THE

WIRELESS ENGINEER

VOL. XVI. JULY, 1939 No. 190

Editorial

Another Classic Experiment

LAST month we described an experiment made in 1905 by Professor H. A. Wilson to determine the e.m.f. induced in a cylinder of insulating material when rotating at a high speed inside a magnetising coil. This experiment was regarded as a crucial test discriminating between two schools of thought, one represented by Lorentz and Larmor and the other by Hertz. The result confirmed the views of the former that the e.m.f. induced in the insulating material is less than that which would be induced in a similar conducting cylinder rotated in the same magnetic field at the same speed, the e.m.f. being reduced from $n\phi$ to $n\phi(1 - 1/\kappa)$. The terminal p.d. is less than this by an amount depending on the internal and external capacitances so that $V = n\phi(1 - 1/\kappa) \dfrac{C}{C + C'}$ where C is the internal and C' the external capacitance. Even a megohm connected between the terminals would act as a dead-short and reduce V to zero; the induced e.m.f. would be unchanged but it would all be dropped in the internal capacitance.

Eight years later Prof. Wilson carried out another crucial experiment* of a somewhat similar but more complex character. If the rotating cylinder of insulating material were magnetic so that it not only had a dielectric constant κ but also a permeability μ, how would the induced e.m.f. be affected? To quote Wilson "According to the theory based on the principle of relativity this induced electromotive force should be equal to that in a conductor multiplied by $1 - (\mu\kappa)^{-1}$, . . . whereas the effect to be expected on the theory of H. A. Lorentz and Larmor depends on assumptions as to the constitution of the material medium. . . . These experiments therefore confirm the theory of relativity but do not necessarily conflict with the fundamental assumptions of H. A. Lorentz and Larmor's theory."

As no magnetic insulator is known, Wilson made a model of one. He took a number of small steel spheres $\frac{1}{8}$ inch diameter, coated them with sealing wax, packed them into a hollow brass cylinder, and poured in molten wax. This composite material was found to have a dielectric constant of 6 and a permeability of 3. This cylinder was then rotated at speeds up to 12,000 r.p.m. in an axial magnetic field produced by a water-cooled solenoid. The apparatus employed was that used in the earlier experiment at the Cavendish Labora-

* Marjorie Wilson & H. A. Wilson. *Proc. Roy. Soc.*, A 89, 1913, p. 99.

tory but these later tests were made at the Rice Institute, Houston, Texas, where H. A. Wilson is Professor of Physics. Now $1 - 1/\kappa = 0.83$ and $1 - 1/\mu\kappa = 0.944$; the experiments gave the value 0.96, thus confirming the latter formula.

Steel balls $\frac{1}{8}$in. diameter almost in contact and embedded in wax are such a far cry from a magnetic insulator that one might go a little further and make a model much more amenable to mathematical calculation. It is important to note that the permeability is only of interest in the axial direction since there is no magnetic field in any other direction. Similarly the dielectric constant is only of interest in the radial direction since this is the only direction in which there is any electric field. If one imagines a composite cylinder made up of a number of concentric metal cylinders with small air spaces, and if the fraction of the total radial depth occupied by metal is $1 - 1/\kappa$, then that occupied by air will be $1/\kappa$ and the resultant capacitance of the cylindrical condenser will be the same as if the whole space were occupied by a dielectric of constant κ. If the permeability of the metal of which the cylinders are made is μ_1 the resultant effective permeability μ in the axial direction is simply $\mu_1(1 - 1/\kappa) + 1/\kappa$ because $1 - 1/\kappa$ of the cross-section is occupied by the metal and $1/\kappa$ by air; hence $\mu = \mu_1 - (\mu_1 - 1)/\kappa$. We thus have a cylinder with a dielectric constant κ in the only direction in which the dielectric constant matters, and a permeability μ in the only direction in which the permeability matters. If μ and κ are specified, then we must use a metal with $\mu_1 = \dfrac{\mu\kappa - 1}{\kappa - 1}$, although this limitation could be avoided by combining magnetic and non-magnetic cylinders in certain proportions; also, of course, the dielectric employed cannot be entirely air but must be to some extent solid. If the fractions of the total radial depth occupied by brass of unit permeability, iron of permeability μ_1 and dielectric of constant κ_1, be α, β, and γ respectively, so that $\alpha + \beta + \gamma = 1$, the dielectric may be replaced in calculations by brass of radial depth $\gamma(1 - 1/\kappa_1)$ and air of depth γ/κ_1. The total equivalent depth of metal is therefore $\alpha + \beta + \gamma(1 - 1/\kappa_1)$; the effective radial dielectric constant κ of the whole mass is κ_1/γ and the effective axial permeability μ is $\mu_1\beta + \alpha + \gamma$. Thus with a given dielectric material γ is fixed by the required κ, and then the required μ fixes $\mu_1\beta + \alpha$; α and β are then determined by the μ_1 of the magnetic material available.

Assuming the simplest case of alternate cylinders of metal of $\mu_1 = \dfrac{\mu\kappa - 1}{\kappa - 1}$ and air, the fraction of the total flux that goes through the metal is

$$\frac{(1 - 1/\kappa)\mu_1}{(1 - 1/\kappa)\mu_1 + 1/\kappa} = \frac{(\kappa - 1)\mu_1}{(\kappa - 1)\mu_1 + 1}$$

$$= \frac{\mu\kappa - 1}{\mu\kappa} = 1 - \frac{1}{\mu\kappa}.$$

When the cylinder is rotated it is only the flux through the metal cylinder that is effective in the production of e.m.f. and if the total flux through the whole model is ϕ the induced e.m.f. will be $n\phi(1 - 1/\mu\kappa)$ as found by Wilson.

In the compound cylinder considered above the ratio of the effective flux-cutting radius to the total radius is easily seen to be

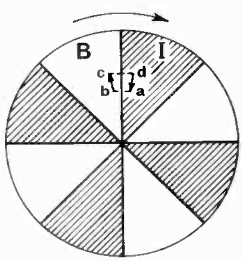
$$\frac{\mu_1\beta + \alpha + \gamma(1 - 1/\kappa_1)}{\mu_1\beta + \alpha + \gamma} = \frac{\mu - \gamma/\kappa_1}{\mu} = 1 - \frac{1}{\mu\kappa}.$$

Looked at in this way the question appears to have little to do with Lorentz or Larmor, or with the principle of relativity.

As in the case of the plain dielectric cylinder this induced e.m.f. is in series with the internal capacitance of the cylinder and the terminal p.d. is less than the e.m.f. by the amount Q/C.

It must be confessed that our concentric cylinder model of a magnetic dielectric, although lending itself to simple calculation, is less satisfying than Wilson's embedded spheres because its properties depend on the direction in which they are measured. In our opinion, however, this disadvantage is more than counterbalanced by the obvious advantage of being able to calculate the result by relatively simple methods applied to the cylinder itself. It may be thought at first sight that the case of the embedded spheres could be calculated simply by assuming the flux to be made up of two components, (*a*) that which would exist apart from the magnetic effect of the steel balls, i.e. if the balls were of brass, and (*b*) the additional flux due to the ferromagnetism of the balls. Cullwick adopts this method in his recent book* and assumes the first component to remain at rest with the cylinder rotating through it while the second component is supposed to go round like a sheaf of bristles and cut the external circuit. Unfortunately Cullwick goes astray, but, if correctly applied, this method of calculation—for it is nothing more—should give the correct result. Anyone who thinks that this reduces the problem to a simple one has only to attempt to calculate the e.m.f. on the assumption that Wilson used brass balls instead of steel ones.

A much simpler problem which is apt to worry the enquiring mind desirous of probing the mysteries of electromagnetism is the cylinder made up of alternate sectors of brass and iron revolving in an axial magnetic field. The problem is simplified by the omission of insulating material, but the principles are the same. We assume a long cylinder and neglect end effects. Let the flux density in the brass be B and that in



the iron μB, and let the velocity (relatively to the centre) at a given point be v, then if the point be in a brass sector the conductor is moving at velocity v through a magnetic field of flux density B, whereas if the point be in an iron sector it is moving through μ times the flux density and consequently inducing μ times the radial electric force. During a complete revolution, however, the total flux "cut" by any radius is the same whether in the brass or in the iron. Both these statements are correct, but the former is only half the truth. If the flux density is everywhere unchanging one can calculate the induced e.m.f. from the rate at which conductors are moving through the magnetic field, but when, as in this problem, the flux density is undergoing changes, the induced e.m.f. due to these changes must be taken into account. Consider the figure abcd of 1 cm radial depth to be stationary, i.e. not rotating with the cylinder, and assume that the flux is away from us into the paper, then at the moment shown when a junction between the iron and brass sectors is sweeping across the figure with the velocity v the e.m.f. induced around abcd will be $-d\phi/dt = (\mu B - B)v$ in the direction shown. Due to rotation in the fields the induced electric forces were Bv and μBv acting radially outwards, and we see that the induced e.m.f. $(\mu B - B)v$ must be equally divided between *bc* and *da*, so that the resultant value of the induced electric force in the brass is $Bv + \frac{\mu - 1}{2} Bv = \frac{\mu + 1}{2} Bv$, while that in the iron is

$$\mu Bv - \frac{\mu - 1}{2} Bv = \frac{\mu + 1}{2} Bv.$$

The e.m.f. induced in any radius must be the same whether in the brass or the iron because on open circuit the accumulation of charges must be such that they produce at every point in the metal an electric force equal and opposite to the induced electric force. Since this radial electric force due to the charges cannot undergo any discontinuity at the boundary between the brass and iron, the induced electric force must be the same on either side.

The same principles would apply if the cylinder consisted to some extent of insulating material but the conditions would become more complex, especially if discontinuities occur in the axial direction. The same result is obtained—apart from accidents—whether one bases the calculation on the rotation of the conducting mass in the magnetic field (by which term we mean space in which certain phenomena are observed with magnet poles and current-carrying conductors) or whether one gives play to his imagination and endows the lines of force with physical reality and pictures them going round with the iron like a sheaf of bristles cutting the stationary external circuit. G. W. O. H.

* *The Fundamentals of Electromagnetism*, p. 117.

Properties of Biased Diode Rectifiers*

By F. C. Williams, M.Sc., D.Phil., Grad. I.E.E., and Alan Fairweather, M.Sc., Grad. I.E.E.

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1. Introduction

In modern radio receivers there are many uses for biased diode rectifiers; they are used to provide A.V.C. voltages, "quiet tuning" and occasionally for signal rectification. Such rectifiers are required to furnish an output voltage which is either steady or varying at modulation frequency, and which is at all times very nearly equal to the peak voltage applied to the rectifier. We shall consider here only the derivation of a steady output voltage from a sinusoidal input voltage of constant peak value: the most important parameter to be discussed is the ratio of these two quantities, and will be denoted by the symbol K. J. Marique[1] has evaluated K for unbiased rectifiers, using a linear approximation to the diode characteristic, and the purpose of this contribution is to extend his analysis to biased rectifiers, and to check both discussions experimentally.

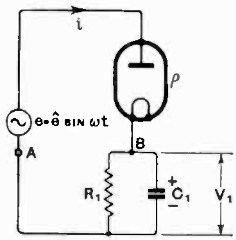

Fig. 1.

2. Analysis

Marique considered the circuit shown in Fig. 1 and assumed the valve characteristic to be as shown in Fig. 2. He evaluated $K\left(=\frac{V_1}{\hat{e}}\right)$ as a function of $R_1C_1\omega$ for various values of R_1/ρ. Two conditions are of interest, $R_1C_1\omega \gg 1$, the condition which holds in most radio applications, and $R_1C_1\omega \not\gg 1$. In the first condition, K is almost independent of $R_1C_1\omega$, and V_1 is sensibly smooth, but for the smaller values of $R_1C_1\omega$, this is not so, and V_1 then has an appreciable ripple component. Both conditions will be discussed in the sections which follow.

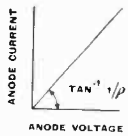

Fig. 2.

(a) $R_1C_1\omega \gg 1$

i. *Output voltage as a function of the peak input voltage.*

Marique's results relevant to $R_1C_1\omega \gg 1$ are shown in Fig. 3, which relates K to R_1/ρ: this has been prepared from Fig. 8 of his original paper.

The operation of the rectifier is illustrated in Fig. 4: potentials are reckoned relative to the point A in Fig. 1, the corresponding datum line in Fig. 4 being indicated by AA. Since $R_1C_1\omega \gg 1$, the output voltage, V_1, is sensibly steady throughout the cycle of input voltage. Current i flows in the diode

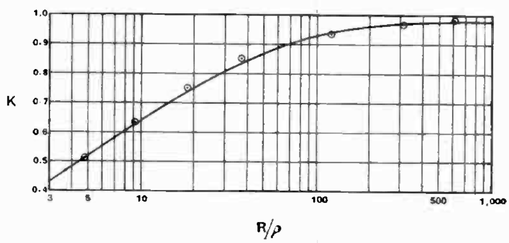

Fig. 3.

intermittently only, and V_1 adjusts itself so that the mean charge entering the condenser through the valve per cycle equals that leaking away through the resistance

* MS. accepted by the Editor, February, 1939.

per cycle ; hence in the steady state,

$$\frac{1}{T}\int_0^T i\,dt = \frac{V_1}{R_1} \quad \ldots \quad \ldots \quad (1)$$

$$\text{where } T = \frac{1}{f} = \frac{2\pi}{\omega}$$

also, by definition,

$$K = V_1/\hat{e} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

It has been shown elsewhere [2,3], that the effective input resistance of such a rectifier, R_{e1}, is given by

$$R_{e1} = R_1/2K \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$= R_1/2 \text{ (approx.)} \quad \ldots \quad \ldots \quad (4)$$

(An example of the use of this quantity has been given recently[4].)

The circuit of a positively biased rectifier is shown in Fig. 5 and its operation is illustrated in Fig. 6. Comparison of Figs. 4 and 6 shows that, so far as diode conduction is concerned, the operation is the same as before except that the composite voltage,

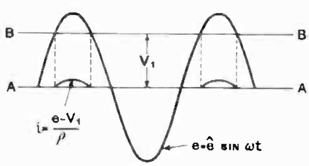

Fig. 4

$$V_3 = V_2 - E_b \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

replaces V_1. In this case V_3 adjusts itself until

$$\frac{1}{T}\int_0^T i\,dt = \frac{V_2}{R_2} \quad \ldots \quad \ldots \quad (6)$$

(*cf.* (1)). The new definition of K corresponding with (2) is clearly

$$K_b = V_3/\hat{e} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

where the subscript "b" indicates the presence of bias. If the values of $\hat{e}$ and ρ in Figs. 1 and 5 are identical, it follows that for any given value of R_1 in Fig. 1 there must be some value of R_2 in Fig. 5 which will make

$$V_3 = V_1 \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

and K_b, therefore, identical with K. Comparison of Figs. 4 and 6 shows that the diode current in each case will be identical ; hence from (1) and (6)

$$V_1/R_1 = V_2/R_2 \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

and substituting for V_2 from (5)

$$V_1/R_1 = (V_3 + E_b)/R_2 \quad \ldots \quad \ldots \quad (10)$$

It follows from (7), (8) and (10) that

$$R_1 = \left(\frac{K\hat{e}}{K\hat{e} + E_b}\right) R_2 \quad \ldots \quad \ldots \quad (11)$$

which equation yields the value of R_2 necessary to the assumed equality of V_1 and V_3. The subscript "b" can now be omitted since, by hypothesis, K and K_b are always equal. Since we are more concerned with the ratios between the various parameters than with their absolute magnitudes, it is desirable to divide (11) throughout by ρ, and to assign a symbol to the ratio $\hat{e}/E_b$. We shall write, therefore,

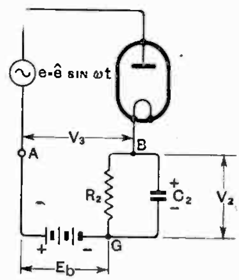

Fig. 5.

$$\phi = \hat{e}/E_b \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

and (11) becomes, accordingly,

$$\frac{R_1}{\rho} = \left(\frac{1}{1 + 1/K\phi}\right)\frac{R_2}{\rho} \quad \ldots \quad \ldots \quad (13)$$

which may be written

$$\phi = \frac{R_1/\rho}{K[(R_2/\rho) - (R_1/\rho)]} \quad \ldots \quad (14)$$

The value of K relevant to any value of R_1/ρ can be found from Fig. 3 and, with a given value of R_2/ρ, (14) yields the value of ϕ at which this value of K will obtain with a biased rectifier. By assigning a series of such values to R_2/ρ it is possible to prepare a family of curves showing the relationship between ϕ and K for different values of R_2/ρ. This has been done in Figs. 7 and 8 which relate, respectively, to positive* and negative values of bias—and, therefore, to

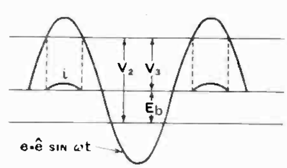

Fig. 6.

* Fig. 5 defines the sense of positive bias.

positive and negative values of ϕ. It may be seen that, provided $R_2/\rho > 500$, K is sensibly independent of ϕ throughout the ranges (1 to $+\infty$) and ($-\infty$ to -1.25): the curve for $R_2/\rho = 500$ has been omitted in Fig. 8 but it is evidently even flatter than that for $R_2/\rho = 200$. It is of interest to discuss the general shape of these curves, especially since this permits the evaluation of asymptotes to which the curves tend outside the scope of the figures.

Fig. 7, which relates to positive values of ϕ and E_b, will be discussed first. When R_1/ρ is zero it is clear that K is also zero: the corresponding value of ϕ is, however, indeterminate, as can be seen by reference to (14). This difficulty can be avoided by evaluating K for $\phi = 0$: thus, with finite bias, ϕ is zero only when $\hat{e}$ is zero, when, from Fig. 5,

$$[V_2]_{\hat{e}=0} = \left(\frac{R_2}{R_2 + \rho}\right) E_b \quad \ldots \quad \ldots \quad (15)$$

Hence, from (5), $[V_3]_{\phi=0}$ is negative, and from (7), $[K]_{\phi=0}$ is $-\infty$. As R_1/ρ increases towards R_2/ρ ϕ approaches $+\infty$ and K approaches Marique's values relevant to R_2/ρ in an unbiased rectifier. This is otherwise obvious since ϕ is ∞ when E_b is zero. Hence each curve of Fig. 7 is asymptotic to the value read off Fig. 3 corresponding with R_1/ρ equal to the particular value of R_2/ρ relevant to that curve.

Referring now to Fig. 8, this is best considered as the lower part of the range from $\phi = -\infty$ to lower numerical values of ϕ. From (14) ϕ is $-\infty$ when R_1/ρ is infinitesimally greater than R_2/ρ. Hence, the curves of Fig. 8 have the same asymptotes as those of Fig. 7: this is again physically obvious since ϕ is $-\infty$ when E_b is -0. Further increase of R_1/ρ towards ∞ will increase ϕ towards -1 (see (14)), and, correspondingly, K, from Fig. 3, will approach unity.

There remains to be considered the range of ϕ between 0 and -1: this corresponds with negative values of R_1/ρ and R_2/ρ in (14), and, therefore, any results deduced from it would have no practical significance.

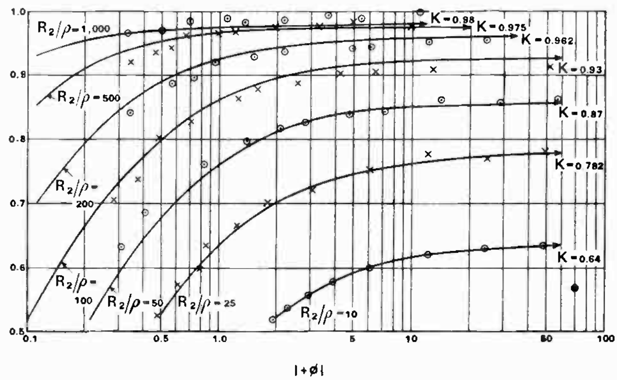

Fig. 7

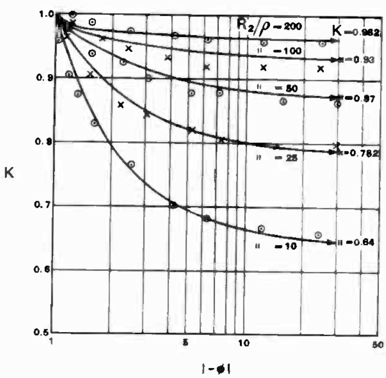

Fig. 8

The actual value of K in this range can be deduced as follows: from (5) and (7)

$$K = (V_2 - E_b)/\hat{e} \quad \ldots \quad \ldots \quad (16)$$

But from Fig. (5), with E_b negative and $\hat{e} < |E_b|$, there will be no conduction in the diode, hence V_2 is zero and

$$\left.\begin{aligned} K &= -E_b/\hat{e} \\ &= -1/\phi \end{aligned}\right\} \quad \ldots \quad \ldots \quad (17)$$

Since ϕ is negative, and ranges from 0 to -1, K ranges from $-\infty$ to $+1$. This completes the graph of K, but the results are without practical value since the output voltage, $K\hat{e}$, is $-E_b$ throughout, and the diode is effectively out of circuit.

It is of interest to note that (5) may be written

$$V_2/E_b = 1 + K\phi \quad \ldots \quad \ldots \quad (18)$$

Hence V_2 does not become a linear function of $\hat{e}$ until V_2/E_b becomes a linear function of ϕ, and this does not happen until K is sensibly independent of ϕ: such linearity is desirable in radio rectifiers.

The effective input resistance of the biased rectifier, R_{e2}, follows quite readily: since, by hypothesis, the currents drawn by the biased and unbiased rectifiers are indentical, their effective input resistances are also identical. Hence

$$R_{e2} = R_{e1}$$
$$= R_1/2K \quad \text{from (3)}$$

or from (13)

$$R_{e2} = \left(\frac{1}{1 + 1/K\phi}\right) \frac{R_2}{2K} \quad \ldots \quad (19)$$

and it is worth noting that

$$[R_{e2}]_{\phi = \mp\infty} = \frac{R_2}{2K} \quad \ldots \quad \ldots \quad (20)$$

ii. *Output voltage as a function of the peak input voltage and the bias.*

In the previous section V_3 was regarded as the output voltage of the rectifier and $\hat{e}$ as the input voltage: this was convenient for the derivation of K. More usually the output voltage of interest is V_2, the voltage across R_2. This is most conveniently related to $(\hat{e} + E_b)$, but if the relation between V_2 and $\hat{e}$ is required, it can readily be deduced from the results which follow, though it is not readily shown graphically. Accordingly, taking $(\hat{e} + E_b)$ as the input voltage, let

$$K' = \frac{V_2}{\hat{e} + E_b} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

and from (5) and (7)

$$V_2 = K\hat{e} + E_b \quad \ldots \quad \ldots \quad (22)$$

Thus

$$K' = \frac{K\hat{e} + E_b}{\hat{e} + E_b} \quad \ldots \quad \ldots \quad (23)$$

which may be written

$$K' = \frac{1 + K\phi}{1 + \phi} \quad \ldots \quad (24)$$

Curves showing the relationship between K and ϕ for various values of R_2/ρ have already been calculated and are given in Figs. 7 and 8. Using these, (24) enables a similar family to be drawn giving the relationship between K' and ϕ for various R_2/ρ: this has been done in Figs. 9 and 10 for positive and negative values of ϕ respectively. In order to include the origin in Fig. 9 without making the curve sheet unduly lengthy, it was found desirable to divide the range of $+\phi$ into two portions, and to use different scales for each. Thus the scale of $+\phi$ is linear for values of $+\phi$ from zero to $+0.5$, and logarithmic thereafter. The general shape of these curves is of some interest and will be briefly discussed.

It was shown in the previous section that the ranges of ϕ of practical interest, are (0 to $+\infty$) and (-1 to $-\infty$). When ϕ is 0 it follows from (15) and (21) that K' is $R/(R + \rho)$: as ϕ tends to $\mp\infty$, K' approaches K. When ϕ is -1, K is 1, and (24) takes the indeterminate form 0/0: evaluation of this in the usual manner

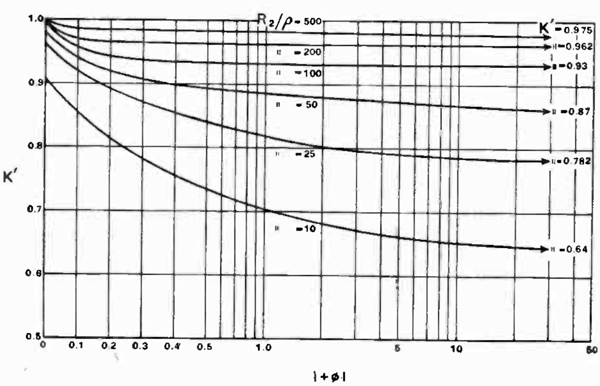

Fig. 9

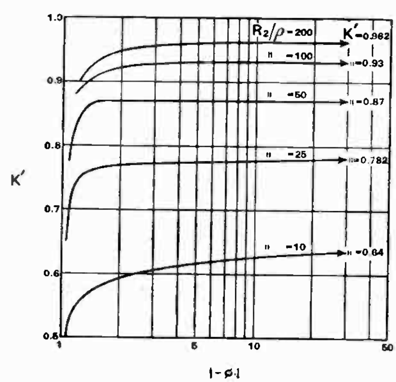

Fig. 10

gives

$$[K']_{\phi=-1} = \left[\frac{\dfrac{d}{d\phi}(1+K\phi)}{\dfrac{d}{d\phi}(1+\phi)}\right]_{\phi=-1} \quad .. \quad (25)$$

$$= \left[K + \phi\frac{dK}{d\phi}\right]_{\phi=-1} \quad .. \quad (26)$$

$$= \left[1 - \frac{dK}{d\phi}\right]_{\phi=-1} \quad .. \quad (27)$$

From (14)

$$K = \frac{1}{\phi}\left[\frac{R_1}{R_2 - R_1}\right] \quad .. \quad .. \quad (28)$$

where, under the conditions envisaged, R_2 is a constant.

Hence,

$$\frac{dK}{d\phi} = \frac{-1}{\phi^2}\left[\frac{R_1}{R_2 - R_1}\right] + \frac{1}{\phi}\left[\frac{\dfrac{dR_1}{d\phi}(R_2 - R_1) + R_1\dfrac{dR_1}{d\phi}}{(R_2 - R_1)^2}\right] \quad .. \quad (29)$$

which, on substituting for $R_1/(R_2 - R_1)$ from (28) and simplifying, becomes

$$\frac{dK}{d\phi} = \frac{1}{\phi}\left[-K + \frac{R_2\dfrac{dR_1}{d\phi}}{(R_2 - R_1)^2}\right] \quad .. \quad (30)$$

When ϕ is -1, K is 1 and R_1 is ∞, so

$$\left[\frac{dK}{d\phi}\right]_{\phi=-1} = 1 \quad .. \quad .. \quad (31)$$

and on substituting this in (25) it follows that

$$[K']_{\phi=-1} = 0 \quad .. \quad .. \quad (32)$$

a result which is in accord with physical argument since, as ϕ moves infinitesimally towards zero from -1, conduction in the diode becomes impossible, so that V_2 is zero whereas $\hat{e}$ and E_b are not.

The expression for the input resistance R_{e2} given in (19) may be rewritten in terms of K': thus from (24)

$$K = \left[\frac{K'(1+\phi) - 1}{\phi}\right] \quad .. \quad (33)$$

and (19) may be written

$$R_{e2} = \frac{R_2}{\dfrac{2}{\phi}(K\phi + 1)} \quad .. \quad .. \quad (34)$$

which becomes, on substituting for K from (33)

$$R_{e2} = \frac{R_2}{2K'(1 + 1/\phi)} \quad .. \quad .. \quad (35)$$

Figs. 9 and 10 are useful in studying the behaviour of resonant circuits loaded by biased diodes: one of the authors has recently discussed the application of such circuits to modulation as well as rectification[5]. In that paper K' was treated as sensibly independent of ϕ, an assumption which these curves show sufficient throughout the ranges ($-\infty$ to -2.0) and (0.3 to $+\infty$) provided $R_2/\rho > 100$. It is important in all applications of biased diodes to the rectification of modulated signals to know within what limits ϕ may lie, without serious cyclic variations of K' being introduced. If such variation occurs during the modulation cycle, harmonic distortion ensues. The curves suggest that, in practice, a value of $R_2/\rho > 500$ is sufficient to ensure satisfactory rectification for all likely values of ϕ. The curve for $R_2/\rho = 500$ has been omitted from Fig. 10 to avoid cramping; it is considerably flatter than that for $R_2/\rho = 200$.

