surfaces].—Mahl & Stranski. (*Naturwiss.*, 1st Jan. 1943, Vol. 31, No. 1/2, pp. 12–17.)

158. BIOLOGICAL APPLICATIONS OF THE ELECTRON MICROSCOPE.—Donovan. (*Nature*, 16th Sept. 1944, Vol. 154, No. 3907, pp. 356–358.)

159. ELECTRON - MICROSCOPIC OBSERVATIONS OF POLIOMYELITIS - VIRUS PREPARATIONS.—Tiselius & Gard. (*Naturwiss.*, 27th Nov. 1942, Vol. 30, No. 48/49, pp. 728–731.) A summary (in which the second writer's name was given wrongly) was referred to in 3376 of 1944.

160. STUDIES OF PURIFIED PREPARATIONS OF THE MV STRAIN OF POLIOMYELITIS-VIRUS BY MEANS OF THE ELECTRON MICROSCOPE.—Loring, Schwerdt, & Marton. (*Phys. Review*, 1st/15th June 1944, Vol. 65, No. 11/12, p. 354 : summary only.) *Cf.* 3376 of 1944.

161. ELECTRON MICROSCOPES [New " Universal " Model with Electron-Diffraction Camera, and " Console " Model, " an Entirely New Type "].—R.C.A. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, pp. 154–155.) For a German " table model " on the reflecting principle *see* 3116 of 1943.

162. OPTICAL CONSTANTS OF A MAGNETIC-TYPE ELECTRON MICROSCOPE.—Marton & Hutter. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 546–552.)

A summary was referred to in 1951 of 1943 : for other papers *see* 2006 & 2943 of 1944 and back references. The sections deal with : the field form of common magnetic lenses (" the best measurements to date have been published by Dosse " : his curves are reproduced) : the paraxial-ray equation : optical constants : lens aberrations : minimum conditions and resolving power : unsymmetrical fields : aperture considerations : stability of the power sources : numerical example.

163. A CLOSED CELL FOR ELECTRON MICROSCOPY [to protect Specimen against Effects of High Vacuum (*cf.* von Ardenne's " Reaction Chamber," 1774 of 1942 [also 3488/91 of 1941 and 178/9 of 1944]) : a Simple Closed Chamber with Collodion-Film (spread on Mercury, Not Water) Windows : the Problem of Liquid Specimens : the Problem of observing Brownian Movement].—Abrams & McBain. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, pp. 607–609.)

164. ON THE HISTORY OF THE ELECTRON MICROSCOPE [with Tables of the First Literature Citations for the Various Developments (Transmission, Emission, Re-Radiation, Field-Electron, " Raster," and " Shadow " Types : Progress in Resolving Power : etc.)].—Küpfmüller. (*Physik. Zeitschr.*, 1st April 1944, Vol. 45, No. 1/2, pp. 47–51.) From the Siemens & Halske A.G. For Brüche's views on conflicting claims *see* 3115 of 1943.

165. A BIBLIOGRAPHY OF ELECTRON MICROSCOPY : II.—Marton & Sass. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, pp. 575–579.) For I *see* 545 of 1944.

166. ELECTRON-MICROSCOPE STUDY OF FERROMAGNETIC DOMAINS [by Use of Replicas prepared by suspending a Ferromagnetic Colloid in the Solution of a Plastic to be cast on the Polished Ferromagnetic Surface].—Marton. (*Phys. Review*, 1st/15th June 1944, Vol. 65, No. 11/12, pp. 353–354 : summary only.)

167. ON THE THEORY OF FERROMAGNETIC HYSTERESIS AND INITIAL PERMEABILITY [New Theory based on the Influence of Foreign Inclusions, Accidental or (for Permanent-Magnet Materials) Deliberate, acting as Anchors for the Walls between the Weiss Domains].—Kersten. (*Physik. Zeitschr.*, 15th Feb. 1943, Vol. 44, No. 3/4, pp. 63–77.) From the Siemens & Halske laboratories. A summary is given in *E.T.Z.*, 29th July 1943, Vol. 64, No. 29/30, p. 404.

168. MAGNETIC PERMEABILITY AT VERY RAPID RATES OF CHANGE OF INDUCTION [such that Average Velocity of Domain-Boundary Movement must be of order of 10^5 cm/s : Magnetisation Mechanism appreciably Different from Usual].—Glick & Siegel. (*Phys. Review*, 1st/15th June 1944, Vol. 65, No. 11/12, p. 348 : summary only.)

169. MAGNETIC MATERIALS : I—THE DOMAIN THEORY OF FERROMAGNETISM.—Brailsford. (*Electronic Eng:g*, Sept. 1944, Vol. 17, No. 199, pp. 142–145.)

170. ON THE SHIFTING OF THE CURIE TEMPERATURE BY ALL-ROUND COMPRESSION [as by Hydrostatic Pressure : Its Increased Importance now that the Connection between Curie Temperature and Coercive Force & Initial Permeability is recognised : Theory, and Measurements on Nickel–Iron & Nickel–Copper Alloys : Deductions].—Kornetzki. (*Physik. Zeitschr.*, 15th Aug. 1943, Vol. 44, No. 13, pp. 296–302.)

171. THE EFFECT OF ELASTIC ALTERNATING STRESSES ON THE PERMEABILITY OF FERROMAGNETIC MATERIALS [Bad Effect as well as the (Ewing) Good Effect].—Fahlenbrach. (*Naturwiss.*, 30th July 1943, Vol. 31, No. 31/32, pp. 371–372.) " The now-described and hitherto unknown vibration and demagnetisation influence on the permeability of magnetic materials must be taken carefully into account in practical measurements."

172. INTERACTION BETWEEN LONGITUDINAL CURRENT AND FLUX IN A NICKEL BAR [New Results apart from " Shock Effect " : including Discovery that a 60 c/s Field *lowers* Resistance even more than a Steady Field *raises* It].—Perkins. (*Phys. Review*, 1st/15th July 1944, Vol. 66, No. 1/2, pp. 21–25.)

173. STUDY OF THE PERMEABILITY OF A FERRO-NICKEL UNDER TENSION.—Bayen. (*Comptes Rendus* [Paris], 1st/29th March 1943, Vol. 216, No. 9/13, pp. 440–442.)

