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Cycles per Second

IN the March number of the *Journal of Scientific Instruments* there is an editorial note commenting on the slovenly tendency to refer to the frequency as being so many "cycles" without any reference to the time. It is suggested that "Editors should correct it whenever it is served up in this form of half-truth." It is pointed out that "a 50-cycle supply" has become such a common phrase that it is, alas! becoming almost pedantic to speak of "a 50-cycle per second supply." *The Wireless Engineer* is given honourable mention as being always meticulously correct and using c/s, but it is doubtful if its contributors or its Editor are always so meticulously correct in their conversation.

No reference is made, however, to an even worse example of jargon that one meets with even in examination papers of learned institutions, viz., the statement that a motor is connected to a 50-frequency supply. The frequency is a property of the supply, just as the height of a house is a property of the house, or the length of a street a property of the street. To talk of a 50-frequency supply is equivalent to saying that one lives in 60-height house in a 500-length street.

To obviate the necessity of saying and writing "cycles per second," Professor Kennelly proposed the abbreviation "cyps," pronounced, presumably, "sipes," but we do not remember ever hearing anyone in conversation refer to a 50- "sipes" supply, although, after a while, it would probably sound no worse than "amps," which, as Heaviside feared, followed the adoption of the ampere as the unit of current, or than "revs," which, by the way, is commonly misused in the same way as cycles without any reference to the time. In Germany the difficulty has been avoided by the adoption of the name Hertz as the unit of frequency.

There is no excuse for this slovenliness in writing, for c/s and r.p.m. are no longer than cycles and revs, and if read as c.p.s. and r.p.m. they are as easy to say as cycles and revs. Similarly, if kc/s is read as k.c.p.s. it trips off the tongue quite as readily as kilocycles.

It is, of course, open to anyone to say that none of these considerations is of any weight so long as nobody is misled, especially if the wrong term has been used so much that it may be regarded as a convention. Why be pedantic? What does it matter if one describes an 8-pole machine as an 8-pole 50-cycle machine, although an 8-pole machine is essentially one of 4 cycles, so long as everyone knows that you mean that it is intended to be driven at such a speed that the frequency is 50 cycles per second? Why bother about the units at all if everyone knows what you mean, as they would if you said that a motorist was stopped when he was doing over 90 and, on being examined, his pulse was found to be under 50 and his temperature over 100? You might also add that his car had a "100 horse" motor, although you would hardly find this in the most carelessly prepared makers' pamphlet.

Slovenliness in such things is very insidious, and it is surely preferable for a scientific journal to err on the safe side and run the risk of being regarded as somewhat pedantic by those who are not particular about such matters. G. W. O. H.

Rhombic Transmitting Aerial*

Increasing the Power Efficiency

By L. Lewin

Introduction

THE rhombic or diamond aerial, introduced into radio practice by E. Bruce some ten years ago, consists essentially of four straight conductors arranged in a horizontal plane in the form of a rhombus. At one apex the aerial is terminated by an ohmic resistance, whilst at the opposite end it is fed by a twin wire feeder. The magnitude both of the resistance and of the surge impedance of the feeder is made equal to that of the surge impedance between the aerial wires; and in this case the current distribution along the aerial takes the form of a progressive wave running from the fed to the terminated end.

The height of the rhombus, together with its size and shape, is determined from the circumstances of transmission or reception; and in both cases the diagonal from the feeder to the resistance is directed along the line of transmission, with the terminated end lying towards the other service station.

The rhombic aerial is suitable both for transmission and for reception, and besides being comparatively cheap to erect, it has the advantages of being serviceable over a broad frequency range, and of possessing a substantial degree of uni-directivity. These two properties are a consequence of the running wave current distribution, itself dependent on the correct terminating of the aerial. It is therefore necessary to ensure that the terminating resistance does not become unduly heated by the very considerable power it may have to dissipate if the antenna is used for transmitting. On account of this requirement, and of the difficulties arising in the construction of resistances capable of dissipating great high frequency powers, it has not yet been found practicable to use rhombic aerials in conjunction with high-power transmitting stations.

In practice, aerial terminating resistances capable of dissipating powers up to about 2 kW. are in use, whilst for greater powers, lengths of iron wire arranged in the form of a folded feeder have been tried. But inherent in the use of both these terminations there is a considerable waste of valuable transmitter power, whilst the larger resistances may be expensive. It is therefore a matter of some importance in aerial design to be able to predict what losses are to be associated with a particular rhombic aerial system.

The object of this paper is to give in a form suitable for practical use an expression for the aerial power efficiency and also a means whereby the latter may be increased.

Current Distribution

The approximate shape of the current distribution along the aerial wires can be readily found if it is assumed that, for this purpose, the aerial may be regarded as a twin wire feeder. The well-known transmission line equations are then available, and a simple analysis shows that, if the aerial is terminated by a surge-impedance resistance, the current distribution takes the form of a progressive wave running from the fed to the terminated end of the aerial.

This distribution, wherein the radiation from the aerial has been neglected, is suitable for most theoretical calculations, such as the determination of the input impedance or of the form of the far-field directive patterns, but unfortunately it is not sufficiently accurate for the purpose of computing the aerial power efficiency, as the calculated losses in the termination would be found, on the above assumptions, to be equal to the input power.

This result is due to the complete neglect of the radiation from the aerial. A more satisfactory hypothesis, and one which still permits us to retain the very useful application of transmission line theory, is to assume that the effect of the radiation on the current distribution may be simulated by an ohmic

* MS. accepted by the Editor, December, 1940.

resistance uniformly distributed over the aerial wires. Introducing the symbols

L = length of one limb of the rhombus,
Z_0 = surge impedance between the aerial wires,
R = resistance distributed over the aerial,
p = attenuation constant,
and $q = 2\pi/\lambda$ where λ is the wavelength of the oscillations,

we find, from transmission line theory, that provided the ratio p/q is small, the current distribution takes the form of an exponentially damped progressive wave of attenuation constant

$$p = \frac{R}{2Z_0 \cdot 2L} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The magnitude of the resistance R should be such that the power dissipated by it would be equal to that radiated by the aerial. This suggests the identification of R with the radiation resistance R_c of the aerial, calculated from a current distribution of constant amplitude, since the expression for the power dissipated by the resistance on the one hand, and radiated by the aerial on the other, takes the same form in both cases, namely

resistance × (mean value of current amplitude)²

The resulting current distribution, shown

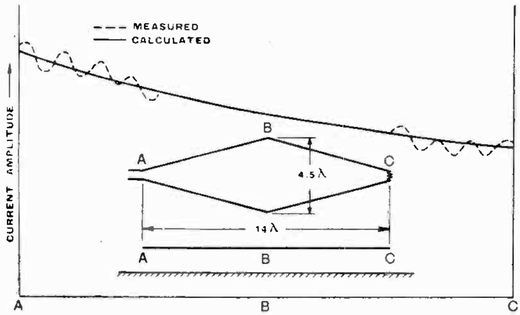

Fig. 1.—*Current distribution over the rhombus wires.*

in Fig. 1 for a rhombus of length 14λ and breadth 4.5λ, agrees very well with the measured values, the small residue of standing waves shown in the figure arising probably from errors in termination and from reflections of the current wave at the corners of the rhombus.

Calling I_0 the current amplitude[1] at the feeder, the amplitude at the termination will be $I_0 e^{-p \cdot 2L} = I_0 e^{-\frac{R_c}{2Z_0}}$, so that the losses in the terminating resistance are $Z_0 I_0^2 e^{-\frac{R_c}{Z_0}}$. The input power is $Z_0 I_0^2$, so that, defining the aerial power efficiency η by the ratio of the radiated power to the input power, we have

$$\eta = \frac{(Z_0 I_0^2 - Z_0 I_0^2 e^{-\frac{R_c}{Z_0}})}{Z_0 I_0^2}$$

$$= (1 - e^{-\frac{R_c}{Z_0}}) \times 100\ \% \quad \ldots \quad (2)$$

It is interesting to note that the expression $Z_0 I_0^2 (1 - e^{-\frac{R_c}{Z_0}})$ for the radiated power can be written in the form

$$R_c \left(\sqrt{\frac{1 - e^{-2p \cdot 2L}}{2p \cdot 2L}} \cdot I_0 \right)^2$$

$$= R_c \left(\sqrt{\frac{1}{2L} \int_0^{2L} I_0^2 e^{-2px} \cdot dx} \right)^2$$

so that the assumptions made are equivalent to the hypothesis that the power radiated may be calculated from a current distribution of constant amplitude of magnitude equal to the root-mean-square amplitude over the aerial wires.

Radiation Resistance

In order to complete the expression in equation (2) for the aerial power efficiency, it remains to compute the value of the radiation resistance R_c of the rhombic aerial. The calculation is somewhat complicated, and the present section will be devoted to an exposition of the method employed, which is a generalisation of that applied by Bechman[2] to aerial arrays of parallel conductors. An outline of the method of evaluating the various expressions and integrations involved is given in the appendix.

Considering first a single linear radiator, we find from Bechman's analysis[2], that the power radiated by it is given by minus the integral of the in-phase scalar product of the current and electric field strength,

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[1] Effective values of all temporally variable quantities are used throughout this paper.

[2] Rudolf Bechman "On the Calculation of Radiation Resistance of Antennas and Antenna Combinations," *Proc. Inst. Rad. Eng.*, Vol. 19, Aug. 1931.

taken along the conductor. This can be put in the form[3]

$$\text{Power radiated} = -Re\int E_s \bar{I} \, . \, ds \quad .. \quad (3)$$

where E_s = the electric field strength component parallel to and at the surface of the radiator,

I = the current in the radiator,

$\bar{I}$ = the complex conjugate to I,

ds = a line element of the conductor,

and Re signifies that the real part of the integral is to be taken.

Considering still the power radiated by this one conductor, it is apparent that if other radiators are present, E_s will be the sum of the field strength components produced by each of them. If the electric field strength component produced by the mth radiator is denoted by E_m, then this will give rise to a term $P_m = -Re\int E_m\bar{I} \cdot ds$ in the expression for the power radiated by the conductor under consideration. This power term is conveniently referred to as the power influence from the mth radiator to the conductor in question.

In general, if I_n is the current in the nth conductor, the power influence from the mth to the nth conductor will be represented by

$$P_{mn} = -Re\int E_m\bar{I}_n \cdot ds_n \quad .. \quad .. \quad (4)$$

and the total power radiated from the aerial system by

$$P = \Sigma_m \Sigma_n P_{mn} \quad .. \quad .. \quad .. \quad (5)$$

Referring now to the rhombic aerial, Fig. 2 shows the scheme of the array, which consists of four linear radiators, numbered 1 to 4 in the figure. Applying equation (5), the expression for the power radiated by this system becomes $P = \sum_{1}^{m=4} \sum_{1}^{n=4} P_{mn}$, which, from the symmetry of the aerial, can be written

$$P = 4P_{11} + 2(P_{13} + P_{24}) + 2(P_{12}+P_{34}) + 2(P_{23} + P_{41}) \quad .. \quad .. \quad (6)$$

Since such a term as P_{mn} concerns only two radiators, the mth and the nth, it is convenient to consider one of them, the first, fixed relative to a rectangular co-ordinate system. By placing the second radiator in various positions, the combination can then be made to correspond to any pair of conductors of the original rhombic array.

Fig. 3 shows this fixed radiator placed along the y-axis of a co-ordinate system x, y, the lower end being at the origin. In the figure, s is the distance of a point on the radiator from the origin, and r and θ are polar co-ordinates from the upper end.

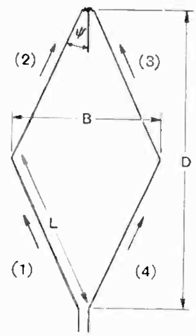


Fig. 2.—*The scheme of the rhombic aerial. The arrows indicate the directions of the current waves.*

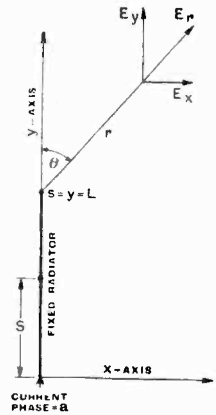


Fig. 3.—*The fixed radiator and its associated co-ordinate system.*

According to equation (4), we require the electric field strength produced by the fixed conductor, and to this end we introduce the Hertzian vector Π defined as[4]

$$\Pi = -\frac{30j}{q}\int I_s \frac{e^{-jq\sqrt{x^2+(y-s)^2}}}{\sqrt{x^2+(y-s)^2}} \cdot ds \text{ volt cm.} \quad .. \quad .. \quad .. \quad (7)$$

I_s being the current at the point s.

The electric field strength E is then given by the vector equation

$$E = \text{grad div } \Pi + q^2\Pi \text{ volt/cm.} \quad .. \quad (8)$$

or, in terms of its rectangular components

$$E_x = \frac{\partial^2\Pi}{\partial x \partial y} \quad .. \quad .. \quad .. \quad (9)$$

$$E_y = \frac{\partial^2\Pi}{\partial y^2} + q^2\Pi$$

The expression for the current I_s takes the form

$$\pm I_s = I_0 e^{j\alpha} e^{\pm jqs} \text{ amps} \quad .. \quad .. \quad (10)$$

[3] See footnote 1.

[4] All complex quantities are referred in phase to $e^{j\omega t}$.

where I_0 = the current amplitude at the point $s = 0$,

and a = the current phase at $s = 0$, referred to the current phase at the feeder.

Two possible algebraic signs arise because the current wave may run in the direction either of s decreasing or of s increasing. The subscripts + and − respectively are used to indicate to which direction of current wave the quantities concerned refer.

Introducing the limits of integration, we then have, for the Hertzian vector

$$\pm \Pi = -\frac{30j}{q} I_0 e^{ja} \int_0^L e^{\pm jqs} \frac{e^{-jq\sqrt{x^2+(y-s)^2}}}{\sqrt{x^2+(y-s)^2}} \cdot ds \qquad \text{(11)}$$

As an illustration of the use of these equations, we shall here calculate P_{11}, the simplest of the power terms of equation (6). If we identify the fixed radiator with the 1st conductor of the rhombus (see Fig. 2), we find from equation (9) that the field strength produced at the radiator's own surface is given by

$$-E_y = \underset{x=0}{Lt} \cdot \left(\frac{\partial^2 \Pi_-}{\partial y^2} + q^2 \Pi_-\right)_{a=0}$$

Then, from equation (4)

$$P_{11} = -Re \int_0^L -E_y \bar{I}_y \cdot dy \text{ watts}$$

$$= -\underset{x=0}{Lt} \cdot Re \int_0^L \left(\frac{\partial^2 \Pi_-}{\partial y^2} + q^2 \Pi_-\right)_{a=0} \cdot I_0 e^{+jqy} \cdot dy \qquad \text{(12)}$$

The integration is performed on page 185, and quoting the result, we have

$$P_{11} = 60\left[S_1(2qL) - 1 + \frac{\sin(2qL)}{2qL}\right] I_0^2$$

The method of procedure for the evaluation of the remaining terms of equation (6) is outlined in the appendix, where the final expression for the radiation resistance is found in terms of the length D of the rhombus, its breadth B, its semi-vertical angle ψ, and the length L of one limb. The expression is somewhat complicated, but if B, D and L are great compared to λ, as will be the case in most practical applications, the formula given simplifies considerably, and, approximately

$$R_c = 240(\log_e(qB \,.\, \sin\psi) + 0.577) \text{ ohms} \qquad \text{(13)}$$

Influence of the Earth on the Radiation Resistance

The preceding expression for R_c is the value of the radiation resistance of the rhombus in free space, whilst in practice the aerial will be about one wavelength high. By the usual device of representing the effect of the earth by a negative image, the influence of the height can be considered. However, the additional terms complicate the final expression for the radiated power sufficiently to warrant the retention of the free-space formula for actual use.

In order to estimate the error that is likely to arise from this simplification, there is shown in Fig. 4 the theoretical curve of the radiation resistance versus height of a horizontal linear radiator 4λ long, carrying a progressive wave. This curve is a typical one of the variation with height of the radiation resistance of a long horizontal conductor, and it is not unreasonable to expect the corresponding curve for a long rhombic aerial to be very similar. In the figure the resistance is seen to attain the free-space value at a height of about 0.4 λ, and then to oscillate rather closely about it as the height increases. As the optimum

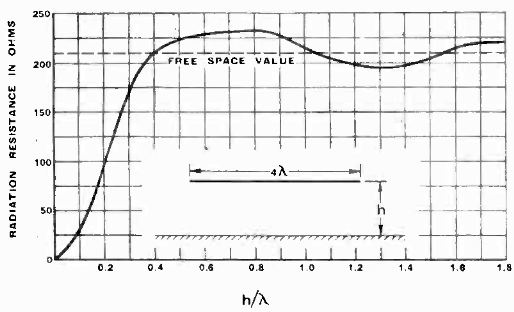


Fig. 4.—*Effect of the height above earth on the radiation resistance of a linear horizontal radiator 4λ long, carrying a progressive wave current distribution.*

heights for rhombic aerials designed to radiate maximum energy at elevation angles of 10 deg. and 20 deg. are respectively 1.44 λ and 0.73 λ, it is to be expected that little error is likely to arise from the use of the free-space formula.

Power Efficiency of the Rhombic Aerial

Equation (2), taken in conjunction with equation (13) for the radiation resistance (or if necessary, the more exact formula of equation (18) of the appendix), provides a fairly simple expression for the power efficiency of the rhombic aerial.

The aerial dimensions B, D, L, and ψ are not all independent, as we have, from the geometry of the rhombus

$$B = D \cdot \tan\psi \text{ and } 2L = \sqrt{B^2 + D^2} \qquad \ldots \quad \ldots \quad \ldots \quad (14)$$

A further relation is obtained from the dimensioning condition that maximum radiation will be required at some elevation angle δ_{max} say. It can be shown that the electric

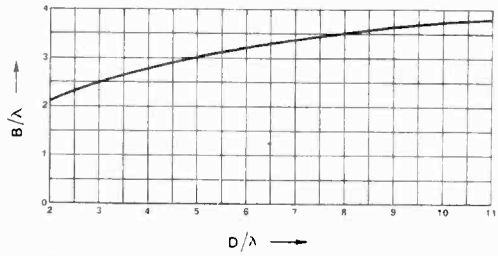


Fig. 5.—*Relation between B and D for maximum field strength at 15°.*

field strength at an elevation δ in the principal axial plane of the aerial is proportional to $\frac{B}{\lambda} \cdot \frac{\sin^2\alpha}{\alpha}$ where α stands for

$\pi \frac{L}{\lambda}(1 - \cos\psi \cdot \cos\delta)$, whence the required dimensioning relation can be found by maximising the former expression at $\delta = \delta_{max}$. If the available length D of the rhombus is given, and $\frac{D}{\lambda} > 2$, then, approximately

$\alpha = \frac{\pi}{2}$ or

$$B = \sqrt{(\lambda + D \cdot \cos\delta_{max})^2 - D^2} \qquad (15)$$

The curve of this function is shown in Fig. 5 for the case $\delta_{max} = 15$ deg. It is seen that for values of D greater than about 8λ, the corresponding increase in B, and therefore of field strength which is proportional thereto, is small, so that little field strength gain is procured by constructing transmitter rhombuses of great length.

By means of equations (14) and (15), B, L and ψ can be eliminated from the expression for R_c, which then depends only on D and δ_{max}. As an example, Fig. 6 shows the variation of R_c with D for the case $\delta_{max} = 15$ deg. The radiation resistance is seen to be somewhat constant at about 700 ohms, decreasing slightly for large D.

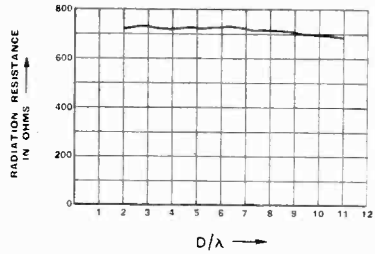


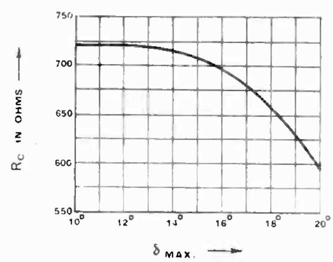
Fig. 6.—*Radiation resistance versus length for a rhombic aerial designed to give greatest field strength at 15°.*

This is probably due, as pointed out in connection with Fig. 5, to the relatively small increment in B associated with an increase in D, when the total length exceeds about 8λ.

Fig. 7 shows how the radiation resistance varies with the optimum elevation angle in the range 10 deg. to 20 deg., D being taken constant at 8λ. R_c is seen to be about 700 ohms for the smaller optimum angles, decreasing to about 600 ohms when $\delta_{max} =$ 20 deg.

From equation (2) the aerial power efficiency depends on Z_0, the surge impedance between the aerial wires; the smaller the surge impedance, the greater the efficiency.

Fig. 7.—*Variation of R_c with optimum angle of radiation. $D = 8\lambda$.*



For example, a rhombus of length 8λ, and designed to give maximum radiation at 15 deg. elevation, has an efficiency of 58 per cent. if constructed of normal wire ($Z_0 \approx 800$ ohms), whilst if built up of two wires in parallel spaced a few metres apart ($Z_0 \approx 500$ ohms) the efficiency rises to about 75 per cent.

From the foregoing, it is to be concluded that a parallel arrangement of rhombic aerials provides an effective and practical means of increasing the power efficiency of the aerial.

APPENDIX TO "THE RADIATION RESISTANCE"

In order to evaluate the power terms P_{mn} of equation (6), we require the following transcendental functions, tabulated in "Jahnke-Emde," "Funktionentafeln" and *Electrical Communications*, April, 1937.

$$Ei(jx) = Ci(x) + jSi(x) = -\int_x^{\infty} \frac{e^{jx}}{x} \, . \, dx + j\frac{\pi}{2}$$

$$Ci(x) = -\int_x^{\infty} \frac{\cos(x)}{x} \, . \, dx$$

$$Si(x) = \int_0^{x} \frac{\sin(x)}{x} \, . \, dx$$

and

$$S_1(x) = \int_0^{x} \frac{1 - \cos(x)}{x} \, . \, dx = \log_e x + 0.577 - Ci(x)$$

Calculation of P_{11}

By double integration by parts of the first term of equation (12), we have

$$P_{11} = -\underset{x=0}{Lt} \, . \, Re \, I_0 \left[\left(\frac{\partial \Pi_-}{\partial y} - jq\Pi_- \right) e^{jqy} \right]_0^L \qquad (16)$$

the remainder of the integrand vanishing.

Now the expression of equation (11) for Π_- may be integrated directly by the substitution

$$u = \sqrt{x^2 + (y - s)^2} - (y - s) \qquad \text{giving}$$

$$\Pi_- = -I_0 \frac{30j}{q} \left\{ Ei\left[-jq\left(\sqrt{x^2 + (y - L)^2} - \overline{y - L}\right) \right] - Ei\left[-jq\left(\sqrt{x^2 + y^2} - y\right) \right] \right\} e^{-jqy}$$

Substituting into equation (16) yields

$$P_{11} = \underset{x=0}{Lt} \, . \, Re \, I_0^2 \, \frac{30j}{q} \left\{ \begin{array}{l} -2jq\left(Ei\left[-jq\left(\sqrt{x^2 + (y - L)^2} - \overline{y - L}\right) \right] - Ei\left[-jq\left(\sqrt{x^2 + y^2} - y\right) \right] \right) \\ -\dfrac{e^{-jq\left(\sqrt{x^2 + (y-L)^2} - \overline{y - L}\right)}}{\sqrt{x^2 + (y - L)^2}} + \dfrac{e^{-jq\left(\sqrt{x^2 + y^2} - y\right)}}{\sqrt{x^2 + y^2}} \end{array} \right\}_0^L$$

of which the real part is

$$P_{11} = 60 \left[S_1(2qL) - 1 + \frac{\sin(2qL)}{2qL} \right] I_0^2$$

Calculation of P_{13} and P_{24}

According to the method explained on page 182 for the evaluation of P_{mn}, two conductors are placed in the same relative positions as the *m*th and *n*th radiators of the rhombus, the fixed conductor of Fig. 3 corresponding to the *m*th, and the variable one to the *n*th.

Fig. 8 a and b shows these arrangements for the computation of P_{13} and P_{24}, the current phases and the co-ordinates being marked on the diagrams.

From equations (4) and (9), we have

$$P_{13} + P_{24} = Re \, . \, -\frac{30j}{q} \left\{ e^{jq(L - L\cos 2\psi)} \int_{L\cos 2\psi}^{L + L\cos 2\psi} e^{jqy} \left[\frac{\partial^2}{\partial y^2} + q^2 \right] \Pi' dy + e^{-jq(L - L\cos 2\psi)} \int_{-L\cos 2\psi}^{L - L\cos 2\psi} e^{jqy} \left[\frac{\partial^2}{\partial y^2} + q^2 \right] \Pi' dy \right\} I_0^2$$

where Π' stands for

$$\int_0^L \frac{e^{-jqs} \, e^{-jq\sqrt{L^2\sin^2 2\psi + (y - s)^2}}}{\sqrt{L^2 \sin^2 2\psi + (y - s)^2}} \, . \, ds$$

The integrations follow the same lines as those given in the calculation of P_{11}, and although quite

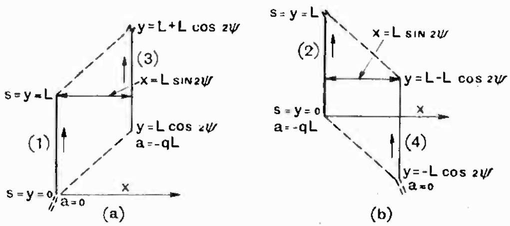


Fig. 8.—*Arrangements for the calculation of, (a) P_{13}; and (b) P_{24}.*

straightforward, are rather lengthy. The value obtained is

$$P_{13} + P_{24} = 60 I_0^2 \left[\frac{\sin 2qL}{qL} - \frac{\sin(2qL\sin\psi)}{2qL \, . \, \sin\psi} - \frac{\cos 2qL \, . \, \sin(2qL\cos\psi)}{2qL \, . \, \cos\psi} \right.$$

$$-\cos(qB\sin\psi) \left\{ \begin{array}{l} S_1 qB(1 + \sin\psi) \\ + S_1 qB(1 - \sin\psi) - 2S_1(qB\sin\psi) \\ + S_1 qD(1 + \cos\psi) \\ + S_1 qD(1 - \cos\psi) - 2S_1(qD\cos\psi) \end{array} \right\}$$

$$\left. + \sin(qB\sin\psi) \left\{ \begin{array}{l} SiqB(1 + \sin\psi) \\ - Siq\,B(1 - \sin\psi) - 2Si(qB\sin\psi) \\ - SiqD(1 + \cos\psi) \\ + SiqD(1 - \cos\psi) + 2Si(qD\cos\psi) \end{array} \right\} \right]$$

Calculation of P_{12}, P_{34}, P_{23}, and P_{41}

Fig. 9 *a* — *d* shows respectively the arrangements used for the calculation of the remaining power terms of equation (6). In each case it is seen that we shall require the field strength produced by the fixed radiator along the line θ = constant, in terms of the radial co-ordinate r measured from the upper end of the radiator.