(b) $R_1C_1\omega \gg 1$

Let us suppose that Figs. 1 and 5 relate to conditions where $R_1C_1\omega \not\gg 1$: then, Figs. 4 and 6 which describe the rectification process when $R_1C_1\omega \gg 1$, are replaced by Figs. 11 and 12. In both these figures

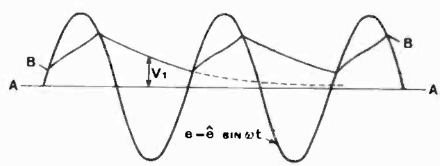

Fig. 11.

the descending portion of the output voltage curve is a segment of an exponential curve; in the non-biased case, Fig. 11, it is falling towards AA, and in the biased case, Fig. 12, towards a line GG displaced E_b below AA. Thus, precise geometrical similarity between the two figures is impossible since the decaying exponential segments tend to different limits. However, if the ripple components of the output voltages are fairly small, these segments are sensibly straight, and approximate geometrical similarity will be ensured by simply equating the mean ordinates (from AA) and the mean slopes of the two segments.

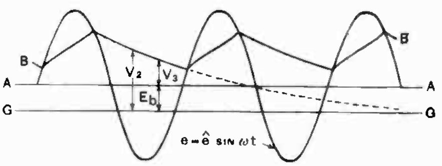

Fig. 12.

Considering the first of these, and following the method of the preceding section, suppose the two figures to be similar as regards input and output voltages. The necessary conditions can then be described approximately by an anlaysis identical with that given in (5) *et seq.*, provided that the mean values of V_1, V_2 and V_3 are considered instead of the sensibly steady values which they have when $R_1C_1\omega \gg 1$. Let the added subscript "m" denote the mean value of the quantity concerned: the mean currents through the diodes will again be equal and, as in (9), it follows that

$$V_{m1}/R_1 = V_{m2}/R_2 \quad \ldots \quad \ldots \quad (36)$$

and similarly, as shown in (8), (5) and (13)

$$V_{m3} = V_{m1} \quad \ldots \quad \ldots \quad \ldots \quad (37)$$

$$= V_{m2} - E_b \quad \ldots \quad \ldots \quad (38)$$

and

$$R_1 = \left(\frac{1}{1 + 1/K\phi}\right) R_2 \quad \ldots \quad (39)$$

This equation sets the necessary relative values for R_1 and R_2 in order that the values of K in the two cases shall be equal, and demands the equality of V_{m3} and V_{m1}.

The criterion for approximate equality of mean slope follows quite readily: if a condenser C be discharged through a resistance R, then the slope of the exponential curve relating condenser voltage with time t, at an instant when this voltage is V, is V/RC. Hence, if we assume that the mean value of the voltage during the decaying epoch differs insensibly from the mean value throughout the whole cycle, it is necessary that

$$V_{m1}/R_1C_1 = V_{m2}/R_2C_2 \quad \ldots \quad \ldots \quad (40)$$

and therefore from (36) that

$$C_1 = C_2 \quad \ldots \quad \ldots \quad \ldots \quad (41)$$

Marique has given the values of K relevant to Fig. 11 as a function of $R_1C_1\omega/2\pi$ for various values of R_1/ρ: it follows from (39) and (41) that these values will apply to biased rectifiers if they are interpreted as values of K as a function of $R_2C_1\omega/(1 + 1/K\phi)2\pi$ for various values of $R_2/(1 + 1/K\phi)\rho$. They thus permit calculation of the lowest permissible value of $R_2C_2 (= R_2C_1)$, consistent with a high value of K, for given values of ϕ and R_2/ρ. It is often desirable to use this minimum value in radio receivers if distortion is to be avoided. The values of K could also be deduced and sets of curves such as those given for $R_1C_1\omega \gg 1$ might be drawn. These would, however, include the further parameter $R_2C_2\omega$, and would involve reference to Marique's curves relating K and θ/T ($\theta = R_1C_1$ and $T = 2\pi/\omega$). In fact, however, the dependence of K on $R_1C_1\omega$ is not very marked until values of $R_1C_1\omega$ are reached corresponding with a very pronounced ripple. Thus the curves obtained in the range of interest, which is confined to small ripples, would differ insensibly from those given.

3. Influence of Curvature of Valve Characteristics

A typical valve characteristic, that of a Mazda D1 is shown in Fig. 13 curve (a). It may be seen at once that it differs from Marique's idealised characteristic in three ways: it is only approximately straight at the higher currents; when extended this "straight" part does not pass through the origin; and finite reverse potential is necessary to reduce the flow of current to negligible proportions. A straighter curve can be obtained by putting resistance in series with the diode and curve (b) shows the result

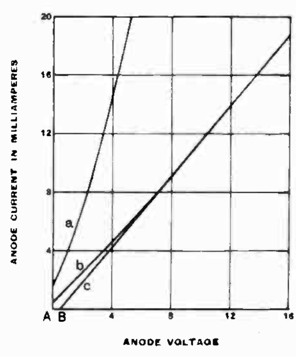

Fig. 13.

of adding 500 ohms of metallic resistance in series with the anode. The characteristic is now closely linear over a wide range, but still does not pass through the origin when extended, (c): it intersects the positive voltage axis. With such a linear approximation to the characteristic, anode current would not flow until the attainment of a certain positive potential given by the intercept AB in Fig. 13: this potential may be termed the "inherent bias" of the diode. Thus the *extended* characteristic may be made to pass through the origin by adding such positive potential in series with the anode. The resulting composite diode approximating to Marique's idealisation is shown in Fig. 14. In later figures the whole of Fig. 14 will be represented by the usual diode symbol.

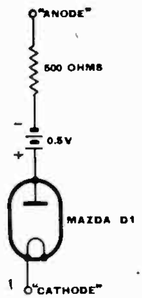

Fig 14.

This composite diode still differs from the ideal in that, although the *extended* characteristic passes through the origin, the *actual* characteristic does not and is, moreover, curved at the foot: thus i is not zero when $\hat{e}$ is zero. We shall not, therefore, expect Marique's values of K to hold until the excursions of $(\hat{e} - V_1)$ are such as to lie mainly on the straight part, i.e. with large

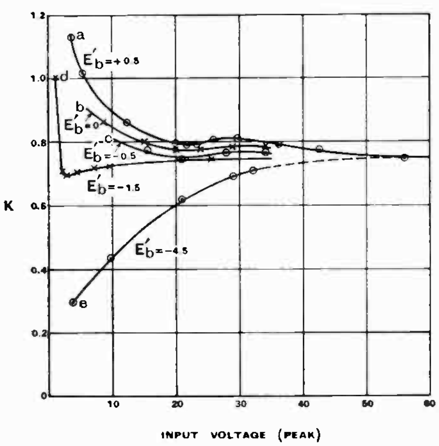

Fig. 15.

values of $\hat{e}$. When $\hat{e}$ is 0, V_1 is not 0 and K, therefore, is ∞. It follows that, as $\hat{e}$ increases, K should approach Marique's values from ∞. The manner of approach will, of course, depend upon the shape of the valve characteristic. Fig. 15 shows several possible forms: the first of these, marked (a), $E'_b = +0.5$, was taken with the composite diode of Fig. 14, the second (b) with the bias battery removed, and the third (c) with the bias battery re-inserted in the opposite sense: in the fourth and fifth the bias battery voltage was increased from 0.5 to 1.5 and 4.5 respectively. The shape of these latter two is most easily explained: thus, consider the conditions relevant to a high negative value of E'_b; then the finite electron emission energies will ensure that some current still flows with $\hat{e}$ zero and K therefore is ∞. As $\hat{e}$ tends to ∞, the bias becomes negligible, and K approaches Marique's value; but as $\hat{e}$ is reduced, K must fall as the negative bias becomes progressively more important, for negative bias in series with the anode must tend to reduce the output voltage of the rectifier. Hence, with these requirements, the only possible shape for the curve relating K and $\hat{e}$ is that typified by the two lowest curves (d) and (e). With positive E'_b, the same argument shows that K must approach Marique's value from above as K tends to ∞.

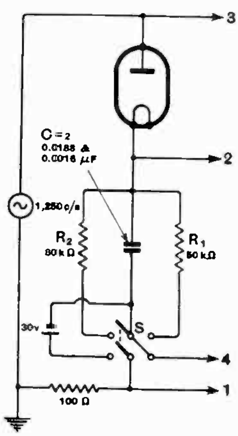

Fig. 16.

Hence curves (a), (b) and (c) are in accord with expectation for positive bias, the general shape being the same as that of (d) and (e) with a kink clearly in evidence.

These curves indicate that the dependence of K on $\hat{e}$ becomes very small when $\hat{e}$ exceeds 50 volts peak and it is to these final values that Marique's analysis properly applies. Care was therefore taken in the experiments to keep $\hat{e}$ greater than 50 volts wherever possible.

4. Experimental Check

Before proceeding to a detailed quantitative check of the curves deduced in the preceding section it was thought worth while to check oscillographically the equivalence principle upon which the curves are based. For this purpose the circuit of Fig. 16 was set up. Change from the biased to the non-biased régime could rapidly be effected by means of the switch S. The leads marked 1, 2, 3 and 4 were taken to the four "live" input terminals of the recently described multi-channel oscillograph amplifier[6]. Thus it was possible to observe simultaneously curves of input voltage, output voltage (V_3 or V_1), bias voltage and diode current. This last was observed as a P.D. across the 100 ohms resistance which was small enough to have no appreciable effect on the operation of the circuit.

The oscillograms correspond with those sketched in Figs. 4 and 6 and 11 and 12. The value of R_1/ρ was 41.6, that of R_2/R_1 was 1.6 and the bias voltage was 30.

The first pair, Fig. 17 (a) and (b), was designed to illustrate the essential difference between unbiased and biased régimes; for this purpose a low value of $R_1C_1\omega$ (0.625) was used and permitted observation of the trend of the descending exponential segment. In (a), which relates to the unbiased case, it tends to the zero line whereas in (b) it tends to the bias line.

The next pair, Fig. 18 (a) and (b) relates to $R_1C_1\omega \gg 1$ (785) and in obtaining it the input amplitude was adjusted until operation of the switch gave no observable change in the height of the diode current pulse. Such adjustment corresponds with choosing ϕ to satisfy (14) and inspection of the oscillograms shows them to be closely similar, in fact superposition of the original plates failed to reveal any detectable difference. From the oscillograms the values of K and ϕ were found to be 0.84 and 2.15 respectively; substitution in (13) yields a value of 1.56 for R_2/R_1 which compares favourably with the actual value of 1.6 quoted earlier. Thus the first equivalence principle is established.

The last pair, Fig. 19 (a) and (b) relates to $R_1C_1\omega \not\gg 1$ (7.4) and establishes the validity of the second equivalence principle. It is, perhaps, worth noting that the equivalence holds even when the ripple is such as to yield values of K different from Marique's limiting values, but the first pair of oscillograms, Fig. 17 (a) and (b), shows that there

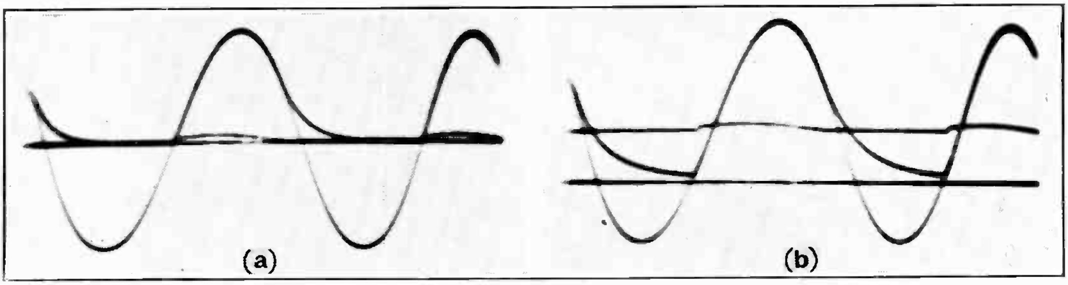

Fig. 17.

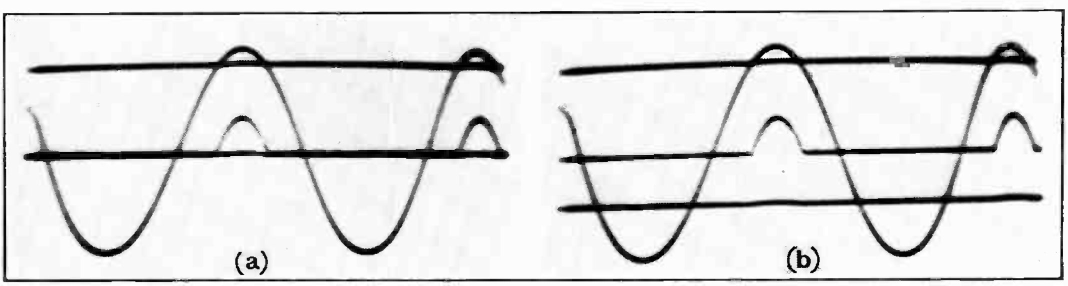

Fig. 18.

is a value of $R_1C_1\omega$ below which the equivalence ceases to hold.

A complete quantitative check of the curves was then undertaken.

The circuit used is shown in Fig. 20. Since Marique's analysis relates essentially to sinusoidal input voltages, the first consideration in setting up the apparatus was to ensure a low harmonic content in the input voltage to the rectifier. The signal frequency employed was 1,000 c/s and was derived from a heterodyne oscillator, the output from which was known to contain less than 5 per cent. of harmonic distortion. The signal was passed through a series resonant circuit, the Q (i.e. quality $= X/R$ where X and R are element reactance and total circuit resistance respectively) of which never fell below 20, even when loaded by the rectifier. The harmonic content of the rectifier voltage due to distortion of the original signal was, therefore, entirely negligible. There is, however, a second source of distortion in that the rectifier draws a current rich in harmonics which traverses the resonant circuit and develops harmonic voltages across it : this will now be considered in some detail. It has been shown[3] that if A_0 is the steady component of rectifier current, the amplitude of the first few sinusoidal components is $2A_0$, i.e. the amplitudes of the fundamental and low order harmonic components of rectifier current are equal. The impedance presented by the resonant circuit at the nth harmonic frequency is approximately $1/nC_R\omega$, since the high impedance shunt due to L_R may be neglected. If R_e is the effective input resistance of the rectifier, the amplitude of the fundamental current component it draws is $\hat{e}/R_e$, and hence the amplitudes of the low order harmonic current components are also $\hat{e}/R_e$. If $\hat{e}_n$ denotes the peak value of the nth harmonic voltage developed across C_R, it follows that

$$e_n = \left(\frac{\hat{e}}{R_e}\right)\left(\frac{1}{nC_R\omega}\right) \quad \ldots \quad \ldots \quad (39)$$

and if the ratio $(\hat{e}_n/\hat{e})$ be denoted by the symbol r_n, then

$$r_n = 1/(nR_eC_R\omega) \quad \ldots \quad \ldots \quad (40)$$

With E_b zero R_e has the approximate value $R_1/2$ given in (4) and, therefore,

$$r_n = 2/(nR_1C_R\omega) \quad \ldots \quad \ldots \quad (41)$$

In the experiments, $1/C_R\omega$ was approximately 120 ohms, and hence values of R_1 as low as 6,000 ohms could be used without introducing more than 2 per cent. second harmonic ; actually the lowest value used was 3,000 ohms yielding 4 per cent. second harmonic. The higher harmonics decrease in amplitude from these figures in the ratio $2/n$ and soon become entirely negligible.

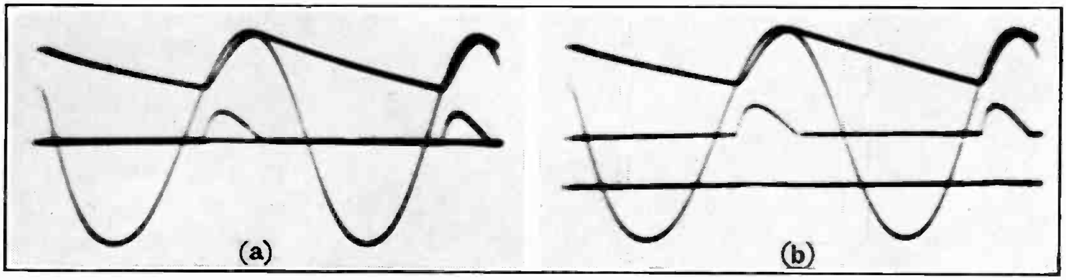

Fig. 19.

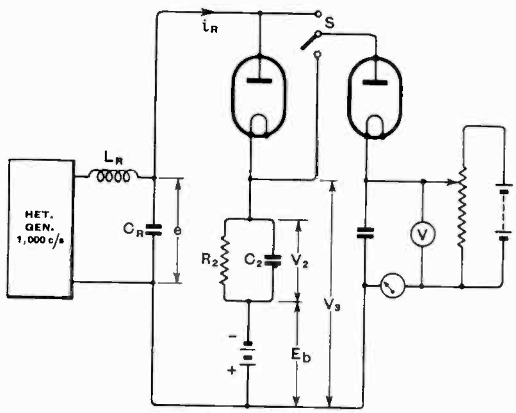

Fig. 20.

For the biased case it was shown in (19) that

$$R_{e2} = \left(\frac{1}{1 + 1/K\phi}\right) \frac{R_2}{2K}$$

and again care was taken to ensure that this did not fall below 3,000 ohms during the experiments.

It is unlikely that a harmonic content of this order will seriously affect the value of K provided the actual peak value of input voltage is measured, and is not deduced from a measurement of the R.M.S. or arithmetic mean value. In any event, these figures only obtain for a few measurements at low values of K: for over 70 per cent. of the actual measurements R_e was such that the second harmonic was less than 1 per cent. of the fundamental. A slide-back voltmeter of conventional design was employed to measure $\hat{e}$ directly; it drew a current of 2μA only, and so neither damped the circuit, nor introduced further harmonics. The same voltmeter was used to measure V_1 and V_2, since an ordinary one would have shunted R_1 and R_2 appreciably, and would also have reduced the effective value of E_b at the cathode. Discrepancies between instruments were also avoided and the only possible source of error lay in the difference between the A.C. and D.C. calibrations of the slide-back voltmeter. Accordingly it was calibrated with D.C. and 50 c/s A.C. against a substandard D.C./A.C. instrument; the A.C. mains were used for the purpose and were assumed sinusoidal.

The first experiments were designed to check Marique's figures, and the composite diode of Fig. 14 was employed. E_b was put equal to zero and $\hat{e}$ and V_3 measured in turn by using the switch S: several values of R_2 were used and the results are plotted on Fig. 3, where the full line curve shows the calculated relationship between K and R_1/ρ. Throughout the tests the product $R_1C_1\omega$ was kept $\gg 1$, otherwise the measurement of V_3 would have been inaccurate, since the peak value of any superposed ripple would have been recorded, and Marique's results would not have held. Agreement is seen to be excellent, the average error being of the order of 0.1 per cent.

An identical technique was used to check the curves for biased rectifiers: the results of these tests are shown on Figs. 7 and 8 and again agreement is satisfactory. The equivalence developed in Section 2(a)i. is thus fully substantiated.

Acknowledgment

The research described in this paper was carried out partly in the Signalling Apparatus Laboratory of the Post Office Engineering Research Station and partly in the Electrotechnics Department of the Victoria University of Manchester. The authors' thanks are due, therefore, to Captain B. S. Cohen, O.B.E., F.Inst.P., M.I.E.E., to W. G. Radley, Esq., B.Sc., Ph.D., M.I.E.E., and to Professors R. Beattie, D.Sc., and Willis Jackson, D.Phil., D.Sc., for the facilities provided.

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Television Receiver Construction

FROM the offices of *Television and Short-Wave World*, 37/8, Chancery Lane, London. W.C.2, has been published a 2s. 6d. handbook entitled "Building Television Receivers at Home." In this book, which contains 112 pages and 97 diagrams and illustrations, are given constructional details of three receivers with twelve-inch, four-inch and one-inch cathode-ray tubes. The material in this book is reprinted, with revisions, from contributions to *Television and Short-Wave World*.

Lanchester's "Potted Logs"

A 28 pp. booklet published by Taylor and Francis, Ltd., Red Lion Court, Fleet Street, London, E.C.4, price 2s., combines the previously published Parts I and II of Lanchester's "Potted Logs." Seven-figure common logarithms tabulated in five pages in a form suitable for interpolation by slide rule are given in the first part. Part II gives a similar basis for natural logarithms and a useful table in anti-log form to the base 1.059463 for calculating musical scales.

Tung-Sol Valve Data

A LOOSE-LEAF book of data sheets for Tung-Sol valves has been received. Characteristics of about 130 American types are given and the book is obtainable from the Commercial Engineering Dept., Radio Tube Division, Tung-Sol Lamp Works, Inc., Newark, N.J., U.S.A., at $1.50.

Experimental Ultra-Short-Wave Transmitter*

Frequency Range 100-150 M/cs: Power 200 watts

By J. S. McPetrie, D.Sc., A.M.I.E.E., and C. G. Carter

(Radio Department, National Physical Laboratory)

SUMMARY.—The paper contains a brief description of an experimental ultra-short-wave transmitter and aerial system which has been installed at the National Physical Laboratory, Teddington, for research on the propagation of waves in the wavelength range 2–3 metres (frequencies 100–150 Mc/s.)

Transmitter

It was decided that for the type of research envisaged the transmitting system should be capable of radiating on wavelengths of either 2 or 3 metres with perhaps occasional use on intermediate wavelengths. A convenient design of transmitter for this purpose was considered to be one consisting of a simple uncontrolled oscillator working on the waveband 4-6 metres followed in turn by a frequency doubling and amplifying stage.

The circuit arrangement is shown in Fig. 1, the dotted lines indicating roughly the three stages of the transmitter. The oscillator stage is of the conventional series Hartley form with a blocking condenser C_2 of capacitance 20 $\mu\mu$F between the resonant circuit L_1, C_1 and the grid of the valve V_1. In order to decrease the inductance introduced by connecting leads, this condenser (C_2) is constructed of three copper plates $\frac{1}{2}$in. × $\frac{1}{2}$in. × $\frac{1}{8}$in. separated by mica insulation; the centre plate forming one electrode fits directly over the grid pin of the valve V_1, which in the type used is at the top of the glass envelope, while the other two plates are connected together and to the circuit

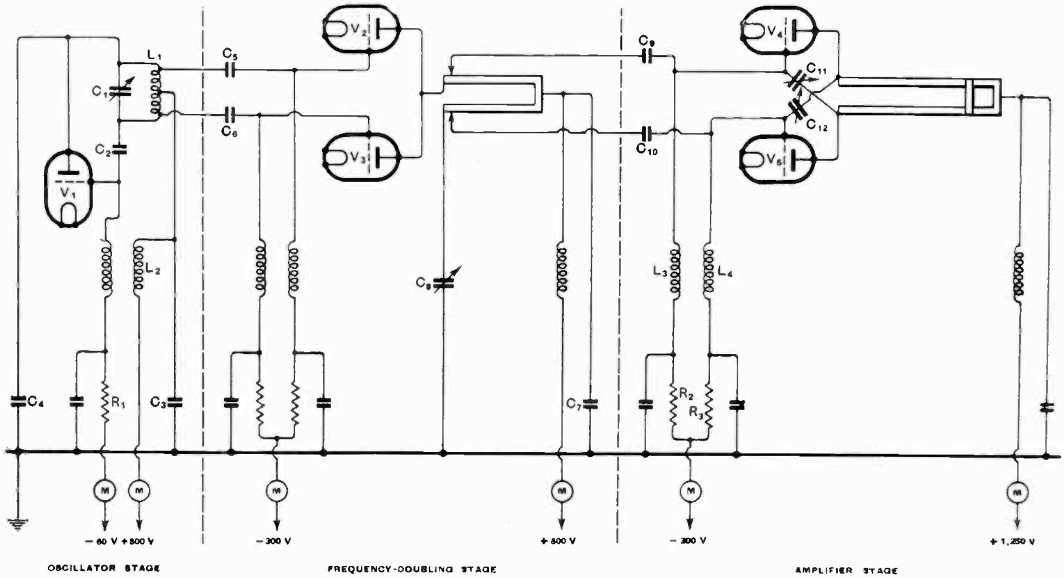


Fig. 1.—*Schematic diagram of the ultra-short-wave transmitter.*

* MS. accepted by the Editor, March, 1939.

by wide copper strip. The anode supply current passes through a choking coil L_2 to the mid-point of the coil L_1, which consists of three air-spaced turns of $\frac{1}{4}$in. copper rod wound to a diameter of approximately 2in. In order to ensure that equal and opposite voltages with respect to earth should be impressed on the grids of the frequency-doubling stage, the centre of the coil L_1 is earthed by a condenser C_3 of 80 $\mu\mu$F capacitance, and a small condenser C_4 equivalent approximately to the grid filament capacitance of the valve V_1 is introduced between the anode end of the coil L_1 and earth. A choking coil and condenser by-pass system is connected in the grid circuit to prevent large high-frequency currents flowing in the 20,000 ohm grid resistance R_1. The ends of the coil L_1 are attached directly to the $\frac{1}{16}$in. copper plates of the tuning condenser C_1 which has a maximum capacitance of 30 $\mu\mu$F. A drawing of this condenser is given in Fig. 2 from which it will be noted that the fixed plates are supported on ceramic insulators on a copper spider which also forms the bearing for the rotor. By means of two tapping leads of copper strip arranged symmetrically about the mid-point of the oscillator coil L_1 equal and opposite voltages are impressed on the two grids of the frequency-doubling stage which is separated from the oscillator by a copper screen.

The two blocking condensers C_5, C_6, between the oscillator and frequency-doubling stages are each of 80 $\mu\mu$F capacitance and are similar in construction to the grid-blocking condenser C_2 in the oscillator circuit. One plate of each of these condensers is mounted on a copper rod which passes through a ceramic bush into the frequency-doubling compartment of the transmitter. At the far end of these rods are connectors constructed so that they can be made to engage with contact plates fitted to the grid pins of the frequency-doubling valves V_2 and V_3. Similar contact plates were constructed for the anode pins of these valves so that the valves can be pushed into position with a minimum amount of connecting leads. These plates along with spring contacts fitted to the filament pins serve to hold the valves rigidly in position. Since the grids of this stage are fed in push-pull the anodes must be connected in parallel in order to obtain frequency doubling. This is arranged by connecting the two anodes together by wide copper strip to one end of the anode circuit which is in the form of a Lecher wire system. In order to preserve the symmetry of the complete system so that the final amplifier stage can again be fed in push-pull connection, a condenser C_7 of 80 $\mu\mu$F capacitance is connected between the centre of the anode circuit and earth, and a second small condenser C_8 between the end of the anode circuit remote from the anodes and earth.

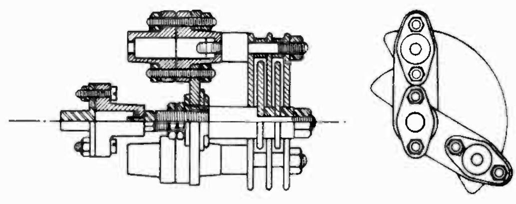


Fig. 2.—*Tuning condenser (ceramic insulation and copper) for ultra-short-wave transmitter.*

This small condenser is required to simulate the anode-earth impedances of the two frequency-doubling valves and as their reactances are not wholly capacitive, readjustment of its capacitance is necessary for each change in frequency of the transmitter.

The output power of the frequency-doubling unit is 40–50 watts, which is more than sufficient to drive the amplifier stage. The connection between the intermediate and final stages is essentially the same as that between the oscillator and frequency-doubling stages, the blocking condensers C_9 and C_{10} each having a capacitance of 80 $\mu\mu$F. Grid-bias to the amplifier stage is provided by a machine through resistances R_2, R_3 and choking coils L_3, L_4. In order to obtain as high an efficiency as possible the resonant circuits in the anode circuits of both frequency-doubling and amplifier stages are in the form of spaced copper lines, the frequency being altered by change in the positions of bridges on the lines. It was found essential to keep the reactances of these bridges as small as possible. This requirement was met best by clamping a pair of relatively large (3in. × 3in.) copper plates across the two copper rods forming the lines. The increase in output obtained in this way over that with ordinary apparently low impedance bridges was almost 100 per cent. Neutralisation by condensers C_{11}, C_{12} is effected very easily and efficiently by arranging the frequency-doubling valves V_2, V_3 and the amplifier valves V_4, V_5 so that all the connections are very short. The condition for neutralisation is obtained in the usual way and it is possible to vary the tuning of the amplifier circuit through resonance with its input without noticeable reduction in grid current, even when there is no load in the anode circuit.

The valves throughout the transmitter are of carbon anode construction and capable of dissipating 50 watts. The complete transmitter is mounted in separate compartments of copper sheet bolted together on an angle iron framework. No arrangements for modulation have been attempted as it is not required for the present series of experiments. An output of at least 200 watts as measured in a lamp load is obtainable on all wavelengths between 2 and 3 metres with an efficiency in the anode circuit of the last stage of approximately 60 per cent. This high efficiency is obtained partly because copper is used for all screens, conductors and also the plates of both variable and fixed condensers, and partly because resonant lines are used as the circuit elements in the frequency-doubling and amplifier stages. No alteration in either the choking coils or condensers in the filament circuits is required on change of wavelength.