174. INFLUENCE OF TEMPERATURE ON THE POISSON COEFFICIENT OF IRON ALLOYS : ANOMALY OF THIS COEFFICIENT CONNECTED WITH THE MAGNETIC TRANSFORMATION OF REVERSIBLE FERRO-NICKELS [Investigation of Interest in the Preparation of Elinvar, etc.].—Chevenard & Crussard. (*Comptes Rendus* [Paris], 6th/27th July 1942, Vol. 215, No. 1/4, pp. 58–61.)

175. Anomalous Behaviour of the Electrical Resistivity of Some Iron–Cobalt Alloys.—Siegel & McGreary. (*Phys. Review*, 1st/15th June 1944, Vol. 65, No. 11/12, p. 347: summary only.)

176. On the Magnetisation of Rocks due to Disseminated Grains [Application of Chevallier's Formula for the Mean Magnetisation due to Magnetic Grains included in an Inactive Material].—Coulomb. (*Comptes Rendus* [Paris], 1st/29th March 1943, Vol. 216, No. 9/13, pp. 351–352.)

177. Theory of the Hysteresis Curves.—Herpin. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 137–139.)

The curves derived fit in well with the experimental curves. "This theory explains, moreover, a curious characteristic of the Barkhausen effect, namely that the discontinuities always appear at the same value of the field and do not depend on the amplitude of the variation of the field . . . This shows the correctness of our hypothesis of domains reverting suddenly for a definite value of field."

178. Theory of the [Magnetic] Lag Effect.—Herpin. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 193–195.)

If a magnetic field is applied suddenly, the magnetisation does not immediately follow the change of field; the lag effect or magnetic viscosity shows itself. In weak fields this lag effect satisfies the Boltzmann principle of superposition. But for stronger fields the effect is irreversible; what happens is that the Barkhausen jumps occur, with a certain delay. It is to this effect only that the present theory applies. It satisfactorily explains the lag effect, but does not conform to the principle of superposition, for if the field is annulled there is no subsequent variation of magnetisation. "Magnetic viscosity should only be important where the Barkhausen effect is intense: it should be zero on the descending branch of the hysteresis curve and maximum at the point of inflection. This is confirmed very well by experiment."

179. Demagnetisation Technique, taking into Account the Form of the Component Part [Inadequacy of the Simple "Neutralisation" Method: A.C. Field Technique].—Kracke. (*E.T.Z.*, 14th Jan. 1943, Vol. 64, No. 1/2, p. 22: summary, from *Werkstattstechnik*.)

180. The Phosphating of Magnet-Core Sheet [and Comparison with Other Insulating Methods].—Macchia & Borla. (*Bull. Assoc. Suisse des Élec.*, 28th June 1944, Vol. 35, No. 13, p. S.20: short summary only, from *Korrosion u. Metallsch.*, 1943.)

181. Magnet Shields [for Protection of Permanent Magnets against Momentary Contacts with Tools, etc.].—Cinaudagraph Corporation. (*Review Scient. Instr.*, June 1944, Vol 15, No. 6, p. 158.)

182. A Quenching Furnace suitable for Small Specimens, *and* A Note on an Arrangement for Bright Annealing of Nickel and Other Metals.—Owen: Balicki. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, pp. 65–66: pp. 67–68.)

183. The Electrical Properties of Thin Annealed Films of Nickel as a Function of Their Thickness.—Colombani. (*Comptes Rendus* [Paris], 4th/27th May 1942, Vol. 214, No. 18/21, pp. 794–795.) For subsequent work *see* 3126 of 1943, and for a Note on the ferromagnetism of nickel films *see* same journal, 4th/25th Jan. 1943, Vol. 216, No. 1/4, pp. 115–117.

184. Metrosil: Its Characteristics and Applications discussed.—Metropolitan-Vickers. (*Electrician*, 3rd Nov. 1944, Vol. 133, No. 3466, pp. 406–407.)

185. Mechanism of Electrolytic Oxidation of Aluminium [Theory leading to Consistent Explanation of the Observed Properties of the Film].—Anderson. (*Journ. Applied Phys.*, June 1944, Vol. 15, No. 6, pp. 477–480.)

186. Formation of Aluminium Hydride Layers on Aluminium.—Parshad. (*Nature*, 5th Aug. 1944, Vol. 154, No. 3901, p. 178.)

187. Titanium Pre-Dip Process Increases Life of Zinc Coatings.—Westinghouse. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, pp. 327–328: summary, from *Iron Age*, Vol. 153.)

188. Mechanical [and Electrical] Properties of Metals and Alloys [Notice, & Review, of Circular C447].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, April 1944, Vol. 237, No. 4, p. 310: *Engineering*, 25th Aug. 1944, Vol. 158, No. 4102, p. 143.)

189. "Metals and Alloys Data Book" [Book Review].—Hoyt. (*Journ. Franklin Inst.*, Dec. 1943, Vol. 236, No. 6, pp. 595–596.)

190. Physical Metallurgy of Copper and Copper-Base Alloys.—Brace. (*Elec. Engineering*, Jan. 1944, Vol. 63, No. 1, pp. 11–17.)

191. Copper-Free Aluminium Alloys of High Strength ["Konstruktal 20/42 & 20/53", etc.].—(*E.T.Z.*, 15th July 1943, Vol. 64, No. 27/28, p. 384: summary, from *Zeitschr. V.D.I.*, 1943.)

192. Ultra-Low-Melting Alloys [and Their Many Uses: the "Cerro" Series of Bismuth Alloys (*cf.* 2738 of 1944)].—Cerro de Pasco Corporation. (*Scient. American*, Jan. 1944, Vol. 170, No. 1, pp. 16–18.)

193. The Metallurgical Aspect of Metals.—Robinson. (*Marconi Review*, Oct./Dec. 1944, No. 75, pp. 25–33.)

"The following article is not intended to be in any way exhaustive or to take the place of such a book [A. C. Vivian's book, 194, below, referred to here as meeting a serious need], but rather to stimulate an interest in Metallurgy, for there is no doubt that the heat treatment of metals and alloys will become of great importance in the near future, and Engineers, especially those engaged on design work, will need to know something about such treatment."

194. "Essential Metallurgy for Engineers" [Book].—Vivian. (Mentioned in 193, above.)

195. "Gravity Die-Casting Technique" [Book Review].—Lowe. (*Engineering*, 8th Sept. 1944, Vol. 158, No. 4104, p. 184.)