This field strength component $\pm E_r$ can be put in the form

$$\pm E_r = \pm E_y \cos\theta + \pm E_x \cdot \sin\theta$$
$$= \left\{ \cos\theta \left(\frac{\partial^2}{\partial y^2} + q^2 \right) + \sin\theta \, \frac{\partial^2}{\partial x \partial y} \right\} \Pi\pm$$

which, on transforming to co-ordinates r and θ, becomes

$$\pm E_r = \left\{ \cos\theta \frac{\partial^2}{\partial r^2} - \frac{\sin\theta}{r} \frac{\partial^2}{\partial r \partial\theta} + \frac{\sin\theta}{r^2} \frac{\partial}{\partial\theta} + \cos\theta \,.\, q^2 \right\} \Pi\pm \quad .. \quad (17)$$

This equation may also be obtained directly from the vector equation (8).

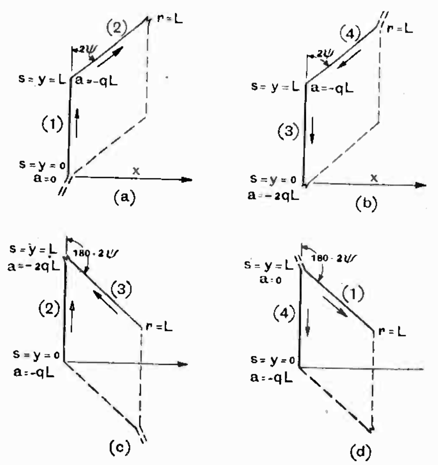


Fig. 9.—*Arrangements for the calculation of (a) P_{12}; (b) P_{34}; (c) P_{23}; and (d) P_{41}.*

Putting $L - s$ for s in the integral of equation (11) for $\Pi\pm$, and writing, for brevity

$$R = \sqrt{s^2 + 2rs \,.\, \cos\theta + r^2}$$
$$R' = \sqrt{L^2 + 2rL \,.\, \cos\theta + r^2}$$

and
$$\Pi'\pm = \int_0^L e^{\mp jqs} \frac{e^{-jqR}}{R} \,.\, ds$$

we have
$$\Pi\pm = - I_0 e^{ja} \,.\, \frac{30j}{q} \,.\, e^{\pm jqL} \, \Pi'\pm$$

By differentiation under the integral sign, we find

$$\cos\theta \frac{\partial \Pi'\pm}{\partial r} - \frac{\sin\theta}{r} \cdot \frac{\partial \Pi'\pm}{\partial\theta} \mp jq\Pi'\pm = \left(e^{\mp jqs} \frac{e^{-jqR}}{R} \right)_0^{s=L}$$

and, eliminating $\frac{\partial \Pi'\pm}{\partial\theta}$ from equation (17) by means of this identity,

$$\pm E_r = - \frac{30j}{q} I_0 e^{\pm jqL} e^{ja} \left(\frac{\partial}{\partial r} \left(e^{\mp jqs} \frac{e^{-jqR}}{R} \right)_0^L + q^2 \cos\theta \, \Pi'\pm \pm jq \frac{\partial \Pi'\pm}{\partial r} \right)$$

This expression further reduces to

$$\pm E_r = - \frac{30j}{q} I_0 e^{ja} e^{\pm jqL} \left(\frac{\partial}{\partial r} \left(e^{\mp jqs} \frac{e^{-jqR}}{R} \right)_0^L - jq \frac{e^{-jqr}}{r} + jq \frac{e^{\mp jqL} e^{-jqR'}}{R' \pm (L + r\cos\theta)} \left[\left(\frac{L\cos\theta + r}{R'} \right) \pm \cos\theta \right] \right)$$

after substituting for the value of $\Pi'\pm$.

Referring now to Fig. 9, where the current phases, direction of current waves and the co-ordinates of the conductors are marked, we obtain, from equation (4) and from the preceding expression for the electric field strength, the following equations

$$P_{12} = I_0^2 Re \,.\, \frac{30j}{q} \int_0^L \left\{ \frac{\partial}{\partial r} \left(e^{jqs} \frac{e^{-jqR}}{R} \right)_0^{s=L} - jq \frac{e^{-jqr}}{r} + jq \frac{e^{jqL} e^{-jqR'}}{R' - (L + r\cos\theta)} \left(\frac{L\cos\theta + r}{R'} - \cos\theta \right) \right\} e^{jqr} dr_{\theta = 2\psi}$$

$$= 30 I_0^2 \left\{ - \frac{\sin 2qL(1 - \cos\psi)}{2qL \,.\, \cos\psi} + Re \int_0^L \frac{e^{-jq(R' - r - L)}}{R'(R' - L + r \,.\, \cos 2\psi)} (R' - r - L) (1 + \cos 2\psi) \,.\, dr \right\}$$

(by integration by parts of the first term)

$$P_{34} = I_0^2 Re \,.\, \frac{30j}{q} \int_0^L \left\{ \frac{\partial}{\partial r} \left(e^{-jqs} \frac{e^{-jqR}}{R} \right)_0^{s=L} - jq \frac{e^{-jqr}}{r} + jq \frac{e^{-jqL} e^{-jqR'}}{R' + L + r \,.\, \cos\theta} \left(\frac{L\cos\theta + r}{R'} + \cos\theta \right) \right\} e^{-jqr} dr_{\theta = 2\psi}$$

$$= 30 I_0^2 \left\{ \frac{\sin 2qL(1 + \cos\psi)}{2qL \,.\, \cos\psi} - 2 \frac{\sin 2qL}{qL} + 2 - Re \int_0^L \frac{e^{-jq(R' + r + L)}}{R'(R' + L + r\cos 2\psi)} (R' + r + L) (1 + \cos 2\psi) \,.\, dr \right\}$$

$$P_{23} = I_0^2 Re \frac{30j}{q} \int_0^L \left\{ \frac{\partial}{\partial r} \left(e^{-jqs} \frac{e^{-jqR}}{R} \right)_0^{s=L} - jq \frac{e^{-jqr}}{r} + jq \frac{e^{jqL} e^{-jqR'}}{R' - (L + r\cos\theta)} \left(\frac{L\cos\theta + r}{R'} - \cos\theta \right) \right\} e^{-jqr} dr_{\theta = 180 - 2\psi}$$

$$= 30 I_0^2 \left\{ \frac{\sin(2qL\sin\psi)}{2qL\sin\psi} - \frac{\sin 2qL}{2qL} - 2S_1(2qL) - Re \int_0^L - \frac{2}{r} + \frac{e^{-jq(R' + r - L)}}{R'(R' - L + r\cos 2\psi)} (R' + r - L) (1 + \cos 2\psi) dr \right\}$$

$$P_{41} = I_0^2 Re \frac{30j}{q} \int_0^L \left\{ \frac{\partial}{\partial r} \left(e^{jqs} \frac{e^{-jqR}}{R} \right)_0^{s=L} - jq \frac{e^{-jqr}}{r} + jq \frac{e^{-jqL} e^{-jqR'}}{R' + L + r\cos\theta)} \left(\frac{L\cos\theta + r}{R'} + \cos\theta \right) \right\} e^{jqr} dr_{\theta = 180 - 2\psi}$$

$$= 30 I_0^2 \left\{ \frac{\sin(2qL\sin\psi)}{2qL\sin\psi} - \frac{\sin 2qL}{2qL} + Re \int_0^L \frac{e^{-jq(R' - r + L)}}{R'(R' + L - r\cos 2\psi)} (R' - r + L) (1 + \cos 2\psi) \, dr \right\}$$

The substitution $u = R' \pm r \pm L$ enable the indicated integrations to be performed directly, as they each then take the form $\int \frac{e^{-jqu}}{u} du$.

If we substitute the values of the power terms thus calculated into equation (6) and divide by I_0^2, we have, for the radiation resistance,

$$R_e = 120 \Bigg[S_1 q(2L + D) + S_1 q(2L - D) - 2S_1(2qL) + 2S_1(qB) - \cos(qB \sin\psi) \cdot \left\{ \begin{array}{l} S_1 qB(1 + \sin\psi) \\ + S_1 qB(1 - \sin\psi) - 2S_1(qB \sin\psi) \\ + S_1 qD(1 + \cos\psi) \\ + S_1 qD(1 - \cos\psi) - 2S_1(qD \cos\psi) \end{array} \right\} + \sin(qB \sin\psi) \cdot \left\{ \begin{array}{l} SiqB(1 + \sin\psi) \\ - SiqB(1 - \sin\psi) - 2Si(qB \sin\psi) \\ - SiqD(1 + \cos\psi) \\ + SiqD(1 - \cos\psi) + 2Si(qD \cos\psi) \end{array} \right\} \Bigg] \text{ ohms} \quad \ldots \quad (18)$$

In most practical applications, L, D and B will be large compared with λ, so that the approximations $S_1(x) = \log_e x + 0.577$ and $Si(x) = \frac{\pi}{2}$ for large x may be used. In this case the above formula simplifies considerably, and, approximately,

$$R_e = 240(\log_e(qB \sin\psi) + 0.577) \text{ ohms.}$$

The Industry

SUPPLEMENTS dealing with the applications of flexible remote controls have been issued for the treatise on this subject recently published by The S.S. White Co. of Gt. Britain, Ltd., St. Pancras Way, London, N.W.1.

British Insulated Cables, Ltd., Prescot, Lancs, have developed a plastic insulating tape suitable for use in wet and corrosive atmospheres. The properties and uses of this tape, which is known as "Pernax," are dealt with in Leaflet NSG6.

The head offices of the Sloan Electrical Co. Ltd., are now at 41, Kingsway, London, W.C.2, and a new East London Depot has been opened at 6, Albany Road, E.10.

The head office of Holsun Batteries, Ltd., is now at 137, Victoria Street, London, S.W.1. The telephone number (Victoria 1431/4) remains unchanged.

Wireless Patents

A Summary of Recently Accepted Specifications

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

AERIALS AND AERIAL SYSTEMS

531 382.—Aerial switching arrangement for changing-over from one aerial to a duplicate or "reserve" aerial by remote control.

F. C. McLean. Application date 20th July, 1939.

DIRECTIONAL WIRELESS

530 935.—Phase-meter type of indicator for use with a direct-reading radio compass, or direction finder.

Soc. Française Radio Electrique. Convention date (France) 6th July, 1938.

530 979.—Direction-finding system in which deflecting pulses are used to reproduce both a compass scale and bearing-trace on the fluorescent screen of a cathode-ray indicator.

Marconi's W.T. Co. (assignees of D. G. C. Luck). Convention date (U.S.A.) 30th June, 1938.

531 060.—Direction finder in which compensation is made for local re-radiation errors by means of auxiliary pick-up loops.

Telefunken Co. Convention date (Germany) 11th July, 1938.

531 204.—Method of coupling a directive and non-directive aerial to give the "sense" of a bearing indication.

Standard Telephones and Cables and C. W. Earp. Application date 30th June, 1939.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

530 578.—Preventing backlash in the keyboard movement of a push-button tuning system for wireless receivers.

Kolster-Brandes and P. A. Tiller. Application date 13th June, 1939.

530 615.—Superhet receiver with single-span tuning, depending upon an input circuit with a multiple-peaked resonance curve.

L. L. de Kramolin. Convention date (Germany) 25th May, 1938.

530 616.—Variable glow-discharge tube co-operating with a calibrated scale for indicating the adjusted frequency of an oscillatory circuit, e.g. the tuning of a wireless receiver.

L. L. de Kramolin. Convention date (Germany) 25th May, 1938.

530 620.—Intervalve coupling-network designed to give equal attenuation over a wide band of signal frequencies.

E. L. C. White. Application date 10th May, 1939.

530 693.—Filter circuit of flexible design applicable to wide-band amplifiers, narrow band-pass circuits with a flat-topped response, or to variable-selectivity control in a wireless receiver.

Marconi's W.T. Co.; N. M. Rust; J. D. Brailsford; and E. F. Goodenough. Application date 8th June, 1939.

530 793.—" Anti-hunting " device for the motor of an automatic-tuning system for a wireless set.

Marconi's W.T. Co. (assignees of H. H. Beizer and W. E. Newman). Convention date (U.S.A.) 17th June, 1938.

530 835.—Indicating dial, and means for illuminating it, when making the pre-setting adjustments for an automatic-tuning system.

Marconi's W.T. Co. (assignees of P. F. G. Holst). Convention date (U.S.A.) 18th June, 1938.

530 870.—Detecting or rectifying ultra-short-wave signals by bunching or grouping an electron stream to which the signals are applied.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 14th April, 1938.

530 871.—Means for stabilising a regenerative amplifier of very high frequencies, particularly for handling phase-modulated signals.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 14th April, 1938.

530 886.—Wireless receiver with automatic tuning control by a motor of the shaded-pole induction type.

Standard Telephones and Cables ; W. A. Beatty ; and E. W. Braendle. Application date 23rd June, 1939.

530 936.—Balanced bridge or neutralising coupling for stabilising amplifiers handling very short waves.

Telefunken Co. Convention dates (Germany) 6th July and 18th November, 1938.

531 102.—Transmission mechanism between the selector button and a movable powdered-iron core forming the variable element of a push-button tuning system.

Philips Lamps. Convention date (Netherlands) 14th July 1938.

531 141.—Motor-driven cam mechanism for setting or operating the moving parts of a push-button tuning system.

A. C. Cossor ; F. A. Jollyman ; K. I. Jones ; and E. L. Parker. Application date 13th July, 1939.

531 187.—Remote tuning and volume control of a wireless set by current impulses of predetermined and regulated duration.

Philco Radio and Television Corporation (assignees of M. L. Thompson). Convention date (U.S.A.) 20th July, 1938.

531 191.—Remote control, say of a wireless set, by the inductive effects of low-frequency oscillations.

Philco Radio and Television Corporation (assignees of D. Grimes). Convention date (U.S.A.) 20th July, 1938.

531 248.—Push-button tuning system in which provision is made for ensuring and indicating the correct position of the wave-change switch.

The General Electric Co. and W. H. Peters. Application date 24th May, 1939.

531 405.—Means for adjusting or varying the pre-selected wavelength in a switch-controlled tuning system for a wireless receiver.

Philips Lamps. Convention date (Netherlands) 23rd July, 1938.

531 406.—Automatic wave-switch control in a tuning arrangement in which each selector button serves more than one station.

Philips Lamps. Convention date (Netherlands) 23rd July, 1938.

531 416.—Remote control system, of the impulse type, for operating the station selectors and other controls of a wireless set.

Radio Gramophone Development Co. and W. R. Parkinson. Application date 21st July, 1939.

531 494.—Arrangement and mounting of the positioning discs in an automatic tuning control system for a wireless set.

Philips Lamps. Convention date (Netherlands) 25th July, 1938.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

530 591.—Mosaic screen arrangements for a cathode-ray television tube of the kind utilising secondary emission.

Baird Television and P. W. Willans. Application date 28th June 1939.

530 776.—Secret system of television, depending upon the use of irregularly-timed synchronising impulses.

Scophony and A. H. Rosenthal. Application dates 6th and 17th March, 1939.

530 794.—Amplitude-limiting circuit for minimising the effect of interference, particularly in television.

Philco Radio and Television Corporation (assignees of A. R. Applegarth Junr.). Convention date (U.S.A.) 16th July, 1938.

531 148.—Means for increasing the brightness of the fluorescent screen of a cathode-ray tube when viewed from the side on which the electron stream is incident.

The British Thomson-Houston Co. Convention date (Germany) 15th July, 1938.

531 159.—Transmitting a number of different television pictures, or picture-sequences, simultaneously and without mutual interference.

The General Electric Co. and D. C. Espley. Application date 19th July, 1939.

531 219.—Method of using an electron-multiplier tube as a modulator, particularly for television.

The General Electric Co. and D. C. Espley. Application date 13th July, 1939.

531 220.—Electron-multiplier circuit for producing synchronising signals of the " blacker than black " type in television.

The General Electric Co. and D. C. Espley. Application date 14th July, 1939.

531 306.—Construction from clay-like materials of a bi-refringent screen through which the image is projected in a television receiver.

Scophony and A. H. Rosenthal. Application date 18th July, 1939.

531 653.—Television receiver in which the gain control is automatically varied according to the particular station selected.

The General Electric Co. and T. R. Cowley. Application date 28th July, 1939.

531 712.—Timing circuit for a television receiver designed for use with double-interlaced scanning.

Hazeltine Corporation (assignees of J. C. Wilson). Convention date (U.S.A.) 26th August, 1938.

531 724.—Means for eliminating interference, particularly that caused by car ignition systems, from television signals.

The General Electric Co. and B. J. O'Kane. Application date 31st July, 1939.

531 755.—Time-base circuit of the relaxation oscillator type, particularly suitable for scanning in television.

Marconi's W.T. Co. and W. S. Mortley. Application date 9th June, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

530 785.—Means for passing an electron stream through resonant chambers, and setting-up changes of group-velocity, for the transmission and reception of phase-modulated waves.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 14th April, 1938.

530 893.—Means for synchronising the frequency of a carrier-wave signalling system in which a number of stations are connected by a line wire.

Automatic Telephone and Electric Co. and T. B. D. Terroni. Application date 4th July, 1939.

530 958.—Negative feed-back and attenuation equaliser for a transmission system incorporating volume-range expansion and compression.

Standard Telephones and Cables and R. A. Meers. Application date 7th July, 1939.

530 869.—Modulating very short waves produced by passing a stream of electrons through resonating chambers in which their velocity is periodically varied.

Thr Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 14th April, 1938.

531 104.—Means for preventing or eliminating simple and multiple echo effects or "trail" distortion, particularly in a high-frequency transmission line. (Addition to 523 434.)

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 13th July, 1938.

531 067.—Means for controlling the frequency of oscillation of a bunched stream of electrons, particularly for phase modulation.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 14th April, 1938.

531 150.—Secret radio telephony system in which the band of signalling frequencies are subjected to phase modulation and inversion.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 31st August, 1938.

531 454.—Shielded multi-stage tube and cylinder system for generating ultra-short waves.

Marconi's W.T. Co. (assignees of W. H. Happe Junior and A. K. Wing). Convention date (U.S.A.) 19th August, 1938.

531 554.—Automatic change-over switch for a combined telegraphic transmitter and receiver installation.

Standard Telephones and Cables and P. H. Spagnoletti. Application date 5th July, 1939.

531 556.—Means for suppressing the carrier-wave during the short intervals between the actual transmission of a sequence of signals.

Standard Telephones and Cables; R. A. Meers; G. O. Probert; and E. A. Rattue. Application date 5th July, 1939.

531 646.—Modulating circuit of the capacity type, particularly suitable for ultra-high frequencies.

W. O. Duncan (communicated by International Service Corporation). Application date 28th July, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

530 701.—Single-ended valve constructed so as to reduce capacity coupling between the terminals and lead-in wires.

The British Thomson-Houston Co. Convention date (U.S.A.) 16th June, 1938.

530 914.—Construction and assembly of the external focussing magnet of a cathode-ray tube.

The General Electric Co. and W. H. Peters. Application date 5th July, 1939.

531 541.—Construction and assembly of the electrodes of an electron-multiplier tube.

F. J. G. van den Bosch and Vacuum-Science Products. Application dates 11th and 23rd May, 1939.

531 558.—Construction and assembly of the target and other electrodes in an electron-multiplier tube.

F. J. G. van den Bosch and Vacuum-Science Products. Application date 5th July, 1939.

531 628.—Construction and assembly of the electrode system of a thermionic valve operated at high voltages, say as a rectifier for supplying voltages to a cathode-ray tube.

Standard Telephones and Cables and R. R. Back. Application date 7th July, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

530 107.—Thermionic valve control circuit, particularly for regulating the frequency of an A.C. source and for synchronising it with another A.C. source.

The British Thomson-Houston Co. Convention date (U.S.A.) 28th April, 1938.

530 410.—Frequency-control circuit in which a high-pass and a low-pass filter are co-ordinated to give a critical regulation.

Telefunken Co. Convention date (Germany) 24th June, 1938.

530 456.—Photo-electric control circuit in which a pair of sensitive cells are connected in series across a source of direct current and operate a pair of relay discharge valves.

The British Thomson-Houston Co. Convention date (U.S.A.) 23rd June, 1938.

530 509.—Combined direction finder and gyro-compass for automatically steering an aeroplane towards a beacon transmitter.

S. Smith & Sons (Motor Accessories) and F. W. Meredith. Application date 31st March, 1939.

Receiver Aerial Coupling Circuits

By K. R. Sturley, Ph.D., A.M.I.E.E.

(Marconi School of Wireless Communication)

(Concluded from page 137 of the previous issue)

2. Experimental Results

2.1.—*The Variation of T_R, S_R, M_R, ΔC_2 and Frequency Error over the Medium Wave Range*

A series of experiments was carried out to check the validity of the formulae for the various types of coupling and to show the general trend of T_R, S_R, ΔC_2 and M_R over the medium wave range, 600 to 1,400 kc/s. The apparatus consisted of a Marconi-Ekco Signal Generator and Circuit Magnification Meter. The latter was used for measuring L, C and R of the test components and its valve voltmeter section was later employed to measure transfer voltage ratio. The signal generator supplied the aerial input voltage and its internal resistance, 42 ohms on the 0.1 to 1 volt range used, together with a series capacitor of 177 $\mu\mu$F simulated the aerial terminal impedance Z_{a0}. Transfer voltage ratio and capacitance correction ΔC_2 were noted at convenient frequency intervals for the following forms of coupling.

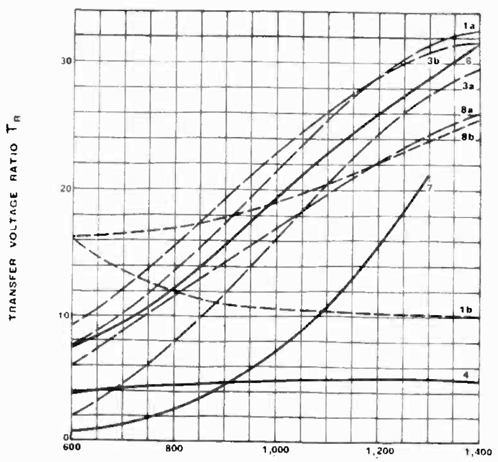


Fig. 5.—*Transfer voltage ratio curves. Broken lines—mutual inductance small primary; dotted lines—mutual inductance large primary.*

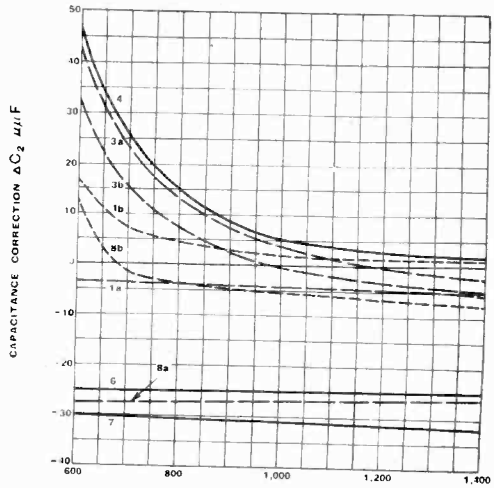


Fig. 6.—*Capacitance correction curves. Broken lines—mutual inductance small primary; dotted lines—mutual inductance large primary.*

1a. Mutual inductance with a small primary coil giving capacitive X_{a1}.

1b. Mutual inductance with a large primary coil giving inductive X_{a1}.

3a. Positive mutual inductance (small primary coil) and shunt capacitance.

3b. Negative mutual inductance (small primary coil) and shunt capacitance.

4. Shunt capacitance.

6. Series capacitance.

7. Series capacitance and shunt inductance.

8a. Positive mutual inductance (small primary coil) and series capacitance.

8b. Negative mutual inductance (large primary coil) and series capacitance.

The results for T_R and ΔC_2 are plotted in Figs. 5 and 6 and the calculated value of selectivity ratio is shown in Fig. 7. The measured values of T_R and ΔC_2 are set out for 1a, 6 and 8a, in Tables 5, 6, and 7, together with those calculated from expressions 13a and 15. Details are also given at 600, 1,000, and 1,400 kc/s. of the important factors in the expressions so as to convey some idea of their magnitude. The agreement between the measured and calculated, which is quite satisfactory, also held for the other tested couplings. Mistune ratio and frequency error curves are shown in Figs. 8 and 9.

The curves follow closely the predictions of Table 3. Some modification occurs when the aerial and coupling circuit approaches resonance. Thus mutual inductance with a large primary coil, which should, according to Table 3, give a constant value of T_R and S_R, shows an increase of the former and decrease of the latter at the low frequency end of the range (curves 1b in Figs. 5 and 7) due to X_{a1} approaching zero. The increase in M_R (curve 1b in Fig. 8) is due to the same cause.