Aerial System

Various attempts were made to couple an aerial to the transmitter without the production of stationary waves in the coupling device. They were unsuccessful, however, and finally the aerial and feeder system shown diagrammatically in Fig. 3 was adopted. In this system two half-wavelength aerials are connected in line to the two open ends of a quarter-wavelength matching section. To appropriate points on this matching section is attached a parallel wire feeder consisting of two No. 14 S.W.G. copper wires spaced 2in. apart by means of ceramic spreaders placed at intervals of 8ft. An air-spaced condenser is inserted in series with each wire of the feeder so that the latter can be tapped directly on to the anode circuit of the amplifier without the anode voltage of that stage being impressed on the aerial system. By the use of two half-wavelength aerials the symmetry to earth of the whole transmitting system is preserved; also the electric field along the length of any small aerial placed near and parallel to the main aerials in the direction normal to them

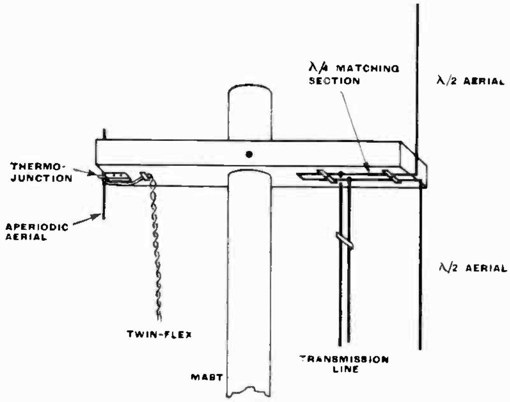


Fig. 3.—*Arrangement of aerial system.*

is much more uniform than would be the case if only one half-wavelength aerial were used. This characteristic is utilised to determine the current in the aerials. The method for finding the aerial current is described later.

An aerial and matching section for each of the spot wavelengths 2 and 3 metres are erected with the matching sections supported by insulators on horizontal arms at the tops of two 60ft. wooden masts at the National Physical Laboratory, Teddington. Arrangement is made so that by a system of cords worked from the ground the aerials can be rotated into either the vertical or horizontal planes. At the end of each cross arm remote from the main aerials a small aerial (40 cm. and 28 cm. in length for the 3 and 2 metre aerials respectively) is fitted with a non-contact type of thermojunction at its centre. Twisted leads from the thermo-couples of these junctions are brought to a microammeter installed in the hut containing the transmitter so that direct observation of the radiation of the aerials can be made. If the length of the monitoring dipole is $2l$ metres its impedance at wavelength λ is given by

$$Z = jZ_0 \cot \frac{2\pi l}{\lambda} \quad \ldots \quad (1)$$

in which Z_0 represents the characteristic impedance of the aerial and is in the neighbourhood of 500 ohms. If the electric field at this small aerial is E volts per metre, the voltage induced in it is El as its effective length is very nearly equal to half its geometrical length. As the impedance Z of the aerial is very much higher than the resistance of the thermojunction heater the current in the latter is

$$I = \frac{El}{Z_0 \cot \frac{2\pi l}{\lambda}} \quad \ldots \quad (2)$$

The current I in any particular case can, of course, be determined from a D.C. calibration of the thermojunction. Fig. 4 gives as ordinates the product of the computed field in volts per metre per ampere, and the wavelength against the ratio of distance to wavelength in the direction through one end of a half-wavelength aerial and normal to the aerial. The computation was made by a method already described by one of the authors.[1] If the current I in the small dipole is measured the field E at that dipole can be determined from relation (2) above. From Fig. 4 a knowledge of E is sufficient to determine the current in each of the main aerials as the field with two half-wavelength

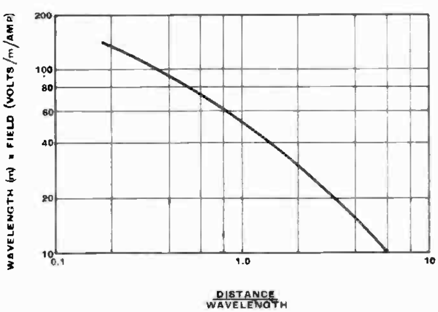


Fig. 4.—*Relation between electric field and distance from a half-wave aerial.*

aerials is exactly twice that due to one half-wavelength aerial carrying the same current. The use of two aerials, as mentioned above, reduces the variation in electric field along the length of the detector dipole so that the field and therefore the current in the main aerials can be determined more accurately. The distance between the main and small dipoles is approximately 0.6λ. This method for measuring aerial current has been found very satisfactory and the accuracy is quite sufficient so far as can be judged from the difference between the total input to the last stage of the transmitter and the heat dissipation on the anodes. Measurements of field-strength made at a distance of a few miles show that the leads from the couple do not give rise to appreciable radiation.

[1] J. S. McPetrie: "A Graphical Method for Determining the Magnitude and Phase of the Electric Field in the Neighbourhood of an Antenna carrying a known Distribution of Current." *Journ. I.E.E.*, 1931, Vol. 69, pp. 290–298.

Acknowledgment

The development work described above was carried out as part of the programme of the Radio Research Board and this paper is published by permission of the Department of Scientific and Industrial Research.

The Industry

ALL enquiries regarding British Tungsram valves should now be addressed to the enlarged premises of British Tungsram Radio Works, Ltd., West Road, Tottenham, London, N.17, to which the Theobald's Road departments have now been transferred.

Salford Electrical Instruments, Ltd., have issued technical descriptions of the revised production models of their thermionic Test Set and the G.E.C. Heterodyne Reactance Comparitor. These have been developed from the earlier designs shown at this year's Exhibition of the Physical Society.

Leaflet No. 1308 issued by Marconi's Wireless Telegraph Co., Ltd., gives full technical details with performance curves of the Type R.C.64 short-wave telegraph-telephone receivers. These receivers have been designed for high quality telephony, facsimile and high-speed telegraph services.

Magnetic Television Receiver

COMMENCING with the issue dated June 29th, *The Wireless World* will publish a series of descriptive articles on the design of a modern television receiver. The laboratory equipment upon which the articles are based proved capable over an extended period of test of giving extremely good results. These articles will provide adequate data to enable any proficient constructor to follow the design.

Pentode and Tetrode Output Valves

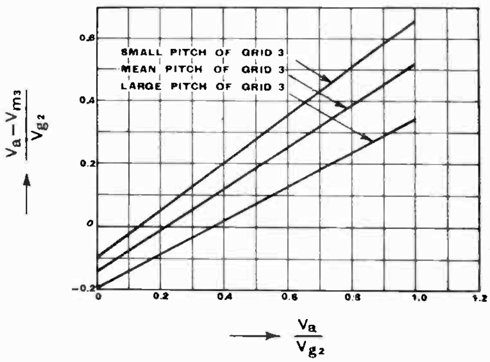
By J. L. H. Jonker

(Natuurkundig Laboratorium der N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland)

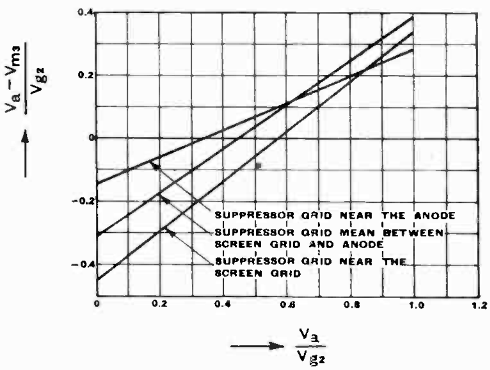
[*Concluded from page 286 of June issue.*]

§ 5. The Suppressor Grid

The use of a separate grid at cathode potential as a means of suppressing secondary emission offers the advantage that the action of the grid is entirely independent of the value of the anode current, so that the whole area of the $I_a - V_a$ characteristics may in principle be free from secondary emission. That this, however, is not sufficient for a good modern pentode, is obvious from the fact that older type pendodes with complete suppression of secondary emission are far inferior in efficiency to the more recent types. These improvements have been made possible by the increased knowledge and by the judicious application of the phenomena occurring in a pentode during operation. To illustrate this we will examine the action of a suppressor grid before making a study of the potential minimum which the suppressor grid creates between the anode and screen-grid. To facilitate comparison, a curve similar to that in Fig. 12 may be plotted for the potential minimum caused by suppressor grid. The mean potential[24] in the plane of the suppressor grid being represented by V_{m3}, we have plotted in Fig. 15 (a) the value of the counter-voltage $\frac{V_a - V_{m3}}{V_{g2}}$ for different values of $\frac{V_a}{V_{g2}}$. This has been done for different values of the pitch of the suppressor grid. Owing to the influence which the screen-grid, being at high potential, exerts upon the mean potential in the plane of the suppressor grid, it is possible that, at low values of the anode voltage, the latter may drop below the potential V_{m3}, in which case there will be no counter-voltage left. If the $I_a - V_a$ characteristic is not to show any deformation, which means that no secondary emission may be allowed to pass, the suppressor grid will need to be of so small a pitch that the potential V_{m3} up to the elbow of the $I_a - V_a$ characteristic remains sufficient to suppress secondary emission. For other reasons, however, a small pitch is undesirable, because, when primary electrons are approaching the wires of the suppressor grid, they are



(*a*)



(*b*)

Fig. 15.—*Characteristic of the counter-voltage caused by a suppressor grid in a pentode, as a function of anode voltage. This counter-voltage is the difference between the anode voltage and the mean potential in the suppressor grid. (a) The pitch of the suppressor grid was taken as parameter. (b) The position of the suppressor grid between the screen-grid and anode has been taken as parameter.*

repelled by the negative charge on these grid wires[25] and either deflected from their path or thrown straight back. If the screen-grid potential is high and the anode voltage low, a number of electrons that have been strongly deflected may return to the screen-grid. However, when the anode voltage rises, the potential V_{m3} will increase, a portion of these electrons will be deflected less and manage to reach the anode. At low anode voltages, therefore, the screen-grid current will increase at the expense of the anode current. If on this account the elbow of the $I_a - V_a$ characteristic shows too great a rounding, the valve will have too low an efficiency (§ 2).

Fig. 16 (a) gives a photograph of the course of the electrons in a grid of this type, taken from a model using small balls rolling across a sheet of rubber[26]. In order to show up the deflection, it is assumed for simplicity's sake that the electrons do not undergo tangential deflection at the other grids and therefore move straight towards the suppressor grid. V_a is assumed to be equal to $\frac{1}{8} V_{g2}$.

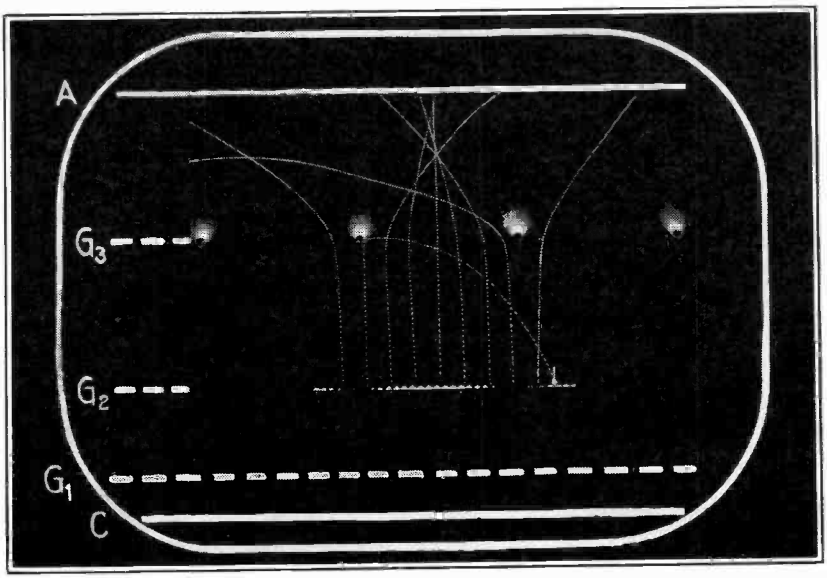


Fig. 16 (*a*).—*Photograph of the course of the electrons between the screen-grid and anode of an old type pentode output valve at low anode voltage* ($V_{g2} = 8\ V_a$). *The photograph was taken from a model using small balls rolling over a sheet of rubber. Electrons that come close to the wires of the suppressor grid are strongly deflected, so that many of them cannot reach the anode and must therefore return to the screen-grid.*

The photograph shows plainly which of the electrons are strongly deflected or thrown back; it can be seen that these are the electrons which happen to come too close to a grid wire. In order to diminish the number of electrons returning in this way, the following expedients may be adopted:

(1) Diminish the charge of the suppressor grid wires, thus reducing the force of repulsion acting upon a passing electron and so diminishing the deflection.

(2) Give the suppressor grid a larger pitch, thus diminishing the number of points of disturbance.

(3) Direct the electron beams between the suppressor grid wires, so that no primary electrons can come within close quarters of these wires.

Points 2 and 3 have been applied in beam tetrodes. The "beam plates" are positioned as far as possible outside the electron beam and form a sort of grid with a very large pitch. In this way the rounding of the elbow is diminished, but a large part of the effect of the suppressor grid is lost. A certain counter-voltage will be possible only at high anode voltages as can easily be inferred from Fig. 15 (a). The necessary counter-voltage can, however, be obtained by the use of a space charge as we have seen in § 4. The action of the suppressor grid and space charge do not, however, completely supplement each other, as the counter-voltage produced by these two expedients decreases for lower anode voltages and is at its maximum for equal values of the anode and screen-grid voltages.

Points 1 and 2 have been applied in the modern pentodes. We will now examine, how this has been achieved while at the same time making use of space charge to supplement the action of the suppressor grid. It is found that points 1 and 2 can be complied with by placing the suppressor grid in a favourable position. In Fig. 15 (b) a graph has been plotted which shows how the trend of the counter-voltage varies with anode voltage in the case of a suppressor grid with a constant pitch, when this grid is set at different positions in the space between the anode and screen-grid. With a small distance between suppressor grid and anode, the counter-voltage at low anode potential still remains positive.

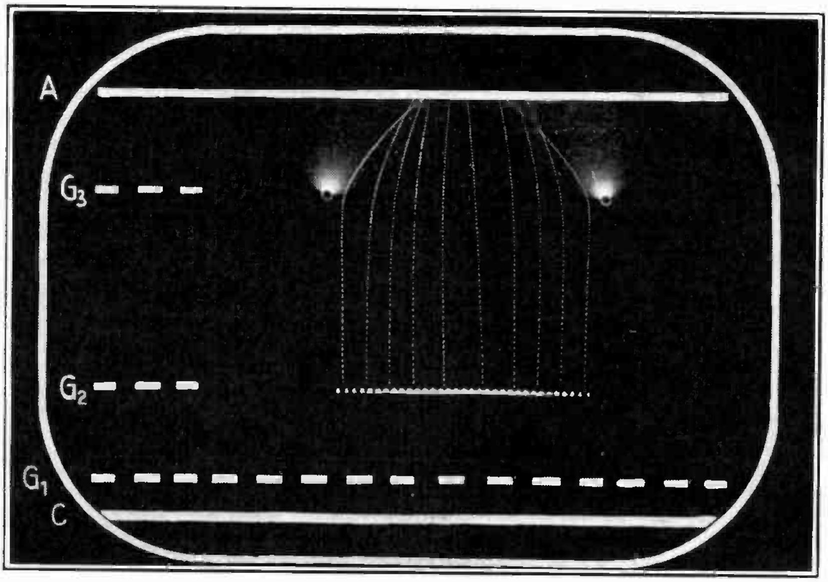


Fig. 16 (*b*).—*Photograph of the course of the electrons in the space between the screen-grid and anode of a modern pentode output valve at low anode voltage* ($V_{g2} = 8\ V_a$). *The photograph was taken from a model using small balls rolling over a sheet of rubber. In contrast to Fig.* 16 (*a*), *the deviation in this case is not so serious and the electron focus is behind the plane of the anode.*

If, therefore, the suppressor grid is positioned close to the anode and relatively far away from the screen-grid, a larger pitch may be taken. A photograph of the course of the electrons through a suppressor grid of this kind is given in Fig. 16 (b). In this example also $V_a = \frac{1}{8} V_{g2}$. A larger pitch has been selected than in Fig. 16 (a), and it can be seen that the deflections are smaller. However, the wires of the suppressor grid still tend to repel the electrons and give rise to the formation of a convergent beam whose focus is in this case behind the anode, whilst the maximum concentration of electrons on the anode is located midway between the grid wires. By means of this construction we can make the suppressor grid and the space charge co-operate in such a manner that they supplement each other. In what respect does the action of the suppressor grid need supplementing? If the pitch of the suppressor grid is made too large, the counter-voltage will prove insufficient at low anode voltages as shown by Figs. 15 (a) and 15 (b). As this action is independent of anode current, we would thus obtain—in contrast to Fig. 14—a set of curves in which all the curves show, below a certain anode voltage, a dip due to secondary electrons. The reason for this is that the anode voltage, when at low values, becomes equal to the potential at the suppressor grid and therefore the counter-voltage vanishes. This, as shown in § 2, would be no drawback for low anode currents, as the dynamic curves do not come within this region. For higher currents this would, however, cause undue distortion. We have seen in § 4 that when an electron current passes between two electrodes of equal potential, the potential characteristic soon begins to sag. A virtual cathode will, however, only be formed at very high values of the current (Fig. 12), so that an undesirable distribution of current due to returning electrons will not so readily occur. The current density in the space between the anode and the suppressor grid may be assigned such a value that a sufficient potential minimum is formed at high current values. The beam formation caused by the convergent lens effect of the suppressor grid wires helps to bring about this result. In old pentodes, on the contrary, the current density in the electron focus occurring between anode and suppressor grid (Fig. 16a) may cause the appearance of a virtual cathode at a relatively high anode voltage. Up to now we have, for simplicity's sake, only taken into account the mean potential in the plane of the suppressor grid. If the grid has a large pitch, the potential characteristic will show a pronounced sag in the plane between two wires of the suppressor grid[25]. The potential is most positive midway between these wires, so that this is the first place at which secondary electrons can pass to the screen-grid. It is at this spot, therefore, that the supplementary effect of space charge should first be exercised, and we achieve this by forming the primary electrons into a beam at the middle position as mentioned above.

It thus appears that, by selecting a suitable value for the current density and a suitable geometrical form for the suppressor grid, a space charge can be made to act as a very good supplement to the action of an open meshed suppressor grid.

An open meshed suppressor grid does not cause the detrimental rounding at the elbow of the anode current/anode voltage characteristic, common to the older grid constructions, and at the same time secondary emission can be suppressed over the entire region of operation.

§ 6. Deflection of the Electron Paths in Grids

As we have already seen, a sharp bend in the $I_a - V_a$ characteristic is not of itself sufficient to ensure good efficiency in a power valve. To enable the valve to be "swung out" to the fullest extent, the envelope formed by the elbows of the various anode current characteristics should be positioned as close as possible to the vertical axis. Hence, with increase of anode voltage, from zero onwards, the anode current should show as steep a rise as possible.

There are, however, two important factors, indicated by Below[14] and other writers, which tend to diminish the steepness of this rise. These are: the formation of a virtual cathode between the anode and screen-grid, and the deflection of the electron paths in the grids. The electrons which are most strongly deflected have a lower velocity in the anode direction and hence do not reach the anode until higher anode voltages are applied, and this causes the elbow of the $I_a - V_a$ characteristic to be shifted over a certain voltage V_{max} to higher potentials. As we have seen above, a virtual cathode is only formed in tetrode output valves, so that these valves are at a disadvantage as compared with pentodes. In both cases, however, the deflections in the grids should be reduced to a minimum. Deflection in the suppressor grid has already been dealt with.

As the screen-grid voltage V_{g2} is the highest potential, the absolute value of the sideways velocity component due to deflection will be greatest in this grid, so we must investigate this deflection. Assuming for simplicity's sake that the mean potential in the 1st and 3rd grid is nil, we can deduce from Below's calculations for concentric cylindrical electrodes that the maximum voltage (velocity) which electrons can lose for a plane parallel electrode arrangement in the anode direction will be

$$V_{max} = \frac{V_{g2} S^2}{16}\left(\frac{1}{d_1} + \frac{1}{d_2}\right)^2,$$

where S is the pitch of the screen-grid and d_1 and d_2 are the distances to the adjacent electrodes.

It is thus essential to make this deflection as small as possible. This means that the screen-grid should have a small pitch and that its distance to the adjacent electrodes should be large. If the screen-grid had a small pitch the screen-grid current would show too great an increase unless the wires of the 1st and 2nd grid were placed one behind the other. By doing this it is possible to direct the concentration of electrons in the screen-grid in such a manner that the bulk of the electrons do not come near the screen-grid wires and hence are less liable to be picked up and diverted from their path (Fig. 17).

This state of affairs has been realised, for instance, in certain tetrode output valves. However, it also has its disadvantages. For instance, the screen-grid current differs considerably in different specimens of the same valve type, because a very slight displacement of the grids with respect to each other gives rise to large differences. This will be no drawback if the screen-grid current is not supplied via a series resistance. A drawback does, however, lie in the fact that the size of pitch is subject to practical limits. If the screening of the screen-grid wires by the wires of the control grid is to be effective, the electron lens formed by these grids should have its focus as close to the screen-grid as possible. It is obvious, however, that for certain grid voltages, we are bound down to certain geometrical relationships. The minimum distance between the two grids, itself limited for constructional reasons, determines the pitch of the two grids and hence the distance between the control grid and the cathode, which is an undesirable restriction.

For valves with a high slope it is, however, particularly desirable to have a small distance between the control grid and the cathode. Modern valve technique is perfectly able to achieve distances of from one to three tenths of a millimetre between an incandescent cathode and a grid of very fine wire (30 — 80μ). But in that case it is also necessary to give the control grid a small pitch, otherwise the slope, especially for small currents, will be diminished by the formation of a tail (diode effect). This would cause undue distortion at high signal amplitudes. Hence, even with a system of grids placed one behind the other, we must accept a compromise between distortion, slope and screen-grid current.

It is also possible in this way to obtain a more uniform distribution of electrons in the space between the anode and screen-grid, which in tetrodes is of special interest for the formation of space charge. A possible advantage would thus seem to be afforded for tetrodes, whereas in modern pentodes no improvement is to be gained. Deflection at the control grid is usually of less consequence than in the screen-grid, though under certain conditions it may tend to increase the anode voltage at which the elbow in the $I_a - V_a$ characteristic occurs.

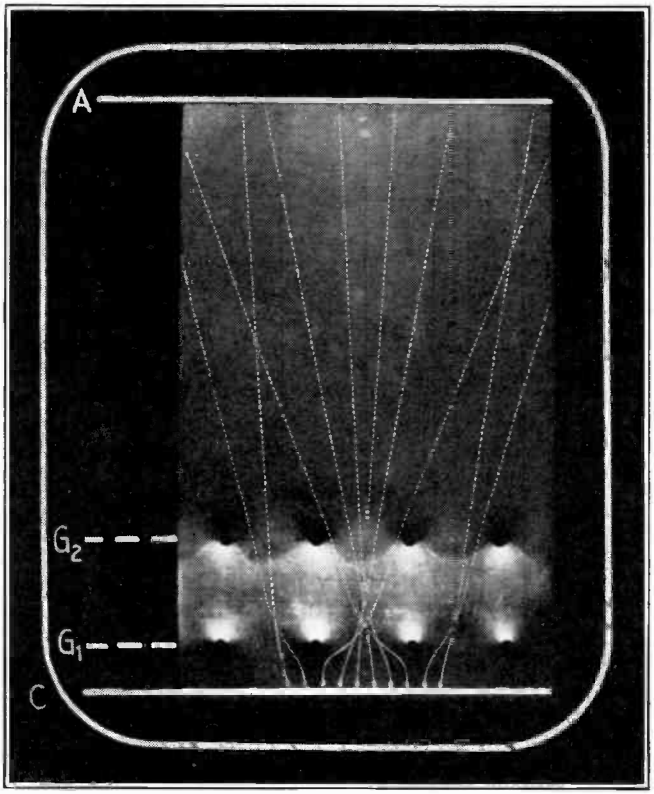


Fig. 17.—*Photograph of the course of the electrons in the space between cathode and anode when the wires of the control grid and screen grid are positioned one behind the other. The photograph was taken from a model using small balls rolling over a sheet of rubber. By placing the grid wires one behind the other a decrease of the screen-grid current has been achieved. A considerable deflection still occurs, however, in the screen-grid. The anode voltage was low* ($V_{g2} = 8\ V_a$), *and the control grid was at zero potential.*

§ 7. Conclusion

Both the tetrode and pentode output valves, when used singly, are able at low potentials to yield a good efficiency with low distortion. This can be achieved by employing a simple construction and by suppressing secondary emission by means of a minimum potential which is formed by the mixed effect of a suppressor grid and a space charge. In the tetrode, the effect of space charge is predominant and the suppressor grid is reduced to a pair of plates. This involves the disadvantage that for *low currents* the detrimental influence of secondary emission cannot be entirely avoided The maximum output that can be delivered is then limited by the fact that the formation of a virtual cathode reduces the swing of the anode voltage.

In the pentode, secondary emission is suppressed mainly by the action of the suppressor grid, and this action can be supplemented at low anode voltages by the use of space charge. Distortion may be less than in tetrodes, as the entire serviceable region of the $I_a - V_a$ characteristics can be kept free from secondary emission and as a result the characteristics show less deformation.

As the formation of a virtual cathode can be avoided, the "elbow voltage" will be determined only by deflections in the grids. By the employment of good geometrical proportions these deflections can be reduced to a very low value.

Finally, I should like to tender my hearty thanks to Messrs. Gall and Heins van der Ven for the kind assistance they have rendered in enabling me to obtain some of the data used in this paper.

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Correspondence

Ground and Ionospheric Rays

To the Editor, The Wireless Engineer.

SIR,—In the course of some recent work I have discovered an error in some of the curves given in my paper "Ground and Ionospheric Rays—A Computation of the Relative Intensities on Various Wavelengths from Existing Data" which was published in *The Wireless Engineer*, June, 1937, Vol. XIV., pp. 306–314. I wish to draw your attention to this error and to correct it as far as possible. The error was due to a slip in the computation of the attenuation of the direct ray over sea and was of such a nature as to have a negligible effect on wavelengths of 300 metres and above.

The curves which are in error are those giving the intensity of the "ground" ray for earth conductivity $\sigma = 10^{10}$ e.s.u. (i.e. over sea) in Figs. 1–5 inclusive and 10 and 11. All the other curves in the paper are unaffected, in particular all the curves for the ground ray over soil having specific conductivity $\sigma = .9 \times 10^8$ e.s.u. and the curves for the intensity of the ionospheric ray are correct as published.

I should be indebted to you if you would publish the two diagrams given herewith. The curves

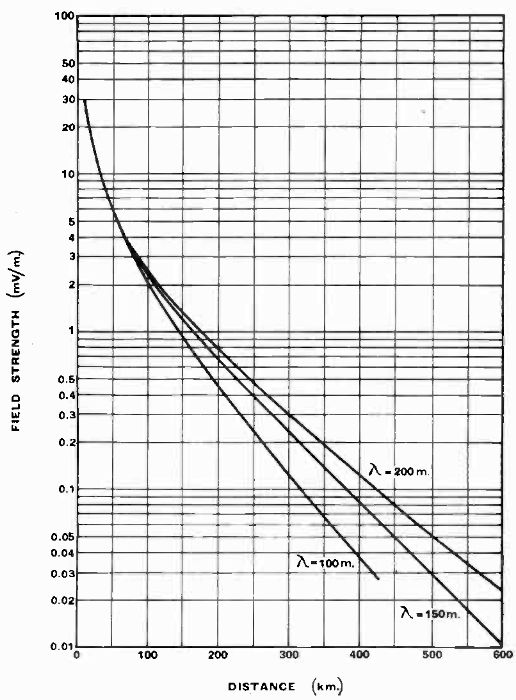

Fig. 1.—*Field strength over sea* ($\sigma = 10^{10}$ *e.s.u.*). *Transmitter — ground level. Radiation* — 1.5 *kW. Energy uniformly distributed in all directions.*

in these diagrams give the corrected values for the field strength of the direct ray over sea (specific conductivity $\sigma = 10^{10}$ e.s.u.) and are intended to replace the curves for this ground conductivity in Figs. 1, 2, 3, 4, 5, 10 and 11. The curves for

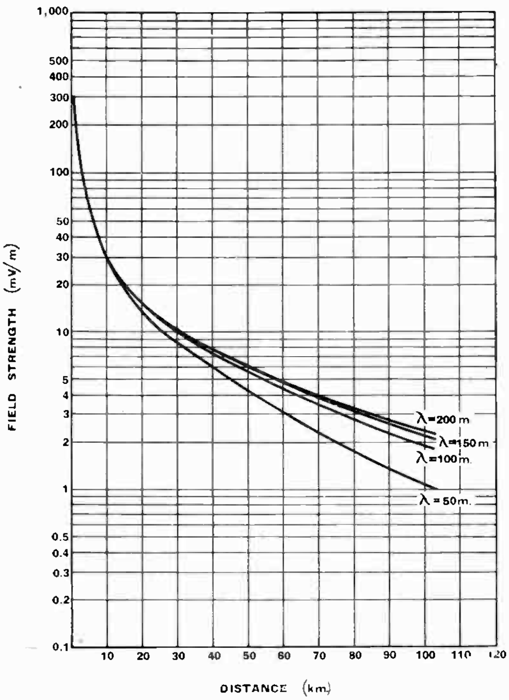

Fig. 2.—*Field strength over sea* ($\sigma = 10^{10}$ *e.s.u.*) *Transmitter — ground level. Radiation — 1.5 kW. Energy uniformly distributed in all directions.*

$\sigma = 0.9 \times 10^8$ e.s.u. in these Figures remain unchanged.