196. Metallurgy of Wiped Solder Joints [of Lead Cable-Sheath].—Phipps. (*Bell Lab. Record*, July 1944, Vol. 22, No. 11, pp. 472–475.)

197. Field-Laboratory Tests of Alloy Cable-Sheath [Lead–Calcium & Lead–Antimony Sheaths and the Defects due to "Bowing" in Summer].—Livingston. (*Bell Lab. Record*, June 1944, Vol. 22, No. 10, pp. 441–444.)

198. The Beckman "Helipot" [New Kind of Potentiometer-Rheostat "combining, in a Compact Unit, Unusually Wide Range with Extreme Fineness of Adjustment."]—Nat. Technical Laboratories. (*Review Scient. Instr.*, May 1944, Vol. 15, No. 5, p. 134.) The nature of the design is conveyed by the name.

199. The Vibration of Electric Contacts [Hitherto Neglected Problem of the "Making" of Switch Contacts].—Russell & Keilien. (*Elec. Engineering*, April 1944, Vol. 63, No. 4, Transactions pp. 153–155: Discussion in *Supp. to Elec. Engineering, Transactions Section*, June 1944, Vol. 63, p. 478.)

200. Fractional-Horse-Power Motors.—Philpott. (*BEAMA Journal*, Sept. & Oct. 1944, Vol. 51, Nos. 87 & 88, pp. 295–303 & 330–335.)

201. Newly Patented Motor-Driven Rectifier with Efficiency of Nearly 100%.—(*Sci. News Letter*, 22nd July 1944, Vol. 46, No. 4, p. 64: paragraph only.)

202. On Field and Charge Distributions in Plasmas [Theory throwing light on Processes in Grid Control of Plasmas].—Schumann. (*See* 58.)

203. Transit-Time Oscillations, Self-Excitation, and Density and Current Fluctuations in the Passage of Electrons through a Space with Constant Positive Density of Charges.—Schumann. (*See* 59.)

204. Investigations on the Dynamics of the Glow Discharge and on the "Counter" Effect in Glow-Discharge Tubes [Survey of Parma University Researches in the Last Ten Years: including a Comparison with the Geiger–Müller Counter].—Valle. (*Physik. Zeitschr.*, 15th Nov. 1942, Vol. 43, No. 22, pp. 473–486.)

205. The Glow Discharge under the Action of Visible Light and X-Rays [Unsatisfactory State of Existing Knowledge: the Writer's Previous Discovery that X-Rays cause a *Decrease* in the Current in a Self-Sustaining Discharge: Further Experimental Investigations].—Reiter. (*Physik. Zeitschr.*, 1st April 1944, Vol. 45, No. 1/2, pp. 37–44.)

From the author's summary:—"Through the action of light a semi-self-sustaining discharge may be produced, in which the discharge current is proportional to the square root of the light intensity. If the glow-discharge lamp is used as a relaxation-oscillation generator, its irradiation with light produces a rise in frequency which is approximately proportional to the cube root of the light intensity. This frequency increase is the result of a lowering of the ignition voltage, itself a result of the photo-electric effect. The extinction voltage normally remains unaffected by the illumination, but if a high series resistance is connected in front of the lamp a rise in the extinction voltage may occur in some circumstances . . . Interrupted light behaves like continuous light, with only the difference that the light oscillations are transmitted to the relaxation-oscillation system and can be detected by an amplifier arrangement.

"The action of X-rays is no different from that of visible light provided that the volume of the irradiated glow-discharge lamp is small. With a lamp of very large volume distinct signs of a frequency and current *decrease* were observed, arising from an *increase* of ignition voltage produced by the irradiation. The oscillations of the X-rays may, as with the visible light, be transmitted to the relaxation-oscillation system, so that there is a 'coupling' between the relaxation frequency and the X-ray alternation frequency."

206. Knudsen-Type Vacuum Gauge in Technical High-Vacuum Work [Satisfactory Performance when Principal Objection to Widespread Application is removed by Addition of Internal Damping Vane].—Turner & Ullrich. (*Phys. Review*, 1st/15th July 1944, Vol. 66, No. 1/2, p. 37: summary only.)

207. High-Vacuum Valves with Free and Large Openings ["Slide-Valve" Type, with 100 mm-diameter Opening: "Swing-Valve" Type, with 20 mm Opening (but Design suitable for Larger Dimensions)].—Geismann. (*Physik. Zeitschr.*, 15th July 1943, Vol. 44, No. 12, pp. 268–270.) Primarily for long canal-ray tubes.

208. A Convenient Type of Vacuum Chamber for the Evaporation of Optical Films.—Banning & Paul. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 152.)

209. The Planning of a Glassworking Department.—Breadner & Simms. (*Journ. of Scient. Instr.*, Oct. 1944, Vol. 21, No. 10, pp. 169–173.) From the G.E.C. Laboratories.

210. Transmission of Power in Compressed-Gas Atmospheres ["an Experiment in Library Research" (*see* "Library *versus* Laboratory Research," by Connolly, 308 of 1942) to advance Interest in Use of Compressed Gases for Insulating Purposes, with Special Reference to D.C. & 60 c/s Power Transmission by Underground or Ground-Level High-Voltage Pipe-Enclosed Systems: also Compressed Gas for Power Transformers].—Hobart. (*Journ. Franklin Inst.*, Sept. & Oct. 1942, Vol. 234, Nos. 3 & 4, pp. 251–273 & 331–354.)

Among the results of this "library research" is the discovery of the need for more "laboratory research" on the phenomena of dielectric breakdown in compressed gases.

211. Dielectric Loss, etc., of Enamelled Wire.—Potthoff & Müller: Hetzel. (*See* 118 & 119.)

212. "Speedairbonds" Insulating Varnishes [giving "Complete Protection & Insulation under Adverse Circumstances & Atmospheric Conditions."]—Sterling Varnish. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 157.)

213. The Dielectric Properties of Lac [Measurements over Wide Range of Temperature & Frequency (50 c/s and 500 c/s to 500 kc/s): Discussion of Results].—Bhattacharya. (*Indian Journ. of Phys.*, Feb. 1944, Vol. 18, No. 1, pp. 1–22.)

"Thus we see that the dipolar theory can be satisfactorily applied to resins like lac to explain their electrical behaviour, provided all factors like the inner frictional forces, the distribution range of relaxation times of their molecules with regard to the size and shape of the rotator, etc., are properly taken into consideration."