The use of combined forms of coupling mainly affects x and mixed couplings reducing the variation of x over the frequency range are advantageous in reducing the

TABLE 5

MUTUAL INDUCTANCE COUPLING.—Small Primary Coil (Curves marked 1*a* and broken line)

$R_{a0} = 42$ ohms. $C_{a0} = 177\ \mu\mu$F. $L_2 = 160\ \mu$H. $L_1 = 31.3\ \mu$H.
$M = 22\ \mu$H. Self Capacitance of $L_2 = 7\ \mu\mu$F.
Self Capacitance of $L_1 = 8\ \mu\mu$F.
(For circuit diagram see 1 in Table 1)

Frequency (kc/s)	600	700	800	900	1,000	1,100	1,200	1,300	1,400
Measured T_R	6.7	9.8	13.5	17.5	21.2	25.5	29.0	31.5	32.5
Calculated T_R	6.72	10.0	13.65	17.7	21.6	25.8	29.3	32.1	33.1
ΔC_2 Measured	−4.0	−4.0	−4.0	−4.0	−5.0	−5.0	−5.0	−5.0	−6.0
($\mu\mu$F) Calculated ..	−3.6	−3.71	−3.85	−3.96	−4.28	−4.53	−4.7	−4.95	−5.47

Frequency (kc/s)	R_2	C_2	Z_{a1}	R_1	x^2R_{a1}
600	5.26 ohms	437 $\mu\mu$F.	1,382 ohms	2.0 ohms	0.158 ohms
1,000	7.63 ,,	155 ,,	704 ,,	2.5 ,,	1.7 ,,
1,400	11.47 ,,	75 ,,	366 ,,	3.2 ,,	12.65 ,,

TABLE 6

SERIES CAPACITANCE COUPLING. (Curves marked 6 and full line)

$R_{a0} = 42$ ohms: $C_{a0} = 177\ \mu\mu$F.; $C_4 = 30\ \mu\mu$F.; $L_2 = 160\ \mu$H.: Self capacitance of $L_2 = 7\ \mu\mu$F.
(For circuit diagram see 6 in Table 1)

Frequency (kc/s)	600	700	800	900	1,000	1,100	1,200	1,300	1,400
Measured T_R	6.4	9.1	12.5	15.8	19.0	23.0	25.8	28.5	31.5
Calculated T_R	6.78	9.75	13.35	16.85	20.0	24.2	26.7	29.9	32.2
Calculated T_R .... (Colebrook)	6.78	9.76	13.27	16.8	20.3	23.6	27.0	29.8	32.2
ΔC_2 Measured	−25.0	−26.0	−28.0	−27.0	−25.0	−27.0	−25.0	−25.0	−26.0
($\mu\mu$F.) Calculated .	Constant at −25.6 $\mu\mu$F.								

Frequency (kc/s)	R_2	C_2	Z_{a1}	$x^2(R_{a0} + R_2)$	$\frac{2x^2X_{a1}R_2}{\omega L_2}$
600	5.02 ohms	416 $\mu\mu$F.	9,747 ohms	0.181 ohms	0.623 ohms
1,000	6.95 ,,	134 ,,	5,195 ,,	1.82 ,,	2.68 ,,
1,400	9.68 ,,	55 ,,	3,012 ,,	11.3 ,,	9.05 ,,

TABLE 7

Positive Mutual Inductance and Series Capacitance Coupling

Small Primary Coil (Curves marked 8*a* and broken line)
$C_5 = 30\ \mu\mu$F. Remainder of components as for Table 5. (For circuit diagram see 8 in Table 1)

Frequency (kc/s)	600	700	800	900	1,000	1,100	1,200	1,300	1,400
Measured T_R	6.0	8.6	11.6	14.5	17.0	20.0	21.85	24.0	26.1
Calculated T_R	6.18	8.87	11.85	14.9	17.42	20.35	22.2	24.6	26.65
ΔC_2 Measured	−27.0	−28.0	−28.0	−26.0	−25.0	−25.0	−26.0	−24.0	−26.0
($\mu\mu$F.) Calculated..	−28.0	−28.0	−28.0	−26.5	−26.2	−25.5	−26.2	−24.7	−25.9

R_2 and R_1 as for Table 5.

Frequency (kc/s)	C_2	M'	Z_{a1}	A	R_Δ	R_β	x^2R_{a1}	$2R_\beta x^2\frac{X_{a1}}{X_\beta}$
600	414 $\mu\mu$F.	21.4 μH.	1,382 ohms	1.07	6.09 ohms	−0.133	0.149	−0.016
1,000	134 ,,	20.2 ,,	704 ,,	1.21	11.55 ,,	−0.53	1.44	−0.191
1,400	55 ,,	17.5 ,,	366 ,,	1.52	27.3 ,,	−1.67	7.95	−1.4

$$M' = M - \frac{\omega(L_1 - M)(L_2 - M)}{B_1}; \quad R_\Delta = A_1\left[R_2 + \frac{(R_1 + R_2)\omega(L_2 - M)}{B_1}\right]$$

variation of T_R and S_R. For example, negative mutual inductance and shunt capacitance (curves 3b) giving

$$X_\beta = -\left(\omega M + \frac{1}{\omega C_3}\right)$$

and positive mutual inductance with series capacitance (curves 8a) giving

$$X_\beta = \omega M - \frac{\omega^2(L_1 - M)\,(L_2 - M)}{B_1}$$

show reduced variation of T_R and S_R over the frequency range as compared with mutual inductance alone (curves 1a). The disadvantage of the above combined couplings is that though less variation of S_R is obtained the average value of S_R is reduced. This is a particular characteristic of combined couplings producing a more level T_R curve.

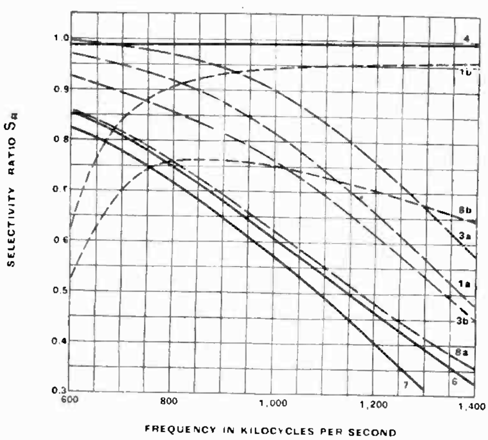


Fig. 7.—*Selectivity ratio curves. Broken lines—mutual inductance small primary; dotted lines—mutual inductance large primary.*

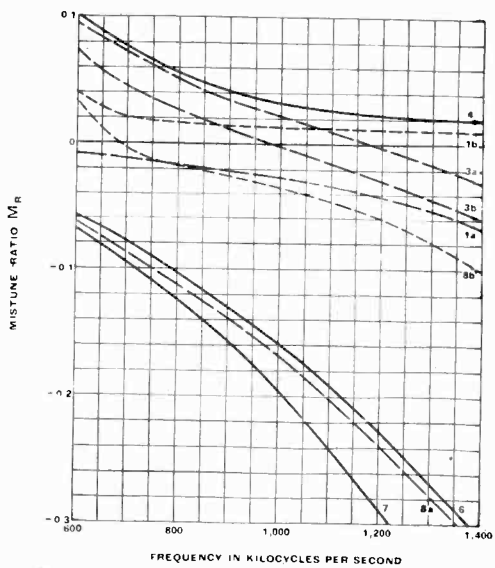


Fig. 8.—*Mistune ratio curves. Broken lines—mutual inductance small primary; dotted lines—mutual inductance large primary.*

The addition of series capacitance coupling to negative mutual inductance with a large primary coil (curve 8b) can be used to increase T_R at the high frequency end and so produce a more level T_R curve. A value

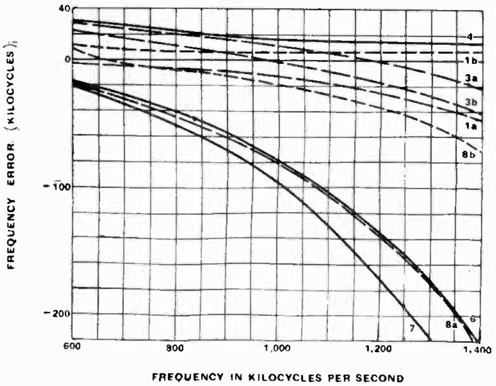


Fig. 9.—*Frequency error curves. Broken line—mutual inductance small primary; dotted line—mutual inductance large primary.*

of approximately 4 $\mu\mu$F produced a practically flat T_R curve. Average S_R is again reduced as compared with curve 1b.

The variation of capacitance correction over the frequency range also follows the predictions of Table 3. For combined couplings it may change its sign at some point in the frequency range (curves 3a and b and 8b). This is due to the fact that the reflected aerial reactance x^2X_{a1} is opposite in sign to that of the coupling reactance. The most desirable curve of ΔC_2 against frequency is that giving a horizontal straight line, i.e. ΔC_2 is independent of frequency. Provided the constant value of ΔC_2 is within the range of the trimmer across the tuning capacitance mistuning effects can be completely cancelled. From this point of view series capacitance (6), mutual inductance with small primary coil (1a), positive mutual inductance (small primary) and series capacitance (8a) and series capacitance with shunt inductance (7) are satisfactory.

It is worth while noting that if $R_{a0} \ll X_{a0}$ for a capacitive aerial terminal impedance, capacitance correction is, in the case of shunt capacitance, (4), series capacitance (6) and combined series capacitance and shunt inductance (7) very nearly given by

$$\Delta C_2 = \frac{-C_{20}^2}{C_3 + C_{a0} - C_{20}} \simeq -\frac{C_{20}^2}{C_3}$$

(C_3 = shunt capacitance)

$$\Delta C_2 = -\frac{C_4 C_{a0}}{C_4 + C_{a0}}$$

(C_4 = series capacitance)

and $$\Delta C_2 = -\frac{C_5}{1 - \dfrac{\omega^2 L_1 C_5}{1 - \omega^2 L_1 C_{a0}}}$$ respectively

(L_1 = shunt inductance, C_5 = series capacitance)

Shunt capacitance coupling gives a much larger variation of ΔC_2 than series capacitance and for this reason it is not a desirable form of coupling.

If no correction is made for the coupling and reflected aerial reactance, mutual inductance with a large primary coil is the best as it gives least magnitude and variation of frequency error. An interesting point to note is that, in contradistinction to the

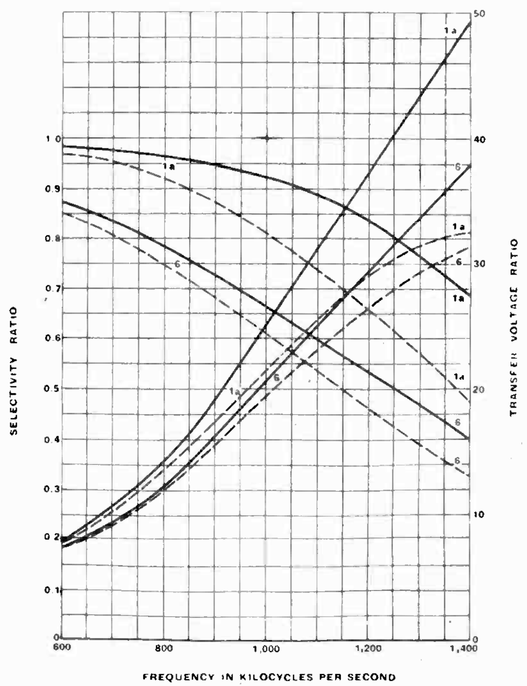


Fig. 10.—*Transfer voltage ratio and selectivity ratio curves for two values of aerial terminal resistance. Full line—R_{a0} = 15 Ω, C_{a0} = 177 $\mu\mu$F; dotted line—R_{a0} = 42 Ω.*

position when correction is possible, shunt capacitance coupling is better than series capacitance. When frequency error varies over the frequency range it is preferable to select a coupling giving least error at the low frequency end because the selective properties of the tuned secondary circuit are usually greatest at this end of the range.

2.2.—*Aerial Terminal Impedance*

The all-important role played by the aerial and coupling circuit impedance (Z_{a1}) is clearly shown in the generalised formulae, and since aerial terminal impedance Z_{a0} is an integral part of Z_{a1} any change in its value has a considerable effect on performance.

Two experiments were made to determine the effect of variation of Z_{a0}; in the first X_{a0} was maintained constant and in the second R_{a0} was constant. Mutual inductance coupling with a small primary coil and series capacitance coupling were examined and the results are shown in Fig. 10, for two values of R_{a0}, 42 and 15 ohms. Selectivity ratio and transfer voltage ratio only are plotted since capacitance correction is practically unaffected by R_{a0}. Increase of R_{a0} increases Z_{a0} and Z_{a1}, but has little effect on the latter unless aerial and coupling circuit resonance ($X_{a1} = 0$) is approached. In this experiment the aerial and coupling circuit is resonant at a high frequency beyond the medium wave range so that increase of R_{a0} has the greatest effect at the high frequency end of the range. The approximate formula 13c shows T_R to be proportional to $x\left(\frac{X_\beta}{|Z_{a1}|}\right)$ so that increase of R_{a0} leads to a decrease of T_R, with greatest effect towards aerial and coupling circuit resonance. Hence the curves show a marked reduction of T_R at the high frequency end of the range. The reverse would be true for aerial and coupling circuit resonance at a low frequency, e.g., mutual inductance, with a large primary coil, and increase of R_{a0} would then decrease T_R at the low frequency end of the range.

The general effect of an increase in R_{a0} is therefore to reduce the variation of T_R over the tuning range and a more constant value of T_R could generally be obtained by adding a resistance in series with the aerial. This has, however, its disadvantages since increase of R_{a0} tends to reduce selectivity ratio unless aerial and coupling circuit resonance is reached, when S_R may increase. The effect of increasing aerial terminal capacitive reactance (X_{a0}) is shown in Fig. 11. As Z_{a1} in this experiment is capacitive (aerial and coupling circuit resonance occurs at a high frequency) increase of X_{a0} increases Z_{a1} and decreases x. Hence T_R is decreased and S_R increased. The curve for $C_{a0} = 240$

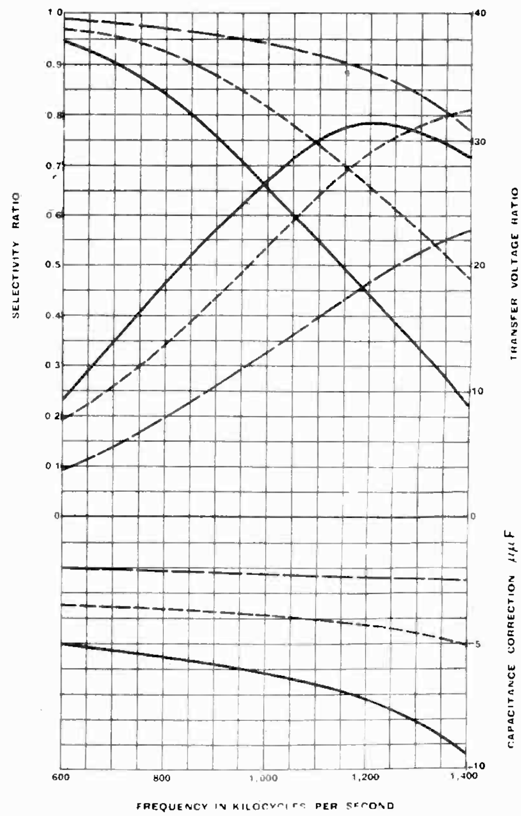


Fig. 11.—*Transfer voltage ratio, selectivity ratio and capacitance correction curves for three values of aerial terminal reactance. Broken line —C_{a0} = 104 μμF; dotted line—C_{a0} = 177 μμF; full line—C_{a0} = 240 μμF, R_{a0} = 42Ω.*

μμF shows a reduction of T_R at the high frequency end of the range as compared with that for C_{a0} = 177 μμF and this is due to the fact that optimum coupling has been exceeded as described in 1.7.

It is known that for vertically polarised transmission the addition of a horizontal "capacity top" to a vertical aerial changes the distribution of voltage and current along the latter so as to increase the effective generated aerial voltage, but the increase of T_R with increase of X_{a0} shows that the output from a receiver can in certain circumstances increase beyond that due to increased generated voltage. The horizontal top reduces X_{a0} if X_{a0} is initially capacitive, and this in turn reduces Z_{a1} and increases x and the transfer voltage ratio, i.e. an approach is made to more correct matching between aerial and receiver.

Capacitance correction (ΔC_2) is decreased and varies to a less extent over the frequency range as X_{a0} is increased. This was to be expected since the aerial and coupling circuit resonant frequency is increased and is therefore further outside the wave range.

When the aerial and coupling circuit reactance X_{a1} is inductive, e.g., mutual inductance with a large primary coil, decrease of capacitive X_{a0} increases Z_{a1} and decreases x. Hence T_R is decreased and S_R increased. Mistune ratio and ΔC_2 are decreased and vary to a less extent over the tuning range.

3. Conclusion

The experimental results fully confirm the validity of the theoretical analysis and the generalised formulae. The predictions of Tables 3 and 4 are also found to be correct.

From the point of view of all round performance, mutual inductance with a large primary coil has much to recommend it for it tends to give constant transfer voltage ratio, selectivity ratio and frequency error. Shunt capacitance produces much the same effect with capacitive aerial terminal reactance but a large value of T_R is not possible if the frequency error is not to be large. In the latter case capacitance correction ΔC_2 varies appreciably over the wave range and it cannot be compensated by trimmer capacitance adjustment. Series capacitance coupling and mutual inductance coupling with a small primary coil tend to produce a constant value of ΔC_2 and their frequency error can be almost entirely eliminated by trimmer capacitance adjustment. T_R and S_R tend to vary considerably from the low to high frequency end of the range, and average S_R is low unless coupling is loose.

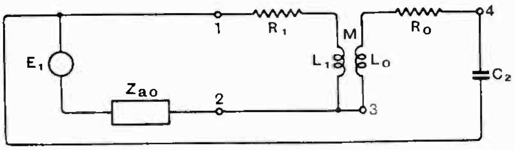


Fig. 12.

Combined couplings can be used to reduce variations of T_R but they generally reduce S_R and increase the variation of ΔC_2 over the frequency range.

Acknowledgments are gratefully made to Messrs. C. and J. Vickers, who assisted in the experimental measurements, and to Marconi's Wireless Telegraph Company for permission to publish the results.

APPENDIX 1.

The Tapped Tuned Coil

Coupling to a tapping point on the tuned secondary coil is similar in form to mutual inductance coupling and the expressions for T_R, S_R and M_R can be developed as in Section 1.1, page 137.

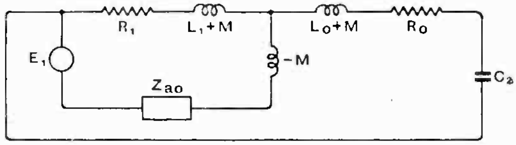


Fig. 13.

However, the equivalent T section network can be deduced by analogy from Figs. 1b and 1c in the paper. The development of the equivalent T section is illustrated by Figs. 12 and 13. Fig. 13 is redrawn in Fig. 14 in a more convenient form. The mutual inductance between the coils is in a direction to

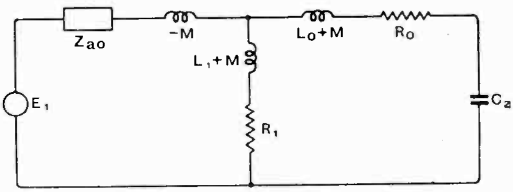


Fig. 14.

increase the total inductance between points 1 and 4 and so by definition in 1.1 is given a negative sign.

APPENDIX 2a

Series Capacitance and Shunt Inductance

The circuit is illustrated in Fig. 15a and in order that the generalised formulae may be applicable it is necessary to change the π section enclosed in the dotted lines into an equivalent T section. The necessary transformation can be accomplished by a variety of well-known methods and Figs. 16a and 16b show an unsymmetrical π section and its equivalent T section. The impedances of the series and shunt arms of the equivalent T section are therefore

$$Z_A = \frac{\left(R_1 + j\omega L_1\right)\frac{1}{j\omega C_5}}{R_1 + R_2 - j\left[\frac{1}{\omega C_5} - \omega\left(L_1 + L_2\right)\right]}$$

Rationalising

$$Z_A = \frac{\left[(R_1 + R_2)\,\omega L_1 + R_1\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right)\right]\frac{1}{\omega C_5}}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

$$+ j\,\frac{\frac{1}{\omega C_5}\left[\omega L_1\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right) - R_1(R_1 + R_2)\right]}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

Similarly

$$Z_B = \frac{\left[(R_1 + R_2)\,\omega L_2 + R_2\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right)\right]\frac{1}{\omega C_5}}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

$$+ j\,\frac{\frac{1}{\omega C_5}\left[\omega L_2\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right) - R_2(R_1 + R_2)\right]}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

and

$$Z_C = \frac{-(\omega^2 L_1 L_2 - R_1 R_2)(R_1 + R_2) + \left(R_1\omega L_2 + R_2\omega L_1\right)\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right)}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

$$- j\,\frac{\left[(\omega^2 L_1 L_2 - R_1 R_2)\left(\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right) - (R_1 + R_2)(R_1\omega L_2 + R_2\omega L_1)\right]}{(R_1 + R_2)^2 + \left[\frac{1}{\omega C_5} - \omega(L_1 + L_2)\right]^2}$$

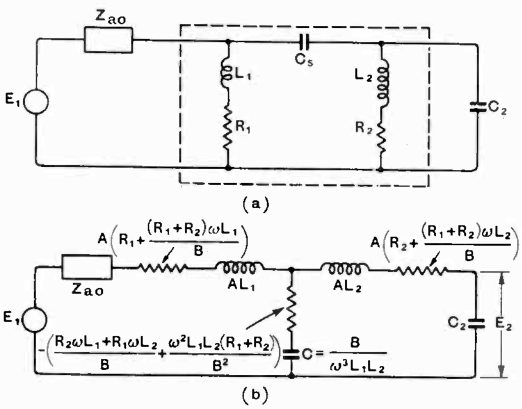


Fig. 15.

In practice $\frac{1}{\omega C_5} - \omega(L_1 + L_2) \gg R_1 + R_2,\ \omega L_1 \gg R_1$ and $\omega L_2 \gg R_2$ and Z_A, Z_B and Z_C can be simplified to

$$Z_A = A\left[R_1 + \frac{(R_1 + R_2)\omega L_1}{B}\right] + jA\omega L_1$$

$$Z_B = A\left[R_2 + \frac{(R_1 + R_2)\omega L_2}{B}\right] + jA\omega L_2$$

$$Z_C = -\left[\frac{R_2\omega L_1 + R_1\omega L_2}{B} + \frac{\omega^2 L_1 L_2(R_1 + R_2)}{B^2}\right] - j\,\frac{\omega^2 L_1 L_2}{B}$$

where $A = \frac{1}{B\omega C_5}$

and $B = \frac{1}{\omega C_5} - \omega(L_1 + L_2)$

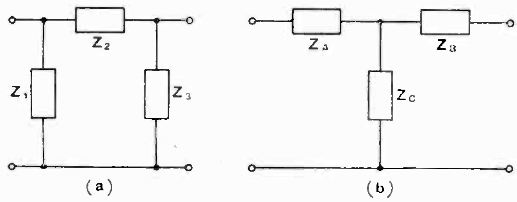


Fig. 16.—*In* (*b*) $Z_A = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3}$; $Z_B = \frac{Z_2 Z_3}{Z_1 + Z_2 + Z_3}$; $Z_C = \frac{Z_1 Z_3}{Z_1 + Z_2 + Z_3}$

The equivalent T section network is that of Fig. 15b and the generalised formulae can be used by noting that

$$R_\alpha = R_{ao} + A\left[R_1 + \frac{(R_1 + R_2)\omega L_1}{B}\right],$$

$$X_\alpha = A\omega L_1 + X_{ao};$$

$$R_\beta = -\left[\frac{R_2\omega L_1 + R_1\omega L_2}{B} + \frac{\omega^2 L_1 L_2(R_1 + R_2)}{B^2}\right];$$

$$X_\beta = -\frac{\omega^2 L_1 L_2}{B}$$

$$R_\gamma = A\left[R_2 + \frac{(R_1 + R_2)\omega L_2}{B}\right];$$

$$X_\gamma = A\omega L_2,\ R_\lambda = 0;\ X_\lambda = -\frac{1}{\omega C_2}$$

APPENDIX 2b

Mutual Inductance and Series Capacitance

The actual circuit is shown in Fig. 17a and the part enclosed by the dotted lines is identical with the unsymmetrical bridge T network of Fig. 18a. This is convertible to the unsymmetrical T network of Fig. 18b and after making the same simplifications as in Appendix 2a the values of Z_A, Z_B and Z_C for positive M are

$$Z_A = A_1\left[R_1 + \frac{(R_1 + R_2)\omega(L_1 - M)}{B_1}\right] + jA_1\omega(L_1 - M)$$

$$Z_B = A_1\left[R_2 + \frac{(R_1 + R_2)\omega(L_2 - M)}{B_1}\right] + jA_1\omega(L_2 - M)$$

$$Z_C = -\left[\frac{R_2\omega(L_1 - M) + R_1\omega(L_2 - M)}{B_1} + \frac{\omega^2(L_1 - M)(L_2 - M)(R_1 + R_2)}{B_1^2}\right] + j\left[\omega M - \frac{\omega^2(L_1 - M)(L_2 - M)}{B_1^2}\right]$$

where $A_1 = \frac{1}{B_1 \omega C_5}$

and $B_1 = \frac{1}{\omega C_5} - \omega(L_1 + L_2 - 2M)$

The above expressions are identical with those in Appendix 2a when $M = O$. For negative M

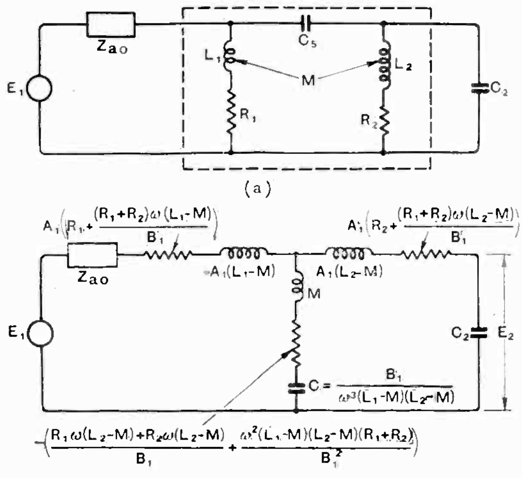


Fig. 17.