I wish to apologise to you for having to make this correction, and to all others who may have been misled in any way by the original curves.

Teddington, Middx. WILLIAM ROSS.

The Input Impedance of Self-Biased Amplifiers

To the Editor, The Wireless Engineer.

SIR,—It has been brought to my notice that the definition of the symbol g at the top of page 232 of the above-mentioned paper, which was published in *The Wireless Engineer*, May, 1939, Vol. XVI, pp. 231–236, is rather misleading; it has been confused with the inverse of the grid to cathode input resistance at high frequencies. Fuller definitions of the symbols g and c are :—

g—Change in cathode current per volt change of grid—cathode potential, all other potentials fixed.

c—Change in cathode current per volt change of anode*—cathode potential, all other potentials fixed.

*In tetrodes, pentodes, etc., read "screen" for anode.

F. C. WILLIAMS.

Bredfield, Nr. Woodbridge,
Suffolk.

Applied Acoustics 2nd Edition.

By Harry F. Olson, E.E., Ph.D., and Frank Massa, B.Sc., M.Sc. Pp. 494 and 278 illustrations. Published by P. Blakiston's, Son & Co., Inc., 1012, Walnut Street, Philadelphia, U.S.A. Price $5.50.

The four or five years that have elapsed since the appearance of the first edition of this book have done nothing to diminish its value as a handy work of reference for those engaged in the practical side of acoustics. The main body of the work remains unchanged and it is a tribute to the authors' original selection of material that so few deletions have been found desirable through obsolescence of principle or application.

Additions, on the other hand, have been numerous and have rounded off many chapters which were originally written during periods of rapid development. Details of logarithmic detectors and automatic curve tracers are included in the chapter on fundamental measurements, as well as a survey of spectrographic methods of sound analysis.

In the chapter on microphones some information is given on piezo-electric and directional instruments and on the effect of wind shields on response. Additions to the loud speaker chapters deal with multiple diaphragm direct radiators, labyrinths and phase invertors and combination horn and direct radiator loud speakers.

The data on horn-type loud speakers which was distributed through the first edition has been collected and amplified to form a new chapter. Among the aspects treated are the throat impedance in relation to reflections at the mouth, multiple flare and multi-cellular horns and notes on the limitations of acoustic power-handling capacity.

The chapter on physiological acoustics now includes tables showing the power output of musical instruments and speech, and some account of the subjective change of pitch with loudness.

As a comprehensive survey of American practice and as a handy work of reference for the laboratory bench, this book has few rivals. F. L. D.

The Institute of Physics

AT the Annual General Meeting of the Institute of Physics, the following were elected to take office on October 1st, 1939: President, Prof. W. L. Bragg; Vice-President, Prof. A. Ferguson; Hon. Treas., Major C. E. S. Phillips; Hon. Sec., Prof. J. A. Crowther; new members of the Board, Dr. H. Lowery, and Mr. R. S. Whipple; and Mr. J. H. Awbery (appointed by the Physical Society).

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

2629. The Influence of the Curvature of Rectangular Hollow Conductors on the Phase Constant of Ultra-Short Waves [Theory].—H. Buchholz. (*E.N.T.*, March 1939, Vol. 16, No. 3, pp. 73–85.)

The curvature is assumed to be small: the theoretical treatment begins (§ 2) with a mathematical description of the field in a hollow conductor, starting with the Hertzian vector. The various types of progressive waves in a straight hollow conductor of rectangular cross section are given in § 3, where the magnetic and electric transverse and longitudinal waves are discussed, with the transformation equations between the transverse and longitudinal waves. The two types of progressive waves in a curved hollow conductor are found (§ 4) to be the magnetic and electric longitudinal waves in the (r, ϕ) plane (Fig. 2). The propagation constant of curved hollow conductors is determined in § 5; the first approximation for magnetic waves is given in eqn. 5.29, for electric waves in eqn. 5.30 a,b. The curvature is found to cause a small increase in the propagation constants of these longitudinal waves, so that longitudinal waves travel undistorted along these curved conductors, for all practical purposes. Transverse waves undergo slight splitting, due to the different velocities of propagation of the longitudinal waves into which they can be resolved.

2630. The Metallic Hollow Conductor of Rectangular Cross-Section as a Transmission Path for Electromagnetic Waves.—H. Riedel. (*Hochf:tech. u. Elek:akus.*, April 1939, Vol. 53, No. 4, pp. 122–129.)

The calculation of the field components from the fundamental wave equation is first shortly given (*see* also Buchholz, above) with the wave types of the magnetic transverse wave, the E-wave, and the electric transverse wave, the H-wave. Fig. 2 gives diagrams of the lines of force in the cross-section of the conductor. The formulae for the attenuation of the separate wave forms are derived in § II; characteristic attenuation curves are shown in Figs. 4, 5. The optimum ratio of the sides of the cross-section and the best order of wave to use can be deduced. The impedance is calculated in § III, the energy content in § IV, for the case when only one wave form is present in the conductor. The case when both an electric and a magnetic wave are present is discussed in § V. It is found that, if these waves are combined with proper choice of parameters, "there result two new wave forms, in which the electric and magnetic fields respectively are only formed in longitudinal sections through the cable and which are thus termed 'longitudinal waves'". Fig. 6 gives diagrams of their lines of force. Their attenuation is calculated; it is found that, in contrast to the H_0-wave with circular cross-section, there is no wave-form for rectangular cross-section in which the attenuation decreases as the frequency increases.

2631. The Transparency of Wire Grids towards Electric Waves.—A. Esau, E. Ahrens, & W. Kebbel. (*Hochf:tech. u. Elek:akus.*, April 1939, Vol. 53, No. 4, pp. 113–115.)

The wire grids considered consist of similar coplanar wires at equal distances d apart, d being small compared with the height and width of the grid and comparable with the wavelength λ of the radiation employed. The radius of the wires is small compared with d. Measurements in the centimetric wave-range are described; the apparatus (Fig. 1) consists of a magnetron generator with a parabolic reflector sending a parallel beam onto a stop and the grid, on the other side of which a bolometer-receiver (Fig. 2), containing a small dipole, and a measuring instrument are placed. Square frames (1) of metal, in which the ends of the wires are connected, and (2) of wood, in which they are insulated from one another, are used for the grid; no disturbing influence of the frame or the ends of the wires is detected. The "transparency" of the grid is the ratio of the bolometer reading with the grid present to that without the grid. The complicated interference phenomena behind the grid are avoided by "wobbling" the emitter frequency (*see* forthcoming paper by Kebbel) with small periodic fluctuations. The incident waves are always perpendicular to the grid; measurements of the frequency variation of the transparency for parallel position of the emitter and bolometer dipoles and grid wires (Table 1; Fig. 3) show that for close grids the transparency is small, while the grid is almost completely transparent for $d = \lambda$ and also for very small λ/d, with a dip in between. The agreement with theory (shortly to be published by W. Wessel) is good. The resultant transparency of two parallel grids depends on their distance apart; it has periodic maxima and minima. Fig. 4 shows the transparency as a function of the angle between the grid and the emitter dipole; for $\lambda/d = 1$, the grid is completely transparent for all angles. For a perpendicular position, all grids are completely transparent. When the grid is rotated, the polarisation of the field behind the grid coincides neither with the direction of the emitter dipole nor with that of the grid wires. Fig. 5 shows the angle receiver-dipole/grid as a function of the angle grid/emitter-dipole, when the receiver dipole is rotated to maximum transparency for each grid position. The explanation is promised in the coming theoretical paper of W. Wessel.

2632. Electromagnetic Screens.—G. Latmiral. (*Radio e Televisione*, Sept. 1938, Vol. 3, No. 2, pp. 69–80.)

Author's summary:—After recalling Kaden's results with magnetic screens [1933 Abstracts, pp. 576–577], it is shown how, by using the generalised impedance concept proposed by Schelkunoff [1740 of 1938], it is possible to reach analogous conclusions which are applicable not only to the case of waves of the "transverse electric" type (equivalent, if the field is essentially inductive, to those in the conditions postulated by Kaden) but also to the "transverse magnetic" type [*cf.* Schelkunoff, 2247 of June]. A magnetic dipole will generate waves of the first type, an electric dipole those of the second type. The importance of these results is brought out, and elucidations and examples are given concerning their practical application, including some considerations on screens of complicated and discontinuous forms.

2633. Velocity of Radio Waves in Air [Determination of Ultra-Short Wavelength of Known Radio-Frequency Source by Interference Measurements in Air over Short Distances gives Results agreeing with Velocity of Light].—A. L. Vitter & L. C. Brieger. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 416.) For results giving slower velocity *see* Colwell & Friend, 3241 of 1937. *Cf.* Ross & Slow, 2050 of 1937.

2634. On the Influence of the Troposphere on Ultra-Short-Wave Propagation [Preliminary Tests (1935/36) leading to Systematic Collaboration between German Post Office and Meteorological Office: Wavelengths around 7 m: Distances up to 350 km].—W. Scholz & L. Egersdörfer. (*T.F.T.*, March 1939, Vol. 28, No. 3, pp. 77–83.)

Authors' summary:—"Long series of tests have established the nature of ultra-short-wave field-strength fluctuations and their connection with tropospheric processes. In particular it was shown that (in contradiction to the results of researches abroad) air layers with abnormal temperature gradients do not only increase abnormally the ranges of ultra-short-wave transmitters but may also diminish these ranges, and that it depends particularly on the position (height) of the transmitting and receiving aerials, with respect to the refracting air layers, whether the received field strength lies under or over the normal value. Changes in the air layers may cause the lower and upper extreme values to be interchanged within the space of about one hour."

The preliminary tests led to the following conclusions:—"The received field strength at distances beyond a certain point outside the line of sight remains no longer constant but varies irregularly, the more vigorously as the distance becomes longer. Over a given transmission path the fluctuations always affect a wide frequency range of at least 5% (probably much more) to the same extent. Interference effects and selective fading, such as are found with longer waves, were not observed. Not the slightest signs of the existence of multiple paths were found. No relation between field-strength fluctuations and the time of year could so far be established: between the fluctuations and the time of day there was a connection in that particularly strong increases and decreases of field strength occurred more frequently between 1.00 & 3.00, 9.00 & 10.30, and 18.00 & 20.00 than at other times: average field strengths were weaker by night than by day. Fog and cloud formations in the neighbourhood of the receiving point were without effect on the received field strength. On the other hand, these preliminary tests already showed marked connections between field strength and meteorological conditions, as when (March 1936) the field strengths at Inselberg from Berlin and Feldberg-in-Taunus fell to about one-third simultaneously with a temperature drop."

The final conclusions from the preliminary and the systematic investigations are as follows:—Field-strength fluctuations from different transmitters can occur simultaneously and similarly only when the transmission paths exactly coincide, since only then are the sums of all tropospherical influences between transmitter and receiver completely similar. For paths which are neighbouring but different in space the fluctuations can only display a common basic tendency, since the different cross-sections through the refracting air layers can, owing to the continuous equilibrating movements of the air masses, only be similar, never congruent. This is especially the case when inversion layers are present. The fact that serious field-strength fluctuations do not occur until beyond the transmitter horizon and then appear increasingly as the distance is lengthened, is due to the received energy being composed of two components, the one constant in time and diminishing exponentially with the distance, surmounting the earth's curvature by diffraction; the other variable in time and refracted towards the earth's surface through the dielectric inhomogeneity of the lower atmosphere. Since the ratio of the second component to the first increases with the distance of the transmitting aerial behind the horizon, the mean amplitude of the field-strength fluctuations increases with the distance. If transmitter and receiver are in a line of sight, field-strength fluctuations are only conceivable under special conditions, *e.g.* with directed-beam (decimetric-wave) communication with very sharp concentration, or when the border of an air layer with abnormal temperature gradients lies along the joining line between transmitting and receiving aerials. In this connection may be mentioned the rarely occurring phenomenon of very rapid (many times in a second) fluctuations of field strength with small, roughly equal amplitudes. This effect usually lasts a few hours and appears specially clearly when, on the part of the path behind the horizon, a strong exchange of heat occurs between the earth and the lower air layer (up to a few metres' height), such as occasionally produces the optical effect of " shimmer " in the air.

2635. EFFECT OF TRANSVERSE MAGNETIC FIELD ON THE REFRACTIVE INDEX AND CONDUCTIVITY OF IONISED AIR AT ULTRA-HIGH FREQUENCIES [with Theoretical and Experimental Curves for Extra-ordinary Wave: Conductivity Not Always Max. at Gyro-Frequency (unlike Longitudinal Field), being Considerably Affected by Values of Collisional Frequency and Electron Density].—S. S. Banerjee & B. N. Singh. (*Sci. & Culture*, Calcutta, April 1939, Vol. 4, No. 10, pp. 597–598.) For previous work on a longitudinal field *see* 2186 & 3839 of 1938.

2636. THE INFLUENCE OF COLLISIONS ON THE PROPAGATION OF RADIO WAVES IN AN IONISED GAS [Establishment of Validity of Equation for Mean Electron Velocity (established by Appleton & Chapman for Sinusoidal $\bar{F}$ and $\bar{H}_0 = 0$) in More General Case where $\bar{F}$ is Any Function of Time and $\bar{H}_0$ is Not Zero].—D. Graffi. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 59–63: in Italian, with French summary.) For Appleton & Chapman's paper *see* 1932 Abstracts, p. 398.

2637. NOTE ON A METHOD OF INVESTIGATING THE INTERACTION OF RADIO WAVES [Suggested Organised Measurements of the Phase Difference demanded by the Theory, and also of Decrease of Ionospheric Reflection Coefficient with Increase of Intensity of Incident Wave, similarly demanded].—E. V. Appleton. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 23–24.)

2638. THE ORIGIN OF RADIO-WAVE REFLECTIONS IN THE TROPOSPHERE [Reply to Discussion].—J. H. Piddington. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, pp. 547–548.) For the paper & discussion *see* 882 of March.

2639. PAPERS ON RADIO SOUNDINGS OF THE STRATOSPHERE.—(*See* under " Atmospherics & Atmospheric Electricity.")

2640. THE DIFFRACTION OF WIRELESS WAVES ROUND THE EARTH (A SUMMARY OF THE DIFFRACTION ANALYSIS, WITH A COMPARISON BETWEEN THE VARIOUS METHODS) [Differences between Methods only a Question of Approximations made, except in One Case of Height-Gain Factor].—G. Millington. (*Phil. Mag.*, May 1939, Series 7, Vol. 27, No. 184, pp. 517–542.)

" This therefore provides another reason for doubting the correctness of their [van der Pol & Bremmer's] height-gain factor." The full diffraction theory suggests that the strong signals obtained by Marconi with micro-waves beyond the horizon (explained by Epstein on the $d^{-5/2}$ law, periods of weak reception being attributed to interference caused by atmospheric refraction) were produced by refraction *assisting* the normal weak signals due to diffraction alone, though at other times reducing these normal signals practically to zero (*cf.* 2634, above).

2641. A NOMOGRAM FOR THE DETERMINATION OF THE FIELD STRENGTH AROUND A TRANSMITTER [issued by Philips Company: Explanation of Use].—H. T. van Veen. (*Philips Transmitting News*, Dec. 1938, Vol. 5, No. 4, pp. 107–109.)

2642. EXPLANATION OF THE PROPAGATION OF EXPLOSION WAVES AT THE BOUNDARY BETWEEN TWO MEDIA [Theory].—G. Joos & J. Teltow. (*Physik. Zeitschr.*, 15th April 1939, Vol. 40, No. 8, pp. 289–293.)

Reference is made to a paper by von Schmidt (1368 of April) in which a new wave front at the boundary of two media is found which appears to contradict Fresnel's formulae. It is here shown theoretically, for the case when the source is on the boundary between the two media, that " the new waves are already contained in Sommerfeld's stationary solution of the fundamental problem of wireless telegraphy. Sommerfeld's calculation can be applied to acoustics without difficulty and gives a complete explanation of waves of the new type, which are thus not to be attributed to transient or non-linear phenomena. The apparent contradiction to Fresnel's formulae is explained by the fact that the wave travelling parallel to the boundary surface is inhomogeneous; thus the formulae cannot be directly applied in this case and recourse must be had to the boundary conditions of the wave function, on which they are based."

2643. REPORT TO COMMISSION II ON INVESTIGATIONS OF THE PROPAGATION OF WAVES CARRIED OUT IN GREAT BRITAIN FROM JULY 1934 TO JUNE 1938.—R. L. Smith-Rose. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 41–52.)

2644. RADIO PROGRESS DURING 1938: PART VI—WAVE PROPAGATION.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 180–183.)

2645. CHARACTERISTICS OF THE IONOSPHERE AT WASHINGTON, D.C., JANUARY, 1939 [including the First of a New Service, the Forecasting of Radio Transmission Data (Max. Usable Frequencies) for Month following That of Publication].—Gilliland, Kirby, & Smith. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 226–227.)

2646. THE E REGION OF THE IONOSPHERE [Numerical Conclusions from Comparison of Observations with Theory of Ionisation caused by Solar Radiation absorbed Exponentially in Relatively Quiet Terrestrial Atmosphere: Relation between Noon Maximum-with-Height Value of Equivalent Electron Density and Sunspots].—E. O. Hulburt. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, pp. 639–645.)

2647. THE E REGION OF THE IONOSPHERE DURING THE TOTAL SOLAR ECLIPSE OF 1ST OCT. 1940 [E-Region Ionisation Curves for Various Values of Ionic-Recombination Coefficient: Eclipse Observations may provide Data for Test of Solar-Radiation Origin of E Region].—E. O. Hulburt. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, pp. 646–647.)

2648. TIDES IN THE UPPER ATMOSPHERE.—E. V. Appleton & K. Weekes. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, p. 71.) *See* 3842 of 1938. In the "Errata & Addenda" inset of these Proceedings a note is added that the conclusions are only valid if Chapman's theory of Region-E formation is correct (height of formation, for given solar zenith distance, is determined by the pressure).

2649. THE LORENTZ TERM IN IONOSPHERE THEORY [Analysis of Reflection incident at Any Angle on Parabolic Distribution of Ionisation: Comparison with Experimental Data which agreed within 0.5% with Theory neglecting Magnetic Field & Lorentz Term —Data should differ by 2.5% from Theory if Term is included].—J. A. Ratcliffe. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, p. 99: short summary only.) For the experimental data in question *see* 4219 of 1938 (Farmer & others).

2650. ON SCATTERING REFLECTIONS AT THE IONOSPHERE.—B. Beckmann, W. Menzel, & F. Vilbig. (*T.F.T.*, April 1939, Vol. 28, No. 4, pp. 130–135.)

Authors' summary:—"In the present paper a report is made on the occurrence of 'flickering' reflections at the apparent height of the F region. The characteristic properties of these reflections are discussed with the help of echo records. On these grounds it seems probable that the phenomenon is a result of lateral dispersions at ionic clouds occurring at the height of the E region. The scattered rays, which in this way reach the F layer at more or less flat angles, make themselves apparent even after the disappearance of the vertical ('sharp') reflections when ionisation is diminishing. In this connection the difference between total reflection and scattering is pointed out [bottom of p. 131 & top of p. 135: T. L. Eckersley's work is here quoted from]. The cause of the scattering ionic clouds, which form themselves not in the usual E-layer height of 120 km but in irregular distribution in the interval from about 100 to 200 km, is taken to be 'auroral disturbance.'" For previous papers *see* 4228 of 1938.

2651. PRELIMINARY MEASUREMENTS OF F_2-REGION IONISATION [in New Zealand: High Ion Content: Auroral Activity and Its Effect: Seasonal Variation (Decrease in Ionisation Sept. to Jan.): Magnetic Field 7% lower than at Ground: Comparison of Recombination Coefficients, etc., in England & New Zealand: etc.].—F. W. G. White & C. Banwell. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 75–84.)

2652. LIMITS OF APPLICATION OF GEOMETRICAL OPTICS TO THE STUDY OF A PARTICULARLY IMPORTANT CASE OF PROPAGATION [Vertical Propagation in Ionosphere].—D. Graffi. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 54–59: in Italian.)

Author's summary: Geometrical optics is an approximation of physical optics: the qualitative conditions for the validity of this approximation are known, but so far as the writer knows there do not exist, up to the present, any quantitative conditions: that is, an upper limit to the error committed in substituting geometrical optics for physical optics. In the present study the writer deals with the special, but very interesting, case of the propagation of a plane wave in a medium which is non-absorbing, isotropic, of constant permeability, and with a dielectric constant varying only in the direction normal to the wave.

He finds an exact expression for the required upper limit, and from this limit deduces the exact condition for the application of geometrical optics: he finds, in particular, the conditions which assure that the reflected wave is negligible. He applies these results to the study of the vertical propagation of an electromagnetic wave in the ionosphere.

2653. CONCERNING THE NATURE OF RADIO FADE-OUT.—L. V. Berkner. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 536–544.)

"It is concluded from the series of observations examined [of vertical-incidence ionospheric echoes] that a fade-out is best described as an upward projection of the lower or absorption limit of echo-return, and that the fade-out is caused by intense absorption of ionising radiation, emanating from bright chromospheric eruptions, at the base of, or below, the E region . . . It is shown that no appreciable absorption of chromospheric-eruption radiation takes place at levels higher than that of the E region; therefore, a process of selective absorption must operate. Since the principal geomagnetic effect associated with fade-outs is an augmentation of the diurnal variation of terrestrial magnetism, it appears that only the Stewart-Schuster 'atmospheric dynamo' theory of diurnal variation is possible under the restrictions imposed by these observations."

2654. Solar Variation and the Weather [23-Year Cycle].—C. G. Abbot. (*Nature*, 29th April 1939, Vol. 143, pp. 705–709.)

2655. Solar Control of the Atmosphere.—M. N. Saha. (*Sci. & Culture*, Calcutta, April 1939, Vol. 4, No. 10, pp. 545–550.) Based on the Presidential Address to the National Institute of Sciences of India.

2656. Nocturnal E-Layer Ionisation [Facts indicating that Nocturnal E Region arises from Process which also produces General Non-Polar Aurora: Support for Chapman's Theory that Energy Source for Night-Sky Light is Recombination of Dissociated Oxygen Atoms].—N. E. Bradbury. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 423: abstract only.)

2657. The Aurora and Short-Wave Reception [Orkney Islands Observations].—(*World-Radio*, 12th May 1939, Vol. 28, p. 13.)

2658. The Aurora of 24th/25th Feb. 1939 in Arosa [and the Simultaneous Magnetic Storm].—F. W. P. Götz & R. Penndorf. (*Naturwiss.*, 14th April 1939, Vol. 27, No. 15, pp. 241–243.)

2659. On the Origin of the Earth's Magnetic Field [Existence of Thermoelectric Currents in Metallic Interior: Bearing of Ideas on Magnetism of Sunspots].—W. M. Elsasser. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, pp. 489–498.)

2660. A Large Sunspot [crossed Meridian on April 16th: Data: Magnetic Storm began April 17th], *and* Large Sunspots [Data of Groups April 20th–May 2nd].—(*Nature*, 22nd & 29th April 1939, Vol. 143, pp. 677 & 717: short notes only.)

2661. Ionosphere Characteristics for Half a Sunspot Cycle.—N. Smith, T. R. Gilliland, & S. S. Kirby. (*Journ. Franklin Inst.*, Jan. 1939, Vol. 227, No. 1, p. 127.) Note on paper dealt with in 1355 of April.

2662. Solar Activity and Its Influence on the Earth [Sunspots now take Secondary Place: Effects of Radiations & Corpuscles: etc.].—G. Abetti. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 68–75: in Italian, with French & English summaries.)

2663. The Existence of Oxygen Phosphorescence in the Spectrum of the Night Sky.—L. & R. Herman. (*Comptes Rendus*, 1st May 1939, Vol. 208, No. 18, pp. 1392–1394.)

2664. Mechanism of Excitation of the Forbidden Lines of Oxygen and Nitrogen in the Spectra of the Aurora and the Night Sky.—M. Nicolet. (*Nature*, 15th April 1939, Vol. 143, p. 639.)

2665. New Description of the Spectrum of the Night Sky in the Ultra-Violet Region [Data: Origins of Lines and Bands].—A. Arnulf, R. Bernard, & others. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1329–1331.)

2666. Presence of the Nitrogen Forbidden Line $^2P \rightarrow {}^4S$ in the Auroral Spectrum.—R. Bernard. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, p. 511.) *See* also 3469 of 1938, and Kaplan, below.

2667. NH Bands in the Night-Sky Spectrum [indicate that Direct Combination between Atomic Nitrogen and Hydrogen takes Place in the High-Pressure Afterglow: Evidence for Existence of Atomic Nitrogen in Upper Atmosphere].—J. Kaplan. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 583.)

2668. Excitation of the New Nitrogen Line [High-Pressure Afterglow as Source of Atomic Nitrogen], *and* A New Nitrogen Afterglow Spectrum [containing Every Known Feature of Nitrogen Afterglows and New Characteristics].—J. Kaplan. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 598: p. 606: abstracts only.)

2669. Band Spectra in Nitrogen at Atmospheric Pressure: Source of Band Spectra Excitation.—O. R. Wulf & E. H. Melvin. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 687–691.)

2670. The Polarisation of the Green Line of the Light of the Night Sky.—I. A. Khvostikov. (*Comptes Rendus (Doklady) de l'Acad. des. Sci. de l'URSS*, No. 7, Vol. 21, 1938, pp. 322–324: in French.)

2671. The Instability of the Ozone Layer at Sunrise and Sunset, and the Problem of Determination of the Height of the Ozone Layer [Necessity for Revision of Methods and Results].—I. Khovstikov & N. Ershova. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 20, 1938, pp. 659–662: in English.)

2672. The Distribution of Ozone in Stratosphere [During Cyclone, Barometric "Low" precedes by Several Hours the Attendant Increase in Ozone Concentration: Balloon Ascensions show Ozone distributed between 18 and 27 km].—W. W. Coblentz & R. Stair. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 590–591: abstract only.)

2673. The Nocturnal Temperature of the Upper Atmospheric Layers [Ozone Bands in Stellar Spectra at Jungfraujoch, Sept. 1938, confirm Low Temperatures previously found].—D. Barbier & D. Chalonge. (*Comptes Rendus*, 17th April 1939, Vol. 208, No. 16, pp. 1238–1240.)

2674. OZONE IN THE UPPER ATMOSPHERE [Observations in North-East Land by Oxford University Arctic Expedition, 1935–36: Large Day-to-Day Fluctuations: Autumnal Decline, Sudden Spring Rise in Amount of Ozone].—R. A. Hamilton. (*Nature*, 22nd April 1939, Vol. 143, p. 688: short note on recent paper to Royal Meteorological Society.)

2675. GROUND RADIATION AND THE "VERTICAL EFFECT" OF CLOSED AERIALS.—Sacco. (*See* 2807.)

2676. IMPULSE BREAKDOWN IN LONG DISCHARGE TUBES.—J. R. Dietrich & L. B. Snoddy. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 591: abstract only.) Continuation of work referred to in 43 of 1938 and back reference.

2677. CONTRIBUTION TO THE FOUNDATIONS OF RADIO MINING PROSPECTING BY THE "ANTENNA EQUIVALENT-CAPACITY" METHOD.—Fritsch & Wiechowski. (*See* 3017.)

2678. THE ATTENUATION OF H. F. TRANSMISSIONS ALONG POWER LINES [Theory].—F. Carbenay. (*Comptes Rendus*, 17th April 1939, Vol. 208, No. 16, pp. 1208–1211.) Continuation of work dealt with in 2262 of June.

2679. METHODS FOR OBTAINING TRAVELLING ELECTROMAGNETIC WAVES (IN A LINE) WITHOUT LOSS OF POWER.—M. S. Neimann. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1939, pp. 19–29.)

Transmission lines carrying travelling waves have many practical applications, but it has been so far considered that the only method for obtaining these waves is to terminate the line with an impedance in which the greater part of the transmitted power is dissipated. In the present paper it is suggested that the energy reaching the end of the line can be brought back through a return line and added to the energy delivered by the feeding oscillator, thus avoiding the loss of power in the terminating impedance.

The theory of the principle is discussed and it is shown that there are several comparatively simple methods for ensuring that the wave will travel in the desired direction only (say clockwise) along the loop.

2680. INVESTIGATION OF THE TRANSMISSION CONDITIONS OF OVERHEAD LINES AT FREQUENCIES OF 55–1600 KC/S.—Waldow, Spang, & Fritzsche. (*See* 2991.)

2681. THE PROPAGATION OF ELECTRIC CURRENTS IN TERMINATED LINES: SOLUTIONS OF THE TELEGRAPHIC EQUATION.—R. H. Kent. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 762–768.)