214. "Litholite" (Lithium Stearate) and Its Interest in the Field of Electrical Insulation.—Foote Mineral. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 157.)

Thus, lithiated paraffins are dust-repellent and have high melting point and good shock resistance.

215. Synthetic Rubber and Plastics: VII—Plasticising of Vinyl Polymers.—Harvey. (*Distribution of Elec.*, Oct. 1944, Vol. 17, No. 156, pp. 318–324.) For VI *see* Penn, 2974 of 1944.

216. A New Name among Vinyl Resins [Introduction of Name "Geon" for Family of Polyvinyl Resins, including the New Vinyl–Vinylidene-Chloride Copolymers].—Moulton. (*Journ. Franklin Inst.*, Aug. 1944, Vol. 238, No. 2, p. 152: summary, from *Mod. Plastics*, Vol. 21.) *See* also *Review Scient. Instr.*, May 1944, Vol. 15, No. 5, p. 136.

217. Longitudinal Dispersion (Plotnikow Effect) of Infra-Red Rays in Polystyrols [and Other Long-Chain-Molecule Substances: including the Writer's Previous Use of the Effect to investigate Vita-Proteids, etc.].—Lepeschkin. (*Physik. Zeitschr.*, 15th Nov. 1942, Vol. 43, No. 22, pp. 489–496.)

218. Polystyrene [General Information, with Table of Data of "Plax" Polystyrene].—Plax Corporation. (*Review Scient. Instr.*, May 1944, Vol. 15, No. 5, p. 137.)

219. The Development of Polythene as a High-Frequency Dielectric.—Jackson & Forsyth. (*Electrician*, 27th Oct. 1944, Vol. 133, No. 3465, p. 373: summary of I.E.E. Radio Section paper.)

220. Moulding Thermoplastics [by the New Low-Pressure Extrusion Method developed by Metropolitan-Vickers].—Ferguson. (*Electrician*, 29th Sept. 1944, Vol. 133, No. 3461, pp. 273–275.)

221. The Future of Synthetic Plastics [Bruce–Preller Lecture].—Melville. (*Proc. Roy. Soc. Edinburgh*, Sec. A, 1943/4, Vol. 62, Part 1, pp. 1–9.)

222. Metal-Plated Plastics [as Alternatives for Critical Metals: including Shielding Applications (*e.g.* at High Frequencies) and the Production of Electrical Units combining Properties of Conductor & Insulator].—Metaplast Corporation. (*Journ. Applied Phys.*, Aug. 1944, Vol. 15, No. 8, p. 628.)

223. Laminated Densified Wood [for Electrical & Mechanical Purposes].—Jervis. (*Electrician*, 20th Oct. 1944, Vol. 133, No. 3464, pp. 343–345.) *See* also 2315/6 of 1944.

224. "A Laboratory Manual of Plastics and Synthetic Resins" [Book Review].—D'Alilio. (*Science*, 30th June 1944, Vol. 99, No. 2583, pp. 538–539.)

225. Interpretation of Striking Expansion Phenomena in Flint-Glass and Special Glasses [Little-Appreciated Fact that Flint-Glass has a Mean Expansion Coefficient which *Decreases* above 400°: Production of a SiO_2–TiO_2 Glass with Smaller Coefficient than Flint-Glass].—Dietzel. (*Naturwiss.*, 1st Jan. 1943, Vol. 31, No. 1/2, pp. 22–23.) For a further letter, on the structure of silicate glasses, *see* issue for 26th Feb. 1943, No. 9/10, pp. 110–112.

226. "Popcorn" Process fluffs Cellulose for Many Uses [Process for making Porous Cellulose Acetate & Similar Plastics], *and* Featherweight Plastic expands an Inch a Second.—Celanese Corporation: General Electric. (*Sci. News Letter*, 5th Aug. 1944, Vol. 46, No. 6, p. 89: p. 93.)

227. On the Current Conduction in Dielectric Liquids in High Electric Fields [Experimental Investigation throwing light on the Mechanism of Carrier-Formation, etc.].—Ruhle. (*Physik. Zeitschr.*, 15th March 1943, Vol. 44, No. 5, pp. 89–101.)

228. Frictional Dispersion of the Dielectric Constants of Organic Liquids for Comparatively Long Electric Waves.—Plötze & Mehler. (*See* 120.)

229. The Physical Chemistry of the Electrolyte [Derivation of Comparatively Simple Equations of State for the Ideal Electrolyte, confirming & extending Debye–Hückel & Onsager Theory, from Combination of Precision Freezing-Point & Conductivity Measurements: leading to Analysis of the Non-Ideal Electrolyte].—Lange. (*Naturwiss.*, 30th July 1943, Vol. 31, No. 31/32, pp. 353–366.)

STATIONS, DESIGN AND OPERATION

230. Combination of Amplitude and Frequency Modulation for Communication in Seismograph Exploration for Petroleum Reservoirs.—Shook, Olson, & Kerr. (*Proc. I.R.E.*, Oct. 1944, Vol. 32, No. 10, pp. 583–590.)

"The combination of the two schemes of modulation provided suitable voice reception without interfering with the f.m. system to record the time break and up-hole geophone electrical impulses free of static and accurate to 1/1000 of a second. The apparatus provides also for transmission of these impulses and voice signals by wire transmission with the same magnitude, clarity and precision by means of simple switching arrangements. The 10-watt-input a.m./f.m. transmitter devised is ample for the purpose up to 1 mile, which is sufficient for reflection seismograph exploration." A wavelength around 9 m was used.

231. High-Frequency Telephone Broadcasting [H.F. Wire Broadcasting on Telephone Network : Recent Extension of the System in Switzerland : the Apparatus & Lines employed].—Keller. (*E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, p. 510 : summary only.) Previous experience with the system has been satisfactory, and it is hoped to extend it still further, with priority to regions with poor wireless reception.

232. The Use of Radio for Railroad Communication and Signalling [Notes on an Interview with the Chairman of F.C.C., James Fly].—Fly. (*Science*, 25th Aug. 1944, Vol. 100, No. 2591, Supp. p. 10.)

233. Inverted Speech [and the Question of Its Effectiveness as a Privacy System].—Ladner. (*See* 78.)

234. A Remote-Controlled Radio-Frequency Booster for a Broadcast Station.—Hollis. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 525–533.)