$(-M)$ replaces M in all the expressions. The equivalent circuit is shown in Fig. 17b and for the generalised formulae.

(a) Positive M

$$R_a = R_{ao} + A_1\left[R_1 + \frac{(R_1 + R_2)\omega(L_1 - M)}{B_1}\right],$$

$$X_a = X_{ao} + A_1\omega(L_1 - M)$$

$$R_\beta = -\left[\frac{R_2\omega(L_1 - M) + R_1\omega(L_2 - M)}{B_1} + \frac{\omega^2(L_1 - M)(L_2 - M)(R_1 + R_2)}{B_1^2}\right]$$

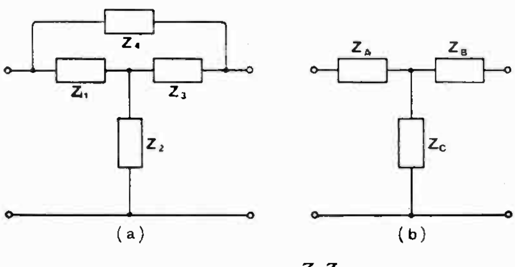


Fig. 18.—*In* (*b*) $Z_A = \frac{Z_1 Z_4}{Z_1 + Z_3 + Z_4}$;

$$Z_B = \frac{Z_3 Z_4}{Z_1 + Z_3 + Z_4};\ Z_C = Z_2 + \frac{Z_1 Z_3}{Z_1 + Z_3 + Z_4}$$

$$X_\beta = \omega M - \frac{\omega^2(L_1 - M)(L_2 - M)}{B_1}$$

$$R_\Delta = A_1\left[R_2 + \frac{(R_1 + R_2)\omega(L_2 - M)}{B_1}\right];$$

$$X_\Delta = A_1\omega(L_2 - M).$$

$$A_1 = \frac{1}{B_1\omega C_5};\ B_1 = \frac{1}{\omega C_5} - \omega(L_1 + L_2 - 2M)$$

(b) Negative M.

$$R_a = R_{ao} + A_1\left[R_1 + \frac{(R_1 + R_2)\omega(L_1 + M)}{B_1}\right];$$

$$X_a = X_{ao} + A_1\omega(L_1 + M).$$

$$R_\beta = -\left[\frac{R_2\omega(L_1 + M) + R_1\omega(L_2 + M)}{B_1} + \frac{\omega^2(L_1 + M)(L_2 + M)(R_1 + R_2)}{B_1^2}\right]$$

$$X_\beta = -\omega M - \frac{\omega^2(L_1 + M)(L_2 + M)}{B_1}$$

$$R_\Delta = A_1\left[R_2 + \frac{(R_1 + R_2)\omega(L_2 + M)}{B_1}\right];$$

$$X_\Delta = A_1\omega(L_2 + M).$$

$$A_1 = \frac{1}{B_1\omega C_5};\ B_1 = \frac{1}{\omega C_5} - \omega(L_1 + L_2 + 2M).$$

Two New British Standards

IN spite of the work undertaken by the British Standards Institution in assisting Government departments in the preparation of War Emergency Specifications, it continues its normal work and has recently issued two Specifications of general wireless interest.

One of these, B.S.415-1941, covers the regulations concerning safety requirements for mains-operated wireless apparatus. This specification, which is a revision of one published in 1936, incorporates much of the material included in the draft international specification prepared by the International Electrotechnical Commission, from which it differs little except that it covers television and public address equipment. A new section, dealing with the installation of apparatus, has been added.

The second Specification, B.S.951-1941, has been drawn up as a basis for the approval of earthing devices to water mains or pipes and is based on the regulations drafted by the Institution of Civil Engineers as a result of agreements arrived at between water supply undertakings and electrical interests. Whilst certain mechanical features of the construction of earthing clamps are laid down in the specification it is mainly concerned with performance.

The Specifications are obtainable from the British Standards Institution, 28, Victoria Street, London, S.W.1, at 2s. 3d. each, including postage.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

1291. AUSTRALIAN RADIO RESEARCH BOARD: 12th ANNUAL REPORT [for Year ended 30th June 1940: Magnetic Disturbances & Region F_2: Measurement of Refractive Indices of Atmospheric Gases for 2.5–5 m Waves (Two Methods): Velocities of Sky & Ground Waves at Wavelengths of Atmospherics (20 000 m upwards): etc.].—(*Journ. of Council for Sci. & Indust. Res.*, Australia, Nov. 1940, Vol. 13, No. 4, pp. 305–309.)
All the papers mentioned as published have been dealt with in past Abstracts.

1292. MEASUREMENTS OF THE DELAY AND DIRECTION OF ARRIVAL OF ECHOES FROM NEAR-BY SHORT-WAVE TRANSMITTERS [Lawrenceville received at Holmdel: Three Types of Echo, Each due to a Different Cause: Multiple-Type the Most Persistent, from Directions corresponding to That of Transmitted Beam: Components from Distances up to 4000 Miles (Scattering at Earth's Surface): Multiple Echoes & Southerly-Deviated Waves from European Stations due to Same Phenomena?].—K. G. Jansky & C. F. Edwards. (*See* 1536.)

1293. SUPPLEMENTARY REPORTS TO THE PAPER "THE ANGLE OF ARRIVAL OF SHORT-WAVE RADIATION IN TRANSOCEANIC COMMUNICATION."—E. Schüttlöffel. (*Hochf:tech. u. Elek:akus.*, Nov. 1940, Vol. 56, No. 5, pp. 136–137.)

See 1003 of April. The present supplementary note was prompted by an enquiry from Zenneck as to the number of reflections between North America and Germany, on the assumption of an F-layer height of 250 or 300 km. The probable number of reflections can easily be calculated from the angles given in the main paper, but as some earlier measurements by the writers of the above paper have an intimate bearing on the subject they are given here.

A pulse transmitter in North America was received at Brück/M. in Germany. The optimum radiating angle could be determined. A pulse signal travelling by several different paths, or different numbers of reflections, would reach the receiving aerial as several separate component pulses, and from the path-time differences of these components conclusions could be deduced as to the paths; also, the optimum radiating angle would be different for various numbers of reflections. For a frequency of about 13 Mc/s the mean values of these optimum angles were 15.41, 19.7, and 24.82°. Assuming a layer height of 250 km, these would give (taking the earth's curvature into account) 4.37, 5.53, and 6.15 reflections; since an incomplete number of reflections is impossible, these numbers are taken to be 4, 5, and 6, and it is consequently assumed that the reflections occur at different heights ("this assumption is probable, but not certain," since the angles are average values, so that a certain uncertainty exists). For the three angles given above, the layer heights would be 280.7 km (4 jumps), 271 km (5 jumps), and 280 km (6 jumps), while the path difference between the first component pulse and the third would be 153.5 km, and between the second and third 283.8 km. The corresponding path differences measured at the receiver are 108.15 km. and 234.3 km, which are lower than the other calculated differences by nearly the same amount in both cases (45.35 and 49.5 km). It is suggested that this discrepancy may be due in both cases to the assumption, which may not be correct, that the F-layer height is the same over the whole path.

"These pulse measurements support, however, the assumption that the outgoing pulse reaches the receiving aerial by three different paths, involving 4, 5, and 6 reflections, and that they are thus split into three component pulses. The angles mentioned represent the optimum radiating angles in America for reception in Germany, but other measurements made by us have shown that the radiating angle in North America is about equal to the angle of arrival at Brück, so that the reciprocity law may be taken as valid, within certain limits, in our tests . . ."

1294. THE IONOSPHERE AND RADIO TRANSMISSION, OCT. 1940 [and the Obscuring of F-Layer Critical Frequencies by Diffuse & Complex Reflections].—Nat. Bur. of Stds. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, pp. 523–524.)

"These diffuse reflections often were observed over a frequency range of 1000 kilocycles or more. This effect is associated with ionospheric storms. It has been observed to be greater and more frequent during the winter than during the summer. . . Analysis shows that the ranges of frequencies over which the diffuse reflections are observed correspond to ranges of ionisation densities which are approximately the same, both in winter and summer. The total ionisation density is in general less during the winter night than during the summer night. Thus the relative effect of the diffuse reflections on radio transmission is augmented during the winter."

1295. PREDICTIONS OF USEFUL DISTANCES FOR AMATEUR RADIO COMMUNICATION IN JANUARY, FEBRUARY, AND MARCH, 1941.—Nat. Bur. of Stds. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 32–33.) A regular feature.

1296. PROPAGATION OF SHORT WAVES: II—CHOOSING THE BEST WAVELENGTH [with Table for 1941].—D. W. Heightman. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 71–73.) For Part I *see* February issue.

1297. ON A NEW METHOD OF MEASURING THE MEAN HEIGHT OF THE OZONE IN THE ATMOSPHERE [making possible Continuous Study of Height during Sunny Weather, regardless of Steadiness of Meteorological Conditions: based on Fact that Ultra-Violet Absorption in Hartley Band is substantially Independent of Total Pressure whereas Infra-Red Absorption by Ozone is proportional to Fourth Root of Total Pressure: Heights of about 25 km obtained].—J. Strong. (*Journ. Franklin Inst.*, Feb. 1941, Vol. 231, No. 2, pp. 121–155.) Beginning with survey of present knowledge and of previous methods.

1298. THE EFFECTS OF TROPOSPHERIC AND STRATOSPHERIC ADVECTION ON PRESSURE AND TEMPERATURE VARIATIONS [Analysis of Radiosonde Observations up to 20 km, at Sault Ste. Marie].—C. M. Penner. (*Canadian Journ. of Res.*, Jan. 1941, Vol. 19, No. 1, Sec. A, pp. 1–20.)

1299. THE DISTRIBUTION OF ENERGY IN THE VISIBLE SPECTRUM OF DAYLIGHT [from Sun, Sky, and Sun & Sky, in Various Conditions].—A. H. Taylor & G. P. Kerr. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 3–8.)

1300. SUNSPOT DISTRIBUTION: WHAT HAD SEEMED TO BE AN ANOMALY PROVES TO BE AN OPTICAL EFFECT WITH ODD CAUSE.—H. N. Russell: Archenhold. (*Scient. American*, Feb. 1941, Vol. 164, No. 2, pp. 82–83.) *See* also 681 of March.

1301. MOTION OF SOLAR PROMINENCES IN THREE DIMENSIONS [by New Spectroheliograph].—(*Nature*, 15th March 1941, Vol. 147, p. 331.)

1302. THE SUN'S MAGNETIC FIELD AND THE DIURNAL AND SEASONAL VARIATIONS IN COSMIC-RAY INTENSITY.—L. Jánossy & P. Lockett. (*Proc. Roy. Soc.*, Ser. A, 24th Feb. 1941, Vol. 177, No. 970, p. S 2.)

1303. EXCHANGE EFFECTS IN THE THEORY OF THE CONTINUOUS ABSORPTION OF LIGHT: I—Ca AND Ca^+.—D. R. Bates & H. S. W. Massey. (*Proc. Roy. Soc.*, Ser. A, 24th Feb. 1941, Vol. 177, No. 970, pp. 329–340.) A summary was dealt with in 689 of March.

1304. MAGNETISATION OF MATTER BY LIGHT [Magnetic Poles in Surface of Pieces of Annealed Iron easily produced by Irradiation with Light rich in Ultra-Violet Rays: etc.].—Ehrenhaft & Banet. (*Nature*, 8th March 1941, Vol. 147, p. 297.) Thus confirming Morichini's experiments (in 1812) and Ehrenhaft's work on magneto-photophoresis—*see* 11 & 222 of January.

1305. INTERFERENCE PHENOMENA WITH A MOVING MEDIUM.—Ives & Stilwell. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 14–24.) A summary was dealt with in 1228 of April.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1306. AUSTRALIAN RADIO RESEARCH BOARD: WORK ON ATMOSPHERICS FOR YEAR ENDED 30TH JUNE 1940.—(In report dealt with in 1291, above.)

1307. THE DISTRIBUTION OF ELECTRICITY IN THUNDERCLOUDS: II.—G. Simpson & G. D. Robinson. (*Proc. Roy. Soc.*, Ser. A, 24th Feb. 1941, Vol. 177, No. 970, pp. 281–329.) A summary was referred to in 695 of March.

1308. IONS IN GASES [Survey, including Theories of Lightning].—J. Zeleny. (*Science*, 21st Feb. 1941, Vol. 93, pp. 167–172.)

1309. RADIO IN UPPER-AIR INVESTIGATION [Survey of Radiosonde Work, with Literature References classified by Countries and giving Wavelengths & Total Weights].—S. V. C. Aiya. (*Current Science*, Bangalore, Dec. 1940, Vol. 9, No. 12, pp. 561–566.) For a correction see *ibid.*, Jan. 1941, Vol. 10, No. 1, p. 47.

1310. ANALYSIS OF RADIOSONDE OBSERVATIONS UP TO 20 KM AT SAULT STE. MARIE.—Penner. (*See* 1298.)

1311. RECURRENCE PULSES [with 27–28 Days' Interval] IN COSMIC-RAY INTENSITY.—A. H. Compton & A. T. Monk. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 112: summary only.)

1312. ELECTRIC FIELDS PRODUCED BY COSMIC RAYS [So Small that They form No Argument against Origin, & Existence in Interstellar Space, of Cosmic Rays as Charged Particles predominantly of One Sign].—Foster Evans. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 1–7.)

1313. CORRELATION BETWEEN COSMIC-RAY INTENSITY AT CHELTENHAM AND THE AIR TEMPERATURES AND PRESSURES FOR 1939.—N. F. Beardsley. (*Phys. Review*, 1st Feb. 1941, Vol. 59, No. 3, pp. 233–237.)

1314. THE EAST-WEST ASYMMETRY OF THE COSMIC RADIATION AT HIGH LATITUDES, *and* THE EAST-WEST ASYMMETRY OF THE COSMIC RADIATION IN HIGH LATITUDES AND THE EXCESS OF POSITIVE MESOTRONS.—F. G. P. Seidl: T. H. Johnson. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 7–10: pp. 11–15.)

1315. PRODUCTION OF MESOTRONS BY A NEUTRAL RADIATION [Good Evidence of Production by Non-Ionising Radiation (not Photons, probably Neutrettos or Neutrons)].—V. H. Regener & B. Rossi. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 113: summary only.) *Cf.* Schein & others, 712 of March.

1316. VARIATION OF THE RATE OF DECAY OF MESOTRONS WITH MOMENTUM [Confirmation of Relativistic Deduction: in Connection with Anomalous Absorption in Air (compared with That in Layer of Condensed Material equivalent in Ionisation Losses)].—B. Rossi & D. B. Hall. (*Phys. Review*, 1st Feb. 1941, Vol. 59, No. 3, pp. 223–228.)

1317. PROTONS OF DOUBLE CHARGE AND THE SCATTERING OF MESONS [Consequences of Writer's Theory predicting Existence of Protons of Charge $2e$ and $-e$: Longitudinally Polarised Mesons are Very Much more Penetrating than the Transversely Polarised].—H. J. Bhabha. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 100–101.)

PROPERTIES OF CIRCUITS

1318. A NEW METHOD FOR THE CALCULATION OF CAVITY RESONATORS.—Hahn. (*See* 1336.)

1319. FORCED OSCILLATIONS IN CAVITY RESONATORS [Calculation of Impedance when excited by Coupling Loop or Capacitive Coupling, in connection with the Coupling of a Transmission Line to a Cavity Resonator].—E. U. Condon. (*Journ. of Applied Phys.*, Feb. 1941, Vol. 12, No. 2, pp. 129–132.)

1320. MANUFACTURE OF QUARTZ CRYSTAL FILTERS [Precision Technique of Western Electric for Carrier-System Filters: Construction, Adjustment, Sealing, etc.].—G. K. Burns. (*Bell S. Tech. Journ.*, Oct. 1940, Vol. 19, No. 4, pp. 516–532: *Bell Tel. System Tech. Pub.*, Monograph B-1253, 17 pp.)

1321. THE CORE SIZE OF FILTER COILS FOR GIVEN FREQUENCY RANGES.—W. Hornauer, Jr. (*E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, pp. 1053–1054.)

It is widely believed that coils with compressed-powder cores (Pupin-type ring cores), possessing the large inductance values required for filters for very low frequencies, would necessarily be so big as to be impracticable. The calculations given here show that this is not always the case. Since low frequencies only are considered, it is assumed that eddy-current losses are negligible: it is also assumed that the magnetisation of the core is negligibly small. A coil is taken as satisfactory if the loss damping V in the pass band (for $\Omega = 0.9$) does not exceed 0.2 neper. For a Pupin-coil core of standard proportions (Fig. 2) V is found to be $440/d^2f_g$ neper, where d, the largest diameter, is measured in cm and f_g, the limiting frequency, in c/s. From this equation the values of d as a function of f_g (from 5 c/s to 1000 c/s) are calculated for three different values of V, namely 0.1, 0.2, and 0.4 neper: the results are shown in curves. The equation shows that the maximum diameter d depends only on the limiting frequency and the damping in the pass band, and is independent of other factors such as characteristic impedance and absolute value of inductance: the curves show that down to 20 c/s the dimensions are quite reasonable (for $f_g = 20$ c/s, d for 0.2 neper lies between 10 and 11 cm): from 20 c/s downwards they rise rapidly and soon become impracticable.

1322. THE BRIDGE CIRCUIT AS AN ACTIVE DIPOLE.—P. E. Weber. (*T.F.T.*, Oct. 1940, Vol. 29, No. 10, pp. 304–307.)

The usual methods of calculating currents and voltages in the branches of a bridge circuit lead to considerable mathematical labour, and graphic methods do not bring any great simplification. But a treatment of the circuit as an active dipole circuit can help very greatly with the aid of diagrams as here described. Table 1 gives formulae by which the short-circuit current I'_k and open-circuit voltage U'_L can be calculated from the resistance ratios R_1/R_2, R_3/R_4, and R_2/R_4, and from I'_k and U'_L the diagonal current I_B can be derived. In the special case when the last two ratios are equal, Figs. 4 and 5 can be used for graphical determination; other cases are provided for by the curves of Figs. 6–8. Table 2 gives formulae by which the branch currents and the total current can be calculated from the diagonal current I_B thus found.

1323. WHEATSTONE BRIDGE CIRCUITS FOR AUTOMATIC TEMPERATURE REGULATORS [Bridge Circuit modified to allow Use of Potentiometers or Multi-Tapping Switches].—F. W. Jones. (*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, pp. 48–49.)

1324. PAPER ON THE EQUIVALENT CIRCUIT OF ELECTROLYTIC CONDENSERS AT VARIOUS AUDIO-FREQUENCIES.—Söchting. (*See* 1503.)

1325. THE COPPER-OXIDE VARISTOR [Characteristics: Mechanism: Ageing: Heat Treatment: etc.].—W. H. Brattain. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 153–159.)

1326. Thermistors, Their Characteristics and Uses [as Resistance Thermometers, Sensitive Current & Power-Measuring Devices (suitable for Low or Ultra-High Frequencies), Vacuum Gauges, Bolometers, Stabilisers, Oscillators (over Whole Voice-Frequency Range), etc.].—G. L. Pearson. (*Bell Lab. Record*, Dec. 1940, Vol. 19, No. 4, pp. 106–111.)

1327. A New Ionisation Amplifier [Linear Amplifier for measuring Ionisation Currents without Defects of Electrometer Valve, Highly Stable Circuits, etc.: Principle of Generating Voltmeter applied to convert D.C. Signal into Alternating Voltage before Amplification, using Electrostatic Translation of Motion of Mains-Driven Reed].—H. Le Caine & J. H. Waghorne. (*Canadian Journ. of Res.*, Feb. 1941, Vol. 19, No. 2, Sec. A, pp. 21–26.)

1328. A Direct-Current Amplifier employing Negative Feedback for measuring Stellar Photoelectric Currents [Full-Scale Deflection with 5×10^{-12} A and Input Resistance of 2×10^{10} Ohms: using Electrometer Valve].—Q. S. Heidelberg & W. A. Rense. (*Review Scient. Instr.*, Nov. 1940, Vol. 11, No. 11, pp. 386–388: *Sci. Abstracts*, Sec. A, Jan. 1941, Vol. 44, No. 517, p. 26.)

1329. Parasitic Couplings in a Three-Stage Amplifier *via* the Anode Power Supply.—Krize. (*See* 1353.)

1330. The Theory of Parasitic Oscillations [in a Neutralised Push-Pull Circuit].—Nevyazhski. (*See* 1340.)

1331. On the Design of a Band-Pass [Intermediate-Frequency] Amplifier.—Christyakov. (*See* 1354.)

1332. Correction of the Frequency-Amplitude and Frequency-Phase Characteristics of an Amplification Stage.—A. Ya. Breitbart & M. M. Weisbein. (Russian Pat. No. 56 814, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 17.)

The necessary correction is effected by obtaining a voltage at the output of the stage, in phase with the anode current of the valve. The voltage is taken off an impedance in which the phase difference between the voltage and current is equal and opposite to that between the current in the conductor feeding the output circuit and the anode current of the valve.

1333. Cross-Modulation Requirements on Multi-Channel Amplifiers below Overload [Analysis of Inter-Channel Interference due to Repeater Non-Linearity: Practical Application].—W. R. Bennett. (*Bell S. Tech. Journ.*, Oct. 1940, Vol. 19, No. 4, pp. 587–610: *Bell Tel. System Tech. Pub.*, Monograph B-1252, 24 pp.) For Russian work *see* 2945 of 1940.

1334. Skin Effect and Similitude [Use of Principle of Similitude & Models in Investigation of Skin & Proximity Effects].—J. Greig. (*Electrician*, 14th March 1941, Vol. 126, pp. 162–163.)

TRANSMISSION

1335. Forced Oscillations in Cavity Resonators.—Condon. (*See* 1319.)

1336. A New Method for the Calculation of Cavity Resonators.—W. C. Hahn. (*Journ. of Applied Phys.*, Jan. 1941, Vol. 12, No. 1, pp. 62–68.)

"From a metre down to about 10 cm wavelength it has been possible to approximate the field effect, reducing everything to a circuit, for certain practical configurations. At 10 cm and below, these approximations rapidly become invalid, for the desired sizes of resonators. Thus an exact and rigorous method of calculation is almost a necessity, either for use directly in design or, if too cumbersome for this, for justifying new approximations which will allow reasonably simple design formulae. The method to be described [a rapidly-converging-series method, for circularly symmetrical resonators] seems to meet these requirements, at least for those applications made so far."

1337. Retarding-Field Valves with a Magnetic Field: Static Characteristics and [Ultra-] Short-Wave Generation.—F. Hoffmann. (*Hochf:tech. u. Elek:akus.*, Nov. 1940, Vol. 56, No. 5, pp. 137–148.)

This theoretical and experimental work to develop a valve with steep slope for u.s.w. generation started with the following idea: if the electrons emitted by a cathode can be collected into a small space with the help of an electric or magnetic lens, driving them through a very small opening constituting a control grid, it must be possible to control the whole emission from the cathode by small potential variations on the control grid. A potential minimum in front of the cathode and control grid would be prevented, as in a space-charge-grid valve, by a high-potential electrode. Apart from the Maxwellian velocity distribution, such an arrangement should enable any desired steepness of slope to be obtained.

However, experiments with electric lenses (using a cathode, a Wehnelt cylinder, focusing electrodes, and a small-aperture stop as control grid) soon showed that the expected result was not obtained: nor did the use of magnetic lenses prevent several volts from being necessary to control the current. A consequent careful theoretical investigation brought out the fact that these negative results were due to the same troubles as occur in the space-charge-grid valve: the electrons are indeed collected into a small region, but are deflected out of their paths by the various electrodes and do not impinge perpendicularly on the potential lines of the control grid, and the steepness of the control characteristic is therefore reduced. Thus in a space-charge-grid valve (as Below has shown: *see* 1929 Abstracts, p. 44: *also* Schulze, 398 & 1877 of 1935) the electrons flying near the grid wires are deflected and receive a lateral velocity v_s. While those which pass centrally between two wires attain the anode even when the grid voltage is zero, the latter must be raised considerably if the deflected electrons are to be drawn to the anode.

The above considerations led the writer to the idea of using a magnetic field, perpendicular to the electrode surfaces [for previous use of a magnetic field, by other workers, *see* for example 1373 of 1940 and back references]. Without the magnetic field the electrons are free to follow the pull of the grid-wire charges and take up a considerable amount of kinetic energy $\frac{1}{2} mv_s^2$: the action of the magnetic field should make them take up approximately spiral paths, with the axis of the spiral parallel to the field. " The diameter of the spiral, and with it the lateral deflection of the electrons, becomes smaller as the magnetic field is increased. Since the electrons deviate only slightly from the perpendicular path, they can take up only a small amount of lateral-velocity energy. An increased steepness of slope is therefore to be expected. The theory was also applied to the conditions existing in space-charge-grid valves. The experimental results obtained with valves constructed according to these theoretical considerations represent a solution of the task set."