Author's summary:—By a transformation of Heaviside's general solution, a special solution for the current having the value $e^{-t}f(t)$ at $x = 0$ is obtained. From this solution, an expression is obtained for the potential difference across the line at $x = 0$ in terms of $f(t)$ and its successive integrals. From this and the terminal conditions, a differential equation of negatively infinite order for $f(t)$ is obtained. This equation can be solved to any given degree of approximation by a method of integral operators. An illustrative problem is solved. An integral solution of the telegraphic equation and a corresponding expression for the potential difference at $x = 0$ are given. An alternative method to Heaviside's and Carson's is suggested for obtaining the general solution for the terminated line.

2682. A PHASE JUMP OF 2π IN METALLIC REFLECTION [calculated from Classical Formulae, explains Contradictory Experimental Results].—P. Rouard. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1294–1296.)

2683. THEORETICAL EVALUATION OF A WIDE-ANGLE INTERFERENCE EXPERIMENT [showing Source of Fluorescent Light to consist of Electric Dipoles], *and* DETERMINATION OF THE NATURE OF A LIGHT SOURCE, FROM WIDE-ANGLE INTERFERENCE EXPERIMENTS.—F. W. Doermann & O. Halpern. (*Phys. Review*, 1st March & 1st April 1939, Series 2, Vol. 55, Nos. 5 & 7, pp. 486–488: p. 681—abstract only.)

2684. STUDY OF PARALLEL-LIGHT DIFFRACTION [Systematic Experimental Investigation and Theoretical Discussion: Introduction of Optical Constants of Metallic Screen (Raman & Krishnan): etc.].—J. Savornin. (*Ann. de Physique*, Feb. 1939, Vol. 11, pp. 129–255.)

2685. ON THE THEORY OF THE OPTICAL GRATING: I, II, & III.—W. Ignatowsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 2/3, Vol. 20, 1938, pp. 105–108: No. 1, Vol. 22, 1939, pp. 16–20 and 21–24: in German.)

2686. PERIODIC ANALYSIS OF SEISMIC WAVES, AND PROBLEMS CONNECTED THEREWITH.—P. Caloi. (*La Ricerca Scient.*, April 1939, 10th Year, No. 4, pp. 275–290.)

2687. THE PROPAGATION OF SPHERICAL [Elastic] WAVES [and Their Passage into Plane Waves at a Great Distance: Longitudinal Waves weaken as Distance increases, Transverse Waves can persist Indefinitely].—L. Lecornu. (*Comptes Rendus*, 17th April 1939, Vol. 208, No. 16, pp. 1185–1188.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2688. PEAK FIELD STRENGTHS OF ATMOSPHERICS DUE TO LOCAL THUNDERSTORMS AT 150 MEGACYCLES [Some Measurements at 70 & 850 Mc/s also were Consistent: Peak Values around 1 mV/m & 3 mV/m from Flashes 15 & 5 Miles away respectively: Decided Advantage of High Receiving Aerial and Vertically-Directive Aerial Gain: Some Advantage in Horizontally-Directive Gain: Effects on Television Image: etc.].—J. P. Schafer & W. M. Goodall. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 202–207.)

2689. Research on Atmospherics in Italy.—P. Ilardi. (*Radio e Televisione*, March 1939, Vol. 3, No. 5, pp. 317–318: in Italian.)

2690. Quantities of Charge Transfers in Lightning Discharges.—E. J. Workman & R. E. Holzer. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 598: abstract only.)

2691. A Recording Generating Voltmeter for Lightning Studies.—E. J. Workman & R. E. Holzer. (*Review Scient. Instr.*, May 1939, Vol. 10, No. 5, pp. 160–163.)

2692. Spark Discharge on Surfaces [Rotating-Mirror Observations show Same Type of Phenomenon as Initiation of Lightning Flash].—L. B. Snoddy & J. W. Beams. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 663.)

2693. The Mechanism of the Positive Point-to-Plane Corona in Air at Atmospheric Pressure [Existence of Current Bursts and Their Development into Streamers].—G. W. Trichel. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, pp. 382–390.)

2694. Onset Studies of Positive Point-to-Plane Corona in Air at Atmospheric Pressure [Pre-Onset Pulses: Streamers initiating Steady Corona Process].—A. F. Kip. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 549–556.)

2695. The Geomagnetic Effects and Their Bearing upon the Fundamental Problems of the Cosmic Ray Investigation.—T. H. Johnson. (*Journ. Franklin Inst.*, Jan. 1939, Vol. 227, No. 1, pp. 37–58.)

2696. Present State of the Theory of the Effect of the Earth's Magnetic Field on Cosmic Rays [Results of Analysis of Motion of Charged Particles in Earth's Field].—Vallarta: Swann: Johnson: Korff. (*Journ. Franklin Inst.*, Jan. 1939, Vol. 227, No. 1, pp. 1–29: Discussion pp. 30–35.)

2697. The Coefficient of Absorption of Small Ions by the Neutral Particles in Suspension in Air.—O. Te-Tchao & H. Le Boiteux. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1288–1289.)

2698. Radioactive Content of the Atmosphere as Affected by the Presence of Condensation Nuclei [Radioactive Matter either Diminished in Amount or rendered Less Effective in Production of Small Ions].—G. R. Wait. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 591: abstract only.)

2699. Stratosphere Ultra-Violet Meter.—R. Stair. (*Journ. Franklin Inst.*, April 1939, Vol. 227, No. 4, p. 547: short note only.) *See* also 2277 of June.

2700. Radio Soundings and Weather Prediction [Advantages of Radio-Sonde over Airplane Soundings: Degree of Accuracy of Observations: Improvements to facilitate Mass Production, etc.].—H. Diamond, W. S. Hinman, A. H. Mears, & C. Harmantas. (*Journ. Franklin Inst.*, April 1939, Vol. 227, No. 4, pp. 545–547: note on paper in *Journal of Aeronautical Sciences*.)

2701. Radio Soundings in the Southern Seas [Data of Altitude and Temperature of Stratosphere].—R. Bureau, M. Douguet, & P. Wehrlé. (*Comptes Rendus*, 1st May 1939, Vol. 208, No. 18, pp. 1419–1420.)

2702. Radio Meteorology in the United States: the Radio-Telemeter [Blue Hill (Harvard) Radio-Sonde] and Its Importance to Aviation.—R. W. Knight. (*Nature*, 29th April 1939, Vol. 143, pp. 716–717: short note on report circulated by U.S. Civil Aeronautics Authority.)

2703. An Integrating Altimeter for [Radio] Aerological Soundings.—J. Lugeon. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1327–1329.)

2704. Discussion on "New Method of Sensitive Temperature and Pressure Measurements" [with Remote Indication].—Zamenhof. (*Acta Phys. Polonica*, Fasc. 3, Vol. 7, 1939, pp. 272–274: in English.) *See* 4265 of 1938.

PROPERTIES OF CIRCUIT

2705. A Laplace Transformation Theorem for the Separation of Steady-State and Transient Processes [with Illustrative Application to Two-Wire Circuits].—H. W. Droste. (*T.F.T.*, March & April 1939, Vol. 28, Nos. 3 & 4, pp. 89–92 & 122–127.)

Author's summary:—"It is shown that the solution of a linear differential equation with constant coefficients, whose 'Störungsfunktion' varies sinusoidally, can, with the help of rules of the Laplace function-transformation, be represented as an expression in which the steady state is clearly separated from the transient process. From the result for the steady state, as determined from the complex transformation, the transient process can be derived. As a not unimportant example, the two-wire line, closed so as to be free from reflection, short-circuited, and finally open-circuited, is dealt with." For a review of Doetsch's important book on the Laplace transformation *see* 3429 of 1938.

2706. Methods for obtaining Travelling Electromagnetic Waves (in a Line) without Loss of Power.—Neimann. (*See* 2679.)

2707. Synthesis of a High-Frequency Reactance [in Terms of Number, Arrangement, and Constants of Transmission Line Reactance Elements: Derivation from Partial Fraction Expansion of Required Function].—S. Ramo. (*Journ. of Applied Phys.*, Feb. 1939, Vol. 10, No. 2, pp. 138–139.)

2708. An Electrically "Cold" Resistance [Theoretical Possibility of Valve Circuit giving "Effective Temperature" (as calculated from Noise Voltage) Lower than Surrounding Temperature ("Valve as Refrigerator"): Experimental Confirmation: Possible Applications (Terminating Resistance for Transmission Line, Resistance in Input Circuit of High-Gain Wide-Band Amplifier, etc.)].—W. S. Percival. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, pp. 237–240.)

2709. Report on the Present State of Knowledge concerning Fluctuation Voltages in Electrical Networks and Thermionic Tubes.—Moullin. (*See* 2788.)

2710. "Théorie et Technique du Bruit de Fond [Background Noise]: Effets Schottky et thermique" [Book Review].—F. Bedeau. (*Current Science*, Bangalore, April 1939, Vol. 8, No. 4, p. 178.)

2711. Mutual and Self Inductors Compensated for Change of Frequency [Mathematical Discussion of Closed Tertiary and Secondary Circuit for Mutual and Self Inductors respectively: Experimental Examples].—A. Campbell. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, pp. 539–544.)

2712. Temperature Coefficient of Inductance.—Bell. (*See* 2886.)

2713. Investigations on Circuits with [Periodically] Variable Capacity [Circuits connected to Direct Voltage Source: Calculations of Current, Voltage, and Power Variations].—O. Schemmrich. (*Arch. f. Elektrot.*, 14th April 1939, Vol. 33, No. 4, pp. 229–241.)

2714. On the Reactive Resistance of Systems, including a Source of Power.—S. I. Tetelbaum. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1939, pp. 29–43.)

It is shown that a circuit (Fig. 1) comprising a source of d.c. voltage and a positive resistance, the value of which is varied in accordance with a certain law, may present a negative capacity or negative inductance to a source of a.c. voltage. In this paper the operation of a circuit employing valves as variable resistances is discussed, and cases of (a) parallel (Figs. 2 & 3) and (b) series (Figs. 4 & 5) grid-voltage controls are investigated separately. Practical applications of these reactive elements are then considered and a report is presented on experiments with resonant circuits and self-excited oscillators employing these elements.

2715. Transformation to Principal Axes of Quadripole Matrices and Their Application [with Examples of Chains of Similar Quadripoles, Homogeneous Cable: Advantages of Method for Special Quadripoles, Matching Calculations, etc.].—W. Weizel. (*Arch. f. Elektrot.*, 28th March 1939, Vol. 33, No. 3, pp. 196–201.)

2716. A Logarithmic Voltmeter with Differential Indication [and Its Use for Filter-Characteristic Plotting, the Calibration of Microphones & Loudspeakers, and the Measurement of Sound Insulation].—Nuovo. (*See* 2909.)

2717. Practical Formulae for Tuning Circuits and Band Filters.—(*Auslese der Funktechnik* [replacing *Radio, B., F. für Alle*], April 1939, No. 1, pp. 28–30.)

2718. "Hochfrequenztechnik: I" [Tuning Coils & Condensers, Negative Feedback, Couplings, etc: Book Review].—J. Kammerloher. (*Auslese der Funktechnik* [replacing *Radio, B., F. für Alle*], April 1939, No. 1, p. 30.) For II *see* 2782, below.

2719. Resistance-Capacity Tuning [Periodic Time of Valve Oscillators increased One Hundred-Fold by Use of Miller Effect].—N. H. Roberts. (*Nature*, 15th April 1939, Vol. 143, pp. 639–640.)

2720. The Input Impedance of Self-Biased Amplifiers.—Williams & Chester. (*See* 2860.)

2721. Control of the Effective Internal Impedance of Amplifiers by means of Feedback [Plate Resistance Decreased by Negative Voltage or Positive Current Feedback (or Both Combined): Increased by Negative Current or Positive Voltage Feedback (or Both Combined): Application to A.F. and I.F. Amplifiers].—H. F. Mayer. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 213–217.) For the papers quoted at the end *see* Vecchiacchi (2923 of 1937), Bartels (395 of 1935), and Ginzton (1080 of March).

2722. Frequency-Response Characteristic of Amplifiers employing Negative Feedback [Simple Flattening Effect only in Single-Stage Case: Peaks of Response present for More than One Stage (Liable to produce Peculiarities in Quality for Transients): etc.].—F. E. Terman & W. Y. Pan. (*Communications*, March 1939, Vol. 19, No. 3, pp. 5–7 and 42..45.)

2723. Degenerative Amplifier Applications [to Sound Analyser, A.F. Oscillator (27 Fixed Frequencies between 20 and 15 000 c/s, with Very Good Wave-Form), and Cathode-Ray Null Indicator for Bridge].—General Radio Company: Scott. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. iv and vi.) Using the selective circuit dealt with in 1802 of 1938 (Scott).

2724. Considerations on the Calculation of R.F. Power Amplifiers.—Institute Galileo Ferraris. (*Alta Frequenza*, March 1939, Vol. 8, No. 3, pp. 147–189.)

Authors' summary:—In the calculation of a class B or C r.f. power amplifier, the valve or the external circuit imposes $n - 3$ equations between the n variables involved (voltages, currents, resistances, etc.). The variables usually considered number 22 (6 currents, 6 voltages, 4 powers, 2 phase angles, efficiency, load resistance, and form & power factors). These give 19 equations. The calculation of an amplifier requires that the values of three (in certain cases four) of these variables be known in order that the remaining 19 (or 18) may be determined purely algebraically.

Corresponding to the large number (more than 500) of groups of 3 variables which may be chosen, there is an equally large number of cases to be solved. When it is remembered also that the valve characteristics may be considered as parabolic, exponential, linear, and so on, it will be realised what a multiplicity of cases is presented.

The case of the linear characteristic is particularly important and is here developed completely, all the processes of calculation being given, in the form of tables, for more than 150 cases, corresponding to the same number of the groups of 3 mentioned above. Only those groups of 3 are omitted in which grid-circuit variables are involved, since these cases have little practical importance. Among the processes of calculation considered there naturally appear, as special cases, most of the methods dealt with in the radiotechnical literature of the last few years. Some numerical examples illustrate the use of the tables and curves.

TRANSMISSION

2725. A High-Frequency Amplifier and Oscillator ["Klystron"].—Varian & Varian. (*See* 2773.)

2726. Velocity Modulation of Electron Beams: a New Ultra-High-Frequency Development [particularly the "Klystron" (Two-"Rhumbatron") Micro-Wave Generator].—N. Wheelock. (*QST*, May 1939, Vol. 23, No. 5, p. 37.) *See* 1848 of May and 2295 of June: *also* 2773, below.

2727. Sinusoidal Oscillations in the Habann Valve [Split-Anode Magnetron with Negative Characteristic].—K. Lämmchen & L. Müller. (*E.N.T.*, Feb. 1939, Vol. 16, No. 2, pp. 37–42.)

This investigation discusses the curve forms of the various types of oscillation in the Habann valve and the means of improving them. The theory of the voltage curve forms of the "long-wave" Habann emitter is dealt with in § II on the basis of the working characteristics (Fig. 1a) of the symmetrical Habann valve circuit (Fig. 1b). It is found that distortions occur which cannot be explained on the basis of the characteristic hitherto assumed. Distortions "occur not only at the intersection of the negative characteristic and linear load, but also when the latter lies altogether below the negative characteristic. It appears that these distortions are caused by an additional load which varies during a period; this arises from the partial anode current to the segment at higher potential. The corresponding working characteristic is deduced not from the negative characteristic and the linear load but from the partial current curves and the linear loads. The distortions due to a bent working characteristic only appear as distortions of the voltage on the oscillating circuit when this has a sufficiently large attenuation." The production of a linear working characteristic (§ III) is found to be possible by using the asymmetrical circuits of Fig. 2, which have respectively (a) a coil in the anode lead coupled to the oscillating circuit, and (b) the anode lead connected directly to an anode segment. Figs. 3a,b show static negative characteristics for a symmetrical and an asymmetrical circuit respectively, Fig. 4 the partial currents and the negative characteristic for the asymmetrical circuit. A push-pull circuit (Fig. 5) works even better than the circuits of Fig. 2; it can be used for very short wavelengths and in conjunction with Lecher-wire systems. Fig. 6 shows a push-pull Habann valve. Confirmatory measurements of the temporal curve of voltage on the oscillating circuit of a Habann emitter for "long-wave" oscillations are described in § IV; the circuit of Fig. 7 is employed to obtain Lissajous' figures (shown in Figs. 8, 9) on the screen of a cathode-ray tube. The results for a non-smoothing and a smoothing external circuit, and with a Lecher-wire system, are described.

In § V the curve form of the push-pull circuit for "transit-time" oscillations (in contrast to the Habann oscillations based on the static negative characteristic) is shortly discussed; it is found to be similar to that of the Habann oscillations. The excitation of independent overtones (dwarf waves; § VI; Fig. 10) shows as the superposition of a disturbing oscillation on the fundamental wave. These arise when a prominent transit-time oscillation coincides with an overtone of the Lecher-wire system. "The whole short-wave investigation shows that, in practical working, attention must be directed not so much to curve distortion by non-linear control, as to excitation of independent overtones. The advantage of the push-pull circuit here developed then lies chiefly in a greater power output."

2728. The Barkhausen-Kurz Electron Oscillations [and the Three Types of Theory, represented by the Theories of Möller, the Author, and Alfvèn respectively].—A. Rostagni. (*Radio e Televisione*, March 1939, Vol. 3, No. 5, pp. 281–286: in Italian.)

2729. Ultra-High-Frequency Oscillators [Negative-Grid Type, including a Circuit for 1600 Mc/s and Some of Its Phenomena, explained by Variation of Capacitance with Frequency].—D. H. Black. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 229: summary only.)

2730. An Improvement in Constant-Frequency Oscillators [applicable to Frequencies from Audio to Ultra-High: Valve Impedances made Small compared with Those of Tuned Circuit, by Impedance Transformation ("Ratio-Coupled" Oscillator): for Frequency Meters, Superheterodyne Receivers, Transmitter Control, etc.].—G. F. Lampkin. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 199–201.)

2731. Notes on a Precise Frequency-Control System for Station W1XJ [for Unsupervised Transmissions for Ionospheric Research].—J. A. Pierce. (*U.R.S.I. Proc. of 1938 General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 133–135.)

Part of the output of the extremely carefully constructed crystal oscillator is mixed with the output of a frequency multiplier driven by a primary frequency standard, and the difference tone, amplified and passed through a magnetostriction filter, is rectified, amplified, and used to control the contactors in the h.t. supply to the last two stages of the transmitter.

2732. FREQUENCY DOUBLERS [and Their Use for making One Quartz Crystal control Transmissions on Several Amateur Frequencies].—H. B. Dent. (*Wireless World*, 11th May 1939, Vol. 44, pp. 439–440.)

2733. FREQUENCY-MODULATION TRANSMITTERS AND PROPAGATION CHARACTERISTICS [Tests between Schenectady & Albany: 6 db Difference between Carriers gives Elimination from A.F. Output: 10 μV Received Input about equals 300 μV of Amplitude-Modulated: etc.].—I. R. Weir. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 229: summary only.)

2734. FREQUENCY MODULATION IN AMERICA.—E. H. Armstrong. (*Wireless World*, 11th & 18th May 1939, Vol. 44, pp. 443–446 & 469–471.)

2735. VOLUME COMPRESSION SIMPLIFIED: A SPEECH AMPLIFIER-COMPRESSER WITH NOVEL FEATURES [using a 6H6 as Full-Wave Audio Rectifier to supply D.C. Control Voltage to Input Stage].—W. C. Lamb, Jr. (*QST*, May 1939, Vol. 23, No. 5, pp. 58–59 and 98.)

2736. RADIO PROGRESS DURING 1938: PART V—TRANSMITTERS AND ANTENNAS.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 177–180.)

2737. A COMPACT AND ECONOMICAL 500-WATT ALL-BAND TRANSMITTER: PRACTICAL APPLICATION OF INDUCTIVE NEUTRALISATION.—C. Jones: Craft & Collins. (*QST*, May 1939, Vol. 23, No. 5, pp. 38–40.) *See* 3349 of 1936.

2738. "SAFETY" BECOMES A WATCHWORD [Progress of A.R.R.L. Campaign against Fatalities from Electric Shock].—De Soto. (*See* 3016.)

RECEPTION

2739. INDUCTIVE TUNING: DESIGN AND APPLICATION [Extension of Use of the CVI (Continuously Variable Inductance) System to Ultra-Short-Wave Oscillators, etc: "Phenomenal Stability over Very Broad Frequency Band": Special Mechanism].—O. J. Morelock: Ware. (*Communications*, March 1939, Vol. 19, No. 3, pp. 34 . . 38.) Continued from 1872 of May.

2740. A SIMPLE 5-, 10-, AND 20-METRE CONVERTER FOR HOME OR CAR.—W. Chapin. (*QST*, May 1939, Vol. 23, No. 5, pp. 44–46.)

2741. PRE-SELECTION POINTERS: AN ACORN REGENERATIVE UNIT FOR 14, 28, AND 56 Mc/s.—D. A. Griffin. (*QST*, May 1939, Vol. 23, No. 5, pp. 30–32.)

2742. THE NEW ARMSTRONG FREQUENCY-MODULATION RECEIVER.—G. W. Fyler & J. A. Worcester. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 229: summary only.)

2743. INTELLIGIBILITY AND LIABILITY TO INTERFERENCE IN SINGLE-SIDEBAND RECEPTION.—Haberkant & Meinel. (*See* 2994.)

2744. PAPERS ON WIRE BROADCASTING SYSTEMS.—(*See* under "Stations, Design & Operation.")

2745. COMMUNITY-AERIAL INSTALLATIONS, CONSTRUCTION AND RESULTS.—Moebes. (*See* 2768.)

2746. SPACE PERCEPTION BY RADIO [Use of Superseded Receiver in conjunction with Its Successor to give Maximum of Aesthetic Appreciation).—M. F. Meyer. (*Science*, 28th April 1939, Vol. 89, p. 389.)

2747. RECEIVER WITH AUTOMATIC SELECTIVITY CONTROL RESPONSIVE TO INTERFERENCE [Selectivity & Fidelity maintained at Optimum under All Conditions of Signal Strength & Interference].—J. F. Farrington. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 239–244.) A summary was referred to in 3558 of 1938.

2748. AMPLITUDE LIMITERS AND AUTO-REGULATING SYSTEMS IN COMMUNICATION TECHNIQUE [Wireless Telegraphy & Telephony, Sound-Film Recording, etc: Survey, with Some Test Results].—M. Nuovo. (*La Ricerca Scient.*, April 1939, 10th Year, No. 4, pp. 261–270.)

2749. THE AVC CHARACTERISTIC [Method of Plotting, and Derivation of Useful Information on General Performance].—M. G. Scroggie. (*Wireless World*, 4th May 1939, Vol. 44, pp. 427–428.)

2750. NEW TONE-CONTROL CIRCUIT [enabling both Bass & Treble Response to be increased: Hum Pick-Up largely reduced by Absence of Inductances].—J. E. Varrall. (*Wireless World*, 11th May 1939, Vol. 44, pp. 449–450.)

2751. RESISTANCE-CAPACITY TUNING [Periodic Time of Valve Oscillators increased One Hundred-Fold by Use of Miller Effect].—N. H. Roberts. (*Nature*, 15th April 1939, Vol. 143, pp. 639–640.)

2752. SHORT SURVEY OF PUSH-BUTTON TUNING.—(*Auslese der Funktechnik* [replacing *Radio, B., F. für Alle*], April 1939, No. 1, pp. 2–6.)

2753. NEW ELECTRIC-RAZOR INTERFERENCE FILTER.—(*QST*, May 1939, Vol. 23, No. 5, p. 110.)

2754. TUBULAR [Paper-Dielectric] CONDENSERS [Forms of Construction: Inductance Negligible compared with That of Connecting Leads: etc.].—F. R. W. Strafford. (*Wireless World*, 11th May 1939, Vol. 44, pp. 437–438.)

2755. THE RADIO RECEIVER AS PART OF THE BROADCAST SYSTEM [Historical Analysis, Present Equipment, Future Possibilities].—A. Van Dyck. (*Communications*, March & April 1939, Vol. 19, Nos. 3 & 4, pp. 8–11 & 7–9 and 44..48.)

2756. RADIO PROGRESS DURING 1938: PART III—RADIO RECEIVERS.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 169–174.)

2757. REMOTELY CONTROLLED RECEIVER FOR RADIOTELEPHONE SYSTEMS [Ship-to-Shore: embodying a "Codan," Crystal Control, etc.].—H. B. Fischer. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 264–269.) *See* also 2999, below.

AERIALS AND AERIAL SYSTEMS

2758. INVESTIGATIONS IN THE NEAR FIELD OF A MIRROR IN THE FORM OF A PARABOLOID OF REVOLUTION.—W. Bach. (*Hochf:tech. u. Elek:akus.*, April 1939, Vol. 53, No. 4, pp. 115–122.)

The questions here dealt with are those of focusing of ultra-short waves in the laboratory, for medical or biological purposes, where the field near the mirror is employed. The apparatus is shown in Fig. 1, § II; the wavelengths used were 4.9, 14.2, and 66 cm. Measurements of the near field are described in § III; curves are given for wavelength 14.2 cm of the decrease of intensity along the mirror axis (Fig. 2), the distribution of intensity across the cross-section of the beam at various distances from the mirror (Fig. 3), and the distribution of energy in space (curves of equal intensity, Fig. 4). The gain obtained from the mirror is also discussed. The intensity distribution for wavelengths of 4.9 and 66 cm are shown in Figs. 5, 6 respectively.

Energy focusing with a mirror is discussed in § IV, where the aim is to obtain an image of the emitting dipole, in analogy to optical focusing. The relative received intensity as a function of the distance of the emitting dipole from the mirror is measured, with the aim of testing whether a formula analogous to the optical image equation is valid. The positions of the intensity maxima give the distances to be taken as the image distances; Fig. 8 shows good agreement between the experimental and the theoretical image curve for 4.9 and 14.2 cm wavelength. The aperture of the mirror used was too small to give an image with a 66 cm wavelength. Increase of amplification in the near field by image formation, and the sharpness of energy concentration (Fig. 9), are discussed.

Energy focusing using a mirror at the receiver as well as at the emitter, for a wavelength of 14.2 cm, is described in § V (curves Fig. 10). Practical application of the results to biological irradiation (§ VI) necessitates a trial-and-error method of finding the most favourable positions. The numerical results are summarised (§ VII).

2759. A NEW TELEVISION AERIAL [on Empire State Buildings, for NBC Transmitter W2XBS: Four Torpedo-Shaped Radiators (forming Two Dipoles for Vision) surmounted by Four Dipole Elements arranged in Circle, for Sound].—N. E. Lindenblad. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 223: photograph and note only.) The shape of the vision dipoles was chosen to give "almost constant impedance over a wide band of frequencies. It is claimed that there is no mutual impedance between the sound and vision radiators." See *RCA Review*, April 1939, Vol 3, No. 4, pp. 387–408

2760. ANDREA TELECEPTOR [Special Television Receiving Aerial System with "Climate-Sealed" Coupling, Low-Loss Transmission Line, etc.].—(*Communications*, March 1939, Vol. 19, No. 3, pp. 27 and 47.)

2761. ABSORPTION AND RE-RADIATION BY RESONATORS [Laws: Distance Relationships for Maximum Effects, when Great Total Energy is induced in Receiving Aerial].—C. R. Fountain & E. G. Pigg. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 592: abstract only.)

2762. INFLUENCE OF ELECTRICAL CONDUCTIVITY OF SURROUNDINGS ON THE NATURAL WAVELENGTH OF AN ANTENNA [Increase of Wavelength with Conductivity up to Definite Limit, Constant for Greater Conductivities: Limit is Boundary between Dielectric and Conductive State.].—R. Nakhla. (*Nature*, 29th April 1939, Vol. 143, p. 723.)

2763. THEORETICAL INVESTIGATIONS INTO THE TRANSMITTING AND RECEIVING QUALITIES OF ANTENNAE.—E. Hallén. (*Nova Acta Regiae Societatis Scientiarum Upsaliensis*, Series IV, No. 4, Vol. 11, 1938, pp. 3–44.)

The one-dimensional antenna equation (eqn. 13) is first derived, starting from Maxwell's equations, neglecting the cross-section diameter of the wire compared with its length but treating log (greatest diameter of cross-section of wire/length of wire) as finite. This is then applied to the discussion of the straight dipole antenna with tuning circuit in the central point (Fig. 1), picking up a plane wave. The general formulae are found (eqn. 22, also valid for a transmitter by equating the received field to zero; eqns. 24, 26, 29, the current). The calculations can be extended to very general antennae (bent, curved, etc.); calculations are given for the first terms of the solution. The impedance is given by eqn. 39. The radiation absorption of a dipole antenna is derived in § 3. The circular frame antenna with a connected tuning circuit (Fig. 7) is discussed in a similar way, with formulae for the input current, antenna impedance in the absence of a received field, the natural frequencies of a circular ring with a small gap, the voltage caused by a received field on the connected tuning circuit, the damped natural frequencies of the whole oscillatory circuit, etc. The reception of transient radiation is also discussed, with a formula for the antenna current.