Author's summary :—" Adequate coverage of the business districts of major cities by medium- or low-powered transmitters operating in the high-frequency end of the broadcast band has always presented a big problem to the broadcast engineer. This paper describes an auxiliary transmitter which was installed as a means of overcoming this handicap in Cincinnati, Ohio, where WSAI on 1360 kc/s is located 10 miles from the business district.

" A special receiving antenna and a straight r.f. amplifier without detection are used to produce sufficient signal, after re-radiation, to provide adequate service to the business area." The reason for the urgent need to keep the booster transmitter distortion at an absolute minimum is discussed on p. 527, and the final section, on the selection of the receiving-loop location, includes a description of trouble from field shifts ultimately traced to street-car movements : the double trolley-wires act as a very effective transmission line, and the cars as they move along act as short-circuiting bars and change the standing-wave pattern on the wires, with a resultant change in the field at the loop.

GENERAL PHYSICAL ARTICLES

235. Comparison of a Degenerate Form of Einstein's with Birkhoff's Theory of Gravitation [Ref. " 1 " & 3010 of 1944].—Weyl. (*Proc. Nat. Acad. Sci.*, Aug. 1944, Vol. 30, No. 8, pp. 205–210.)

236. Quantum Mechanics of Fields : I—Pure Fields : II—Statistics of Pure Fields.—Born & Peng. (*Proc. Roy. Soc. Edinburgh*, Sec. A, 1943/4, Vol. 62, Part 1, pp. 40–57 : pp. 92–102.) *See* also 237, below.

237. The Divergence Difficulty of Quantized Field Theories [Heitler–Peng Provisional Method (*see* Schrödinger & others, 2764 of 1944, and back references) Rigidly Established : Some Consequent Possibilities of Progress].—Peng. (*Nature*, 28th Oct. 1944, Vol. 154, No. 3913, pp. 544–545.)

238. Models of the Universe and Cosmological Time-Scales [Discussion of Milne's "Dynamical" & "Cosmological" Time-Scales and Eddington's Time-Scale based on Unification of General Relativity & Quantum Theory].—McVittie. (*Nature*, 14th Oct. 1944, Vol. 154, No. 3911, pp. 477–481.)

239. Analogy between Electrostatics and Magnetism, and an Ampèrian Theory of Electrostatics.—Bouthillon. (*Comptes Rendus* [Paris], 4th/27th May 1942, Vol. 214, No. 18/21, pp. 855–857.)

240. Havelock's Formula and a New Formula for the Dispersion of Electric and Magnetic Double Refraction.—Servant. (*Comptes Rendus* [Paris], 4th/25th Jan. 1943, Vol. 216, No. 1/4, pp. 177–178.) Following on 935 of 1944.

241. Problems of Modern Physics : the Atomic Nuclei, Elementary Particles, and the Nature of Matter.—Frenkel. (*Nature*, 7th Oct. 1944, Vol. 154, No. 3910, pp. 450–454.)

242. A New Natural Alpha-Radiation.—Karlik & Bernert. (*Naturwiss.*, 18th June 1943, Vol. 31, No. 25/26, pp. 298–299.)

243. On the Properties of a New Elementary Particle [Continuation of the Work (" On a New Type of Electron ") dealt with in 2766 of 1944].—Proca. (*Comptes Rendus* [Paris], 1st/29th March 1943, Vol. 216, No. 9/13, pp. 337–339.)

244. On the Excitation Mechanism in the H_2O Molecule, on the Basis of Results of Investigations on Its Emission Spectrum in the Visible Region [Interpretation making use of Previous Results (2297 of 1944) on the Different Actions of Electron Impact & Light].—Schüler & Woeldike. (*Physik. Zeitschr.*, 1st Sept. 1943, Vol. 44, No. 14/15, pp. 335–340.)

245. The Problem of Two Electrons and Newton's Third Law [Supplement to Editorial dealt with in 2765 of 1944].—G. W. O. H. (*Wireless Engineer*, Nov. 1944, Vol. 21, No. 254, p. 511.)

246. Are there Density-Maxima of the Free Electrons in the Metal Lattice ? [Note on Results & Deductions of Brill & others].—Sauter. (*Naturwiss.*, 18th June 1943, Vol. 31, No. 25/26, pp. 302–303.)

247. A Fundamental Point concerning the Superconducting State [Its Destruction by a Magnetic Field : Fresh Support for the Writer's 1907 Theory of the Ring Shape of the Electron, with Electromagnetic Energy flowing along Closed Paths].—Stark. (*Physik.

Zeitschr., 1st June 1943, Vol. 44, No. 9/10, pp. 211–212.) For further deductions *see* the next two papers (pp. 213–214 & 215–216) on "the atomic-structural interpretation of the polarisation in spectral series" and "the axial nature of the atomic structure in the polarised fluorescence of crystals."

248. On the Electronic Theory of Superconductivity [Combination of Electrodynamic & Thermodynamic Treatments leads to Elucidation of Superconductivity Phenomena in terms of a Single Quantity, the "Path-Reversal Energy"].—Welker. (*Physik. Zeitschr.*, Vol. 44, 1943, p. 134 onwards: summary in *E.T.Z.*, 7th Oct. 1943, Vol. 64, No. 39/40, p. 540.)

249. On the Connection between Resistance-Change and Magnetic Induction at the Onset of Superconductivity, *and* A New Phenomenon at the Onset of Superconductivity.—Steiner & Schoeneck. (*Physik. Zeitschr.*, 1st Oct. 1943, Vol. 44, No. 16/17, pp. 341–346 : pp. 346–347.)

250. Reform of Electrical Units.—Durack. (*See* 136.)

251. On the Rationalisation [Elimination of the Factor 4π] of the Magnetic Units, *and* On the Rationalisation of the Electric Units.—Bryliński. (*Comptes Rendus* [Paris], 4th/25th Jan. 1943, Vol. 216, No. 1/4, pp. 113–114 : 1st/22nd Feb. 1943, No. 5/8, pp. 266–268.)

252. On the Dimensions of Physical Magnitudes (Fourth Paper) [Reply to Dalzell's Criticisms of the Third Paper (930 of 1944)].—Dingle. (*Phil. Mag.*, May 1944, Vol. 35, No. 244, pp. 296–300.] For a letter from W. Wilson, on a remark in the third paper, *see* June issue, No. 245, pp. 420–425.