In the theoretical section of his paper the writer considers first the action of a magnetic field, perpendicular to a greatly simplified plane-electrode arrangement, in reducing the lateral velocity (pp. 138–139). Having thus shown that such a reduction would be possible with a feasible value of field, he then examines to what extent the assumptions made are valid in a space-charge-grid valve: namely, how far the lateral electric field strength can be taken as constant during the stay of an electron, and whether this stay is long enough for the effect of the magnetic field to be utilised (pp. 140–141). The first assumption is obviously not valid, since at the cathode the lateral field strength is zero. Examination of the potential distribution in the plane of the grid (Fig. 4) shows that it is too rough an approximation to assume that the lateral field is constant even in the limited region near the grid, and the situation in the space-charge-grid valve with a magnetic field is finally represented as follows: the electron passes with constant velocity through a region where a lateral field exists which, during the first half of the transit time, increases linearly to a maximum value, and during the second half decreases similarly (Fig. 6): a constant uniform magnetic field acts also in the direction of the initial velocity. The lateral field is all in the neighbourhood of the grid: the effect of the small fields near the cathode and anode are found to be negligible (Fig. 5). The lateral velocities during the first and second halves of the passage are calculated separately (p. 142), and from these the final lateral velocity is found to be $v = (4\beta/\omega^2) . \sin^2 (\omega t_o/2)$. For a particular valve in which $D/d = 2$, $D = 0.1$ cm and grid voltage $\phi = 50$ v, a field of 6000 gauss gives (for all paths between $x = d/4$ and $x = 3d/4$) a reduction of lateral velocity to at most one-twentieth of that in the absence of the magnetic field; even for a path $x = d/10$ the velocity is more than halved. For this particular valve the value of 6000 gauss is an optimum, and a further increase of field is inefficient. The theoretical section ends with the calculation of the static characteristics for various magnetic fields: " with the construction of the characteristics a complete theory of space-charge-grid valves with magnetic fields is attained."

The experimental section, pp. 144–148, describes the difficulties in constructing a valve which would correspond to the assumptions made in the theoretical work. Thus the first cathode tried was made in the form of a small flat platinum box, one surface of which was coated with oxide, heated by an internal tungsten filament; but this was later replaced by a commercial large-diameter tubular cathode specially flattened to give two large flat surfaces which alone were coated with oxide. The double grid was formed of tungsten wires stretched parallel to each other. This " double-sided " valve had a very large emission and fulfilled the conditions of the theoretical section quite well, but measurements with it were seriously troubled by the occurrence of oscillations of a wavelength around 50 cm. Attempts to prevent these were unsuccessful, and the valve finally adopted was of single-sided design (Fig. 12) using the same cathode but with only one of its two surfaces oxide-coated. " The electrodes had a large capacity to one another through built-in mica plates " [" Glimmer " in the diagram]. The valve was kept connected to the vacuum pump: after overcoming certain practical difficulties the glass container was given a rectangular cross section, so that the magnet gap might be as small as possible (Fig. 13).

With this valve, curves were plotted for grid voltages of 40, 80, and 120 volts (Figs. 14–17), but only those for 40 v (the first two) are discussed, since this is the grid voltage assumed in the theoretical section. For these curves various discrepancies between theory and experiment are examined: thus the theoretically expected saturation at $u_a = 3 + u_k = 4.2$ v (u_k is the contact potential, measured by Schulze's method as 1.2 v) does not occur, owing to the use of the oxide-coated cathode. But the most serious phenomenon brought out in the experiments was trouble due to space charges; since the electrons are hindered in their lateral movements by the magnetic field, they oscillate much more frequently between cathode and anode than they would in its absence (when after a few swings they are captured by the grid). If therefore the anode voltage is very small, the number of oscillating electrons becomes large and a large space charge, with a potential minimum, is formed in front of the cathode. Only a small part of the emission, therefore, passes through the grid wires at the first flight, and this reduces the steepness of slope below the theoretical value. However, " since the ' shadow current ' [*see* p. 147] found by comparison between theory and measurement agrees in magnitude and in its behaviour to a magnetic field with the predicted results, the theory is confirmed. An important advantage in the use of the magnetic field, in addition to the increased steepness of slope, is the considerable decrease in grid current which is directly indicated in Figs. 14–17."

It is only in the final, short section that the deliberate generation of ultra-short waves is considered. As mentioned above, unwanted oscillations had already been encountered with some of the earlier models worked with, and the construction represented by Fig. 10, with small tubular cathode and a single-aperture grid, was first tried as a generator, with the addition of a Lecher system through which the anode and grid voltages were applied (Fig. 19). The grid/cathode spacing was 2.0 mm, the grid/anode spacing 1.5 mm: grid voltage up to 1000 v. The shortest wave obtained was 40 cm. Subsequent valves were designed for shortness of wavelength irrespective of efficiency: spacings were reduced and a directly heated tungsten filament was used. Finally, when both spacings were reduced to 0.2 mm, the wavelength was brought down to 5.6 cm: the grid and anode voltages were then + 340 and − 9 volts respectively. In all cases the magnetic field was kept at 5700 gauss. The table shows that for the whole range from 9.3 to 5.6 cm obtained with this last valve, the product $\lambda^2 V_g$ varies between 9000 and 16 000. The product according to the Barkhausen-Kurz formula should be 6400 (if the grid/cathode and grid/anode spacings are taken as 0.2 mm) or 14 400 (if half the thickness—0.2 mm—of the grid itself is added, making 0.3 mm): in view of the difficulties in measuring these small spacings, their variations with temperature, and the fact that the V_g used in calculating the product is too high ("since the electrons never attain the height of the grid potential—*see* Fig. 4"), it is considered probable that the agreement is close enough to indicate that the oscillations are of pure B-K type. Their energy is increased by the action of the magnetic field in increasing the number of electron swings before capture (*see* above): also, the grid voltage can be much higher than when there is no magnetic field, since the latter greatly reduces the grid current, as was also mentioned earlier.

1338. THE CHARACTERISTICS OF THE NEGATIVE-RESISTANCE MAGNETRON OSCILLATOR [New Methods of Determination, from Static Characteristics and from 60 c/s Tests: Performance Charts: Verification on 5 m Wavelength].—Hsu Chang & E. L. Chaffee. (*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, pp. 519–523.)

Among the results of the analysis and tests are that the tilted magnetic field (essential for transit-time oscillations) is not helpful to the generation of the negative-resistance type: the non-uniform field, however, helps to improve the linearity of modulation: linear modulation cannot be obtained by varying either the plate voltage or the magnetic-field current alone.

1339. THE SIMULTANEOUS GENERATION OF SEVERAL FREQUENCIES IN ONE VALVE [for Note Production by Interference, Multiple Telegraphy, etc: the Use of Sirutor Dry-Plate Rectifiers].—J. Sommer. (*T.F.T.*, Oct. 1940, Vol. 29, No. 10, pp. 307–309.)

The self-excitation condition of the simple valve oscillator of Fig. 1 is that the fraction of the anode alternating voltage which is fed back should be just equal to the grid voltage necessary for the maintenance of oscillation. A decrease in the fed-back fraction causes a dying down of amplitude, an increase causes a growing amplitude. If the fraction exceeds that defined by the self-excitation condition, the oscillation amplitude will build itself up until the decrease in slope and the setting-in of grid current reduces the amplification to such a point that the condition is restored. The frequency excited is determined by the second condition of the vector equation, that the voltage due to feedback should be in phase with the grid voltage.

If two or more oscillatory circuits are connected in the anode circuit, and a fraction of the anode alternating voltage is fed back from each of these to the grid (Fig. 2), normally only one of the possible resonance frequencies will be excited and will build up to the amplitude determined by the valve. The amplitude of the oscillation in the circuit of Fig. 1 is given by the working conditions and data of the valve. It has therefore no influence on the self-excitation process if the amplitude limitation is removed from the valve and transferred to an external element, so that the valve acts only as an amplifier. It is then possible to have a free hand with the amplitude and to choose it of such a value that the valve characteristic is only partially covered. The amplifier valve is then in the position to deliver further energy for the self-excitation of a second or several frequencies: for this it is only necessary that each oscillation should be limited separately. This is best done at the oscillatory circuit for the particular frequency; what is therefore needed is that for each frequency there should be provided an amplitude-dependent effective anode resistance $R_a = L/CR_w$. The loss resistance R_w must increase when a definite, selected amplitude of oscillatory-circuit current or voltage is exceeded. Dry-plate rectifiers have the necessary limiting properties, but it is necessary, in order that the resonance frequency of any circuit may not be affected by its neighbours, to arrange that each rectifier does not reduce the sharpness of resonance of its circuit more than is necessary to ensure the required limitation of amplitude. Fig. 3a shows a rectifier arranged as a current limiter, in series with the circuit elements; Fig. 3b, as voltage limiter, in parallel with the circuit; in both cases a variable bias is provided so that the point at which the amplitude-limiting begins can be adjusted. The parallel connection is adopted because it saves the use of the by-pass choke (*Dr* in Fig. 3a) required for the bias. A suitable rectifier is the Sirutor (*see* for example 866 of 1935) with a blocking resistance of about 1 megohm and a pass resistance which, for a pass voltage of about 1 volt, is of the same order as the resonance resistance of the oscillatory circuit (50–100 kilohms). The ratio of the required h.f. voltage in the oscillatory circuit to the bias necessary is about unity, so that if an effective h.f. voltage of 10 v is required a bias of about 10 v will be needed. Conditions such as the tightness of coupling must be adjusted to ensure that the damping action of the biased Sirutor does not prevent a reliable starting-up of oscillation, and on the other hand that the final state of the oscillation is reached with only a small increase of damping by the Sirutor. Fig. 4 shows a triple-frequency generator of the above type, using a screen-grid valve to avoid a damping of the oscillatory circuits by the internal valve resistance: here each Sirutor has its own source of bias, but Fig. 5 shows a practical modification in which the three oscillatory circuits are connected in parallel and connected through three separate resistances to the valve, so that a common source can provide the bias. The changed conditions produced by this arrangement are discussed at the bottom of p. 308: a pentode has a certain advantage here. It is stated that with the arrangement of Fig. 4, with circuits having a sharpness of resonance $\rho = 60$, a frequency spacing of 1 : 1.05 was obtained

($f_1 = 2000$ c/s, $f_2 = 1900$ c/s) "and both frequencies were kept perfectly stable": no data are given of the third frequency. Fig. 6 shows an oscillogram of a beat-note produced by the circuit of Fig. 5.

1340. THE THEORY OF PARASITIC OSCILLATIONS.—I. Kh. Nevyazhski. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 5–10.)

Continuing previous work (*see* 81 of 1940), equations (1) and (2) determining the conditions necessary for the appearance of parasitic oscillations in a neutralised push-pull circuit are examined, and it is shown that when *m* is unity the circuit becomes a balanced double bridge; the equations are reduced in this case to the simpler forms (4) and (5). It is pointed out that the coupling factor *k* does not appear in the simplified equations and that the two equations are not interdependent, each determining a separate frequency. An analysis of these equations shows that during the oscillations determined by eqn. (4) current does not flow through the external grid circuit (Fig. 2), while in the case of eqn. (5) the external anode circuit remains passive (Fig. 3). Parasitic push-pull oscillations can thus appear in a balanced double bridge, but oscillations of the first type are of purely theoretical interest, since owing to the circuit losses they cannot be sustained in practice; oscillations determined by eqn. (5), on the other hand, may well appear under practical conditions. Eqn. (5) is therefore examined in further detail, and a diagram (Fig. 5) is shown illustrating the effect of various factors on this type of oscillation. The paper is concluded by a discussion of practical measures for preventing the appearance of these oscillations.

1341. A VALVE TRANSMITTER WITH AN ADDITIONAL TUNED CIRCUIT IN THE ANODE CIRCUIT.—A. I. Kolesnikov. (Russian Pat. No. 56 660, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 16.)

"A valve transmitter with an additional tuned circuit in the anode circuit characterised by the fact that in the grid circuit is connected a circuit tuned to the same harmonic as the additional circuit."

1342. AN INVESTIGATION OF CORONA LEAKAGE FROM WIRE CONDUCTORS DURING MODULATION ON SHORT WAVES.—Gonorovski. (*See* 1371.)

1343. THE "VARIARM 150": A SIMPLE ELECTRON-COUPLED-OSCILLATOR EXCITER AND ITS POWER SUPPLY [giving "Chirpless" Keying].—H. E. Rice, Jr. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 8–11 and 74, 76.)

1344. KEYING MONITORS [Description of Three Types].—D. H. Mix. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 15–17 and 80..84.)

1345. THE TELEGRAPH MODULATOR, A CONTACT-LESS KEYING CIRCUIT FOR CARRIER TELEGRAPHY [eliminating Signalling Relays by Use of the Double-Current Keying Signals to bias Dry-Plate Rectifiers].—Bähr & Junga. (*E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, p. 1041: summary only.)

1346. POCKET-SIZE COMPLETE TRANSMITTERS: TRANSFORMERLESS OPERATION WITH THE 117L7GT [Half-Wave Rectifier & Beam-Power Tetrode in One Small Envelope: Two Designs of Crystal-Controlled Short-Wave Transmitters with 3–5 Watts Input].—K. Hayes: R. T. Lawrence. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 12–14.)

1347. WHY NOT PARALLEL FEED? A COMPARISON WITH SERIES FEED IN TRANSMITTER CIRCUITS.—T. M. Ferrill, Jr. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 30–31 and 78, 80, 86.)

RECEPTION

1348. INTERMEDIATE-FREQUENCY VALUES FOR FREQUENCY-MODULATED-WAVE RECEIVERS.—D. E. Foster & G. Mountjoy. (*See* 1536.)

1349. ULTRA-HIGH-FREQUENCY OSCILLATOR STABILITY: POINTS IN THE DESIGN OF SUPERHET RECEIVERS FOR 40 Mc/s.—Seeley & Anderson. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 88–89.) Extracts from the paper dealt with in 3802 of 1940.

1350. BROADCAST RECEIVERS OF THE FUTURE: PROGRESS ALONG LESS STEREOTYPED LINES [Editorial on Paper by Rust & others, 755 of March].—(*Wireless World*, March 1941, Vol. 47, No. 3, p. 61.) *See* also 1351, below.

1351. SELECTIVITY: A SURVEY OF THE PROBLEM AS IT AFFECTS THE WHOLE BROADCASTING SYSTEM.—Rust & others. (*See* 1519.)

1352. SPURIOUS RESPONSES IN SUPERHETERODYNE RECEIVERS [Theoretical Discussion, followed by Comparison of Triode, Pentode, & Pentagrid: etc.].—E. Kohler & C. Hammond. (*See* 1536.)

1353. PARASITITIC COUPLINGS IN A THREE-STAGE AMPLIFIER *via* THE ANODE POWER SUPPLY.—S. N. Krize. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 15–23.)

To improve the stability of a three-stage resistance-coupled amplifier (Fig. 1) it is usual to connect a decoupling filter *R*, *C* in the anode circuit of the 1st stage (Fig. 3). Equation (2) is derived determining the stability condition in this case, and methods are indicated for designing the filter when the amplifier is fed (a) from a dry battery or accumulator, *i.e.* when the impedance $\overline{Z}$ of the power supply can be regarded as a pure resistance, and (b) from a rectifier, *i.e.* when $\overline{Z}$ can be regarded as equal to $1/j\omega C$, where *C* is the capacity of the rectifier output condenser. Curves are plotted in each case to facilitate the necessary calculations, and numerical examples are given. Experimental results are also quoted.

In conclusion, the effect of the back coupling *via* the rectifier on the frequency and phase characteristics of the amplifier is briefly discussed and formula (9) is derived from which the frequency and phase distortions can be calculated.

1354. ON THE DESIGN OF A BAND-PASS [Intermediate-Frequency] AMPLIFIER.—N. I. Chistyakov. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 24–30.)

Various methods are briefly discussed for improving the frequency characteristic of an i.f. amplifier using band-pass filters. The operation of a two-stage amplifier (Fig. 4) with 5 mutually compensating filter elements (two before and after the first stage and one after the second stage) is then considered in detail, and graphical methods are indicated for determining the frequency characteristic. A comparison is made between the five- and six-element amplifiers, from which it follows that the former type, in addition to being of simpler construction, is more selective and possesses a higher amplification factor. Furthermore, the three-hump frequency characteristic of this amplifier (Fig. 7) tends to amplify the lower modulating frequencies which are usually weakened in the l.f. stages of the receiver, whereas the two-hump characteristic of the six-element amplifier has the opposite effect. The band width of a five-element amplifier can be regulated easily by varying the coupling between the filter elements.

1355. GANGING WITH THE BEAT OSCILLATOR [as provided in Communications Type Receivers, for C.W. Reception]: A SUBSTITUTE FOR A SIGNAL GENERATOR [for Ganging & Tracking the R.F. Circuits: Advantages: Practical Circuit].—E. L. Thomas. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 82–84.)

1356. AN EVALUATION OF RADIO-NOISE-METER PERFORMANCE IN TERMS OF LISTENING EXPERIENCE.—C. M. Burrill. (*See* 1536.) *Cf.* Aggers & others, 1832 of 1940.

1357. NOISE-ELIMINATING UNIT FOR JUNCTION CIRCUITS EXPOSED TO POWER INDUCTION.—Carter & Walker. (*See* 1555.)

1358. THE REDUCTION OF HIGH-FREQUENCY INTERFERENCE FROM HIGH-TENSION INSULATORS [already in Position: Investigation on Bracket-Type Insulators HD 20e, with Various Filling Materials in Space between Insulator and Line & Binding Wires].—W. Rojahn. (*E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, p. 1058: summary of Berlin Dissertation, 1938.)

It was decided on theoretical grounds that the use of a semiconducting filling material would obviate the danger of interference due to enclosed flaws: it would be advantageous to make its conductivity as high as possible, limited only by chemical and mechanical considerations, and it would preferably be covered by an insulating layer of high electrical strength. These preliminary ideas were well confirmed by comparative tests with mixtures of ceresin, wax, and tallow, easily moulded at ordinary temperatures, with various amounts of pine-soot added to give different conductivities between 10^{-13} and 10^{-6} mho/cm.

Practical considerations demanded the qualities of resistance to weathering, high elasticity (to prevent the formation of cracks), a good "hold" on the porcelain surface, fire-proofness, and chemical inertness towards insulator and wire. These requirements were best fulfilled by a Mowilith varnish made into square cords by cutting a 2 mm film of the varnish, allowed to dry on a glass plate, into 2 mm strips. These cords were wound round the neck groove of the already bound insulator, and painted during the winding with acetone as a solvent: for the inner windings, near the binding wires, cords of 2.6×10^{-7} mho/cm were used, while for the outer layers lower conductivities of 1.8×10^{-13} mho/cm were chosen. It remains to be seen how the material stands up to the weather and other conditions.

1359. USE OF JOHNSEN-RAHBEK EFFECT FOR AUTOMATIC FREQUENCY CONTROL.—Marconi Company. (*Wireless World*, March 1941, Vol. 47, No. 3, p. 96.) Further development of the patent dealt with in 1056 of April.

1360. A DEVICE FOR INCREASING THE TIME CONSTANT OF A DISCRIMINATOR.—V. A. Ilin. (Russian Pat. No. 56 659, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 16.)

A device for increasing the time constant of a discriminator under fading conditions, characterised by the use of rectifiers which are blocked during fading as a result of the decrease of the rectified signal voltage across a resistance R.

1361. AUTOMATIC VOLUME CONTROL FOR C.W. RECEPTION [usually avoided because Heterodyne Oscillator produces Excessive Sensitivity Reduction: Simple Receiver Modification avoiding This].—E. H. Weber. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 26–28.)

1362. A MODIFICATION OF THE USUAL AUTOMATIC VOLUME CONTROL AND CATHODE-BIAS CIRCUIT WHICH SAVES TWO TUBULAR CONDENSERS.—Murphy. (*Wireless World*, March 1941, Vol. 47, No. 3, Advt. p. 12.)

1363. ECONOMIES IN RECEIVER MANUFACTURE: CONSERVING THE SUPPLIES OF MATERIALS.—(*Wireless World*, March 1941, Vol. 47, No. 3, pp. 74–75.) *Cf.* 1362, above.

1364. VIBRATORY H.T. GENERATORS: COMPENSATING FOR WEAR OF CONTACTS [Fall in Efficiency due to Widening Gap countered by Increase of Vibration Amplitude (& hence of Closing Time) by Increased Energising Current].—Telefunken. (*Wireless World*, March 1941, Vol. 47, No. 3, p. 90.) But *see* April issue, pp. 106–107 (Pollock).

1365. TEST REPORT: COSSOR MODEL 74 [Correction].—(*Wireless World*, March 1941, Vol. 47, No. 3, p. 75.) Incorrectly described in title as Model 74A (*see* 1060 of April).

1366. TEST REPORT: BUSH MODEL PB73 [AC Superhet with Band-Spread on Short Waves (4 Bands by Push-Button): Medium & Long Waves].—(*Wireless World*, March 1941, Vol. 47, No. 3, pp. 76–77.)

1367. EXPORT BATTERY RECEIVER [Ultra Model 350, with 6-Volt Accumulator as Sole Source of Power].—(*Wireless World*, March 1941, Vol. 47, No. 3, p. 78.)

1368. U.S. AMATEURS WARNED BY AMERICAN RADIO RELAY LEAGUE AGAINST FOREIGN STATIONS USING FALSE CALL SIGNS.—(*Wireless World*, March 1941, Vol. 47, No. 3, p. 79.)

AERIALS AND AERIAL SYSTEMS

1369. Simple 28-Mc/s Vertical Aerial [found particularly Effective].—M. C. Hecht. (*QST*, Jan. 1941, Vol. 25, No. 1, p. 40.)

1370. A Short-Wave Aerial.—I. I. Ryzhov. (Russian Pat. No. 56 782, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 17.)

A rotating directional aerial of the " fir-tree " type provided with a movable tuning loop for use on a band of frequencies. The feeder is connected to the aerial through a special commutator.

1371. An Investigation of Corona Leakages from Wire Conductors during Modulation on Short Waves.—I. S. Gonorovski. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 11–15.)

Critical voltages corresponding to the appearance of the corona effect were determined experimentally for a 550 ohm two-wire feeder using brass or copper conductors of 2.5 mm diam. spaced 30 cm apart. Trials were made on 15 m waves, both with modulated and unmodulated oscillations, by applying to the feeder a sufficiently high voltage for the appearance of corona and then reducing this voltage until the effect disappeared. The apparatus used is described and tables are given showing the results obtained.

It appears that the critical voltage (between 11 and 12.5 kv at the voltage antinodes) is practically independent of the modulating frequency when this is not reduced below 1000 c/s. For lower frequencies the critical voltage rises rapidly and at 150 c/s no stable corona effect could be obtained with 14.5 kv at the voltage antinodes. The critical voltage is much lower for modulated than unmodulated waves.

In a short theoretical discussion it is shown that the ratio of the maximum permissible carrier power of a radio transmitter operating on telephony with 100% modulation to that when operating on telegraphy must not exceed 0.54. It is also pointed out that the critical voltage is determined not by the peak modulation voltage U_{max} or the effective voltage U_T but by the equivalent voltage U_{oe} $(= 0.735\ U_{max})$.

1372. Glass-Tubing Feeder Spreaders [and Their Advantages over Porcelain].—F. Sutter. (*QST*, Jan. 1941, Vol. 25, No. 1, p. 86.)

1373. A 60-Foot Mast raised by One Person unaided, by Simple Leverage Arrangement.—B. Snyder. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 41–42.)

VALVES AND THERMIONICS

1374. Retarding-Field Valves with a Magnetic Field: Static Characteristics and [Ultra-] Short-Wave Generation.—Hoffmann. (*See* 1337.)

1375. The Characteristics of the Negative-Resistance Magnetron Oscillator.—Chang & Chaffee. (*See* 1338.)

1376. Three New Ultra-High-Frequency Triodes [GL-8002, GL-889, & GL-880].—De Walt. (*See* 1536.)

1377. A Special Electron-Multiplier Tube for the Measurement of Very Weak X-Rays.—Allen. (*See* 1553.)

1378. A Scanning Device for Plotting Equipotential Lines [in Electrolytic Trough: Work of Plotting speeded up & simplified by making Probe record (on Scale Drawing) Points of an Assigned Value only: Facsimile-Telegraphy Paper employed: Automatic (Motor-Driven) Scanning if desired].—J. A. Simpson, Jr. (*Review Scient. Instr.*, Jan. 1941, Vol. 12, No. 1, p. 37.)

1379. Conjugate Potentials of a Grid between Conducting Planes. — Kirkham. (*See* 1521.)

1380. A Method of Measuring the Cut-Off Angle of a Valve.—G. S. Goldman. (Russian Pat. No. 56 661, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 17.)

A variation of the method proposed by the author (Certificate No. 55 494), in which a differential circuit is used instead of a logometer.

1381. Work Function and Temperature [and the Discrepancy between Theoretical and Experimental Values of Emission Constant A_0].—S. Seely. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 75–78.)

" It appears that the slope of the thermionic-emission logarithmic plot should be associated with the true work function of the metal, E_{wo}. This is a quantity which is constant and independent of the temperature. The effect of the temperature on the values of E_M and E_B results in the appearance of a correction term in the thermionic-emission equation which lowers the thermionic-emission constant below 120 amperes/cm²/degree. Furthermore, the value of the thermionic-emission constant will depend on the metal considered, and will vary from metal to metal. This yields values which are more nearly in agreement with the values determined experimentally . . ."

1382. Explanation of the Periodic Deviations from the Schottky Line [as due to Two Partial Reflections of the Electron Waves on Potential Hill at Surface of Metal, giving rise to Interference and thus to a Periodic Term in Transmission Coefficient for Escaping Electrons: Agreement with Experiment].—C. J. Mullin & E. Guth. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 114: summary only.) *See* Nottingham, 3035 of 1940.