2764. INVESTIGATIONS IN GREAT BRITAIN ON THE RADIATING AND RECEIVING PROPERTIES OF ANTENNAE.—Smith-Rose. (In paper referred to in 2643, above.)

2765. RADIO PROGRESS DURING 1938: PART V—TRANSMITTERS AND ANTENNAS.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 177–180.)

2766. THE DESIGN OF AN AERIAL GIVING A PREDETERMINED DIRECTIONAL CHARACTERISTIC.—A. A. Pistol'kors. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1939, pp. 9–19.)

The disadvantages of Wolff's method (2963 of 1937) for determining a radiating system in accordance with a specified directional characteristic are pointed out, and a new method is proposed in which the directional characteristic of a system of vertical radiators is represented by a Fourier series (6) depending directly on sines and cosines of the angle ϕ and its multiples (and not on the function $md \cos \phi/2$ as in Wolff's method). The method proposed is applied to the cases of radiators arranged in (a) a straight line, (b) two perpendicular lines, and (c) a circle, and the relative advantages of these systems for practical purposes are discussed. A Fourier series (11) depending on angles ϕ and θ, and representing the three-dimensional directional characteristic of a radiating system, is also derived, and practical uses of this formula are indicated.

2767. NBC BEAM ANTENNAS [Stationary System with Beam shiftable, by Remote Control from Transmitter, from Buenos Aires to Rio de Janeiro].—G. Goddess. (*Communications*, March 1939, Vol. 19, No. 3, p. 16.)

2768. COMMUNITY-AERIAL INSTALLATIONS, CONSTRUCTION AND RESULTS [Siemens, Telefunken, & Kapa Systems, and the Slightly Different Sandvoss System].—R. Moebes. (*T.F.T.*, April 1939, Vol. 28, No. 4, pp. 127–130.)

2769. A NEW ANTENNA SYSTEM FOR NOISE REDUCTION [based on "Counterpoise" running Close (about 6″) to Aerial for about Half Its Length and connected to Opposite End of Same Primary as Aerial: Balance Adjustment by Variable Condenser].—V. D. Landon & J. D. Reid. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 188–191.) This is the system referred to in 3577 of 1938. "A partial list of prior art, most of which is available only in patents," is given, and includes a patent by de Monge (*see* also 99 of 1938).

2770. PROPERTIES AND APPLICATION OF TAPERED RADIO-FREQUENCY TRANSMISSION LINES [particularly the Exponential Line, as a High-Pass Impedance-Transforming Filter, etc.].—T. M. Libby. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 230: summary only.) *Cf.* Wheeler, 1454 of April.

2771. ALUMINIUM COAXIAL TRANSMISSION LINE [Gas-Filled: with Special Gas-Tight Coupling eliminating Soldering or Welding].—Isolantite Company. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. ii.) Used for the WTAM aerial. *See* also 1895 of May.

2772. METHODS FOR OBTAINING TRAVELLING ELECTROMAGNETIC WAVES (IN A LINE) WITHOUT LOSS OF POWER.—Neimann. (*See* 2679.)

VALVES AND THERMIONICS

2773. A HIGH-FREQUENCY AMPLIFIER AND OSCILLATOR ["Klystron"].—R. H. Varian & S. F. Varian. (*Journ. of Applied Phys.*, Feb. 1939, Vol. 10, No. 2, p. 140: May 1939, Vol. 10, No. 5, pp. 321–327 [detailed account].)

The "klystron" (*see* 1848 of May) is based on Hansen's h.f. resonators (63 of January [& 2295 of June]) and makes constructive use of the transit time of the electrons. A first rhumbatron, the "buncher," causes a stream of cathode rays to gather themselves into bunches; a second rhumbatron, the "catcher," receives their power. The conditions under which the "klystron" acts as an amplifier, oscillator, or regenerative amplifier are described. *See* also Wheelock, 2726, above.

2774. A NEW "ALL-GLASS" VALVE CONSTRUCTION [with Special Advantages for Short and Ultra-Short Waves: Usual Valve Base abolished: Disadvantages of "Pinch" Construction and Top Lead-Out removed: the Television-Amplifier Pentode EF 50 and Other Types].—F. Prakke, J. L. H. Jonker, & M. J. O. Strutt. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, pp. 224–230.) For previous references to "all-glass" construction *see* 1467/1469 of April; for "single-ended" valves *see* 546 of February.

2775. FOOTLESS VALVES: NEW TUNGSRAM RANGE FOR SHORT [and Ultra-Short] WAVES [All-Glass, with Metal Cover for Screening & Protection: Modified Octal Base: Types EF 11, EBF 11, etc.].—Tungsram Company. (*Wireless World*, 25th May 1939, Vol. 44, pp. 487–488.)

2776. VALVE FOR ULTRA-SHORT WAVES ["Sentron"].—S. Uda. (*Journ. Scient. Instr.*, May 1939, Vol. 16, No. 5, p. 171.) *See* 990 [*also* 991] of March.

2777. CORRECTIONS TO "HIGH FREQUENCY, MIXING, AND DETECTION STAGES OF TELEVISION RECEIVERS."—Strutt. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 236.) *See* 2428 of June.

2778. INPUT RESISTANCE OF R.F. RECEIVING TUBES: EFFECT ON CIRCUIT GAIN AND SELECTIVITY AT HIGH FREQUENCIES [7, 14, & 28 Mc/s].—G. Grammer. (*QST*, May 1939, Vol. 23, No. 5, pp. 41–43 and 90.) Based on data recently given in the RCA *Application Note* No. 101, "Input Loading of Receiving Tubes at Radio Frequencies."

2779. RADIO PROGRESS DURING 1938: PART II—ELECTRONICS: ULTRA-HIGH-FREQUENCY TUBES [and Circuits].—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 165–167.)

2780. ANALYTICAL CHARACTERISTICS OF A TRIODE. —I. I. Teumin. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2155–2167.)

It is pointed out that the classical equations of a triode represent only fixed relationships between different values under definite operating conditions. It is, therefore, stated that "the object of this investigation is to find the simplest universal equations showing the relationship between all the fundamental electric values of a triode, and enabling graphs to be plotted corresponding to the nature of the processes taking place in the triode."

To achieve this result, approximate equations are derived for the following three groups of characteristics :—"load characteristics" of the type $I_{ma} = f_1^{i}(R_e)$ and $I_{ao} = f_2^{i}(R_e)$; "excitation characteristics of the type $I_{ma} = f_1^{ii}(V_g)$ and $I_{ao} = f_2^{ii}(V_g)$ and "régime or bias characteristics" of the type $I_{ma} = f_1^{iii}(E_g)$ and $I_{ao} = f_2^{iii}(E_g)$. On the basis of these equations universal graphs are plotted showing the operation of the triode under various conditions. The accuracy of the method is sufficient for a preliminary choice of operating conditions.

2781. DIFFICULTIES ENCOUNTERED IN MEASURING THE H.F. OUTPUT OF AIR-COOLED TRANSMITTING VALVES AT FREQUENCIES BELOW 20 Mc/s.—J. P. Heyboer. (*Philips Transmitting News*, Dec. 1938, Vol. 5, No. 4, pp. 114–128 : in German & English concurrently.)

Requirements of artificial aerials (up to 150 w, carbon resistance in carbon tetrachloride, kept boiling by the heat evolved, is satisfactory ; for higher powers, up to 1.5 kw, a cross-wound constantan resistance, water-cooled) : difficulties with the "three-ammeter" method of calibration : with the "anode-dissipation" and "calorimetric" (cooling-water temperature-rise) methods.

2782. "HOCHFREQUENZTECHNIK : II" [Valves and Amplifiers : Book Review].—J. Kammerloher. (*T.F.T.*, March 1939, Vol. 28, No. 3, p. 114.) For I *see* 2718, above.

2783. "FUNDAMENTAL ELECTRONICS AND VACUUM TUBES" [Book Review].—A. L. Albert. (*Wireless Engineer*, May 1939, p. 230.)

2784. RADIO PROGRESS DURING 1938 : PART II—ELECTRONICS : RECEIVING TUBES AND GAS-FILLED TUBES.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 167–168.)

2785. MAGNETIC-CONTROLLED DISCHARGE TUBE ["Permatron," for Industrial & Radio Control Purposes : Special Advantages over Thyratron].—Raytheon Corporation. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. vi and viii.) Referred to in 4608 of 1938.

2786. PLASMA OSCILLATIONS AND SCATTERING IN LOW-PRESSURE DISCHARGES [Paths and Scattering of Primary Electrons from Cathode : Plasma Oscillation corresponding to Each Scattering Region : Frequencies agree with Formulae : Oscillations are due to Passage of Fast Electrons through Plasma].—H. J. Merrill & H. W. Webb. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 597–598 : abstract only.) For formulae *see* Tonks & Langmuir, 1929 Abstracts, p. 273.

2787. "THÉORIE ET TECHNIQUE DU BRUIT DE FOND [Background Noise] : EFFETS SCHOTTKY ET THERMIQUE" [Book Review].—F. Bedeau. (*Current Science*, Bangalore, April 1939, Vol. 8, No. 4, p. 178.)

2788. REPORT ON NOISE IN VACUUM TUBES [Agreement between American, English, & German Results : Application to Three- and Multi-Element Valves], *and* REPORT ON THE PRESENT STATE OF KNOWLEDGE CONCERNING FLUCTUATION VOLTAGES IN ELECTRICAL NETWORKS AND THERMIONIC TUBES.—F. B. Llewellyn : E. B. Moullin. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, pp. 8–12 : pp. 12–17.) For errata in the second paper *see* inset : for a review of Moullin's book *see* 1914 of May.

2789. NOISE OF FREQUENCY-CHANGER VALVES [Criticism of Suggestion that Reduction is due to Averaging Effect of Anode Tuned Circuit : Idea of "Fourier Components of Current existing Steadily" is Definitely Wrong : etc.].—D. A. Bell : Lukács & others. (*Wireless Engineer*, April 1939, Vol. 16, No. 187, pp. 187–188.) For previous argument *see* 1913 of May.

2790. NOISE REDUCTION BY MEANS OF PHOTO-ELECTRIC MULTIPLIERS [Comparison with Ordinary Photocells with Amplifiers].—Preisach. (*See* 2864.)

2791. SOME DYNAMIC MEASUREMENTS OF ELECTRONIC MOTION IN MULTI-GRID VALVES.—M. J. O. Strutt & A. van der Ziel. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 218–225.) *See* 147 of January. The theory is found not to apply to the new four-beam converter valve AK2, which will be dealt with later : meanwhile *cf.* Jonker & van Overbeek, 3952 of 1938.

2792. SOME METHODS OF STUDYING THE ELECTRON PATHS IN THE DESIGN OF VALVES AND ELECTRON MULTIPLIERS [Philips and Bell Companies' Versions of the Rubber-Membrane Method].—Gallarati & Madia. (*Radio e Televisione*, Sept. 1938, Vol. 3, No. 2, pp. 101–107 : in Italian.)

2793. ON THE PATHS OF IONS IN THE CYCLOTRON [Calculations extended to Polar Angle Variations of Period $2\pi/3$: Stable Orbits].—L. I. Schiff. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 422 : abstract only.)

2794. INVESTIGATIONS ON WIRES HEATED BY ELECTRIC CURRENTS [as in Hot-Wire Meters, Fuses, etc.].—J. Fischer. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 20, 1939, pp. 140–148.)

Author's summary :—The original fundamental calculations given by the author for the heating of linear conductors by currents [in his 1931 book] . . . contain approximations, from which the author's more complete calculations are free [1895/1896 & 2592 of 1938, and 1929 of May]. In order to test whether the numerous predictions of this original theory are valid, whether, in fact, this theory forms a reliable basis for the calculation of the above-named instruments and the determination of their optimum design, measurements have been made with simple arrangements, on numerous wires of circular cross-section in stationary air, of the extension and the resistance-increase as functions of current, voltage, and power, for various metals and alloys and for various lengths and cross-sections. It was found that these experimental results agreed with the theoretical predictions not only fundamentally but also in many important details. Discrepancies either with the original or the more far-reaching calculations, or lack of completeness in these calculations, did not make their appearance in any single point.

2795. The Emission of Secondary Electrons from Metals bombarded with Protons [Data].—J. S. Allen. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, pp. 336–339.)

2796. The Emission of Secondary Electrons under High-Energy Positive-Ion Bombardment [Measurements for Various Metals].—Hill, Buechner, Clark, & Fisk. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, pp. 463–470.)

2797. Total Secondary-Electron Emission from Tungsten and Thorium-Coated Tungsten [investigated over Primary Electron-Energy Range 100 to 1000 V].—E. A. Coomes. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 519–525.)

2798. The Energy Distribution in Field Emission [from Tungsten: Use of Method of Retarding Potentials: Major Features of Distribution: Evidence that Electrons leaving Metal come through and not over Surface Barrier].—J. E. Henderson & R. K. Dahlstrom. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, pp. 473–481.) *Cf.* (in relation to crystal rectifiers) Mott, 2563 of June.

2799. Field Currents at High and Low Pressures [Emitting Points changed by Local Heating produced by High Current Densities at the Points].—B. E. K. Alter & R. T. K. Murray. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 672: abstract only.)

2800. Time Changes in Emission from Oxide-Coated Cathodes [Study of Decay of Electron Emission when Emission-Limited Current is drawn from Oxide Cathode: Decay due to Transport of Barium or Oxygen by Electrolysis and Diffusion: Value of Heat of Diffusion Process: Discussion of Other Time Variations in Emission].—J. P. Blewett. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 713–717.)

2801. Electron Microscope for the Study of the Thermionic Emission of the Pastes used for Cathodes of Valves and X-Ray & Cathode-Ray Tubes [using Johannson Immersion Lenses].—G. Gallarati. (*Radio e Televisione*, March 1939, Vol. 3, No. 5, pp. 293–296: in Italian.) Developed in conjunction with Castellani.

2802. Ionisation of Sodium Atoms on the Surface of Thoriated Tungsten and Its Effectiveness as a Method of Studying Film Cathodes.—N. D. Morgulis & B. I. Dyatlovitskaja. (*Comptes Rendus (Doklady) de l'Acad. des Sci de l'URSS*, No. 4, Vol. 21, 1938, pp. 165–167: in English.)

2803. The Rate of Evaporation of Tantalum [as Function of Temperature, determined by measuring Change of Resistance and Weight of Uniform Filaments: Empirical Formula].—D. B. Langmuir & L. Malter. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 748–749.)

2804. "Clean-Up" under Canal-Ray Discharge [Experiments at $10^{-2} - 10^{-3}$ cm Hg Pressure: Occurrence of Series of Rapid Fluctuations of Small Amplitude in Fall of Voltage: etc.].—V. T. Chiplonkar. (*Current Science*, Bangalore, April 1939, Vol. 8, No. 4, pp. 160–161.)

DIRECTIONAL WIRELESS

2805. The Production of Decimetric Waves of High Power, and Their Application to the Detection of Obstacles [Havre Equipment detects Packet-Boats at 10 km with Error of 1° in Direction and 200 m in Distance].—H. Gutton. (*Génie Civil*, 6th May 1939, Vol. 114, No. 18, p. 388: summary of lecture.)

2806. Philips Ultra-Short-Wave Beacon BRA 200/8 [Approach Beacon also useful as Navigational Beacon: Automatic Operation].—R. F. Volz & A. G. de Jager. (*Philips Transmitting News*, Dec. 1938, Vol. 5, No. 4, pp. 97–107.)

2807. Surface Radiation and the "Vertical Effect" of Closed Aerials.—L. Sacco. (*U.S.R.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 102–120: in Italian, with French summary: long additions in Inset.)

Mesny in 1925 and Bashenoff & Mjasoedoff (2598 of 1936) have shown, "without going deeply into the subject," how this "antenna effect" can be calculated in certain cases. "In our paper the question is put on a quantitative basis which is sufficiently general for the most common applications, with the sole restriction that the ratio of wavelength to frame perimeter is not less than three," so that the differential equations of lines with uniform electrical constants may be assumed to hold for the frames. A general expression is derived for the equivalent height of the frame, whether for transmission or reception. The second part of this expression, almost independent of the angle between the plane of the frame and the plane of propagation, represents the vertical effect. Circular, rectangular, and triangular frames are considered, and three modes of linking between frame and exciting circuit. The effect of the circuit excited by the frame, or exciting it, is deduced, particularly the influence of electrical symmetry.

2808. Investigations in Great Britain on the Behaviour of Direction-Finding Installations.—Smith-Rose. (In paper referred to in 2643 above.)

2809. The Radio Compass [Survey of Principles].—(*Wireless World*, 4th May 1939, Vol. 44, pp. 414–416.)

ACOUSTICS AND AUDIO-FREQUENCIES

2810. A Loudspeaker System for High-Quality Broadcasting [primarily for Programme Monitoring: Very Uniform Response from 30 to 13 000 c/s, gradually Falling Off to 15 000 c/s: Harmonic Generation Undetectable by Ear: Small Size].—S. A. Waite. (*Communications*, March 1939, Vol. 19, No. 3, pp. 12–13 and 45.)

"Perhaps the reason why a given programme or orchestra, for instance, sounds entirely different over one station than it does when it broadcasts from another . . . can be explained in terms of monitoring loudspeakers better than in any other way."

2811. The Chladni Patterns on Circular Plates.—R. C. Colwell, J. K. Stewart, & A. W. Friend. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 595: abstract only.)

2812. Damping of Flat Impulses of Small Amplitude.—I. M. Shmushkevich. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2168–2174.)

The propagation of impulses of finite amplitude produced by the movement of a piston in a cylinder having an open end is investigated mathematically up to the moment of the break in continuity. The subsequent behaviour of the flat impulses so formed is discussed in detail, and equations are derived determining the damping of such impulses. The actual building up of the front of a flat impulse is not considered.

2813. Piezoelectricity in Electroacoustics [with Characteristic Curves of Rochelle-Salt Microphone, Pick-Up, and Telephone Receiver].—C. Crescini. (*Radio e Televisione*, Jan. 1939, Vol. 3, No. 4, pp. 236–245: in Italian.)

2814. A Dynamic Measurement of the Elastic, Electric, and Piezoelectric Constants of Rochelle Salt.—Mason. (*See* 2897.)

2815. A Logarithmic Voltmeter with Differential Indication [and Its Use for Filter-Characteristic Plotting, the Calibration of Microphones & Loudspeakers, and the Measurement of Sound Insulation].—Nuovo. (*See* 2909.)

2816. Combination Oscillations and Dying-Out Processes of the Carbon-Microphone Diaphragm.—K. Braun. (*T.F.T.*, March 1939, Vol. 28, No. 3, pp. 104–109.)

Author's summary:—"In the first section the mode of vibration of the diaphragm is studied, when the latter is excited simultaneously by two notes. It is found [mathematically] that the diaphragm not only vibrates with the frequencies of the exciting notes but also carries out harmonic and combination vibrations. The amplitudes of the sum and difference notes depend on the frequency gap between the two exciting notes. In the second section the dying-out process of the diaphragm is considered. It is shown not only that the diaphragm's vibrations die out at its own resonance frequency, but that in addition there appear overtones [only the first overtone is strong] as well as a displacement of the diaphragm to one side of its position of rest [this displacement dies away as the damped vibrations are extinguished]." This theoretical result is confirmed by an oscillogram.

2817. A New System of Sound Recording and Reproduction ["I.M.R.C.-Duotrac" System (primarily for Shipboard Entertainment) with One Hour's Programme in Double Track (Unwinding & Rewinding) "dyed straight into" Ozaphane Ribbon], *and* Sound Reproduction on Paper [Russian Development].—Internat. Marine Radio Company: Skvortsov. (*Electrician*, 5th May 1939, Vol. 122, p. 566: p. 567.) For a South American development in the use of paper records *see* 600 of 1936: for Skvortsov's work *see* also *Wireless World*, 11th May 1939, p. 451.

2818. Lateral Disc Recording for Immediate Playback with Extended Frequency and Volume Range [using Lacquer-Coated Discs with Special Cutting-Head and Reproducing Pick-Up].—H. J. Hasbrouck. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 184–187.)

2819. Some Brief Experiments on the "Almite" Gramophone Record [for Direct Recording and Reproduction: Anodised Aluminium Discs for Steel Needles].—A. Miyata. (*Jap. Journ. of Phys., Transactions & Abstracts*, No. 1, Vol. 13, 1939, Abstracts p. 3.)

2820. Electric Gramophone [Seven-Valve Amplifier for Best Quality of Reproduction].—M. G. Scroggie. (*Wireless World*, 11th May 1939, Vol. 44, pp. 432–436.)

2821. Wave-Shape Plots for checking [Audio-Frequency] Amplifier Distortion [Simple Method of determining, with Oscilloscope, whether Distortion exceeds Acceptable Limits].—(*QST*, May 1939, Vol. 23, No. 5, pp. 50–51.)

2822. Control of the Effective Internal Impedance of Amplifiers by means of Feedback [and Its Use for A.F. Power Amplifiers favourable in Frequency Characteristic and Loudspeaker Damping].—Mayer. (*See* 2721.)

2823. Amplitude Limiters and Auto-Regulating Systems in Communication Technique [Wireless Telegraphy & Telephony, Sound-Film Recording, etc: Survey, with Some Test Results].—M. Nuovo. (*La Ricerca Scient.*, April 1939, 10th Year, No. 4, pp. 261–270.)

2824. An Experimental Electronic Violin.—L. H. Stauffer. (*Journ. of Applied Phys.*, Feb. 1939, Vol. 10, No. 2, pp. 96–100.)

2825. ANALYSIS OF MUSICAL SOUNDS [Harmonic Components for Various Instruments].—A. Dammann. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1283–1285.)

2826. ACOUSTIC SPECTRA OBTAINED BY THE DIFFRACTION OF LIGHT FROM SOUND FILMS [Effect of Type and Development of Photographic Emulsion: Spectra of Speech Transients].—D. Brown & others. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, p. 549.) Discussion on paper dealt with in 2402 of June.

2827. A SOUND ANALYSER AND AN A.F. OSCILLATOR USING DEGENERATIVE AMPLIFIER TO GIVE HIGHLY SELECTIVE CIRCUIT.—General Radio Company: Scott. (*See* 2723.)

2828. ORCHESTRAL PITCH [and the Use of a Cathode-Ray Tube, Electrically Driven String, Chronometer, & Synchronous Motor for Precision Measurement of Orchestral Pitch during Broadcast Concerts].—B. van der Pol & C. C. J. Addink. (*Wireless World*, 11th May 1939, Vol. 44, pp. 441–442.)

2829. DISTRIBUTION OF EIGENTONES AT LOW FREQUENCIES [Formulae for Rectangular Room derived from Consideration of Density of Characteristic Points in Frequency Space].—R. H. Bolt. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 420: abstract only.)

2830. RESONANCE IN THE EXTERNAL AUDITORY MEATUS [Influence of Conditions at Entrance to Meatus: Results of Measurements with Meatus open to Air].—N. Fleming. (*Nature*, 15th April 1939, Vol. 143, pp. 642–643.) *See* also Littler, 1538 of April.

2831. RADIO PROGRESS DURING 1938: PART I—ELECTROACOUSTICS. — I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 161–164.)

2832. EXPLANATION OF THE PROPAGATION OF EXPLOSION WAVES AT THE BOUNDARY BETWEEN TWO MEDIA.—Joos & Teltow. (*See* 2642.)

2833. THE TRUE VELOCITY OF SOUND IN AIR [Discrepancies of Various Precision Measurements are due to Curvature of Sound Rays produced along Rough Surface: Best Value of Velocity].—H. O. Kneser. (*Ann. der Physik*, Series 5, No. 7, Vol. 34, 1939, pp. 665–668.)

2834. SUPERSONIC PHENOMENA [Summarising Account: Theory of Propagation of Plane Sound Waves: Experimental Determination of Velocity and Absorption of Sound: Effect of Sound Waves of Large Amplitude: Bibliography].—W. T. Richards. (*Reviews of Modern Physics*, Jan. 1939, Vol. 11, No. 1, pp. 36–64.)

2835. CONSTRUCTION, PERFORMANCE, AND DESIGN OF THE ACOUSTIC AIR-JET GENERATOR.—J. Hartmann. (*Journ. Scient. Instr.*, May 1939, Vol. 16, No. 5, pp. 140–149.) *Cf.* 2419 of June.

2836. AN IMPROVED MAGNETOSTRICTION OSCILLATOR [with Output variable continuously from Zero to 2000 Watts].—W. W. Salisbury & C. W. Porter. (*Review Scient. Instr.*, April 1939, Vol. 10, No. 4, pp. 142–146.)

2837. THE FRESNEL DIFFRACTION PHENOMENON WITH SUPERSONIC WAVES AND ITS EVALUATION BY MASCART'S METHOD [Diffraction at a Finite Distance from the Acoustic Field: Calculation of Variation of Refractive Index; Connection of Mascart's Method with Töpler's "Schlieren" Method: Agreement of Calculated Intensities with Results of Raman & Nath's Theory and with Measurements].—F. Mahler. (*Ann. der Physik*, Series 5, No. 8, Vol. 34, 1939, pp. 689–716.)

2838. MEASUREMENT OF THE ABSORPTION OF SUPERSONIC WAVES IN AIR AND IN ARGON, *and* APPLICATION OF TÖPLER'S METHOD TO THE MEASUREMENT OF SUPERSONIC ABSORPTION IN AIR.—Dadaian & Pumper: Korolev. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 7/8, Vol. 20, 1938, pp. 539–542, in French: pp. 545–546, in English.)

2839. THE DISPERSION OF SUPERSONIC WAVES IN LIQUIDS [No Dispersion at Frequencies near 10^7 c/s in Water or Xylol: Data: Agreement with Theory].—F. Matossi. (*Physik. Zeitschr.*, 15th April 1939, Vol. 40, No. 8, pp. 294–297.)

2840. THE ULTRASONIC METHOD FOR THE DETERMINATION OF THE ELASTIC PROPERTIES OF SOLIDS, *and* ON THERMAL AND STRESS DEPENDENCE OF ELASTICITY IN SOLIDS.—H. Ludloff. (*Phys. Review*, 15th March & 1st April 1939, Series 2, Vol. 55, Nos. 6 & 7, pp. 593–594: p. 681: abstracts only.)

2841. SUPERSONIC METHOD OF MEASUREMENT OF CERTAIN ELASTIC ADIABATIC CONSTANTS OF CRYSTALS [with Results for Rocksalt].—E. Baumgardt. (*Comptes Rendus*, 24th April 1939, Vol. 208, No. 17, pp. 1280–1282.)

2842. SUPERSONIC DISPERSION AND INFRA-RED RADIATION.—Richardson. (*See* 3020.)

PHOTOTELEGRAPHY AND TELEVISION

2843. PEAK FIELD STRENGTHS OF ATMOSPHERICS DUE TO LOCAL THUNDERSTORMS AT 150 Mc/s.—Schafer & Goodall. (*See* 2688.)

2844. TELEVISION ECONOMICS: PARTS II & III—STUDIO-TO-TRANSMITTER LINK, STUDIO RADIO EQUIPMENT [including Recent Improvements in the Iconoscope (Halation Effect avoided by Sand-Blasting the Mica Surface: Use of Semiconducting Glass Plates: the "Image Iconoscope" with Semi-Transparent Photocathode: Reduction of "Dark Spot": etc.): Shading Control: Use of Films: etc.].—A. N. Goldsmith. (*Communications*, March & April 1939, Vol. 19, Nos. 3 & 4, pp. 17–19 and 27, 49 . . 51: pp. 26–27 and 35 . . 39.) For Part I *see* 1989 of May.

2845. Enter American Television [Short Account of NBC and CBS Final Preparations].—(*World-Radio*, 28th April 1939, Vol. 28, p. 13.)

2846. Radio Transmission Considerations [Outline of Differences between Sound and Picture Requirements: Noise & Distortion: Transients & Phase Angle: Partially-Suppressed Sideband (and the RCA Concentric-Line Filters): etc.].—T. A. Smith. (*Communications*, March 1939, Vol. 19, No. 3, pp. 30–32.)

2847. Radio Progress during 1938: Part IV—Television and Facsimile.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 174–177.)

2848. Television Projection by a New Method ["Light Storage" Principle].—M. von Ardenne. (*Auslese der Funktechnik* [replacing *Radio, B., F. für Alle*], April 1939, No. 1, pp. 22–23.) Based on the paper dealt with in 1063 of March.

2849. Scophony's Part in Television.—(*Radio e Televisione*, Nov. 1938, Vol. 3, No. 3, pp. 156–165.)

2850. Official Demonstration of Large-Screen Television at the Théâtre Marigny [Paris, 31st March 1939].—Adam. (*Génie Civil*, 15th April 1939, Vol. 114, No. 15, pp. 324–325.)

2851. Television from the Standpoint of the Motion Picture Industry [Third Annual Report of the Research Council of the Academy of Motion Picture Arts & Sciences].—(*Radio e Televisione*, Jan. 1939, Vol. 3, No. 4, pp. 246–252: in English.)

2852. Television Terminology [Some Equivalents in Italian, French, English, & German].—(*Radio e Televisione*, Jan. & March, Vol. 3, Nos. 4 & 5, pp. 270–277 & 319–324.)