253. On Dimensional Analysis.—Kapp. (*Distribution of Elec.*, Oct. 1944, Vol. 17, No. 156, pp. 312–316.)

MISCELLANEOUS

254. "The Methodology of Pierre Duhem" [Book Review].—Lowinger. (*Journ. Franklin Inst.*, Oct. 1942, Vol. 234, No. 4, pp. 408–409.)

"A study [the first in English] of the remarkable ideas of Duhem," which "have influenced much logical thought in the United States."

255. "Tables of Lagrangian Interpolation Coefficients," *and* "Table of Circular and Hyperbolic Tangents and Cotangents for Radian Arguments" [Book Reviews].—Mathematical Tables Project. (*Journ. Acous. Soc. Am.*, July 1944, Vol. 16, No. 1, p. 81 : p. 81.) For other tables in this series *see* 2363 & 3664 of 1944.

256. Table of the Integral of e^{x^2} [Continuation of Work dealt with in 3662 of 1944].—Terrill & Sweeny. (*Journ. Franklin Inst.*, Sept. 1944, Vol. 238, No. 3, pp. 220–222.)

257. On Whittaker's Solution of Laplace's Equation [and Its Conditions of Validity : a New Formula for the Inverse Distance].—Copson. (*Proc. Roy. Soc. Edinburgh*, Sec. A, 1943/4, Vol. 62, Part 1, pp. 31–36.)

258. "Heaviside's Operational Calculus Made Easy" [Book Review].—Turney. (*Wireless Engineer*, Oct. 1944, Vol. 21, No. 253, pp. 478–479.)

259. Improved Mathematical Notation [$\epsilon \uparrow (-Rt/L)$ for $\epsilon^{-Rt/L}$: *nis* θ for $sin^{-1}\,\theta$: *log* reserved for base 10, *nap* for Naperian : etc.].—Turnbull. (*Electrician*, 18th Aug. 1944, Vol. 133, No. 3455, p. 145.) For comments by Ledward *see* issue for 25th August, p. 171.

260. A New Method of Integration [replacing the Usual Text-Book "Summation of Infinite Numbers of Rectangles"].—Turnbull. (*Distribution of Elec.*, Oct. 1944, Vol. 17, No. 156, pp. 341–342.)

261. Simple Regression and Correlation [I—Estimates of Coefficients of Regression from Samples : II—Estimates of Normal Correlation from Samples].—Sawkins. (*Journ. & Proc. Roy. Soc. New South Wales*, 16th May 1944, Vol. 77, Part 3, pp. 85–95.)

262. Graphical Method of Factoring the Correlation Matrix [in Multiple Factor Analysis], *and* The Minimum Rank of a Correlation Matrix.—Thurston : Albert. (*Proc. Nat. Acad. Sci.*, June 1944, Vol. 30, No. 6, pp. 129–134 : pp. 144–146.)

263. On the Method of Collocation [in connection with Approximations].—Saibel. (*Journ. Franklin Inst.*, Aug. 1944, Vol. 238, No. 2, pp. 107–110.) *See* also 277, below.

264. On Linear Estimation and Testing of Hypothesis [Derivation of Generalisations of Markoff's Theorem, etc.].—Rao. (*Current Science* [Bangalore], June 1944, Vol. 13, No. 6, pp. 154–155.)

265. On Balancing Parameters.—Rao. (*Sci. & Culture* [Calcutta], June 1944, Vol. 9, No. 12, pp. 554–555.) Continuation of the work referred to in 3029 of 1944.

266. Extension of the Difference Theorems of Singer and Bose [in Statistics].—Rao. (*Sci. & Culture* [Calcutta], July 1944, Vol. 10, No. 1, p. 57.)

267. Statistics [No. 156 of the Home University Library of Modern Knowledge : Book Review].—Tippett. (*Nature*, 9th Sept. 1944, Vol. 154, No. 3906, p. 321.)

268. A Formula for the Partial Sums of Certain Hypergeometrical Series, and Its Significance for Probability Theory [and in Other Fields].—von Schelling. (*Naturwiss.*, 11th Dec. 1942, Vol. 30, No. 50/51, pp. 757–758.)

269. Law and Chance in Geophysics [with Special Attention to the Writer's "Generalised Error-Propagation Law" as a Substitute for Probability-Theory Methods].—Bartels. (*See* 14.)

270. QUALITY CONTROL BY STATISTICAL METHODS IN CABLE MAKING.—Thorley. (*Distribution of Elec.*, Oct. 1944, Vol. 17, No. 156, pp. 331–333.)

271. THE BRISCH SYSTEM OF DECIMAL CLASSIFICATION IN PRODUCTION [" effects Considerable Economies in Time & Staff required for Works Management, in addition to Simplifying Costing & Standardisation "].—Hammond: Brisch. (*Engineer*, 11th Aug. 1944, Vol. 178 No. 4622, p. 109.)

272. ON THE MATRIX REPRESENTATION OF COMPLEX SYMBOLS.—Rutherford. (*Proc. Roy. Soc. Edinburgh*, Sec. A, 1943/4, Vol. 62, Part 1, pp. 25–27.)

273. TRANSFORMATION MATRICES IN ELECTRICAL ENGINEERING.—Vowels. (*Journ. Inst. Eng. Australia*, June 1944, Vol. 16, No. 6, pp. 97–104.)

274. CALCULATION WITH MATRICES [as applied to Four-Terminal-Network Theory, etc: Elementary Treatment].—Rossmüller. (*E.T.Z.*, 21st Oct. 1943, Vol. 64, No. 41/42, pp. 555–561.)

275. RECENT PROGRESS IN SCIENTIFIC COMPUTING.—Comrie. (*Journ. of Scient. Instr.*, Aug. 1944, Vol. 21, No. 8, pp. 129–135.) For a letter from T. Y. Baker, on "even more useful formulae" for the numerical evaluation of a definite integral, *see* October issue, No. 10, p. 188.

276. A NUMERICAL METHOD IN THE THEORY OF VIBRATING BODIES [within Frame of Southwell's Relaxation Technique, but with Advantages].—Vazsonyi. (*See* 71.)

277. A GENERAL METHOD OF APPROXIMATION TO THE INFLUENCE FUNCTION [Green's Function] OF AN ELASTIC SYSTEM.—Saibel. (*Journ. Franklin Inst.*, Dec. 1942, Vol. 234, No. 6, pp. 535–547.) *See* also 263, above.