1383. Sparking of Oxide-Coated Cathodes in Mercury Vapour [and the Destruction of the Cathode by Incandescent Spots: Test Procedure enabling Many Readings to be made on Each Tube without Damage, yielding Light on Sparking Mechanism].—D. D. Knowles & J. W. McNall. (*Journ. of Applied Phys.*, Feb. 1941, Vol. 12, No. 2, pp. 149–154.)

1384. A METHOD OF PREPARING THE CORE OF AN OXIDE CATHODE.—A. A. Ivanov. (Russian Pat. No. 56 796, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 21.)

The core is heated in an atmosphere containing vapours of silicon and hydrogen at a temperature suitable for depositing a silicon layer on it.

1385. A HEATED CATHODE.—S. A. Zusmanovski. (Russian Pat. No. 56 801, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 21.)

A high-emission cathode covered with a layer of thoriated and carbonised molybdenum.

1386. A CATHODE FOR ELECTROVACUUM TUBES.—S. A. Zusmanovski. (Russian Pat. No. 56 802, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 21.)

The core of this cathode is made of an alloy of barium and nickel or molybdenum, and is covered with a film of an oxide whose dissolution temperature is higher than the diffusion temperature of barium in the core.

1387. SPUTTERING AND SECONDARY ELECTRON EMISSION OF METALS BOMBARDED WITH ARGON IONS [Method of determining (within 6–7%) the Number of Atoms liberated by Single Ion of Known Energy: Results on Sputtering of Silver by Argon, & on Secondary-Electron Emission from Aluminium & Molybdenum].—G. Timoshenko. (*Journ. of Applied Phys.*, Jan. 1941, Vol. 12, No. 1, pp. 69–77.)

1388. THE THEORY OF ADSORPTION OF GASES ON SOLIDS WHEN THE POTENTIAL ENERGY VARIES CONTINUOUSLY OVER THE SURFACE [with Application of Results to Adsorption of Hydrogen on Tungsten].—A. R. Miller & J. K. Roberts. (*Proc. Cambridge Phil. Soc.*, Feb. 1941, Vol. 37, Part 1, pp. 82–94.)

1389. SOME APPLICATIONS OF RADIOGRAPHY TO THE ELECTRICAL INDUSTRY.—H. P. Rooksby & K. L. Jackman. (*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, pp. 33–38.) From the G.E.C. laboratories.

1390. FIELD-EMISSION X-RAY TUBE [for High-Speed Radiography: Discovery of Possibility of drawing Currents of Several Thousand Amperes from Cold Metals by Field Emission *in Vacuo* applied to Condenser-Discharge X-Ray Tube, with Help of Auxiliary Electrode to initiate Discharge, which is then Automatically Transferred to Anode].—C. M. Slack & L. F. Ehrke. (*Journ. of Applied Phys.*, Feb. 1941, Vol. 12, No. 2, pp. 165–168.) *See* also 999 of March.

1391. MICRO-GAS ANALYSIS METHODS AND THEIR APPLICATION TO RESEARCH [Survey].—L. A. Wooten. (*ASTM Bulletin*, Jan. 1941, No. 108, pp. 39–44.)

ACOUSTICS AND AUDIO-FREQUENCIES

1392. BRITISH AND GERMAN QUALITY RECORDINGS [particularly the Influence of the Reverberation Characteristics of the Concert Halls on Personal Choice].—W. T. Purser: Aldous. (*Wireless World*, March 1941, Vol. 47, No. 3, p. 92.) Prompted by a letter in the February issue. *See* also April issue, p. 106 (Gamble, Aldous).

1393. DICTATING MACHINE [with 7-Inch Alloy Wafer Discs (100 measure 0.6 Inch—50 Hours' Recording Capacity), Practically Indestructible: No Chips or Shavings].—SoundScriber Corporation. (*Scient. American*, Feb. 1941, Vol. 164, No. 2, p. 104.)

1394. CLEANING SMALL MAGNET-GAPS [including Annular Gaps of Loudspeakers: Use of Adhesive Tape].—J. G. Beard. (*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, p. 50.)

1395. MAGNETIC RECORDING AND SOME OF ITS APPLICATIONS IN THE BROADCAST FIELD.—S. J. Begun. (*See* 1536.) For previous work *see* 426 of February.

1396. PUT MICROPHONE OFF STAGE TO INCREASE REALISM [of Broadcasting & Sound Recording: Line Microphone placed where Audience would be].—H. F. Olson. (*Sci. News Letter*, 25th Jan. 1941, Vol. 39, No. 4, p. 57.) For this microphone *see* 641 of 1940.

1397. AUTOMATIC APPARATUS FOR THE RECORDING OF SOUND-LEVEL CURVES [Improved Design: Examples of Use (Loudspeaker Response Curve, Gas-Mask Attenuation, etc.)].—A. Manfredi. (*Alta Frequenza*, Jan. 1941, Vol. 10, No. 1, pp. 43–63.)

A detailed description of an equipment made up of a beat-frequency oscillator (with special precautions for constance of frequency, pp. 53–55) giving 0.8 v between 5 and 21 000 c/s, with amplitude constant within ± 0.5 db and mean distortion 0.25%; a motor-driven variable condenser giving a linear frequency variation from 0 to 100 c/s and a logarithmic variation from 100 c/s upwards (plate profile Fig. 9); a rotating howling condenser with variable maximum capacity and constant mean capacity, thus giving a sinusoidal variation of frequency, and with a speed control of howl frequency between 5 and 66 c/s (plate profile Figs. 13–15); a pre-amplifier giving a 3-watt a.f. output with a distortion of 0.8%; an output amplifier giving a 30-watt output with a distortion of 1.3%, driving a pen recorder; mains units; and finally a frequency-meter panel with a small cathode-ray tube as indicator.

1398. A SOUND-SPOTTING SCHEME [for Roof Spotters: as used by Benjamin Electric, Ltd.].—(*Engineer*, 14th March 1941, Vol. 171, p. 184.) *Cf.* 790 of March.

1399. THE LIGHT MODULATION OF THE HIGH-PRESSURE MERCURY-VAPOUR DISCHARGE BETWEEN 50 c/s and 100 kc/s.—Mangold. (*See* 1537.)

1400. THE INTERFEROMETER METHOD OF DETERMINING THE AMPLITUDES OF SMALL MECHANICAL VIBRATIONS [of Telephone Diaphragms, Quartz Plates, etc.].—Kennedy. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 99–101.)

Experimental verification of Osterberg's analysis (Abstracts, 1932, p. 235: also 1934, p. 449—*see* also Cortez, same page). For Thomas & Warren's original paper *see* 1928 Abstracts, p. 404.

1401. VIOLIN PRACTICE MADE PAINLESS [to Neighbours] BY NEW INVENTION [Mute for Bridge with Pick-Up delivering to Headphones].—M. Rice. (*Sci. News Letter*, 8th Feb. 1941, Vol. 39, No. 6, p. 89.) A recent patent.

1402. MEASUREMENTS OF ORCHESTRAL PITCH [Measurements of Note A in Treble Clef in Broadcast Musical Programmes: Symphony Orchestras average More than 1 c/s Higher than Light Concert Orchestras & Dance Bands: String Groups consistently Higher than Other Classes: etc.].—O. J. Murphy. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 143–146.) *See* also *Science*, 28th Feb. 1941, Supp. p. 7.

1403. RESULTS OF THE WORLD'S FAIR HEARING TESTS.—Steinberg & others. (*Bell S. Tech. Journ.*, Oct. 1940, Vol. 19, No. 4, pp. 533–562: *Bell Tel. System Tech. Pub.*, Monograph B-1256, 30 pp.) The full paper, an abridged form of which was dealt with in 127 of January.

1404. THE CARRIER NATURE OF SPEECH [Speech Synthesis discussed in Terminology of Carrier Circuits].—H. Dudley. (*Bell S. Tech. Journ.*, Oct. 1940, Vol. 19, No. 4, pp. 495–515: *Bell Tel. System Tech. Pub.*, Monograph B-1254, 21 pp.) A product of the "Vocoder" researches dealt with in 655 & 1064 of 1940.

1405. AN EVALUATION OF RADIO-NOISE-METER PERFORMANCE IN TERMS OF LISTENING EXPERIENCE.—C. M. Burrill. (*See* 1536.) *Cf.* Aggers & others, 1832 of 1940.

1406. SOUND-PROOF ROOM NOT SEALED FROM THE OUTSIDE [New Sound-Inspection Chamber (for Refrigerator Units) floating on Springs at Mid-Point of Labyrinthine Passages].—Westinghouse. (*Scient. American*, Feb. 1941, Vol. 164, No. 2, p. 101.)

1407. DEVICES FOR COMBINING DECIBEL LEVELS [Special Slide Rules].—K. G. Van Wynen. (*Bell Lab. Record*, Dec. 1940, Vol. 19, No. 4, pp. 112–116.)

1408. AN AMATEUR APPLICATION OF THE WIEN BRIDGE [A.F. Oscillator with Continuously Variable Range & Good Wave-Form].—R. W. Caywood. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 22–23.)

1409. THERMISTORS AS A.F. OSCILLATORS.—Pearson. (In paper dealt with in 1326, above.)

1410. THE 1000-CYCLE RINGER-OSCILLATOR [primarily for Signalling on Toll Circuits with Intermediate Voice Repeaters, but applicable to Other Purposes].—G. A. Pullis. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 147–152.)

1411. A LATTICE-TYPE ACOUSTIC FILTER [for Band Elimination: Parallel Grooved Slats, Spaces acting as Transmission Lines and Grooves as Side-Branches: Attenuations of 40–70 db over Wide Bands].—H. K. Schilling. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 111: summary only.)

1412. PROGRAMME-OPERATED LEVEL-GOVERNING AMPLIFIER [having Constant Gain to Predetermined Point, and acting as Compressor above This Point: Requirements, Design, & Performance].—W. L. Black & N. C. Norman. (*See* 1536.)

1413. SOME NOTES ON FIDELITY: SIMPLE DESIGN SUGGESTIONS FOR A.F. AMPLIFIERS [Benefits of All-Push-Pull Operation: Single-Ended Input with Phase-Inversion Valve & Push-Pull Output: etc.].—H. Brooks. (*QST*, Jan. 1941, Vol. 25, No. 1, pp. 20–21 and 28.)

1414. AUTOMATIC REGULATION OF THE OVER-ALL ATTENUATION IN MULTI-CHANNEL TELEPHONE SYSTEMS.—N. I. Fedorov. (Russian Pat. No. 56 753, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 15.)

Two thyratrons are used which respectively strike when the l.f. reception level falls below or rises above the predetermined limits. The thyratrons operate a system of relays controlling the correcting elements.

1415. CROSS-MODULATION REQUIREMENTS ON MULTI-CHANNEL AMPLIFIERS BELOW OVERLOAD.—Bennett. (*See* 1333.)

1416. "ELEKTROAKUSTISCHES TASCHENBUCH" [Pocket Book: Second Edition: Book Review].—Rickmann & Heyda. (*Hochf:tech. u. Elek:akus.*, Nov. 1940, Vol. 56, No. 5, p. 160.)

1417. THE EXTRACTION OF ANTIGENS BY [High or Supersonic] SOUND WAVES.—Chambers & Flosdorf. (*Science*, 21st Feb. 1941, Vol. 93, Supp. p. 10.)

1418. EXPERIMENTAL PROOF OF SUPERSONIC BLIND-FLYING BY BATS.—Galambos & Griffin. (*Sci. News Letter*, 4th Jan. 1941, Vol. 39, No. 1, pp. 5–6.) *See* also Galambos, *Science*, 28th Feb. 1941, Vol. 93, p. 215.

1419. EFFECTIVE FREQUENCIES OF SENSITIVE FLAMES.—P. Savic. (*Nature*, 22nd Feb. 1941, Vol. 147, p. 241.)

1420. SOUND VELOCITY IN LIQUID MIXTURES [and Solids: Application of Writer's Equation involving Chemical Composition].—M. R. Rao. (*Current Science*, Bangalore, Dec. 1940, Vol. 9, No. 12, p. 534.) *See* 1097 of 1940.

1421. On the Velocity of Sound in, and Chemical Reactivity of, Bromine and Iodine [Application of Writer's Formula for Velocity in Metals].—B. N. Sen. (*Current Science*, Bangalore, Jan. 1941, Vol. 10, No. 1, pp. 22–23.)

PHOTOTELEGRAPHY AND TELEVISION

1422. Television Transmission over Wire Lines [Vital Part likely to be played by Inter-City Networks: Long-Haul Coaxial Systems, with Vestigial-Sideband Carrier Transmission & Frequency Transposition: $2\frac{3}{4}$ Mc/s Repeaters ("3-Megacycle Amplifiers"), Design & Performance: Short-Haul (Video-Frequency) Local Lines: New-York/Philadelphia Republican Convention Link: etc.].—M. E. Strieby & J. F. Wentz. (*Bell S. Tech. Journ.*, Jan. 1941, Vol. 20, No. 1, pp. 62–81.)

1423. Stevens Point-Minneapolis Coaxial Cable [with Certain Mechanical Improvements in Construction (similar to Baltimore-Washington Cable)].—O. S. Markuson. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 138–142.) Referred to in the paper dealt with in 1422, above. The journal year is wrongly given as 1940.

1424. Gopher-Protected Cables [Method of Protection applied to Buried Portion of Stevens Point-Minneapolis Cable—1423, above].—R. P. Ashbaugh. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 165–166.)

1425. The Subjective Sharpness of Simulated Television Images.—M. W. Baldwin, Jr. (*Bell S. Tech. Journ.*, Oct. 1940, Vol. 19, No. 4.) Already dealt with in 802 of March.

1426. Quality in Television Pictures.—P. C. Goldmark & J. N. Dyer. (*Journ. Soc. of Mot. Pict. Eng.*, Sept. 1940, Vol. 35, pp. 234–253.) Same as 131 of January but with Discussion.

1427. Colour Television [Criticism of Article on Baird Demonstration: the Inferiority of the Two-Colour Process to the Three-Colour: Reply].—F. C. Arnaud. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 90–91.) *See* 1125 of April.

1428. Television in Colour.—I. G. Kesaev, A. M. Gurevich, L. N. Nagornichnykh, & N. Khlebnikov. (Russian Pat. No. 56 658, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 14.)

Use is made in the transmitter of an auxiliary iconoscope operating under saturation conditions and thus responding to the spectral sensitivity of light only. A Kerr cell, polariser, analyser, and a doubly reflecting plate are employed in the receiver.

1429. The Shape of Stereoscopic Images [Geometrical Considerations for Analysis of Stereoscopic Effects and Prediction of Results of Any Proposed Optical System].—J. T. Rule. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 124–129.)

1430. Brightness Distortion [analogous to Harmonic Distortion in Sound Transmission] in Television [Admissible & Inadmissible Types: including Suggested Research to permit Controlled Compensation of Limitations of Present Apparatus].—D. G. Fink. (*See* 1536.)

1431. A New Method of Synchronisation for Television Systems [making possible Automatic Operation of Receiver Synchronising Circuits at Variable Line & Frame Frequencies (to allow for Future Development without Replacement of Equipment): a "Transition" Type Receiver].—T. T. Goldsmith, Jr., R. L. Campbell, & S. W. Stanton. (*Journ. Soc. of Mot. Pict. Eng.*, Sept. 1940, Vol. 35, pp. 254–255.) From the DuMont laboratories: *see* also 3480 of 1940 and back references.

1432. Television Pick-Up of Pasadena Rose Tournament Parade [by New Portable Equipment of Don Lee Broadcasting System].—H. B. Lubcke. (*Journ. Soc. of Mot. Pict. Eng.*, Sept. 1940, Vol. 35, pp. 221–233.)

1433. An Investigation of the Spectral Characteristics of the Iconoscope.—I. G. Kesaev, A. M. Khalfin, & A. M. Gurevich. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 31–41.)

The operation of the iconoscope is discussed and formulae (3) and (4) are derived for determining the equilibrium potential U_3. In a modified form (3′ and 4′) these formulae can be used for calculating the monochromatic-light and spectral characteristics (Figs. 6 and 8 respectively; also Fig. 7, showing a family of light characteristics for different wavelengths). It is pointed out that the initial portion of the light characteristics corresponding to lower intensities of light is a straight line, while at higher intensities a clearly marked saturation effect is observable. This effect is due to the fact that under these conditions the mosaic elements cannot acquire an equilibrium potential exceeding the maximum velocity (in volts) of the photoelectrons. With regard to the spectral characteristics it is noted that the shape of the curve depends on the power of the light beam and that at lower intensities the curve becomes a normal characteristic of the mosaic material. The absence of a hump in the spectral characteristics at longer waves is also pointed out. This is probably due to the presence of a large space charge near the mosaic which returns the slower photoelectrons back to the same mosaic elements.

The theoretical part of the paper is followed by a report on experiments made to verify the conclusions reached above. Some of these were made with an ordinary photocell operating under conditions approximating those of an iconoscope (Fig. 9). The equilibrium potential of the cell was measured with a quadrant electrometer, and the light and spectral characteristics so obtained are shown in Figs. 10 and 11 respectively. In other experiments the output of an iconoscope, previously amplified by a photocurrent amplifier ϕ and an intermediate amplifier ΠY, was measured with a cathode-ray oscillograph TMY-136-B (Fig.

13). In order to confine the observations to the signal sent by one or two lines only of the iconoscope, a special impulse generator was developed (Fig. 14) from which narrow positive impulses were applied to the control grid of the oscillograph for triggering the electron beam. The duration of the impulses was made equal to the time necessary for transmitting one or two lines. Several iconoscopes were experimented with and a typical family of light characteristics, for various separate wavelengths from 469 mμ to 832 mμ, is shown in Fig. 15. A family of spectral characteristics obtained graphically from Fig. 15 is also shown (Fig. 16). The experimental results fully confirm the theoretical curves.

1434. Remote-Control Television Lighting [in N.B.C. Studios at Radio City].—W. C. Eddy. (*Journ. Soc. of Mot. Pict. Eng.*, Sept. 1940, Vol. 35, pp. 268–281.)

1435. The Leningrad Experimental Television Centre.—V. L. Kreuzer. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 41–51.)

The Leningrad Centre is equipped with two television systems, one using iconoscopes, for transmitting scenes and films, and the other developed by the Soviet engineer Braude for transmitting films only. The systems are designed for transmitting 240–300 lines, 25 frames per second, with progressive scanning. The images are transmitted in the negative form. The video signals are transmitted by a transmitter operating on a wavelength of 8 m with an aerial power of about 3.5 kw. A wavelength of 288.6 m is used for sound.

In the present paper the television system with the iconoscopes is described in detail and various circuit diagrams are given. A short description is included of the studios and control apparatus. All the equipment has been designed by Soviet engineers and manufactured from Soviet materials.

1436. A Secondary-Emission Electron Commutator.—D. V. Zernov & A. S. Naumovets. (*Izvestiya Electroprom. Slab. Toka*, No. 12, 1939, pp. 52–57.)

The difficulties of an electron commutator with a large number of lamellae are pointed out and a detailed report is given on a new commutator developed for sweeping over the elements of a line of a remote-indication device such as a television receiving screen. The screen had 30 lines each of 40 elements (neon glow-discharge tubes), and there were 25 frames per second. The commutator had therefore to have 40 separate lamellae and to be capable of switching all these in 1/750th sec., or 1/3000th sec. for each separate switching operation. Moreover the commutator had to deliver sufficient power for feeding the neon tubes through one stage of amplification only.

The principle of the operation of the new commutator is as follows. The lamellae are given a potential with respect to the cathode sufficiently high to enable the electrons to reach the lamellae surface with a velocity corresponding to the maximum coefficient of secondary emission σ from the lamellae surface. If $\sigma > 1$ the current through the lamella will flow in the direction opposite to that of the electron beam and the lamella will charge *positively*. Secondary electrons emitted from the lamella will be attracted by the anode or a collector kept at a high potential. Free electrons in the tube and secondary electrons emitted from adjacent lamellae will not interfere with the current flowing through the lamella circuit under the action of the electron beam, and the current will stop as soon as the beam leaves the lamella.

An equivalent circuit of the commutator is shown in Fig. 1, and its operation is discussed. Experimental curves and oscillograms are also shown. The construction of a commutator (Figs. 5 and 6) based on the above principle is described. The circuit in which the commutator is connected is shown in Fig. 7. Tests have proved complete reliability and stability in operation of the commutator. With a scanning frequency of the electron beam of 750 per sec. and impedances of 0.5 megohms connected in the lamellae circuits, voltage impulses of the order of 80 volts were obtained.

Detailed methods are indicated for the design of the commutator and a numerical example is given. In conclusion, various possibilities of increasing the lamellae current are discussed and experiments described.

1437. Television Reception on a Large Screen.—A. L. Lubny-Gertsyk & B. M. Konoplev. (Russian Pat. No. 56 805, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 14.)

A moving system (drum) covered with a mosaic of a secondary-emitting dielectric is used on which an electric image is obtained when scanned by a modulated electron beam.

1438. Television Pictures thrown on Screen from Balcony [by Projector formed by Schmidt Astronomical Camera in Reverse Position: 30-Inch Concave Mirror].—R.C.A. (*Sci. News Letter*, 8th Feb. 1941, Vol. 39, No. 6, pp. 86–87.) Demonstration to F.C.C: *see* also 806 of March.

1439. Home Receiver projecting onto $13\frac{1}{2}'' \times 18''$ Screen, by High-Speed Lens treated with Non-Reflecting Films.—R.C.A. (In article dealt with above, 1438.)

1440. Two New Television Receivers.—T. Mulert & F. Rudert. (*Mitteil. Fernseh-A.G.*, No. 1, Vol. 2, 1940, pp. 7–11: *E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, pp. 1059–1060—summary only.)

The abstractor remarks: "The development of the television home receiver has not stood still at the 'Unit' receiver [*see*, for example, 1124 of 1940] shown for the first time last year at the Radio Exhibition. On the contrary, several firms have turned their attention to the combination of television and broadcast receivers. Thus Mulert & Rudert describe two home receivers in which, by the multiple use of various components, a practical instrument for broadcast and television reception is obtained. The first type contains a c-r tube with a picture size of 31.5×27.5 cm². The second is provided with a lens-raster screen of 50×42 cm². In spite of the size of the screens, both types are made as table models. Fig. 3 gives a view of circuit lay-out of both receivers, which are similar except in the generation of the high voltage. By the inclusion of the broadcast receiver, by the design of the image amplifier for the reception of wire-television transmissions, and by the method of introduction of contrast control, both receivers contain new types of circuit, which are discussed below."

For the combination of broadcast and television amplifiers, for the sound channel the detector, l.f. stage, out-put valve, and loudspeaker can be used unchanged in common, but the i.f. amplifier and the mixing valve require special switching arrangements. The intermediate frequency for the broadcast circuit is about 500 kc/s, while for the image amplifier it is 4.2 Mc/s, for matching with the television wire-network. The necessary switching-over of the i.f. amplifier from television to broadcasting is carried out simply. The mixing-valve switching was found to require very careful design.

The "fairly low" i.f. of 4.2 Mc/s for the picture amplifier produces a great liability to interference owing to the small separation of the resulting image-frequency and to the formation of a difference-frequency between picture and sound carriers which lies in the pass-band of the amplifier. This trouble is countered by specially good selectivity: already in the u. s. w. amplification stage selective filters are provided. By special circuit arrangements the image-signal ratio can be reduced to 1 : 80. Moreover, the automatic amplification-control of the picture amplifier (*see* below) limits the amplification of the u.h.f. pre-amplifier valve, so that the voltage on the grid of the mixing valve never becomes too high.

Automatic picture-amplification control not only prevents over-modulation but also simplifies the adjustment of the apparatus. Usually two separate controls are needed for contrast regulation, but the automatic control enables contrast regulation (with the necessary working-point displacement) to be obtained by coupling the amplification and background-brightness controls to a single knob. The reference point for the automatic control is the "black" value of the carrier. A fraction of the i.f. voltage from the last valve of the picture i.f. amplifier is tapped off, rectified, and applied as bias and control voltage to three amplifier valves. This arrangement reduces a variation of 1 : 100 at the amplifier input to a 1 : 5 change at the output.

The line-deflection voltages in both receivers are obtained by the "transformer kipp device" (*see* 220 of 1940), which proved so successful in the "Unit" receiver. The 13 kv high tension for the first receiver, could not, because of the too great energy consumption, be taken directly from the anode of the deflecting valve as in the "Unit" receiver: two component voltages are therefore generated according to a new plan and connected in series. For the second (projection) receiver the 25 kv high tension is obtained in four stages (each with its own rectifier valve) from the line-deflection stage. In both receivers the combination of high-tension generation and line deflection into one device saves a great deal of space and also of power. In both receivers the frame deflection is on the principle used in the "Unit" receiver. In the projection receiver the distortion due to the obliquely incident ray has to be corrected by the use of a specially shaped magnet yoke.

1441. The Cathode-Ray Tube used in the German E.1 Receiver.—Knoblauch & Schwartz. (*Journ. Television Soc.*, No. 5, Vol. 3, 1940, pp. 130–132.) Long English abstract of the third paper referred to in 4601 of 1939.

1442. Photoconductivity of a Natural Willemite Crystal [and Its Dependence on Wavelength of Exciting Light, Temperature, & Time: Ultra-Violet Absorption Spectrum of the Crystal].—R. C. Herman & R. Hofstadter. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 79–84.) For previous work, on the dark current, *see* 3100 of 1940.

1443. Photoelectric Sensitisation of Metal Surfaces in Group II by Optical Dissociation of Water Vapour [Greatest Increase (about 50 Times) with Be Surface].—J. T. Tykociner & L. R. Bloom. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 115: summary only.)

1444. Fundamentals of Phototelegraphy Technique.—H. Bitter. (*T.F.T.*, Oct. 1940, Vol. 29, No. 10, pp. 296–304: concluded.)