2853. Safety in Television Receivers.—A. W. Barber. (*Communications*, March 1939, Vol. 19, No. 3, pp. 26–27.)

2854. "Safety" becomes a Watchword [Progress of A.R.R.L. Campaign against Fatalities from Electric Shock].—De Soto. (*See* 3016.)

2855. Radio Progress during 1938. Part II—Electronics: Cathode-Ray and Television Tubes.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 164–165.)

2856. Intensifier-Type Cathode-Ray Tube [Sensitivity increased by Use of Post-Deflection Acceleration by Metallic-Deposit Rings].—Du Mont Laboratories. (*Communications*, March 1939, Vol. 19, No. 3, p. 33.)

2857. "Electron Optics" [Book Review].—Klemperer. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 236.) Prepared by the E.M.I. Research Staff.

2858. Papers on Fluorescent Materials.—(*See* under "Subsidiary Apparatus & Materials.")

2859. Practical Aspects of Wide-Band Television Amplifier Design [also for Biological Research or Study of Transient Wave Forms: Practical Advantages of Unbalanced over Balanced Types: Selection of Valves: Noise: Use of Negative Feedback: Power Supplies: etc.].—F. A. Everest. (*Communications*, March 1939, Vol. 19, No. 3, pp. 21–22 and 24, 38, 39, 48, 49.) The IRE Convention paper, a summary of which was referred to in 4472 of 1938. *Cf.* also 2018 of May.

2860. The Input Impedance of Self-Biased Amplifiers [primarily in connection with a Frequency-Corrected Amplifier for Television].—F. C. Williams & A. E. Chester. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, pp. 231–236.)

"Experimental tests only verified the simple theory for a single stage. When two similar stages in cascade were tested the amplification at high frequencies exceeded the expectation." This was traced to the behaviour of the input capacitance of the second stage, and led to the present investigation, which was made as general as possible in view of the several applications of the circuit (as means of obtaining negative grid bias, as rectifier, and as frequency-corrected wide-band amplifier). It forms a special case of the general theorem of feedback amplifiers given independently by Brayshaw (881 of 1938).

2861. Corrections to "High Frequency, Mixing, and Detection Stages of Television Receivers."—Strutt. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 236.) *See* 2428 of June.

2862. Television Transmission by Telephone Cable [from the O.B. Point to the Special Television Cable: the Practical Aspects].—S. H. Padel. (*World-Radio*, 28th April & 5th May 1939, Vol. 28, pp. 16–17 & 14–15.)

2863. Experimental Investigations on the Susceptibility to Interference [from Broadcasting & Commercial Long-Wave Stations, and from a Neighbouring Cable of Same Type] of Wide-Band Cables with Tubular Outer Conductor.—E. Müller & H. Riedel. (*T.F.T.*, April 1939, Vol. 28, No. 4, pp. 116–122.)

Interference from a wireless station was imitated by sending a h.f. interference current along the lead covering of a 284 m length of laid cable; the resulting interference voltage was measured in the central conductor. Fig. 3 shows a comparison between a "tube" cable (with one longitudinal slit only, with no extra screening except a thin aluminium foil covering: lower curve) and a "shell" cable (Schalenkabel, with two longitudinal slits: with thicker walls and supplementary screening by copper and iron ribbon: upper curve). Although the "tube" cable was better at low frequencies, the interference not passing the measuring limit (broken line) till 400 kc/s, both types are considered to be protected against this kind of interference to frequencies of 50 kc/s, since at this frequency the measured values for both correspond to less than 0.1 μV. This agrees with Wuckel's results with a receiver of about this sensitivity (1464 of 1937 & 2902 of 1938).

Section II deals with interference caused by a neighbouring coaxial line of the same type embodied in the same cable: the experiments form a check on Buchholz's theoretical treatment of the effect of longitudinal slits (1530 of 1938): good agreement is found. The effects of varying the orientation of the slits with regard to one another on the over-all coupling resistance, and consequently on the resulting cross-talk, are investigated, for both the single-slit and double-slit types of external conductor, and other tests include the effects of binding the tubes with paper, metallised-paper, copper, and iron ribbons (Figs. 9 & 11). Fig. 10 shows the curve of the coupling resistance of two coaxial lines, each sheathed only with a thin lead covering (as might occur when the two lines of a two-way cable are led in separately and extended to the amplifier-rack), for various gaps between the external conductor and the lead sheath: the corresponding mutual interference vanishes when the gap is zero. The above tests were made on short lengths, but Fig. 12 shows the cross-talk and far-end cross-talk of a two-way cable of the "shell" double-split type over a section of 10.8 km.

The conclusions reached are that cables with a single coaxial line combined with a number of telephone conductors need only a covering of metallised paper over the outer coaxial conductor; cables with two coaxial lines, for a two-way service, are liable to an increased magnetic interaction due to their slits (whose relative positions are bound to be at random in commercial lengths of cable), but one, or two, metallised-paper coatings to each coaxial line is enough to give an adequate freedom from cross-talk. If a specially complete freedom is required an additional iron-ribbon screening of each coaxial line is satisfactory.

2864. NOISE REDUCTION BY MEANS OF PHOTO-ELECTRIC MULTIPLIERS [Limit of Sensitivity in Circuits with Ordinary Photocells compared with That in Electron-Multiplier: Gain of about 200 obtained by Use of Latter: etc.].—F. Preisach. (*Wireless Engineer*, April 1939, Vol. 16, No. 187, pp. 169–173.)

2865. THE SURFACE EFFECT AND DEPTH EFFECT IN COMPOSITE PHOTOCATHODES.—R. Fleischer & H. Pech. (*Zeitschr. f. Phys.*, No. 3/4, Vol. 112, 1939, pp. 242–251.)

Continuation of work dealt with in 626 of 1938. The relation between the spectral selective maximum and the accelerating anode voltage is investigated. Its displacement towards long or short wavelengths is found to depend on the sensitivity to red light of the photocathode. "An attempt is made to explain the wandering of the selective maximum towards long wavelengths by the photoelectric depth effect and the wandering back to shorter wavelengths by a space charge built up in and under the cathode surface by slow electrons supplied in large numbers by the depth effect. Asymptotic approach of the spectral maximum as it wanders back to short wavelengths to a definite position in the spectrum points to the development of equilibrium in the space charge." The investigations are extended to the voltage variation of the long-wave photoelectric limit and the spectral characteristic there. Neither is found to depend on voltage for voltages above 10 volts. This indicates that "the electrons arising from the depth effect are not a factor in determining the long-wave photoelectric limit; the depth effect in the neighbourhood of the long-wave limit does not supply enough electrons to build up a space-charge in and under the cathode surface." The study of the voltage dependency of the selective maximum is found to supply a method of investigating the construction of the photocathode.

2866. TOWNSEND IONISATION COEFFICIENTS IN Cs/Ag/O PHOTOTUBES FILLED WITH ARGON.—W. S. Huxford. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 754–762.) A summary was referred to in 4488 of 1938.

2867. PHOTOEFFECT AND SECONDARY EMISSION WITH [Caesium-] ALLOY CATHODES.—N. M. Gopstein & D. M. Khorosh. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2103–2106.)

An account of an experimental investigation of the photoelectric and secondary-emission properties of alloys of caesium with heavy metals (Sb, Bi, As, Te, and P). The preparation of these cathodes is described, and it is pointed out that since the cathodes so obtained are transparent, they retain their sensitivity when illuminated from either the front or the rear. The integral sensitivity and coefficients of secondary emission of these cathodes were found to be approximately as follows:—Sb–Cs, 60–70 mA/Lm; 8: As–Cs, 20–40 mA/Lm; 6: Bi–Cs, 10–15 mA/Lm; 3. The integral sensitivity of P–Cs and Te–Cs is very low (of the order of a few mA/Lm).

2868. THE QUANTITATIVE TREATMENT OF THE PRIMARY AND SECONDARY PHOTOELECTRIC CURRENTS [Corrected Formula and Diagram for Yield of Fully-Illuminated Crystal].—R. Hilsch & R. W. Pohl: Schottky. (*Zeitschr. f. Phys.*, No. 3/4, Vol. 112, 1939, pp. 252–255.) Correction to paper dealt with in 1548 of 1938.

2869. PHOTOCONDUCTIVITY OF CROCOITE CRYSTALS.—J. J. Brady & W. H. Moore. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 424: abstract only.)

2870. THE RELATIONSHIP BETWEEN TEMPERATURE AND BARRIER-LAYER PHOTOEFFECT IN COPPER-OXIDE PHOTOCELLS ACTUATED BY X-RAYS.—A. N. Kronhaus. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2097–2100.)

The effect of x-rays on copper-oxide photocells was investigated for temperatures from − 160°C to + 80°C. The apparatus used is described and a number of experimental curves are shown. The main conclusions reached are as follows:—The photo e.m.f. and photocurrent greatly increase at low temperatures; the photocurrent passes through a maximum between − 50°C and − 70°C, while the corresponding point for the e.m.f. lies between the same limits for one type of cell and between − 100°C and − 110°C for another type. Furthermore, at low temperatures the photo e.m.f. appears to be independent of the voltage applied to the x-ray tube (*i.e.* of the intensity of x-rays falling on the cell), while the resistance of the cell decreases with the increase in that voltage.

2871. On the Photoeffect in Semiconductors.—K. G. Trofimov. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2101–2102.)

The theory of Schottky that the presence of a barrier layer between the semiconductor and the electrode is an essential condition for the appearance of a photoeffect was replaced later by the theory of the insulating layer. The correctness of this theory has, however, also been challenged (*see* Behrendt, 1057 of 1937), and in the present paper an account is given of experiments which give further confirmation that neither of these theories is satisfactory. The experiments described are interesting not only from the theoretical point of view but also because they may lead to simpler methods for manufacturing selenium photocells.

2872. Experimental Results obtained by Photo-electronic Photography [Potassium Photo-sensitive Surfaces are Stable to High Voltages at Low Pressures and can photograph Photo-electronic Images under High Accelerating Voltages: Advantages of Photographic Plate over Counter, for Feeble Illuminations].—A. Lallemand. (*Comptes Rendus*, 17th April 1939, Vol. 208, No. 16, pp. 1211–1212.) For previous work *see* 606 of 1937.

2873. Radio Progress during 1938: Part II—Electronics: Photoelectric Devices.—I.R.E. Tech. Committee. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 168–169.)

2874. Electro-Optical Effects in [Bentonite] Colloids, *and* Influence of Frequency on the Electro-Optical Effect in Colloids.—H. Mueller: F. J. Norton. (*Phys. Review*, 1st March & 15th April 1939, Series 2, Vol. 55, Nos. 5 & 8, pp. 508 & 792: 1st April 1939, No. 7, pp. 668–669.)

2875. Critical Frequency of Flicker and Indirect Stimuli; *and* On Some Correlations of Different Receptors in Our Colour Vision; *also* Some Regularities underlying the Effect of Indirect Stimuli upon the Discrimination Sensitivity of the Eye.—S. V. Kravkov: N. T. Fedorov. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 2, Vol. 22, 1939, pp. 64–66 and 67–69: pp. 70–74: all in English.)

2876. Development of Television in Japan.—Arakawa, Kimpara, & Amisima. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 32–33: in French.) This wrongly titled abstract refers to the paper on facsimile telegraphy dealt with in 3294 of 1938.

2877. "Radio Facsimile" [Book Review].—Radio Corporation of America. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 232.)

2878. A Narrative Bibliography of Radio Facsimile.—J. L. Callahan. (*Radio e Televisione*, March 1939, Vol. 3, No. 5, pp. 297–308: in English.) With a bibliography of 261 items, including many patents.

2879. Tests of Facsimile Radio Transmission in Italy.—Magneti Marelli Company. (*Radio e Televisione*, March 1939, Vol. 3, No. 5, pp. 309–316: in Italian.)

MEASUREMENTS AND STANDARDS

2880. Nomogram for the Inductance of a Circular Ring [as used in Ultra-Short-Wave Circuits: based on Kirchhoff's Formula].—T. S. E. Thomas. (*Communications*, March 1939, Vol. 19, No. 3, pp. 14 & 15.)

2881. An Ultra-High-Frequency Measuring Assembly [for Precise Frequency Measurements up to 360 Mc/s: with Appendices on New Formulae for Multivibrator Oscillation at Frequencies of 1 Mc/s or More, and on Simple Method for Calibration of Lecher-Wire Pair].—S. Sabaroff. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 208–212.) Using the writer's stabilised oscillator (2919 of 1937) to give the selected standard frequency of 7 Mc/s.

2882. Ultra-High-Frequency Thermocouple Instruments [Impedance and Skin Effect reduced by Doubled-Back Very Thin Flat Ribbon Heater: Stray Fields reduced by Concentric Arrangement of Conductors: Small Diameter].—General Electric Company. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. ii.)

2883. On the Sensitivity Threshold of a Gas Radiometer [only about Same as That of Ordinary Thermocell: Rejection of Hayes's Claims and Veingerov's Supporting Calculations].—K. Wulfson: Heiess [Hayes]. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 21, 1938, pp. 224–227: in English.) For Veingerov's acknowledgment *see* p. 228; the Hayes receiver of radiant energy is dealt with in 2854 of 1936.

2884. Search-Coil Oscillator for measuring Fields of Magnetic Electron Lenses.—Klemperer & Miller. (*See* 2927.)

2885. Report to Commission I on the Measurement of Radio Field Intensity [Progress at N.P.L. since London Meeting, 1934].—R. L. Smith-Rose. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 28–31.) For additions *see* inset. For the 1934 Report *see* 3309 of 1938.

2886. TEMPERATURE COEFFICIENT OF INDUCTANCE [Doubt that It can be Calculated from Data so far Available: Discrepancy between Theory and Experiment: "Proximity Factor" Phenomenon preferable to Groszkowski's "Eddy-Current" Hypothesis as Cause of Discrepancy].—D. A. Bell. (*Wireless Engineer,* May 1939, Vol. 16, No. 188, p. 240.) For the papers quoted *see* 1636 of April (Thomas) and 2695 of 1937 (Groszkowski).

2887. A FALLING-WEIGHT TIME SWITCH: ITS STANDARDISATION AND APPLICATION TO THE DETERMINATION OF THE TIME CONSTANT OF AN INDUCTIVE CIRCUIT.—E. J. Irons & G. A. Bennett. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, pp. 459–464.)

2888. AN IMPROVEMENT IN CONSTANT-FREQUENCY OSCILLATORS.—Lampkin. (*See* 2730.)

2889. REPORT TO COMMISSION I [on Piezoelectric Quartz: Frequency Standards: International Comparisons of Radio Frequencies (Cause of Frequency "Wobble": Spurious Beat Phenomena: etc.)], *and* REPORT TO COMMISSION I [Vienna Results].—E. H. Rayner: Petritsch. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 34–41: pp. 91–93.) For an addition to the first paper *see* inset.

2890. MECHANICAL OSCILLATIONS OF A PIEZOELECTRICALLY EXCITED QUARTZ CRYSTAL [Microphotographs of Chladni Figures on Surface: Calculation of Frequency and Velocity of Propagation of Vibration].—F. Seidl. (*Zeitschr. f. Phys.*, No. 5/6, Vol. 112, 1939, pp. 362–363.)

2891. EQUIVALENCE OF TWO PIEZOELECTRIC OSCILLATING QUARTZ CRYSTALS OF SYMMETRICAL OUTLINES WITH RESPECT TO A PLANE PERPENDICULAR TO AN ELECTRICAL AXIS [Theory: Unique Determination of Piezoelectric Oscillating Quartz by Identification of Relationship to Particular Faces, whether Mother Crystal is Right- or Left-Handed].—I. Koga. (*Phil. Mag.*, May 1939, Series 7, Vol. 27, No. 184, pp. 640–643.)

2892. DISPERSION OF LIGHT IN CRYSTALS OF QUARTZ [and Its Relation to the Orientation of the Crystallographic Axes: Experiments].—K. S. Wulfson & M. I. Lombert. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 1/2, Vol. 21, 1938, pp. 25–27: in French.)

2893. EFFECT OF QUARTZ FILTERS [and Their Piezoelectric Oscillations] ON THE DISTRIBUTION OF ENERGY IN LAUE PATTERNS [Results explained by Reduction of Primary Extinction and Increased Range of Wavelength reflected from Interior during Oscillation].—Fox & Stebbins. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, pp. 405–408.)

2894. THE STRIATED LUMINOUS GLOW OF THE PIEZOELECTRIC QUARTZ RESONATOR AT FLEXURAL VIBRATION FREQUENCIES.—J. R. Harrison & I. P. Hooper. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 674: abstract only.)

2895. FREQUENCY DEPENDENCE OF THE VELOCITY OF PROPAGATION OF FLEXURAL OSCILLATIONS [of Rectangular Quartz Plates cut Perpendicular to the Optical Axis: Theory: Agreement with Experimental Results].—F. Krista. (*Zeitschr. f. Phys.*, No. 5/6, Vol. 112, 1939, pp. 326–338.)

2896. THE FORMATION OF ELASTIC TWINS DURING THE TWINNING OF CALCITE CRYSTALS [Elastic Twins produced by Stresses as low as 26 g/mm²: etc.].—R. I. Garber. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 21, 1938, pp. 229–231: in English.)

2897. A DYNAMIC MEASUREMENT OF THE ELASTIC, ELECTRIC, AND PIEZOELECTRIC CONSTANTS OF ROCHELLE SALT [Theoretical Frequencies agree with Experiment: Difference between Piezoelectric Constants measured Dynamically and Statically: Possible Finite Relaxation Time for Piezoelectric Elements].—W. P. Mason. (*Phys. Review*, 15th April 1939, Series 2, Vol. 55, No. 8, pp. 775–789.)

2898. A VALVE FREQUENCY-METER FOR DIRECT INDICATION AT HIGH FREQUENCIES [Condenser-Charging Method].—L. Pajetta. (*Radio e Televisione*, Sept. 1938, Vol. 3, No. 2, pp. 113–130.) Conclusion of the paper dealt with in 4018 of 1938.

2899. THE UTILISATION OF ABSOLUTE FREQUENCY METERS FOR SCIENTIFIC REQUIREMENTS [*e.g.* for checking Astronomical Pendulum (Detection of Earth Tremors, Gravity Variations) and Absolute Determination of Ohm].—J. Jouaust. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 26–27: in French.)

2900. TIME: THE QUESTION OF GREENWICH CIVIL TIME *versus* GREENWICH MEAN TIME [Definitions and Comments].—J. B. Moore. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, p. 231.). *Also* May, No. 5, pp. 357–358.

2901. DIFFICULTIES ENCOUNTERED IN MEASURING THE H.F. OUTPUT OF AIR-COOLED TRANSMITTING VALVES AT FREQUENCIES BELOW 20 Mc/s.—Heyboer. (*See* 2781.)

2902. INVESTIGATIONS ON WIRES HEATED BY ELECTRIC CURRENTS [as in Fuses, Hot-Wire Meters, etc.].—Fischer. (*See* 2794.)

2903. THERMAL POWER METER OF HIGH ACCURACY AND SENSITIVITY: CALCULATIONS AND EXPERIMENTS.—J. Fischer. (*Arch. f. Elektrot.*, 14th April 1939, Vol. 33, No. 4, pp. 242–260.)

2904. Thermal Wattmeter for High-Frequency Circuits [using Two Thermocouples (or, for Low Frequencies, Dry-Plate Rectifiers): Theory and Experimental Results].—G. Maione. (*U.R.S.I. Proc. of* 1938 *General Assembly, Venice & Rome*, Vol. 5, Fasc. 1, 1938, pp. 122–127: in Italian, with French summary.)

The experimental work dealt with voltages of some hundreds of volts and currents of some tenths of an ampere. For frequencies up to 500 kc/s, the phase error and Fleming factor were negligible; for higher frequencies the writer proposes to use condensers shunted by resistances.

2905. Wattmeters using Non-Linear Impedances.—E. E. Vartel'ski. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1939, pp. 51–62.)

The operation of a circuit employing two non-linear impedance (diodes) with square-law characteristics is discussed, and it is shown that this circuit is suitable for power measurements in d.c., single-phase, and multi-phase systems. The circuit, in a modified form, can also be used as a voltammeter and for measuring reactive power. Methods are indicated for designing the wattmeter.

2906. The Measurement of the "Quality" of Coils.—G.W.O.H: Opitz. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, pp. 221–223.) Editorial prompted by Opitz's paper (2046 of May). The lack of commercial condensers which are really free from inductance is commented on (Opitz's paper, p. 30, r-h column): "this is a subject on which one would like to have more information."

2907. Circuit Magnification ["Q Value"] Meter.—Marconi-Ekco Company. (*Journ. Scient. Instr.*, April 1939, Vol. 16, No. 4, p. 127.)

2908. A Sound Analyser and an A.F. Oscillator using Degenerative Amplifier to give Highly Selective Circuit.—General Radio Company: Scott. (*See* 2723.)

2909. A Logarithmic Voltmeter with Differential Indication.—M. Nuovo. (*Alta Frequenza*, March 1939, Vol. 8, No. 3, pp. 206–216.)

Author's summary:—If the grid circuit of a valve is fed through an ohmic resistance which is very high in comparison with the resistance of the grid/cathode space, the anode current of the valve will be a logarithmic function of the grid voltage. Using this principle, a differential logarithmic voltmeter has been developed and some measurements have been made on electric, electroacoustic, acoustic, and mechanical quadripoles: namely the determination of the response curves of electric filters, the calibration of microphones & loudspeakers, the measurement of sound insulation, and the determination of the curves of mechanical resonance of elastic materials, respectively.

2910. An Improvement of Rogowski's Magnetic Voltmeter [Winding balanced by Compensation Windings].—E. Baum. (*Arch. f. Elektrot.*, 14th April 1939, Vol. 33, No. 4, pp. 275–276.)

2911. A Recording Generating Voltmeter for Lightning Studies.—E. J. Workman & R. E. Holzer. (*Review Scient. Instr.*, May 1939, Vol. 10, No. 5, pp. 160–163.)

2912. Microvolt Potentiometer Circuit [for Maximum Accuracy & Reproducibility in measuring Voltages up to 100 000 μV].—S. C. Collins. (*Review Scient. Instr.*, April 1939, Vol. 10, No. 4, p. 147.)

2913. A Potentiometer for measuring Voltages of 10 Microvolts to an Accuracy of 0.01 Microvolt.—R. P. Teele & S. Schuhmann. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1939, Vol. 22, No. 4, pp. 431–439.)

2914. A Method of Reducing the Effect of Disturbances in the Galvanometer Branch of a Potentiometer Circuit.—F. Wenner. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1939, Vol. 22, No. 4, pp. 425–430.)

2915. Einthoven String Galvanometer used with a Vacuum-Tube Microvoltmeter [as D.C., Short-Period Measuring Instrument of High Voltage Sensitivity, for recording Bioelectric Potentials, etc.].—W. R. Miles. (*Review Scient. Instr.*, April 1939, Vol. 10, No. 4, pp. 134–136.)

2916. The Unit of Resistance [Definition: Methods of Measurement: General Account].—E. Haak. (*E.N.T.*, March 1939, Vol. 16, No. 3, pp. 69–72.)

2917. "Misure radiotechniche e Formulario" [Fourth Edition: Book Review].—G. Pession. (*La Ricerca Scient.*, April 1939, 10th Year, No. 4, pp. 359–360.)

SUBSIDIARY APPARATUS AND MATERIALS

2918. A Sensitive Two-Beam High-Power Oscillograph with Separate Discharge Tubes, for Low Exciting Voltage.—Thielen. (*Arch. f. Electrot.*, 28th March 1939, Vol. 33, No. 3, pp. 189–196.)

Author's abstract:—A description is given of a two-beam oscillograph with separate discharge tubes [schematic cross-section Fig. 3], giving high performance with low exciting voltage and having a common container for the locking, deviating, and recording mechanisms. Records are given to show that the oscillograph satisfies all conditions of a measuring instrument for technical use in respect to the freedom from interaction of the beams and deviating systems, and the equality of phase for the separate rays. The spatial dimensions and the amount of apparatus involved are scarcely greater than in a one-beam design capable of equal efficiency.

2919. INTENSIFIER TYPE CATHODE-RAY TUBE [Sensitivity increased by Use of Post-Deflection Acceleration by Metallic-Deposit Rings].—Du Mont Laboratories. (*Communications*, March 1939, Vol. 19, No. 3, p. 33.)

2920. CATHODE-RAY MONITOR TUBE [Type 4081, $2\frac{3}{4}''$ Screen, 8″ Over-All Length: for Radio Servicing, etc.].—General Electric Company. (*Journ. Scient Instr.*, April 1939, Vol. 16, No. 4, p. 131.)

2921. THE ABERRATIONS OF THE ORTHOGONAL SYSTEMS OF ELECTRON OPTICS, BY RELATIVISTIC APPROXIMATION.—Cotte. (*Ann. de Physique*, March 1939, Vol. 11, pp. 351–352.) Supplement (also a correction) to the paper referred to in 1126 of March.

2922. "ELECTRON OPTICS" [Book Review].—Klemperer. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 236.) Prepared by the E.M.I. Research Staff.

2923. THE SIEMENS-RUSKA ELECTRON MICROSCOPE, THE LALLEMAND ELECTRON TELESCOPE, AND THE HENROTEAU ELECTRON SPECTROGRAPH.—(*Radio e Televisione*, Nov. 1938, Vol. 3, No. 3, pp. 166–171: in Italian.)

2924. THE ELECTRON MICROSCOPE AND MICROBIOLOGY [Results with the Siemens-Ruska Supermicroscope].—Pampana. (*Radio e Televisione*, Jan. 1939, Vol. 3, No. 4, pp. 253–261: in Italian.)

2925. ELECTRON MICROSCOPE FOR THE STUDY OF THE THERMIONIC EMISSION OF THE PASTES USED FOR CATHODES OF VALVES AND X-RAY & CATHODE-RAY TUBES.—Gallarati. (*See* 2801.)

2926. FIELD MEASUREMENTS AND POSSIBLE CORRECTION OF ABERRATIONS FOR MAGNETIC ELECTRON LENSES.—Marton. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 672: abstract only.)

2927. SEARCH-COIL OSCILLATOR FOR MEASURING FIELDS OF MAGNETIC ELECTRON LENSES [4 mm Diam. Coil with Reciprocating Rotational Motion, eliminating Errors due to Slip Rings or Commutators: Resonance Amplifier tuned to Coil-Oscillation Frequency].—Klemperer & Miller. (*Journ. Scient. Instr.*, April 1939, Vol. 16, No. 4, pp. 121–123.) From the E.M.I. laboratories. For the instruments of Kohaut and Cole, referred to as liable to suffer from such errors, *see* 4140 of 1938.

2928. A SPHERICAL COIL FOR A MASS SPECTROMETER [giving Rather Strong Field of Great Uniformity throughout Large Volume with High Economy in Power and Copper: Special Variation of Current Density].—Hipple. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 597: abstract only.)

2929. ON THE PATHS OF IONS IN THE CYCLOTRON [Calculations extended to Polar Angle Variations of Period $2\pi/3$: Stable Orbits].—Schiff. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 422: abstract only.)

2930. SOME METHODS OF STUDYING THE ELECTRON PATHS IN THE DESIGN OF VALVES AND ELECTRON MULTIPLIERS [Philips and Bell Companies' Versions of the Rubber-Membrane Method].—Gallarati & Madia. (*Radio e Televisione*, Sept. 1938, Vol. 3, No. 2, pp. 101–107: in Italian.)

2931. A SIMPLE ARRANGEMENT FOR MEASURING THE CHARGING POTENTIAL OF FILMS OF LUMINESCENT MATERIALS IRRADIATED BY ELECTRONS.—Frerichs & Krautz. (*Physik. Zeitschr.*, 1st April 1939, Vol. 40, No. 7, pp. 229–230.)

The arrangement consists of a magnetic electron microscope with an indirectly heated hollow cathode surrounded by a Wehnelt cylinder at one end. The luminescent film is on the glass end plate of the microscope; on the outer side of this is a conducting film of (*e.g.*) Aquadag connected to the needle of a Brown electrometer of small capacity and suitable voltage range. Measurements with this device are described; curves are shown of the screen charge as a function of the cathode/anode voltage.

2932. VARIATION OF LIGHT OUTPUT WITH CURRENT DENSITY, AND CLASSIFICATION OF WILLEMITE PHOSPHORS [Evidence that Willemite falls into Same Class as ZnS Phosphors].—E. G. Ramberg & G. A. Morton. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 409.)

2933. LIGHT OUTPUT AND SECONDARY EMISSION CHARACTERISTICS OF LUMINESCENT MATERIALS [Data for Zinc Sulphide, Calcium Tungstate, Willemite, Silicate Phosphors: Light Output as Function of Screen Voltage: Relation between Light-Output/Current-Density Characteristic and Persistence Characteristic].—Martin & Headrick. (*Journ. of Applied Phys.*, Feb. 1939, Vol. 10, No. 2, pp. 116–127.)

2934. ON A NEW EFFECT IN LUMINESCENT ZINC SULPHIDE [excited by Ultra-Violet Light].—Riehl. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 20, 1939, pp. 152–155.)