278. HARMONIC SYNTHESIZER FOR DEMONSTRATING AND STUDYING COMPLEX WAVE FORMS [combining Any Seven Sinoidal Electric Oscillations, 50–20 000 c/s, with Separate Control of Amplitude & Phase of Each Component: Adaptable to Quantitative Measurement].—Somerville. (*Journ. of Scient. Instr.*, Oct. 1944, Vol. 21, No. 10, pp. 174–177.)

279. " THE TEACHING OF MATHEMATICS TO PHYSICISTS " [Review of Joint Report].—Inst. of Physics, Math. Association. (*Nature*, 16th Sept. 1944, Vol. 154, No. 3907, pp. 355–356.)

280. " ELEKTROTEKNISKE NOMOGRAMMER " [Book Review].—Christensen. (*E.T.Z.*, 25th March 1943, Vol. 64, No. 11/12, p. 170.) Can be used by readers who have no knowledge of Danish.

281. " THERMIONIC VALVE CIRCUITS: SECOND EDITION, ENLARGED " [Book Reviews].—Williams. (*Nature*, 7th Oct. 1944, Vol. 154, No. 3910, p. 446: *Electrician*, 20th Oct. 1944, Vol. 133, No. 3464, p. 354.)

282. " PHYSICS AND RADIO " [Book Review].—Nelkon. (*Wireless Engineer*, Oct. 1944, Vol. 21, No. 253, p. 478.) " An excellent elementary text-book." *See* also *Wireless World*, Oct. 1944, Vol. 50, No. 10, p. 317.

283. " RADIO DATA CHARTS, THIRD EDITION " [Book Review].—Beatty, Sowerby. (*Proc. I.R.E.*, Aug. 1944, Vol. 32, No. 8, p. 501.)

284. " PRACTICAL ELECTRICAL WIRING AND CONTRACTING " [Book Review].—Greenwood (Edited by). (*Electronic Eng:g*, Sept. 1944, Vol. 17, No. 199, p. 174.) " An extraordinarily comprehensive treatise . . . ."

285. AUTHOR TO PUBLIC: THOUGHTS ON THE PRINCIPLES OF BOOK PRODUCTION.—de la Mare. (*Journ. Roy. Soc. Arts*, 29th Sept. 1944, Vol. 92, No. 4675, pp. 574–582.)

286. THE STANDARD OF ENGLISH [Leading Article on *Times* Correspondence on the Norwood Report].—(*BEAMA Journal*, Oct. 1944, Vol. 51, No. 88, p. 323.)

287. TRANSMISSION OF POWER IN COMPRESSED-GAS ATMOSPHERES: AN EXPERIMENT IN " LIBRARY RESEARCH."—Hobart. (*See* 210.)

288. MICROFILM READER–PROJECTOR [in Case, like Portable Typewriter: weighs 8½ lb].—Federal Mfg. Engineering. (*Scient. American*, Aug. 1944, Vol. 171, No. 2, p. 84.)

289. EXCHANGE OF ABSTRACTS BETWEEN THE *Journ. I.E.E.* AND *Proc. I.R.E.*—Kirke. (*Electrician*, 20th Oct. 1944, Vol. 133, No. 3464, p. 336: paragraph on Radio Section announcement.)

290. *The Marconi Review*: FOREWORD ON THE RESUMPTION OF PUBLICATION.—Walker. (*Marconi Review*, Oct./Dec. 1944, No. 75, p. 1.)

291. EDITORIAL CHANGES OF SCIENTIFIC PAPERS [Addition to Correspondence referred to in 3060 of 1944: One Journal's Sad Experiences, and the Lesson successfully Learnt].—Tukey. (*Science*, 16th June 1944, Vol. 99, No. 2581, p. 492.)

292. TRANSLITERATION OF RUSSIAN NAMES AND WORDS [Point missed in Previous Correspondence (3063 of 1944) is Whether the Transliteration is desired for Filing Purposes or for writing the Proper Sound: Strong Advocacy of *Chemical Abstracts* System].—Kosolapoff. (*Science*, 16th June 1944, Vol. 99, No. 2581, pp. 491–492.)

293. INTERNATIONAL RADIO LANGUAGE [and a Letter (from *R.S.G.B. Bulletin*) in favour of " Interglossa "].—Wilson. (*Wireless World*, Oct. 1944, Vol. 50, No. 10, p. 294.)

294. THE SOCIETY OF VISITING SCIENTISTS [Opening of London Headquarters].—Donnan, Crowther. (*Engineering*, 15th Sept. 1944, Vol. 178, No. 4627, p. 195.)

295. CORRESPONDENCE ON " ORGANISATION OF PHYSICS IN AMERICA " [3317 & 3702 of 1944: a Single Journal (based on a New Method of

handling Research Papers) suggested as Most Potent Instrument for producing and maintaining the "More Perfect Union": etc.].—King: Harnwell. (*Review Scient. Instr.*, June 1944, Vol. 15, No. 6, p. 153.)

296. Proposal for Accelerated Dissemination of Scientific Knowledge [Special Broadcasting Stations, established with Aid of Highest Research Organisations of United Nations, should revolutionise Circulation of Scientific Publications: Codewords for Diagrams, Formulae, etc: Cellophane-Tape Recording: Additional Far-Reaching Advantages].—Liu. (*Science*, 16th June 1944, Vol. 99, No. 2581, pp. 492–493.) From Kunming.

297. A Plan for Broadcasting: III [Competitive System does Not Necessarily involve Sponsored Programmes: Its Advantages].—(*Economist*, 11th Nov. 1944, Vol. 147, No. 5281, pp. 630–631: to be concluded.)

298. The British Society for Freedom in Science [History of Its Foundation: Statement of Objects & Methods].—Bridgman: Baker. (*Science*, 21st July 1944, Vol. 100, No. 2586, pp. 54–57.) *See* also 3314 of 1944.

299. Post-War Planning in India: Wanted, a "Roster of Scientific Personnel".—Mukerji. (*Sci. & Culture* [Calcutta], April 1944, Vol. 9, No. 10, pp, 455–456.)

300. The Value of Research in Pure Science [Extract from a Speech by J. J. Thomson, taken from Rayleigh's "Life of Sir J. J. Thomson"].—Thomson. (*Sci. & Culture* [Calcutta], June 1944, Vol. 9, No. 12, pp. 531–532.)