F:—Synchronisation control (precision requirements: the tuning-fork hummer—since low-note forks behave better under temperature and pressure variations, a 510 c/s fork is used and its frequency doubled by full-wave rectification: the tone-wheel drive: phase adjustment: etc.). G.—Design of apparatus (fixed and transportable). H.—Disturbances (through outside interference: through reflections: non-linear distortions: disturbance through line-attenuation fluctuations: phase distortions: apparatus defects: adjustment defects). me of the defects are illustrated by photographs

1445. A Coupling Unit for Telephotograph Transmission [for connecting to Telephone Lines (providing Necessary Holding-Coil Action & Protection of Line against Excessive Signal Levels)].—D. W. Grant. (*Bell Lab. Record*, Dec. 1940, Vol. 19, No. 4, pp. 131–133.)

MEASUREMENTS AND STANDARDS

1446. The Use of Thermistors for Measuring Purposes at Ultra-High Frequencies.—Pearson. (In paper dealt with in 1326, above.)

1447. An Electrodynamic Ammeter for Ultra-High [Decimetric-Wave] Frequencies.—F. W. Gundlach. (*Hochf:tech. u. Elek:akus.*, May 1940, Vol. 55, No. 5, pp. 169–173: *E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, p. 1039—summary only.)

The thermal ammeters usually employed in the ultra-short-wave band have the disadvantage that they consume an appreciable amount of energy. The meter here described is free from this defect: it was developed specially for the measurement of 14 cm waves and is employed as a standard instrument in the calibration of detectors and diodes for measuring purposes. It consists essentially of a 20×5 mm loop of 0.1 mm diam. silver wire hung, by a thin glass and Wollaston-wire suspension, in the h.f. magnetic field of a coaxial line: the strength of the field, and hence the current along the inner conductor, is measured by the angle change indicated by a mirror fixed to the loop. The torsional moment is independent of the frequency of the magnetic field, so that the ammeter can be calibrated by comparison with other current-measuring devices at lower frequencies.

In the equipment used, a closed coaxial line of characteristic impedance $Z = 22$ ohms and length 2λ is excited at a point $\lambda/4$ from the lower end (through a coupling lead passing through a hole in the outer conductor) from a 14 cm " resotank " retarding-field oscillator. At the mid-point of the line the calibration frequency of 3 Mc/s is led in. At a further distance $\lambda/2$ the loop is suspended; since this is at a current antinode, the deflection is a measure of the resonance current. At the current antinode $\lambda/4$ from the upper end of the line there is an extension piece to which can be connected the resonator (with built-in detector) whose calibration is required. In this particular equipment the current range extends to 1 ampere, but with a loop of other dimensions and a suspension of a different thickness the range can be varied. After each u.h.f. measurement a check measurement is made on the 3 Mc/s calibration frequency. The deflection due to the 14 cm wave is smaller by about 8% than that due to an equal current at the 3 Mc/s frequency: this is largely the result of the fact that the magnetic field in the coaxial line is not homogeneous in the axial direction, owing to the formation of standing waves. The loop must therefore be made as short as possible compared with a quarter-wavelength. The method is applicable to other arrangements, such as cavity (Rhumbatron) resonators. For previous work *see* 468 of February.

1448. THE EXACT COMPARISON OF SMALL CURRENTS [of Order of 10^{-12} Ampere: collected on Electrodes connected to Intermediate Cylinders of Two Triple Condensers: Potentials of Outer Cylinders varied to keep Electrodes as near Zero Potential as possible, Adjustment checked by Electrometer connected alternately to One or Other Inner Cylinder: Ratio obtainable within about 1 in 10 000].—R. M. Vanderberg. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 114: summary only.)

1449. THE RESPONSE OF SPUTTERED THERMOCOUPLES TO INTERRUPTED RADIATION.—L. Harris & A. C. Scholp. (*Journ. Opt. Soc. Am.*, Nov. 1940, Vol. 30, No. 11, pp. 519 onwards: Corrections, Jan. 1941, Vol. 31, No. 1, p. 25.)

1450. A METHOD OF MEASURING THE CUT-OFF ANGLE OF A VALVE.—Goldman. (*See* 1380.)

1451. THE LIGHT-FLASH TIME METER, A NEW INSTRUMENT FOR SHORT AND LONG TIME MEASUREMENTS.—Bötz. (*See* 1539.)

1452. DYNAMICAL DETERMINATION OF THE ELASTIC CONSTANTS AND THEIR TEMPERATURE COEFFICIENTS FOR QUARTZ, *and* A DETERMINATION OF THE c_{44} ELASTIC CONSTANT FOR BETA-QUARTZ.—J. V. Atanasoff, P. J. Hart. E. Kammer. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 85–96: pp. 97–99.)

The elastic constants are calculated directly from the theory for infinite plates and the measured piezoelectric frequencies of finite plates, by use of high-order harmonics and consequent elimination of edge effects. The value of 35.75×10^{10} dynes/cm² obtained for the c_{44} constant of beta-quartz is nearly double that obtained by Osterberg & Cookson (284 of 1936) at the same temperature: this is attributed to inadequacy of the mathematical methods used by these workers—which led, incidentally, to different values for the " constant " for different types of vibration and different dimensions of crystal.

1453. MANUFACTURE OF QUARTZ CRYSTAL FILTERS.—Burns. (*See* 1320.)

1454. MEASUREMENTS OF DIELECTRIC CONSTANTS AND LOSS ANGLES OF SOLID DIELECTRICS AT RADIO FREQUENCIES [Survey of Methods & Technique, including Work at the Istituto Galileo Ferraris].—G. Holzner & G. Gregoretti. (*Alta Frequenza*, Jan. 1941, Vol. 10, No. 1, pp. 4–30.)

The following conclusions are reached:—At frequencies above a few megacycles per second, three resonance methods are almost exclusively used in preference to bridge methods: these are (1) the method of parallel substitution, with determination of equivalent conductance in parallel by the method of comparison, (2) the method using a single micrometer-adjusted two-plate test condenser, and (3) the method using two such condensers, with selecting switch.

The first method is liable to serious errors at the higher frequencies: great care has to be taken with regard to the effect of connecting leads and of the residual parameters (series resistance and inductance) of the variable condenser: the errors may be so large, in measuring the equivalent resistance, that the latter may actually come out at a negative value. In this connection references are given to the work of Akahira & others (1561 [*see* also 2496] of 1938), Holzner (4504 of 1938), and Chaffee (1934 Abstracts, p. 628). " However, if a plate condenser with small initial capacity is used as the reference condenser, in which the absence of sliding contacts allows very small values of metallic resistance to be obtained, it is possible to get satisfactory results on elements of small capacity even at extremely high frequencies " [Rohde & Wedemeyer's paper—1455, below—is here referred to].

The third method, using two similar two-plate condensers symmetrically arranged in the circuit, with the sample continuously pressed between the plates of one of them, was employed by Rohde & Schlegelmilch (1933 Abstracts, pp. 512–513) and used in Siemens & Halske apparatus. Figs. 8 & 9 show a Galileo Ferraris (I.E.N.) apparatus on the same principle. The method has great advantages, particularly for measurements in artificial conditions of humidity, etc., but it is limited to frequencies below about 20 Mc/s because the resistances equivalent to the losses of the sample, which must be connected in series with the reference condenser, become too small at the higher frequencies, especially in the case of recent extremely good materials.

The second method, with the single two-plate condenser, is more lengthy than the third, but allows tan δ to be measured up to the highest frequencies (some hundreds of Mc/s) by the measurement of the equivalent parallel resistance of the sample. It is examined in detail on pp. 23–28: various methods of obtaining the required variable r.f. high resistance are discussed (Figs. 5 & 6), including the use of a diode and of a diode-and-triode combination. A special Galileo Ferraris circuit for the determination of the equivalent parallel resistance is described (Fig. 7).

The earlier part of the paper deals at considerable length with the preparation of the sample, nature of the electrodes, influence of moisture, etc.

1455. THE MEASUREMENT OF LOSSES AT HIGH VOLTAGES OF HIGH FREQUENCY.—L. Rohde & G. Wedemeyer. (*E.T.Z.*, Vol. 61, 1940, pp. 577 onwards: referred to in 1454, above.)

1456. LOSS-ANGLE MEASUREMENTS ON SYNTHETIC MATERIALS AT HIGH FREQUENCIES [1 Mc/s, using a New Type of Bridge: Results with Polyvinyl Acetate, Polyvinyl Alcohol, & Novolak].—W. Holzmüller. (*E.T.Z.*, 28th Nov. 1940, Vol. 61, No. 48, p. 1081: summary only.)

In the new bridge "only one component of the alternating voltage was balanced in the diagonal. The remaining voltage was measured with a sensitive valve voltmeter, and the voltages at the test condenser and the reference condenser were also given by other valve voltmeters. By the use of different voltages it was possible to determine the field strength as a function of the loss angle."

With the three materials named, the curves of loss angle as a function of temperature showed a marked maximum. The shape of the dielectric-constant curves corresponded to the behaviour of a loss-free dielectric with a parallel resistance: molecular size showed only a small influence. The addition of polystyrol to a mixture produced a reduction in loss and a displacement of the loss angle maximum to a higher region of temperature. The occurrence of losses is explained, as in liquids, by the combined effects of Brownian movement and the orientation of the dipoles in the direction of the field, in which changes of the binding forces in the molecule presumably occur with oscillation.

1457. REMARKS ON THE MEASUREMENT OF HIGH AND VERY HIGH POTENTIALS [used in X-Ray Tubes, High-Voltage Testing, etc.].—W. Gohlke & U. Neubert. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 21, 1940, pp. 217–222.)

The writers begin by describing the principle of the "rotary voltmeter" first used by Schwenkhagen (in 1926) for measuring the field-strength rise accompanying a lightning flash, and developed by Kirkpatrick into his "generating voltmeter" (1933 Abstracts, p. 172, and back reference); deal with the calculation of the errors due to space charge and other causes and with constructional precautions; and then refer briefly to the rotary voltmeter of Van Atta & his co-workers (3198 of 1936) with a special lemniscate rotor yielding a sinusoidal current.

They then proceed to describe a new device which they term a "vibrating voltmeter," in which the capacity of a two-plate condenser is repeatedly varied by one plate being driven by an electromagnetic vibrator so that its distance from the other plate (carrying the potential under measurement) changes by a small amount 100 times per second, using 50 c/s mains current for the drive. This periodic variation causes a displacement current to flow from the vibrating plate through a resistance to earth, and by measuring this current, or the voltage across the resistance if the latter is made high, the required potential U_0 is obtained by eqn. 18 or 19 respectively: in both cases Δd is half the total stroke of the vibrating mechanism and d the distance between the two plates at rest. In the experimental model used to confirm the calculations (in which edge effect is neglected), the moving plate was provided with a guard ring. Agreement between calculated and observed results is stated to have been good. The current and voltage observed were 0.45 μA and 4.5 v, when the earthing resistance was 10 megohms, the high voltage 10 kv, and $\Delta d/d$ was 1/10.

Figs. 10 a & b show two special forms of electrode suggested by Schmidt in which the surface of the moving electrode is ribbed or studded and the fixed electrode is provided with openings into which the ribs or studs enter. With such an arrangement, amplitude of motion can be sufficiently large while the electrode nearer to the object carrying the potential to be measured screens the other electrode against the electric field, so that practically all the lines from one electrode to the other change over within a half period of motion. The equation for the arithmetical mean of the current in one direction is then given by eqn. 20, while eqns. 21/23 show that the device can be used to give the field strength at the surface of the moving electrode, even (with the help of a preliminary calibration) if the field is not uniform. By employing a resonant drive system, a high rate of oscillation can be obtained with low energy consumption, and it is suggested that there should be many fields of application. The space occupied would be about one-tenth of that taken by a rotary voltmeter, and other advantages are the absence of rotating parts and of the need for any connection between voltmeter and object under test, the fact that no energy is taken from the latter, the absence of any dependence on atmospheric conditions, the continuous voltage indication, etc. It is suggested that the device could be made in the form of an exploring pick-up.

1458. A METHOD FOR MEASURING THE AMPLITUDE OF AN IMPULSE VOLTAGE.—Ya. S. Itskhoki. (Russian Pat. No. 56 722, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 21.)

The impulse charges a condenser through a rectifier, and the discharge (which is a measure of the impulse) passes through a ballistic galvanometer in series with a second rectifier and shunted across the first rectifier.

1459. MEASUREMENT OF VERY SHORT-TIME [around 10^{-6} Second] VOLTAGE PULSES BY MEANS OF THE "BREAK-OFF" LINE OF THE BACK-COUPLED VALVE OSCILLATOR.—H. Wechsung. (*Hochf:tech. u. Elek:akus.*, Nov. 1940, Vol. 56, No. 5, p. 149.)

It was required to measure the absolute voltage amplitude (around 0.1 volt) of a pulse of very short duration, of whose form it was only known that it was a very sharp peak. Such a measurement could have been made by a photographic record from a cathode-ray oscillograph with a high-fidelity amplifier of considerable amplification, but it was desired to avoid the use of so much apparatus and to find a method more suitable for production measurements. A system of glow-discharge lamps, so biased with d.c. that each one required a different additional voltage to fire it, would give an indication of the pulse voltage if the number of lamps which it fired were counted: but the striking voltages of such lamps are not very uniform, and moreover the inertia of the gaseous discharge would introduce an unwanted dependence on the duration of the impulse.

The writer, therefore, decided to replace the glow-discharge lamp by a back-coupled valve circuit. By suitable choice of the values of back coupling and grid bias the phenomenon of oscillation hysteresis (back-lash) can be so obtained that the circuit will start oscillating only when the grid bias is raised by the amount of the pulse voltage, but will continue to oscillate when this voltage has passed. A number of such circuits can be used, like the glow-discharge lamps: or the pulse can be impressed on one circuit by way of a potentiometer. "The value of the oscillator frequency is arrived at from the given duration of the pulse, namely 10^{-6} sec. Since it must be assumed that a pulse of at least half a period's duration is necessary to set the circuit oscillating, the suitable oscillator frequency is equal to or greater than 2×10^6 c/s" [there seems to be something wrong with this reasoning as it stands]. With a short wave like this it is easy to keep the bridging and other condensers so small that they will not distort the pulse voltage. The method has been used very successfully: results obtained with it will be reported later by another worker.

1460. THE SCHERING BRIDGE OVER TWENTY YEARS [Survey of Development and Applications, with Literature References up to 1940].—R. Vieweg. (*E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, pp. 1045–1047.)

1461. THE BRIDGE CIRCUIT AS AN ACTIVE DIPOLE [and the Simple Calculation of Branch Currents, etc.].—Weber. (*See* 1322.)

1462. COMPACT GALVANOMETER SCALE UNIT [for Microphotometers, etc: avoiding Disadvantages of Lamp & Scale].—(*Engineer*, 21st Feb. 1941, Vol. 171, p. 135.)

1463. DIRECT-READING CAPACITANCE METER WITH MAINS-DRIVEN RESONANT VIBRATOR [charging to Constant D.C. Potential and discharging through Galvanometer: Range 0.02–10 μF: Accuracy to 1%: Fixed Polarity, therefore applicable to Electrolytic Condensers (up to 2000 pF only)].—P. K. Hermann. (*Arch. f. Tech. Messen*, No. 107, 1940, V.3532: *E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, pp. 1038–1039—summary only.)

1464. IMPROVEMENT IN THE RESONANT SUBSTITUTION METHOD OF MEASURING DIELECTRIC CONSTANT AND POWER FACTOR, BY USE OF SENSITIVE SLIDE-BACK VALVE VOLTMETER.—Fouts. (*See* 1493.) For Reich's description of this voltmeter *see* 1932 Abstracts, p. 50, l-h column.

1465. LIMITATIONS TO THE USE OF VALVE VOLTMETERS [Diode Peak-Voltmeters].—N. Aliotti. (*Alta Frequenza*, Jan. 1941, Vol. 10, No. 1, pp. 31–38.)

Practically all the valve voltmeters on the market (and the use of these has of recent years reached a vast extent) employ a diode circuit of one of the two types shown in Fig. 1. The writer first examines the components of the input impedance of such an instrument. By the use of a suitable diode and by skilful design the capacity of the input circuit can be kept down to a few micromicrofarads, and its inductance also made quite small: so that if the diode electrodes are closely enough spaced to avoid transit-time effects the voltmeter can be used, without correction, at frequencies up to or beyond hundreds of megacycles per second. As regards the active component of the input impedance, there is the dissipation of energy in the dielectrics of the input capacitance and also the dissipation in the rectifying process. The latter is always present, the former only becomes serious at the high frequencies, and for simplifying the treatment it is here assumed that the working frequency is low enough for the dielectric losses to be neglected.

The absorption of energy by the rectifier is, as is known, highly discontinuous, being limited to a very small fraction of the positive half-period. The input resistance, practically infinite throughout almost the whole period, assumes during a small fraction of it a value which is variable and in general small. The writer examines the equivalent resistance, that is, the resistance which when subjected to a voltage equal to that applied to the rectifier will dissipate, over the whole period, the same total of energy; and concludes that in the case, often arising, where the generator feeding the circuit across which the voltmeter is connected has a high resistance, the introduction of the voltmeter will not only cause a diminution of the charge on the condenser, and thus produce a too-low reading, but will also distort the wave-form of the voltage. Judging by the uses to which these voltmeters are frequently put, the above facts do not seem to be realised sufficiently. In the rest of the paper (pp. 34–38) the writer describes tests made to confirm these conclusions, in which the percentage distortion was measured by a wave-analyser and the reduction factor a, by which the original fundamental voltage must be multiplied to obtain the voltage with the rectifier introduced, was also determined. Figs. 3–7 give the results under various conditions. The distortion can be so great, even with values of R (the rectifier leak resistance) of some tens of megohms, as to prohibit the use of such a voltmeter for certain purposes. The diagrams show that to keep the distortion within reasonable limits the rectifier leak resistance must be made as high as is compatible with the requirements of the later amplifier stages.

1466. On the Final Adjustment of Fixed Resistances, particularly Shunt and Series Resistances for Electrical Measuring Instruments [Bridge Method, eliminating Waste of Time in waiting for Soldered Joint to Cool Down to avoid Thermoelectric Effects].—H. H. Wolff. (*E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, pp. 1035–1036.)

1467. Radio-Frequency Characteristics of Decade Resistors.—(*General Radio Experimenter*, Dec. 1940.)

1468. The Junior VoltOhmyst.—Rider. (*Journ. of Applied Phys.*, Feb. 1941, Vol. 12, No. 2, pp. vi and viii.)

1469. Taylor Model 81A Universal Meter.—(*Wireless World*, March 1941, Vol. 47, No. 3, pp. 66 and 94.)

1470. A Measuring Device for the Rapid Determination of Magnetic Quantities [Two Coils in Opposition (for Introduction of Samples) & Third Separate, All inside Field Coil excited by A.C.: Pair of Integrating Circuits and Amplifiers, leading to Cathode-Ray Oscilloscope].—F. Förster. (*E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, p. 1036: summary only.)

SUBSIDIARY APPARATUS AND MATERIALS

1471. The Effect of the Size of the Particle on the Intensity of Fluorescence of a Phosphor [Investigation of Synthetic Willemite ($ZnBeSiO_3$) with Particles up to 1/16th Inch: Intensity Increase with Decreasing Size: Fluorescence apparently a Surface Phenomenon].—Oldham & Kunerth. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 102–104.)

1472. Photoconductivity of a Natural Willemite Crystal.—Herman & Hofstadter. (*See* 1442.)

1473. The Effect of Infra-Red Rays on the Excitation of the Luminescence of ZnSCu Phosphor.—Popok & Klement. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 800–807.)

The "extinction" of a luminous phosphor by infra-red rays has been investigated by a number of research workers. In this paper a report is presented on an investigation carried out by the authors to determine the effect of infra-red rays on the excitation of ZnSCu phosphor. Two groups of experiments were conducted. In the first group the screen was subjected to a simultaneous action of infra-red and ultra-violet rays. The main conclusion reached is as follows. If α_1 is the probability of the transition of an electron from the excitation level to the normal level, accompanied by the emission of a quantum of light, and α_2 is the probability of such a transition without the emission of light, then α_1/α_2 is proportional to the ratio of the ultra-violet and infra-red light quanta falling on the screen. In the second group of experiments, the effect of a preliminary treatment of the screen by infra-red rays on the subsequent excitation by ultra-violet rays was examined. It can be seen from Fig. 6 that the excitation curve 2 so obtained is considerably "depressed" in comparison with curve 1 corresponding to the excitation by ultra-violet rays only. A further depression (curve 3) is obtained if both types of rays are used simultaneously.

In a theoretical discussion that follows, it is shown that curve 1 is determined by equation (1), based on the assumption that the excitation is a monomolecular process, and curve 3 by equation (4), *i.e.* the phosphor is regarded as a semiconductor and the excitation as a bimolecular process. No equation is given for curve 2.

1474. Spectrophotometric Investigations on a Commercial Luminous Paint [Long-Persistent ZnSCu Phosphor "Grün N"].—Schilling. (*See* 1540.)

1475. A Secondary-Emission Electron Commutator [for Controlling the Neon-Tube Elements in a Line of a Remote-Indication Device such as a Television Screen].—Zernov & Naumovets. (*See* 1436.)

1476. A Scanning Device for Plotting Equipotential Lines [in Electrolytic Trough].—Simpson. (*See* 1378.)

1477. Electron-Microscopy at Higher Voltages [110 Kilovolts: the Question of Contrast].—Kinder. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 21, 1940, pp. 222–223 and Plate.)

"Although the usual voltages employed in electron-microscopy have been extended to about 80 kv, and Marton has even used 90 kv, the highest so far employed, comparative data are at present lacking as regards picture contrast of one and the same object for various electron velocities [*cf.* von Borries & Ruska, 1170 of April].

"With the magnetic-type microscope already briefly described [520 of February], which is particularly suitable for the use of high voltages, photographs were made with electron velocities up to 110 kv and compared with the corresponding photographs taken with 30–50 kv velocities, to examine the question of contrast and the penetrability of thicker objects."

The objects included hay bacteria, bacteria *Coli*, and flies' wings. With the lower voltages a longer plate exposure gave very good contrast in certain thickness regions, but with the higher voltages the contrast, though weaker, covered a far wider range of thickness. Moreover, raising the exposure time for work at the lower voltages is limited by the load put on the object and by the difficulty of obtaining sharp pictures if the exposure is long.

1478. Criteria [for Limit of Resolution] and the Intensity-Epoch Slope.—Ramsay & others. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 26–33.) In connection with the theory dealt with in 170 of January.

1479. Sputtering and Secondary Electron Emission of Metals bombarded with Argon Ions.—Timoshenko. (*See* 1387.)

1480. POINTS OF VIEW IN THE SELECTION OF RECTIFIERS [Comparison of Properties of Mercury-Vapour, Hot-Cathode, & Selenium & Copper-Oxide Dry-Plate Types as regards Efficiency, Frequency Limits, Life, etc.].—Maier. (*E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, pp. 1029–1034.)

1481. SPARKING OF OXIDE-COATED CATHODES IN MERCURY VAPOUR.—Knowles & McNall. (*See* 1383.)

1482. REGULATED FILAMENT EMISSION FOR CYCLOTRONS [Life of 20-mil Tungsten Spirals, carrying 17 A D.C. & giving 100–200 mA Emission, increased from 10–50 to 100–300 Hours].—Pollard. (*Review Scient. Instr.*, Jan. 1941, Vol. 12, No. 1, p. 37.)

1483. SWISS SCIENTIST INVENTS IMPROVED CYCLOTRON [Electric Field progressively Increased from Centre outwards to allow for Relativistic Mass Increase, hitherto Neglected].—Jonas. (*Sci. News Letter*, 1st Feb. 1941, Vol. 39, No. 5, p. 67.) Patent assigned to Brown Boveri.

1484. VOLTAGE DISTRIBUTION ON A MULTI-SECTION ACCELERATING TUBE [Difficulty due to Flow of Large Numbers of Secondary Electrons between Accelerating Electrodes overcome].—Haworth & others. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 108 : summary only.)

1485. INDUCTION ELECTRON ACCELERATOR.—Kerst. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 110–111 : summary only.) *See* also 858 of March.

1486. ELECTROSTATIC GENERATOR WITH CONCENTRIC ELECTRODES.—Herb & others. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 111–112 : summary only.) *See* also 199 of January.

1487. VIBRATORY H.T. GENERATORS : COMPENSATING FOR WEAR OF CONTACTS.—Telefunken. (*See* 1364.)

1488. THE COPPER-OXIDE VARISTOR [Characteristics : Mechanism : Ageing : Heat Treatment : etc.].—Brattain. (*Bell Lab. Record*, Jan. 1941, Vol. 19, No. 5, pp. 153–159.)

1489. THERMISTORS, THEIR CHARACTERISTICS AND USES.—Pearson. (*See* 1326.)

1490. METALLIC BRIDGES BETWEEN CONTACT POINTS [Note on Experiments].—Pearson. (*Bell Lab. Record*, Dec. 1940, Vol. 19, No. 4, p. 130.)

1491. A HARD-VACUUM-TUBE PULSE EQUALISING SHARPENING CIRCUIT [primarily for Scaling Circuits : Amplitude & Width independent of Input-Signal Wave Form].—Huntoon & Strohmeyer. (*Review Scient. Instr.*, Jan. 1941, Vol. 12, No. 1, pp. 35–36.)

1492. A NEW IONISATION AMPLIFIER [Linear Amplifier for measuring Ionisation Currents].—Le Caine & Waghorne. (*See* 1327.)

1493. DIELECTRIC CONSTANT AND POWER FACTOR OF CERTAIN KINDS OF "KOROSEAL" [Elastoplastics : Group of Rubber Substitutes made from Polyvinyl Chloride with Various Plasticisers, in This Case Tricresyl Phosphate : Measurements at 100–2400 kc/s, by Resonant Substitution Method improved by Use of Sensitive Valve-Voltmeter instead of Hot-Wire Galvanometer].—Fouts. (*Journ. of Applied Phys.*, Jan. 1941, Vol. 12, No. 1, pp. 21–22.)

1494. SPECIAL ISSUE ON THE PHYSICS OF RUBBER AND RUBBER SUBSTITUTES.—(*Journ. of Applied Phys.*, Jan. 1941, Vol. 12, No. 1, pp. 1–54.)

1495. PLASTIC MATERIALS : A REVIEW OF NEW TYPES AND GRADES [including "Isolene" and "Chlorovene"].—(*Electrician*, 21st Feb. 1941, Vol. 126, pp. 116–117.)

1496. THE APPLICATION OF STYRENE TO H.T. CABLE SYSTEMS [including the Latest Styrenation Technique].—Scott & Webb. (*Elec. Communication*, Oct. 1940, Vol. 19, No. 2, pp. 108–117.)

1497. THE BEHAVIOUR OF COMMERCIAL CELLULOSE TRI-ESTER FOILS AT HIGH TEMPERATURES [Tests on Cellulose Tri-Acetate Foils, for Cables, Condensers, etc.].—Nowak & Wolter. (*E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, p. 1062 : summary only.)

1498. RECENT DEVELOPMENTS IN ESTERIFIED FIBROUS INSULANTS [including Cotopa 30 & 60, Insuwools & Insusilks, Acetylated Paper, Cellulose Triacetate Silk, Nylon & Vinyon, Crestol, etc.].—New. (*Elec. Communication*, Oct. 1940, Vol. 19, No. 2, pp. 71–93.) With bibliography.

1499. INSULATING PAPER IN THE TELEPHONE INDUSTRY.—Finch. (*Bell Tel. System Tech. Pub.*, Monograph B-1260, 19 pp.)

1500. MEASUREMENTS OF DIELECTRIC CONSTANTS AND LOSS ANGLES OF SOLID DIELECTRICS AT RADIO FREQUENCIES, *and* LOSS-ANGLE MEASUREMENTS ON SYNTHETIC MATERIALS AT HIGH FREQUENCIES.—Holzner & Gregoretti : Holzmüller. (*See* 1454 & 1456.)

1501. CONDUCTION OF ELECTRICITY BY DIELECTRIC LIQUIDS AT HIGH FIELD STRENGTHS [Investigation of Heptane invalidates Thermionic Emission, Cold Emission, Collision Ionisation, etc., as Causes, in favour of Lowering of Energy of Ionic Bond].—Plumley. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 114–115 : summary only.)

1502. "PLASTICS IN INDUSTRY" [Book Review].—(*Electrician*, 28th Feb. 1941, Vol. 126, p. 138.)

1503. ON THE IMPEDANCE OF ELECTROLYTIC CONDENSERS [Bridge Measurements over Audio-Frequency Range : Equivalent Circuits].—Söchting. (*E.N.T.*, March 1940, Vol. 17, No. 3, pp. 71–76 : *E.T.Z.*, 12th Dec. 1940, Vol. 61, No. 50, p. 1156—summary only : *Hochf:tech. u. Elek:akus.*, Nov. 1940, Vol. 56, No. 5, pp. 154–155—long summary.)

With the condensers investigated, no variation of impedance with the amplitude of the a.f. voltage (which was always superposed on a d.c. voltage) could be found. At the lower frequencies the behaviour was represented by an equivalent circuit consisting of a series connection of a constant, real resistance (about corresponding to that of the electrolyte) and an impedance with constant loss angle. Above a few hundred c/s, however, this circuit no longer held good, and the addition of *RC* sections only extended its validity over a limited range of frequency. A better approximation to the measured curve was obtained after it was recognised that the capacity-forming barrier layer presented not a smooth surface but a more or less corrugated one. This was due partly to the mechanical construction of the condensers tested, as roll-type condensers, but partly also to chemical pre-treatment for increasing the area of the anode.

The condenser therefore was considered as a parallel connection of a number of cells of varying smallness, but capable of being dealt with as possessing one average size. Neglecting the anode and cathode resistances and considering only the barrier layer and the electrolyte, the impedance was calculated on the idea that each cell was a homogeneous open-circuited line of finite length ; *i.e.* that the barrier-layer capacity and the electrolyte resistance were distributed instead of concentrated. The formulae of line theory permitted the impedance to be calculated, after a simple approximation had been made, with results agreeing with the previous data at the lower frequencies and also with the measurements at the higher frequencies. "The transition region between the two frequency-zones could also be included, by taking in further terms in the series development. In general, it was found that over the whole frequency range temperature changes only altered the electrolyte resistance, while the capacity and loss angle of the barrier layer remained constant. The capacity of the condenser falls approximately with $1/\sqrt{\omega}$, which agrees with the measured results . . ."

1504. Cleaning Small Magnet-Gaps [including Annular Gaps of Loudspeakers: Use of Adhesive Tape].—Beard. (*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, p. 50.)

1505. A Measuring Device for the Rapid Determination of Magnetic Quantities.—Förster. (*See* 1470.)

1506. The Core Size of Filter Coils for Given Frequency Ranges. — Hornauer. (*See* 1321.)

1507. Analysis of Losses in Magnetic Cores [and the Importance of the Relationship between the Eddy-Current, Hysteresis, & "Residual" Components].—Owens. (*Bell Lab. Record*, Dec. 1940, Vol. 19, No. 4, pp. 117–120.)

1508. The Measurement of Magnetostriction in Transformer Alloys [in connection with Transformer Noise].—Alexander. (*BEAMA Journal*, Feb. & March 1941, Vol. 48, Nos. 44 & 45, pp. 20–22 & 37–39).

1509. On the Theory of Volume Magnetostriction.—Smoluchowski. (*Phys. Review*, 1st Feb. 1941, Vol. 59, No. 3, pp. 309–317.)

1510. On the Quantum Theory of Magnetostriction in Ferromagnetic Single Crystals.—Vonsovski. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 762–773.)

1511. The Magnetic Anisotropy of Polycrystalline Iron due to Internal Stresses.—Yanshin. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 786–799.)

An experimental and theoretical investigation which shows that the magnetic anisotropy of cold-rolled iron is caused not only by the crystallographic orientation of the crystallites but also to a great extent by the residual inner stresses. The magnitude and character of these stresses, as well as changes which take place during recrystallisation and subsequent heat treatment, can be determined by measuring the anisotropy.

1512. On the Hall Effect in Ferromagnetic Bodies : *also* On the Change in Resistance of Ferromagnetic Bodies upon Changing of the True Magnetisation : *and* The Change of Resistance in a Magnetic Field for Ordered and Non-Ordered Solid Solutions.—Rudnitzki. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 774–785.)

1513. Equilibrium Relations in the Solid State of the Iron-Cobalt System [Determination of Location of Alpha-Gamma Transformation, etc.].—Ellis & Greiner. (*Bell Tel. System Tech. Pub.*, Monograph B-1257, 18 pp.)

1514. Columbium-Iron Alloy [with Good Rupture Strength at 1100°F].—Parker. (*Journ. of Applied Phys.*, Jan. 1941, Vol. 12, No. 1, p. 57.)

1515. The Substitution of Materials in Electrical Engineering [in War Time].—Herttrich. (*E.T.Z.*, 5th Dec. 1940, Vol. 61, No. 49, pp. 1085–1087.) Introducing a series of articles, occupying the rest of the issue, on the use of substitute materials and devices for economy in copper, lead, etc.

1516. The Manufacture of Wires from Zinc Alloys for Electrical Conductors.—Deisinger & Reinbach. (*E.T.Z.*, 12th Dec. 1940, Vol. 61, No. 50, p. 1158 : summary only.)

STATIONS, DESIGN AND OPERATION

1517. Frequency-Modulated Emergency Equipment [Transmitter & Receiver].—Brown. (*See* 1536.)

1518. Article on Frequency Modulation, and the Probable Way It will fit into the General Broadcasting Scheme.—Peck. (*Scient. American*, Feb. 1941, Vol. 164, No. 2, pp. 96–98.)

1519. SELECTIVITY: A SURVEY OF THE PROBLEM AS IT AFFECTS THE WHOLE BROADCASTING SYSTEM [Influence of Harmonic Distortion in Transmitter, Geographical & Frequency Distribution of Stations: Receiver Design]. —Rust & others. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 62–66.) Long summary of the paper referred to in 1350, above.

1520. PAN-AMERICAN NETWORK: C.B.S. ENTERPRISE.—(*Wireless World*, March 1941, Vol. 47, No. 3, p. 78.)

GENERAL PHYSICAL ARTICLES

1521. CONJUGATE POTENTIALS OF A GRID BETWEEN CONDUCTING PLANES [Function yielding Conjugate Potentials appropriate to Infinite Grating of Equally Spaced Filaments situated between Two Infinite Parallel Conducting Planes].—D. Kirkham. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 111: summary only.)

1522. THE "RADIUS" OF ELEMENTARY PARTICLES. —Landau. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 718–720.)

The condition limiting the application of classical electrodynamics is $\lambda \gg e^2/mc^2$. In this paper, a method is developed for determining similar conditions for the quantum theory. The method applies to electrons and particles of spin 1.

1523. THE SCATTERING OF MESOTRONS BY NUCLEAR FORCES.—Landau. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 721–722.)

Methods of determining the effective cross-section of the scattering based on perturbation theory cannot be used when energies exceed μc^2 (μ is the mesotron mass). A further analysis of these methods is given which makes them applicable to this case as well.

1524. THE POLARISATION OF ELECTRONS BY DOUBLE SCATTERING [using Dirac's Equations].—Massey & Mohr. (*Proc. Roy. Soc.*, Ser. A, 24th Feb. 1941, Vol. 177, No. 970, pp. 341–357.) *Cf.* Landau, 4091 of 1940.

1525. PHOTO-FISSION OF URANIUM AND THORIUM.—Haxby & others. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, pp. 57–62.) For preliminary announcement *see* 4100 of 1940.

1526. CRYSTALS AND PHOTONS [Presidential Address, Indian Academy of Sciences].—Raman. (*Current Science*, Bangalore, Jan. 1941, Vol. 10, No. 1, pp. 49–56.)

1527. MAGNETISATION OF MATTER BY LIGHT.—Ehrenhaft & Banet. (*See* 1304.)

1528. THE EFFECT OF LIGHT ON THE SKIN EFFECT. —Levitskaya. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 808–813.)

Experiments with flat aluminium and zinc spirals excited on wavelengths from 60 to 120 cm have shown that the effective current through the spiral decreases by a small percentage when the spiral is illuminated by ultra-violet light.

1529. THE DISTRIBUTION OF RADIANT ENERGY (LIGHT) IN A GROUP OF LATTICES [Analysis showing Possibility of Formation of Certain Fringes as Corpuscular Phenomenon independent of Wave Idea].—Serghiesco. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 109–113.)

1530. INTERFERENCE PHENOMENA WITH A MOVING MEDIUM.—Ives & Stilwell. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 14–24.) A summary was dealt with in 1228 of April.

1531. THE THEORY OF ADSORPTION OF GASES ON SOLIDS WHEN THE POTENTIAL ENERGY VARIES CONTINUOUSLY OVER THE SURFACE. —Miller & Roberts. (*See* 1388.)

MISCELLANEOUS

1532. NOTE ON THEORETICAL AND OBSERVED DISTRIBUTIONS OF REPETITIVE OCCURRENCES [*e.g.* in Problem "How Many Times will a New Type of Apparatus perform Its Intended Function without Failure?"].—Olmstead. (*Bell Tel. System Tech. Pub.*, Monograph B-1261, 4 pp.)

1533. SINGLE SAMPLING AND DOUBLE SAMPLING INSPECTION TABLES [Four Sets of Tables which have "Contributed in a Notable Way to Important Reductions in Inspection & Production Costs and Substantial Improvements in Control of Quality for Many Characteristics of Products used in Bell System"]. Dodge & Romig. (*Bell S. Tech. Journ.*, Jan. 1941, Vol. 20, No. 1, pp. 1–61.)

1534. "DIE MATHEMATIK DES FUNKTECHNIKERS" [The Wireless Engineer's Mathematics: Part 5—Symbolic Calculus, II: Book Review].—Schmid. (*E.T.Z.*, 12th Dec. 1940, Vol. 61, No. 50, p. 1160.) For Part 4 *see* 943 of March.

1535. CYCLES PER SECOND [and the Growing Tendency to state Frequencies in Cycles: "Slovenly & Incorrect"].—(*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, p. 51.)

1536. I.R.E. SIXTEENTH ANNUAL CONVENTION, JAN. 1941, NEW YORK [with Summaries of All Papers].—(*Proc. I.R.E.*, Nov. 1940, Vol. 28, No. 11, pp. 525–535.)

1537. THE LIGHT MODULATION OF THE HIGH-PRESSURE MERCURY-VAPOUR DISCHARGE BETWEEN 50 C/S AND 100 KC/S [Experimental Investigation of Possibility of Utilising the Advantages of this Light Source for Electroacoustical Purposes].—Mangold. (*E.N.T.*, March 1940, Vol. 17, No. 3, pp. 57–69: *E.T.Z.*, 14th Nov. 1940, Vol. 61, No. 46, pp. 1039–1940.—summary only.)

Including tests on a special design with an auxiliary unmodulated discharge to prevent the breaking off of the luminous discharge by peak over-modulation or similar causes. Modulation was carried out by a heterodyne generator (with amplifier) between 50 c/s and 15 kc/s, and by a 90 w h.f. signal generator for the higher frequencies.

Among other things, the depth of modulation was measured by a photocell circuit over the range of frequencies mentioned, for three regions of the spectrum, the long-wave ultra-violet (366 $m\mu$), the green (546 $m\mu$), and the region 600–1200 $m\mu$. With suitable precautions, uniform modulation can be obtained over all these regions. The depth of modulation is constant at the lower frequencies; for short, very intense discharges this constancy extends up to 4 kc/s, for longer, less intense discharges it may range down to about 400 c/s. Above the constant region the depth of modulation decreases with the square root of the frequency. For the middle frequencies the factor may be as much as 95%: the time lag between the primary current and the resulting light modulation decreases, as the frequency rises, from about 100 μs to about 2 μs. To sum up, the general suitability of this type of discharge for electroacoustical purposes is affirmed: the auxiliary discharge mentioned at the beginning would seem to be indispensable.

1538. A SMALL LIGHT-FLASH APPARATUS FOR THE PHOTOGRAPHIC RECORDING OF RAPIDLY MOVING OBJECTS [Emission Peak extending over 2–3 Microseconds: Max. Intensity 1.8×10^6 Candles: Spark Gap with Auxiliary Starting Gap driven by Thyratron: Investigation of Causes of Dispersion of the Striking Instant, leading to Remedy: Examples of Projectile Photography, etc.].—Vastmann. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 21, 1940, pp. 223–228.)

1539. THE LIGHT-FLASH TIME-METER, A NEW INSTRUMENT FOR SHORT AND LONG TIME MEASUREMENTS [primarily for Projectile Transit Times: Beginning of Transit illuminates (by Thyratron-Driven Spark) Upper Figures of Double Scale rotating at 100 c.p.s: End of Transit illuminates Lower Figures: Photograph (on Special Paper automatically developed within 30 Seconds) gives Time by Subtraction of Coincident Scale Readings].—Bötz. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 21, 1940, pp. 228–232.)

1540. SPECTROPHOTOMETRIC INVESTIGATIONS ON A COMMERCIAL LUMINOUS PAINT [Long-Persistent ZnSCu Phosphor "Grün N": Spectral Energy Distribution: "Visual Efficiency": Decay Characteristic (by Monochromator, Phosphoroscope, & Photometer): Influence of Film Thickness, Binding Material, etc: Effect of Temperature: etc.].—Schilling. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 21, 1940, pp. 232–239.)

1541. THE EFFECT OF INFRA-RED RAYS ON THE EXCITATION OF THE LUMINESCENCE OF ZnSCu PHOSPHOR.—Popok & Klement. (*See* 1473.)

1542. FLUORESCENCE TECHNIQUE FOR THE RAPID DETECTION OF TUBERCULOSIS GERMS.—(*Sci. News Letter*, 8th Feb. 1941, Vol. 39, No. 6, p. 90.)

1543. MOSQUITOES CAN "SEE" ULTRA-VIOLET RADIATION AND ARE REPELLED BY IT.—Crooks. (*Sci. News Letter*, 4th Jan. 1941, Vol. 39, No. 1, p. 7.)

1544. THE EXAMINATION OF FINELY FINISHED SURFACES IN THE SUPERMICROSCOPE.—von Borries & Janzen. (*Zeitschr. V.D.I.*, 1st March 1941, Vol. 85, No. 9, pp. 207–211.)

1545. ZINC OXIDE SMOKE [and the Information yielded by the Electron Microscope about Shape & Size of Smoke Particles].—Preston. (*Nature*, 8th March 1941, Vol. 147, p. 298.) *Cf.* 4401 of 1940 (von Ardenne & others).

1546. A SECONDARY-EMISSION ELECTRON COMMUTATOR [for Controlling the Neon-Tube Elements in a Line of a Remote-Indication Device such as a Television Screen].—Zernov & Naumovets. (*See* 1436.)

1547. PHOTOGRAPHIC NEGATIVES INSTANTANEOUSLY VIEWED AS POSITIVES BY CATHODE-RAY-TUBE ARRANGEMENT.—Rubert. (*Wireless World*, March 1941, Vol. 47, No. 3, p. 84.)

1548. PROPOSED AMERICAN STANDARD: SPECIFICATIONS FOR DETERMINING PHOTOGRAPHIC SPEEDS OF ROLL FILMS, FILM PACKS, AND MINIATURE-CAMERA FILMS.—(*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 87–92.)

1549. THE DISTRIBUTION OF ENERGY IN THE VISIBLE SPECTRUM OF DAYLIGHT.—Taylor & Kerr. (*See* 1299.)

1550. SOME APPLICATIONS OF RADIOGRAPHY TO THE ELECTRICAL INDUSTRY.—Rooksby & Jackman. (*Journ. of Scient. Instr.*, March 1941, Vol. 18, No. 3, pp. 33–38.) From the G.E.C. Laboratories.

1551. RÖNTGEN-CINEMATOGRAPHY [Short Survey, including Possibility of Important Future Developments using Photocells & Television Technique].—Hasché. (*E.T.Z.*, 28th Nov. 1940, Vol. 61, No. 48, pp. 1074–1075.)

1552. FIELD-EMISSION X-RAY TUBE [for High-Speed Radiography].—Slack & Ehrke. (*See* 1390.)

1553. THE MEASUREMENT OF THE [Very Weak] INTENSITY OF X-RAYS OF WAVELENGTH 0.14 TO 1.0 AU BY MEANS OF AN ELECTRON-MULTIPLIER TUBE [with Thin Tantalum Foil as Photosensitive Surface, & Ten Multiplying Electrodes covered with Thin Layer of Beryllium: about 400 Photons required for Each Pulse recorded].—Allen. (*Phys. Review*, 1st Jan. 1941, Vol. 59, No. 1, p. 110: summary only.)

1554. THE INTERFERENCE COUNTER-TUBE AS AN AUXILIARY IN FINE-STRUCTURE RESEARCH WITH X-RAYS. — Lindemann & Trost. (*Zeitschr. f. Phys.*, Vol. 115, 1940, pp. 456–467: *E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, pp. 1061–1062—summary only.)

1555. NOISE-ELIMINATING UNIT FOR JUNCTION CIRCUITS EXPOSED TO POWER INDUCTION [when Other Methods have Failed: Insertion of Unit (at Each End of Junction) which provides High Attenuation to Longitudinal Voltages while transmitting Loop Circuit Voltages with Very Little Loss].—Carter & Walker. (*P.O. Elec. Eng. Journ.*, Jan. 1941, Vol. 33, Part 4, pp. 186–188.)

1556. THE TELEGRAPH MODULATOR, A CONTACTLESS KEYING CIRCUIT FOR CARRIER TELEGRAPHY.—Bähr & Junga. (*See* 1345.)

1557. MICRO-GAS ANALYSIS METHODS AND THEIR APPLICATION TO RESEARCH [Survey].—Wooten. (*ASTM Bulletin*, Jan. 1941, No. 108, pp. 39–44.)

1558. THE INTERFEROMETER METHOD OF DETERMINING THE AMPLITUDES OF SMALL MECHANICAL VIBRATIONS.—Kennedy. (*See* 1400.)

1559. A DIRECT-CURRENT AMPLIFIER EMPLOYING NEGATIVE FEEDBACK FOR MEASURING STELLAR PHOTOELECTRIC CURRENTS.—Heidelberg & Rense. (*See* 1328.)

1560. DAYTIME PHOTOELECTRIC MEASUREMENT OF CLOUD HEIGHTS [up to 9000 Feet].—Laufer & Foskett. (*Journ. Franklin Inst.*, Feb. 1941, Vol. 231, No. 2, pp. 177–178.)

1561. COMPACT GALVANOMETER SCALE UNIT [for Microphotometers, etc: avoiding Disadvantages of Lamp & Scale].—(*Engineer*, 21st Feb. 1941, Vol. 171, p. 135.)

1562. A CONCAVE GRATING PHOTOELECTRIC SPECTROPHOTOMETER [including a Defence of Barrier-Layer Cells against Accusations of Unsuitability owing to Nonlinearity, etc.].—Sheard & States. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 64–69.) *See* also 4158 of 1940, and 1565, below.

1563. THE MEASUREMENT OF FAST [Chemical] REACTIONS BY ABSORPTION SPECTROPHOTOMETRY, AND ITS APPLICATION TO RESPIRATORY ENZYME KINETICS.—Karush. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 73–76.) Using the high-speed recording instrument dealt with in 4156 of 1940. *See* also pp. 77–84 for further use.

1564. THE PHOTOCHEMICAL PROPERTIES OF THIONINE (LAUTH'S VIOLET), AND ITS USE IN PHOTOGALVANIC CELLS.—Epstein & others. (Mentioned in a paper in *Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 77–84.)

1565. CONSTRUCTION AND TEST OF A GONIOPHOTOMETER [with Barrier-Layer Photocell operating under Short-Circuit Conditions to give Linear Response & Minimum of Fatigue].—Moon & Laurence. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 130–139.)

1566. INCENDIARY BOMB DETECTION: MEMORANDUM ON ELECTRICAL METHODS FOR COMMERCIAL AND INDUSTRIAL APPLICATIONS.—I.E.E. Committee. (*Electrician*, 21st. Feb. 1941, Vol. 126, pp. 113–114.)

1567. NEW LENS-SPEED RATING PERMITS BETTER EXPOSURE [Inadequacy of "F. Value" Rating: Photoelectric Test Method].—Clark. (*Sci. News Letter*, 1st Feb. 1941, Vol. 39, No. 5, p. 73.)

1568. A FOOTCANDLE-HOUR INTEGRATOR FOR DAYLIGHT.—Taylor. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 105–106.)

1569. A NEW NON-RECORDING DENSITOMETER [Projection Type: Balanced Photocells (Vacuum Type) & "Magic Eye" Null Indicator].—Baird. (*Journ. Opt. Soc. Am.*, Feb. 1941, Vol. 31, No. 2, pp. 179–180.)

1570. BORDERLAND PROBLEMS IN BIOLOGY AND PHYSICS [including Applications of Photocells to Spectrophotometry (Zworykin's Automatic Recording Spectroradiometer, primarily for Fluorescent-Material Research: Müller's Instantaneous Cathode-Ray Methods: etc.): Electron-Microscopy: Photoelectric Determination of Micro-organism Population Density: etc.].—Loofbourow. (*Reviews of Mod. Phys.*, Oct. 1940, Vol. 12, No. 4, pp. 267–358.)

1571. PHOTOELECTRIC CONTROLS [particularly the Photoelectric Relay Type RPK2 and Its Various Applications: with Circuit Diagram].—A. E. G. (*E.T.Z.*, 28th Nov. 1940, Vol. 61, No. 48, Advert. p. 17.)

1572. A DEVICE FOR DETECTING SHOALS OF FISH.—Lisanevich. (Russian Pat. No. 56 720, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 36.)

A buoy making use of a photocell 11 and light reflected from the passing shoal. To increase the radius of action, the prism 13 which deflects the light from a source of light 9 downwards, towards the aperture 19, is made to oscillate.

1573. THE REMOTE CONTROL OF A REVERSING MECHANISM.—Bereznegovski. (Russian Pat. No. 56 726, accepted 31.3.40: *Bull. of Inventions Registration Bur. of Gosplan* [in Russian], No. 3, 1940, p. 19.)

A camera 6 with three photocells 1, 2, & 3 is mounted on the shaft of the mechanism and is connected in the control circuit of a servo-motor driving the shaft. The cells are illuminated by circularly arranged lamps 8, and by switching these on and off from a remote position (by means of a movable contact ring 7), the shaft can be made to rotate in the required direction until all three cells are illuminated again.

1574. POSSIBILITIES OF RAPID TEMPERATURE REGULATION [Usual Methods are inadequate for Modern Surface Heating in H.F. Fields (Treatment of Metals, etc.): Objections to Photoelectric Methods (especially Inconstancy): Comparison of Three Methods of Overcoming These].—Lohausen. (*E.T.Z.*, 21st Nov. 1940, Vol. 61, No. 47, p. 1055: summary only.)

1575. CHEMICAL METHODS FOR INCREASING THE TRANSPARENCY OF GLASS SURFACES.—Jones & Homer. (*Journ. Opt. Soc. Am.*, Jan. 1941, Vol. 31, No. 1, pp. 34–37.) For other work on the subject *see* 3656/8 of 1940.

1576. THE SENSITIVITY OF THE DARK-ADAPTED EYE: TESTS WITH ONE-HUNDREDTH OF A SECOND FLASHES SHOW PERCEPTION WITH 8–9 QUANTA REACHING RETINA.—Hecht & others. (*Scient. American*, March 1941, Vol. 164, No. 3, p. 155: *Science*, 7th Feb. 1941, Vol. 93, Supp. pp. 44 and 46.)