301. Scientific and Industrial Research: I–V [Series of Leading Articles].—(*Nature*, 26th Aug. and 2nd, 9th, 16th & 23rd Sept. 1944, Vol. 154, Nos. 3904/8.)

302. The Royal Naval Scientific Service [Notes on the Formation of the R.N.S.S.].—(*Nature*, 23rd Sept. 1944, Vol. 154, No. 3908, 388–389.) For a leading article on the R.N.S.S. see *Engineering*, 15th Sept. 1944, Vol. 158, No. 4105, pp. 211–212.

303. Fundamental Knowledge But Little Advanced by War-Necessitated Research.—Jewett. (*Scient. American*, April 1944, Vol. 170, No. 4, pp. 179, 180.)

304. The Phoenix—A Challenge to Engineering Education.—Everitt. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 509–513.)

"During a time when the flow of scientific knowledge is restricted for security reasons, many Sections of engineering societies could profitably devote meetings to the methods and aims of engineering education, so that, following its resurrection after the war, we may find it indeed a new and better agency for promoting the welfare of the profession and of mankind in general . . ."

"We have, it is true, trained engineers, but we have not taught engineering. We have taught the engineer how his tools are put together, but we have not generally shown him how to use them . . . We must be more articulate in the expression of the engineer's creed. We should have the equivalent of the Hippocratic oath . . . The engineer must be taught the utility of the imperfect, and the importance of the attainable and practical . . . Above all, he should be thoroughly indoctrinated in the economics of everyday life, and how it affects the work of the engineer . . ." Preceded by an enthusiastic Foreword by Walter Campbell, of the U.S. Signal Corps.

For "Suggested Topics for Discussion" (a report on the subject, prepared by the Education Committee of the I.R.E.) *see* October issue, No. 10, pp. 581–583.

305. A Critique of Communication at the Centennial of the Telegraph [Historical Influence of S. F. B. Morse: Effect of Electrical Communication upon World Peace: Engineering Responsibility in Post-War World: etc.].—Coggeshall. (*Proc. I.R.E.*, Aug. 1944, Vol. 32, No. 8, pp. 445–448.)

"We radio-and-electronic engineers inherit from the past an unbroken line of tradition of self-effacing service for the benefit of mankind . . ."

306. The Government of Technical Institutions [Leading Article prompted by *Journ. I.E.E.* Note on the "Government" of That Institution: the Successful Use of Devolution, as often mooted at Westminster: Danger of Overruling by a Non-Technical Assembly: etc.].—(*Engineering*, 15th Sept. 1944, Vol. 158, No. 4105, p. 212.)

307. Problems of Post-War Era: Inaugural Address by New President of I.E.E.—Railing. (*Electrician*, 13th Oct. 1944, Vol. 133, No. 3463, pp. 317–319: also p. 316.) *See* also *Elec. Review*, 13th Oct. 1944, pp. 517–518, and Editorial, pp. 505–506; and "The Engineer and Human Welfare," *BEAMA Journal*, Oct. 1944, pp. 324–329.

308. Radio and Electrical Engineers [I.E.E. and Its Radio Section: the Silver Jubilee Meeting: the Change of Name: Chairman's Address: etc.].—I.E.E. (*Nature*, 28th Oct. 1944, Vol. 154, No. 3913, pp. 555–556.) *Cf.* 3318/9 of 1944.

309. 25 Years of Wireless History: the Commemoration Meeting of the Wireless Section of the Institution of Electrical Engineers, *and* Howe's Address on "Principles and Theory."—I.E.E. (*Electronic Eng:g*, June 1944, Vol. 17, No. 196, p. 9: pp. 10–11.)

310. The Organisation of Experimental Research [Summary of Chairman's Address to I.E.E. Measurements Section].—Radley. (*Electrician*, 27th Oct. 1944, Vol. 133, No. 3465, pp. 371–372.)

311. Electronics, Past and Future [including Recent Advances, Applications & Possibilities (in Industry, etc.), Mechanical Analogies].—Wilson. (*Engineer*, 15th Sept. 1944, Vol. 178, No. 4627, pp. 210–212.) Chairman's Address, S. Midland I.E.E. Radio Group. *See* also *Electrician*, 15th Sept. 1944, pp. 235–236.

312. I.R.E. CONSTITUTIONAL AMENDMENTS : COMMENTS AND CRITICISM OF THE PROPOSED INCREASE IN DUES : ETC.—I.R.E. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 560–568.)

313. THE COMMUTATION OF ANNUAL SUBSCRIPTIONS.—Heron. (*Nature*, 23rd Sept. 1944, Vol. 154, No. 3908, pp. 400–401.) For correspondence *see* issue for 28th October, No. 3913, p. 552.

314. SEX DIFFERENCES IN THE SCIENCE TALENT TEST [3716 of 1944].—Edgerton & Britt. (*Science*, 1st Sept. 1944, Vol. 100, No. 2592, pp. 192–193.)

315. RATIONALISATION OF THE MENTAL WORK OF THE DESIGNER.—Kesselring. (*E.T.Z.*, 21st Oct. 1943, Vol. 64, No. 41/42, pp. 545–550.) *Cf.* the same writer, 2856 of 1942.

316. NATIONAL ELECTRONICS CONFERENCE, CHICAGO, OCT. 1944 : PROGRAMME OF PAPERS.—Nat. Electronics Conference. (*Proc. I.R.E.*, Sept. 1944, Vol. 32, No. 9, pp. 570–571.)

317. INDUSTRIAL SUGGESTION SCHEMES [Correspondence on the Fort Dunlop Scheme, 3054 of 1944].—Pledger : Bond. (*Electrician*, 4th & 18th Aug. 1944, pp. 100 & 145.)

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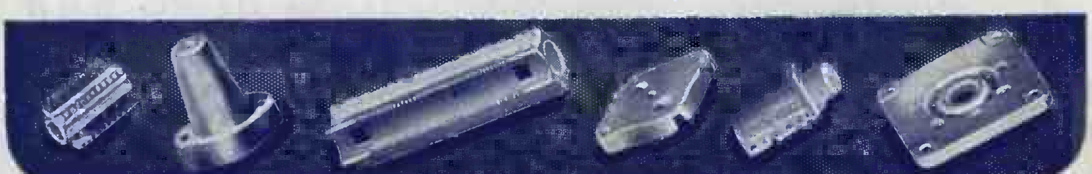

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