Investigations prompted by measurements on the variation of the luminous intensity of certain phosphors with the intensity of the incident ultra-violet light. The measurements were carried out first on a copper-activated zinc sulphide (ZnSCu) with after-glow and a silver-activated zinc-cadmium sulphide (ZnCdSAg) free from after-glow. It was "surprisingly found" that while the fluorescent intensity of the ZnSCu with after-glow was, within the range measured, strictly proportional to the incident ultra-violet intensity, a marked departure from proportionality occurred with the ZnCdSAg free from after-glow, where such a result was least to be expected. It was particularly remarkable that the effect was not one of a saturation type such as has frequently been noticed in luminescent materials. On the contrary, the fluorescent intensity increased *more steeply* than in proportion to the incident ultra-violet light. Further tests showed that the effect occurred in all zinc-cadmium sulphides activated by silver and containing at least 30% of cadmium sulphide. It occurred also in the purest ZnS, so that it could not be attributed to the Cd content. Nor could it be attributed to the presence of Ag as activator, since it did not occur with the cadmium-free ZnSAg. Still further investigation, and theoretical considerations, led to the conclusion that the effect was due to the fact that at lower excitation a *greater fraction of he applied energy is converted into heat*. Since the writer's previous researches [4263 of 1937: *cf.* also Schön, 1674 of April] showed that the decay time is the shorter, the stronger the excitation, it may be said that the probability of a transformation of an absorbed quantum into heat is the greater, the longer the duration of residence of the energy in the crystal: this purely experimental conclusion fits in with theory.

The above and other considerations led to the belief that at higher temperatures the new effect would show itself in materials which gave no such action at room temperatures; for higher temperatures mean increased thermal agitation and an increased number of collisions. This prediction was confirmed: even the ZnSCu showed the departure from proportionality when tested at 270°C, so that it is probable that many other phosphors will display the effect at sufficiently high temperatures. Among the implications of this discovery, of increasing efficiency of transformation into visible light with increasing excitation, is that when the transformation-efficiency of a material as a function of temperature is being measured, the level of the exciting intensity must be considered, or false results will be obtained.

2935. SATURATION EFFECTS IN THE SHORT-DURATION PHOTOLUMINESCENCE OF ZINC-SULPHIDE PHOSPHORS [Fluorescence Intensity at 5 W/cm² Density of Incident Ultra-Violet Light is 5–10% Lower than at 100 Times Smaller Density, for Constant Total Energy].—de Groot. (*Physica*, May 1939, Vol. 6, No. 5, pp. 393–400: in English.) For previous work *see* 2089 of May: some additions to that paper are given here in an addendum on p. 400.

2936. LUMINESCENCE DURING INTERMITTENT ELECTRON BOMBARDMENT [Dynamic Luminescence Characteristics of Commercial Phosphors].—Nelson, Johnson, & Nottingham. (*Journ. of Applied Phys.*, May 1939, Vol. 10, No. 5, pp. 335–342.)

2937. PHOSPHORESCENCE, SELF-EXTINCTION, AND SENSITISING ACTION OF ORGANIC MATERIALS.—Kautsky & Merkel. (*Naturwiss.*, 24th March 1939, Vol. 27, No. 12, pp. 195–196.)

2938. DECAY OF PHOSPHORESCENCE AFTER ELECTRON BOMBARDMENT [Laws for Various Substances].—Nelson & Johnson. (*Phys. Review*, 15th March 1939, Series 2, Vol. 25, No. 6, p. 592: abstract only.)

2939. INVESTIGATION OF THE PHOSPHORESCENCE MECHANISM OF SAMARIUM PHOSPHORESCENT SUBSTANCES BY MEANS OF STUDYING THE DECAY OF THEIR LUMINESCENCE.—Lewschin & Rickman. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 6, Vol. 20, 1938, pp. 445–448: in English.)

2940. THEORETICAL EVALUATION OF A WIDE-ANGLE INTERFERENCE EXPERIMENT [showing Source of Fluorescent Light to consist of Electric Dipoles].—Doermann & Halpern. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, pp. 486–488.)

2941. AUTOMATIC BRILLIANCY-CONTROL UNIT FOR CATHODE-RAY TUBES.—A. C. Cossor, Ltd. (*Journ. Scient. Instr.*, April 1939, Vol. 16, No. 4, pp. 129–130.)

2942. [Cathode-Ray] OSCILLOGRAPH DESIGN CONSIDERATIONS [Design of Amplifier (and Its Gain Control), Sweep Circuit, Grid-Modulation Amplifier (for Timing Signals and Elimination of Return Trace), Amplifier Power Supply, etc.].—Mezger. (*Proc. Inst. Rad. Eng.*, March 1939, Vol. 27, No. 3, pp. 192–198.)

2943. A MULTI-CHANNEL OSCILLOGRAPH AMPLIFIER [" Intermittent " Method]. — T. Vogel: Williams & Beattie. (*Wireless Engineer*, May 1939, Vol. 16, No. 188, p. 240.) Prompted by Williams & Beattie's paper (2071 of May) and referring to the writer's patent of a very similar amplifier.

2944. RECORDING CAMERA [for Cathode-Ray Oscillographs: Advantages of Absence of Sprocket: Time Marker: etc.].—Southern Instruments Company. (*Journ. Scient. Instr.*, April 1939, Vol. 16, No. 4, pp. 131–132.)

2945. INSULATING JOINTS [Rigid & Heat-Proof] IN VACUUM TUBES [Use of a Ceramic Setting Compound].—Ehrenberg. (*Journ. Scient. Instr.*, May 1939, Vol. 16, No. 5, p. 162.) From the E.M.I. Research Laboratories.

2946. AN IMPROVED METHOD OF SPOT WELDING [for welding Disc or Plate (Electrode, etc.) perpendicularly onto a Support Wire].—Bayford. (*Journ. Scient. Instr.*, April 1939, Vol. 16, No. 4, p. 124.)

2947. THE RATE OF EVAPORATION OF TANTALUM.—Langmuir & Malter. (*See* 2803.)

2948. THE ENERGY DISTRIBUTION IN FIELD EMISSION.—Henderson & Dahlstrom. (*See* 2798.)

2949. " CLEAN-UP " UNDER CANAL-RAY DISCHARGE —Chiplonkar. (*See* 2804.)

2950. AN INVESTIGATION INTO THE GETTERING POWERS OF VARIOUS METALS FOR THE GASES HYDROGEN, OXYGEN, NITROGEN, CO_2, AND AIR.—Ehrke & Slack. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 684.)

2951. ELECTROMAGNETIC SCREENS.—Latmiral. (*See* 2632.)

2952. "COLUMBIAN COLLOIDAL CARBONS" [Book Review].—Columbian Carbon Company. (*Communications*, March 1939, Vol. 19, No. 3, p. 16.)

2953. INVESTIGATIONS ON WIRES HEATED BY ELECTRIC CURRENTS [as in Fuses, etc.].—Fischer. (*See* 2794.)

2954. A NEW FUSE PHENOMENON [Importance of "M" Effect (Solution of One Metal in Another) in Fuse Design].—Metcalf. (*BEAMA Journal*, April & May 1939, Vol. 44, pp. 109–112 & 151–152.)

2955. ON THE SO-CALLED "TRANSFORMATION TEMPERATURE" OF A METALLIC FILM: II—BAKE-OUT EFFECT ON THE SUBSTRATUM.—Fukuroi. (*Jap. Journ. of Phys., Transactions & Abstracts*, No. 1, Vol. 13, 1939, Abstracts p. 22.)

2956. ARRANGEMENT OF ATOMS AND MOLECULES IN EXTREMELY THIN FILMS [Formation of True Three-Dimensional Crystals].—Germer. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 605: abstract only.)

2957. ELECTRONIC STATES AT THE SURFACES OF CRYSTALS [Theory]: I—THE APPROXIMATION OF NEARLY FREE ELECTRONS: II—THE APPROXIMATION OF TIGHT BINDING: FINITE LINEAR CHAIN OF ATOMS: III—THE APPROXIMATION OF TIGHT BINDING: FURTHER EXTENSIONS.—Goodwin. (*Proc. Camb. Phil. Soc.*, April 1939, Vol. 35, Part 2, pp. 205–220: 221–231: 232–241.)

2958. EFFECT OF HYDROSTATIC PRESSURE ON THE RESISTANCE OF SINGLE CRYSTALS OF SELENIUM [Decrease of Resistance with Increasing Pressures: Marked Hysteresis Effect: Resistance Temperature Coefficient].—Holmes & Allen. (*Phys. Review*, 15th March 1939, Vol. 55, No. 6, p. 593: abstract only.)

2959. THE EFFECT OF COOLING AND OF MAGNETIC FIELDS ON CRYSTAL RECTIFICATION [Increase in Rectification at Higher Temperature with Silicium, Decrease with Molybdenite: No Effect of Magnetic Field].—El Sherbini & Yousef. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, pp. 449–455.)

2960. SOME CONTRIBUTIONS TO THE THEORY OF SOLID RECTIFIERS [Extension of Davydov's "Changes of Concentration" Mechanism to Boundary between Semiconductors of Same Type but Different Specific Resistances].—Blokhintzev [Blochinzev] & Davydov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 1/2, Vol. 21, 1938, pp. 21–24: in English.) For Davydov's work *see* 1647 & 2892 of 1938 and 1684 of April.

2961. THE COURSE OF THE ELECTROCHEMICAL POTENTIALS IN THE CUPROUS-OXIDE RECTIFIER.—Lange. (*Physik. Zeitschr.*, 1st April 1939, Vol. 40, No. 7, pp. 230–232.)

2962. MAGNETIC-CONTROLLED DISCHARGE TUBE ["Permatron"].—Raytheon Corporation. (*See* 2785.)

2963. ON THE TIME OF THE RESTORATION OF CONTROLLABILITY IN A GAS DISCHARGE [Hull & Langmuir "Semi-Empirical" Formula for "Time of Deionisation" refers really to "Time of Restoration of Controllability": Derivation of Entirely Different Formula, and Confirmation from Experimental Data].—Granovsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 1, Vol. 22, 1939, pp. 29–33: in English.)

2964. IMPULSE BREAKDOWN IN LONG DISCHARGE TUBES.—Dietrich & Snoddy. (*See* 2676.)

2965. PLASMA OSCILLATIONS AND SCATTERING IN LOW-PRESSURE DISCHARGES.—Merrill & Webb. (*See* 2786.)

2966. SPARK DISCHARGE ON SURFACES [Same Type of Phenomenon as Initiation of Lightning Flash].—Snoddy & Beams. (*See* 2692.)

2967. THE SPRAY DISCHARGE FROM BADLY CONDUCTING FILMS ON HEATED GLASS, FORMED IN THE GLOW DISCHARGE.—Wolf. (*Zeitschr. f. Phys.*, No. 3/4, Vol. 112, 1939, pp. 148–158.)

2968. A POSSIBLE CAUSE FOR THE GLOW-TO-ARC TRANSITION [Experimental Studies supporting Theory of Bursts of Gas from Small Patches on Electrode Surface].—Maxfield, Hegbar, & Eaton. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 592: abstract only.)

2969. SPARKING POTENTIALS AT LOW PRESSURES [Measurements on Air and Other Gases up to 24 kV: Calculations of Number of Electrons released by Cathode per Positive Ion Impact].—Quinn. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, pp. 482–485.)

2970. ELECTRONIC BREAKDOWN IN SOLID DIELECTRICS [Experimental Points showing Agreement with Theory].—Austen & Hackett (*Nature*, 15th April 1939, Vol. 143, pp. 637–638.) For the theory *see* Fröhlich, 3503 of 1937.

2971. RESEARCHES ON THE INSULATING PROPERTIES OF MONOMOLECULAR FILMS [*e.g.* of Barium Stearate].—Race. (*Science*, 28th April 1939, Vol. 89, Supp. p. 14: paragraph only.)

2972. THERMAL INSTABILITY OF DIELECTRICS FOR ALTERNATING VOLTAGES WHEN THE LOSS ANGLE IS DEPENDENT UPON THE FIELD STRENGTH [Theory: Formulae for Breakdown Voltage: Application to Experimental Results].—Gemant & Whitehead. (*Phil. Mag.*, May 1939, Series 7, Vol. 27, No. 184, pp. 582–595).

2973. HINDERED MOLECULAR ROTATION AND THE DIELECTRIC BEHAVIOUR OF CONDENSED PHASES.—White. (*Bell T. System Tech. Pub.*, Monograph B-1116, 7 pp.)

2974. LINEAR COEFFICIENT OF THERMAL EXPANSION OF AMBROID.—Yetter. (*Review Scient. Instr.*, April 1939, Vol. 10, No. 4, p. 147.)

2975. TUBULAR [Paper-Dielectric] CONDENSERS.—Strafford. (*See* 2754.)

2976. THE LACK OF COMMERCIAL CONDENSERS REALLY FREE FROM INDUCTANCE.—G.W.O.H: Opitz. (*See* 2906.)

2977. MAGNETIC SUSCEPTIBILITIES IN WEAK FIELDS [Sensitive Method of Measurement: Some Results].—Hector & Peck. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 672: abstract only.)

2978. IRON CRYSTAL ORIENTATION IN MAGNETITE REDUCED BY HYDROGEN.—Buynov & others. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 1, Vol. 22, 1939, pp. 27–28: in English.)

2979. DETERMINATION OF THE THICKNESS OF THE THINNEST FILM OF ELECTROLYTIC IRON AT WHICH MAGNETISATION DISCONTINUITIES DISAPPEAR.—Procopiu. (*Comptes Rendus*, 17th April 1939, Vol. 208, No. 16, pp. 1212–1214.)

2980. THE ANOMALOUS MAGNETIC PROPERTIES OF ANHYDROUS $FeCl_2$. — Shalyt. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 20, 1938, pp. 657–658: in English.)

2981. INFLUENCE OF HEAT TREATMENT IN A MAGNETIC FIELD UPON THE DISTRIBUTION OF THE SPONTANEOUS REGIONS OF A FERROMAGNETIC MONOCRYSTAL.—Shur. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 1/2, Vol. 21, 1938, pp. 18–20: in English.)

2982. THE INNER, INITIAL PERMEABILITY OF IRON AND NICKEL FROM 98 TO 410 Mc/s [Experimental Values].—Hoag & Gottlieb. (*Phys. Review*, 15th Feb. 1939, Series 2, Vol. 55, No. 4, p. 410.)

2983. THE MAGNETIC ANISTROPY OF IRON-NICKEL AND COPPER-NICKEL ALLOYS.—Williams & Bozorth. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 673: abstract only.)

2984. FERROMAGNETIC ANISOTROPY IN NICKEL/IRON CRYSTALS: EVIDENCE FOR SUPERSTRUCTURE NEAR Ni_3Fe.—L. W. McKeehan & E. M. Grabbe. (*Phys. Review*, 1st March 1939, Series 2, Vol. 55, No. 5, p. 505.)

2985. THEORY OF REVERSIBLE MAGNETISATION IN FERROMAGNETICS.—Brown. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, pp. 568–578.)

2986. ON THE THEORY OF PARAMAGNETIC RELAXATION, *and* A THEORY OF FERROMAGNETISM [approached from Bethe's Method of Calculating the Critical Constants of the Ordering Phenomena in Alloys]. — van Vleck: Weiss & van Vleck. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 673: pp. 673–674: abstracts only.)

2987. ON THE SENSITIVITY THRESHOLD OF A GAS RADIOMETER.—Wulfson: Hayes. (*See* 2883.)

2988. A STROBOSCOPIC DEVICE FOR DETERMINING THE SPEED OF MECHANISMS.—M. V. Laufer. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 8, 1938, pp. 2150–2154.)

A circuit (Fig. 5) is described for controlling a neon lamp by a relaxation oscillator (modified Friedlander circuit) giving saw-toothed impulses of duration not exceeding 5% of the interval between two consecutive impulses. The frequency range of the oscillator is 40 to 300 c/s.

2989. A FALLING-WEIGHT TIME SWITCH.—Irons & Bennett. (*See* 2887.)

STATIONS, DESIGN AND OPERATION

2990. EXPLORING BELOW ONE METRE [Experimental Equipment for 5-Mile Telephonic Communication on 325 Mc/s: Absence of Ignition Interference (Too High Losses in Ignition System at This Frequency?): etc.].—Tynes & Babcock. (*QST*, May 1939, Vol. 23, No. 5, pp. 16–18 and 112.)

2991. INVESTIGATION OF THE TRANSMISSION CONDITIONS OF OVERHEAD LINES AT FREQUENCIES OF 55–1600 kc/s, WITH SPECIAL ATTENTION TO THE REQUIREMENTS FOR WIRE BROADCASTING.—Waldow, Spang, & Fritzsche. (*T.F.T.*, March 1939, Vol. 28, No. 3, pp. 93–100.)

The carrier frequencies in wire broadcasting lie in the band 150–250 kc/s, extending below and above these limits in special cases, so that the important band for these tests was reckoned as 100–300 kc/s; it was occasionally extended to 55–1600 kc/s. The main tests were on an overhead-line section of 20 km length, consisting of two two-wire circuits of 3 mm diam. bronze wire, mounted on the ordinary telephone poles and capable of having their transposition sections varied in length as desired. In these tests, the poles carried no other lines on the same cross-arm, only on lower cross-arms at such a distance that they were found to have negligible effects on the test lines. Measurements of kilometric attenuation, characteristic impedance, and phase constant (Figs. 2–4) agreed well with values calculated from approximate formulae taking skin-effect into account. The propagation velocity calculated from the measured phase-constant curve came out at 286 000 km/s.

When, however, actual lines used in practice came to be measured, they behaved very differently; for usually each cross-arm carried several lines which not only had cross-overs to reduce a.f. cross-talk, but also changed their positions on the cross-arms; all of which had a serious effect on the h.f. transmission. Further, they were often combined with cable sections, and Figs. 5 & 6 show the violent changes in characteristic impedance and attenuation produced by such a compounding. This state of affairs could, it is true, be remedied by the use of matching transformers, but this would be expensive, and moreover the correct transformers for h.f. working could block the a.f. currents for which the lines are also required. Figs. 7 & 8 show the seriously disturbing effect, on the kilometric attenuation & the characteristic impedance, of the interaction with a neighbouring circuit with a cross-over pitch of 400 m. *A violent increase in attenuation is seen to occur at a frequency for which the* 400 *m is a quarter-wavelength*, and this effect is reproduced in a weaker form for three-quarters and five-quarters of a wavelength. The difficulties which the above-mentioned facts cause in the planning of a wire-broadcasting system are discussed. An approximate technique which is being tried is to allow, for any overhead-wire sections, an attenuation of 0.1 (instead of 0.025) Neper/km : it remains to be seen if this will give reliable results. The difficulties are increased by the fact that in wire broadcasting the one circuit has generally to carry three carrier frequencies (p. 95, r-h column). The rest of the paper deals at considerable length with the question of cross-talk, with un-transposed lines and lines with cross-overs of different pitches.

2992. THE WIRE-BROADCASTING SEPARATING FILTERS AT THE TELEPHONE EXCHANGE [Older Type (DWa 36) and the Improved New Type (38) : Details of Construction of Latter].—Hinne. (*T.F.T.*, March 1939, Vol. 28, No. 3, pp. 100–104.) For Waldow's paper on the mode of action and electrical conditions of such separating filters *see* 1287 of March.

2993. NEW APPLIANCES FOR WIRE BROADCASTING INSTALLATIONS [with Lay-Outs and Drawings & Diagrams of Separating Filters, Wall Sockets, Distribution Boxes, etc.].—Weisshuhn & Budischin. (*T.F.T.*, April 1939, Vol. 28, No. 4, Supp. pp. 153–163.)

2994. CONTRIBUTION TO THE THEORY AND TECHNIQUE OF WIRELESS SINGLE-SIDEBAND TELEPHONY [Calculation of Distortions to be expected with Linear and Square-Law Detection : Experimental Investigations on Syllable Intelligibility with the Two Types of Detector : Liability to Interference of Single-Sideband Reception].—E. Haberkant & E. Meinel. (*T.F.T.*, April 1939, Vol. 28, No. 4, pp. 140–151.)

Among the conclusions arrived at is that with linear detection it is useless, owing to a "depression" effect as well as to excessive distortion, to modulate a single-sideband transmitter, with radiated carrier, more fully than about 200% (100% is taken to be when sideband and carrier amplitudes are equal : not, as in America, when the former is half the latter). For modulations up to 100% the two types of detector gives equally good intelligibility ; above that percentage the square-law detector gives better speech quality, and with such a detector a 180% modulation will give the permissible limit of 70% syllable intelligibility. As regards interference from a double-sideband transmitter on a neighbouring carrier frequency, for modulations of the single-sideband transmission below 100% the interference is chiefly due to the difference notes between the two carriers ; it is only for higher modulation percentages of the single-sideband transmission that it can be detected whether the interference is on the sideband side of the desired transmission or on the other, for at such higher percentages the interference with the single-sideband increases.

2995. THE IMPORTANCE OF THE MONITORING LOUDSPEAKER IN BROADCASTING.—Waite. (In paper dealt with in 2810, above.)

2996. SIMULTANEOUS-BROADCAST CIRCUITS [and Their Equalising].—Peachey. (*World-Radio*, 12th & 19th May 1939, Vol. 28, pp. 16–17 & 16–17.)

2997. THE SITUATION OF FRENCH BROADCASTING AFTER THE EUROPEAN CONFERENCE AT MONTREUX, MARCH/APRIL 1939.—Adam. (*Génie Civil*, 13th May 1939, Vol. 114, No. 19, pp. 401–403.)

2998. THE BROADCASTING HOUSE OF THE COLUMBIA BROADCASTING COMPANY AT LOS ANGELES, U.S.A.—(*Génie Civil*, 6th May 1939, Vol. 114, No. 18, pp. 385–386.)

2999. RADIOTELEPHONE SYSTEM FOR HARBOUR AND COASTAL SERVICES [embodying Crystal Control on Shore & Ship, "Vogads" & "Codans" (Carrier-Operated Device Anti-Noise) : etc.]. —Anderson & Pruden. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 245–253.) *See* also 3000 & 3001, below, and 2757, above.

3000. A VOGAD FOR RADIOTELEPHONE CIRCUITS.—Wright, Doba, & Dickieson. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 254–257.) *See* also 2999, above. A summary was dealt with in 3801 of 1938.

3001. SHIP EQUIPMENT FOR HARBOUR AND COASTAL RADIOTELEPHONE SERVICE.—Bair. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 258–263.) *See* also 2999, 3000, & 2757, above.

3002. COASTAL AND HARBOUR SHIP RADIOTELEPHONE SERVICE FROM NORFOLK, VIRGINIA.—Swingle & Bailey. (*Proc. Inst. Rad. Eng.*, April 1939, Vol. 27, No. 4, pp. 270–276.)

3003. THE WIRELESS INSTALLATION ON BOARD THE TWIN-SCREW STEAMER "NIEUW AMSTERDAM."—(*Philips Transmitting News*, Dec. 1938, Vol. 5, No. 4, pp. 110–113.)

GENERAL PHYSICAL ARTICLES

3004. INTERNATIONAL TEMPERATURE SCALE AND SOME RELATED PHYSICAL CONSTANTS.—Wensel. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1939, Vol. 22, No. 4, pp. 375–395.)

3005. THE DETERMINATION OF THE IONISATION COEFFICIENTS α AND γ IN GASES [Practical Method based on Transformation of Townsend Formula].—Gosseries. (*Physica*, May 1939, Vol. 6, No. 5, pp. 458–472 : in French.) The method includes an arrangement for the direct compensation of fluctuations in the ultra-violet source.

3006. THE SPECTROSCOPIC AND FREE ELECTRON VALUES OF *e/m* [X-Ray Refraction Measurement is a Free Electron Result and should not be averaged with Spectroscopic Results : Discrepancy between Spectroscopic and Free Electron Values].—Bearden. (*Phys. Review*, 15th March 1939, Series 2, Vol. 55, No. 6, p. 584.)

3007. A RE-EVALUATION OF THE ATOMIC CONSTANTS.—Dunnington. (*Phys. Review*, 1st April 1939, Series 2, Vol. 55, No. 7, p. 683.)

3008. GALVANO-MAGNETIC PHENOMENA [Hall Effect, etc.] IN A DIELECTRIC MATERIAL—MICA.—Prujinina-Granovskaja. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 8, Vol. 21, 1938, pp. 367–370 : in English.) Among the conclusions reached is that conductivity in mica is brought about by fixed electrons.

3009. PECULIARITIES OF THE HALL EFFECT IN SINGLE CRYSTALS OF ZINC, *and* CHANGE OF RESISTANCE OF SINGLE CRYSTALS OF ZINC IN A MAGNETIC FIELD.—Noskov : Lasarew & Noskov. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 13, 1938, pp. 127–129 : pp. 130–132.)

MISCELLANEOUS

3010. A LAPLACE TRANSFORMATION THEOREM FOR THE SEPARATION OF STEADY-STATE AND TRANSIENT PROCESSES.—Droste. (*See* 2705.)

3011. TRANSFORMATION TO PRINCIPAL AXES OF QUADRIPOLE MATRICES AND THEIR APPLICATION.—Weizel. (*See* 2715.)

3012. A NEW METHOD OF CREATING ELECTRIFICATION [Powdered Insulating Materials (Silica) falling onto Perforated Metal Plate : Plate becomes Positively, Powder Negatively Electrified (Not a Frictional Effect) under Certain Conditions].—Fleming. (*Proc. Phys. Soc.*, 1st May 1939, Vol. 51, Part 3, No. 285, pp. 402–406.)

3013. THE MEASUREMENT OF QUICK FLUCTUATIONS OF ROTATIONAL SPEEDS [Perforated Disc, Photocell, Adjustable Resonant Circuit, and Oscillograph Combination].—Eckel. (*Zeitschr. V.D.I.*, 1st April 1939, Vol. 83, No. 13, pp. 381–382.)

3014. A STROBOSCOPIC DEVICE FOR DETERMINING THE SPEED OF MECHANISMS.—Laufer. (*See* 2988.)

3015. A METHOD FOR INDICATING SPEEDS OF ROTATION [of High-Speed, Carefully Balanced Rotors, etc : Small Rotating Bar in Magnetic Field, combined with Tuned Vibration Galvanometer].—Morris & Silver. (*Journ. Scient. Instr.*, May 1939, Vol. 16, No. 5, pp. 149–150.)

3016. "SAFETY" BECOMES A WATCHWORD [Progress of A.R.R.L. Campaign against Fatalities from Electric Shock : Criticisms of Instructions for Artificial Respiration : etc.].—De Soto. (*QST*, May 1939, Vol. 23, No. 5, pp. 47–48 and 90..94 : *also* p. 65.) *See* 802 of February and 1422 of April.

3017. CONTRIBUTION TO THE FOUNDATIONS OF RADIO MINING PROSPECTING [Funkmutung] BY THE "ANTENNA EQUIVALENT-CAPACITY" METHOD.—V. Fritsch & W. Wiechowski. (*Hochf:tech. u. Elek:akus.*, April 1939, Vol. 53, No. 4, pp. 129–134.)

For work on the practical use of this capacity method in determining subterranean tectonics, etc., *see* 20 of 1936. Its fundamental principles are here set out ; Fig. 1 shows the basic experimental arrangement, in which the measuring aerial is stretched above the ground to be investigated. Figs. 2, 3 illustrate the introduction of equivalent imaginary homogeneous conductors to replace the natural ground beneath the aerial, and the "fictitious depth" at which an infinitely good conductor must extend in all directions to give the same electrical properties as the natural ground. The determination, from the measurements, of this "fictitious depth" and the attenuation in the layer between it and the aerial is the fundamental problem of the method. Figs. 4, 5 show equivalent electrical arrangements with double transmission lines, whose electrical dimensions are calculated in § II. Three methods of measurement (§ III) are (1) the height method, by variation of the height of the aerial above the ground ; (2) the base-line method, in which the aerial is moved along a base-line and the "fictitious depth" determined as a function of its position ; (3) the method of "C-bars" or curves of equal "fictitious depth". These are described in §§ IV, V, VI respectively, with illustrative diagrams including the case when the aerial is near a deep cleft (Figs. 10–13) or over water or caverns. Methods (2) & (3) are found to be suitable for investigation of large tracts, method (1) for detailed investigations. "The effect of the weather is always very large." For other work by the same writer *see*, for example, 809, 1659, 2051, 2052, 2422 of 1937 ; 1269, 3050, 3866 of 1938 ; and 39 of January & 1317 of March.

3018. ELECTRO-OPTICAL EFFECTS IN [Bentonite] COLLOIDS, *and* INFLUENCE OF FREQUENCY ON THE ELECTRO-OPTICAL EFFECT IN COLLOIDS.—Mueller : Norton. (*See* 2874.)

3019. EXPERIMENTAL RESULTS OBTAINED BY PHOTOELECTRONIC PHOTOGRAPHY.—Lallemand. (*See* 2872.)

3020. SUPERSONIC DISPERSION AND INFRA-RED RADIATION [Absorption of Supersonics in Carbon Dioxide increased by Subjecting Gas to Infra-Red Radiation of Wavelengths corresponding to Natural Frequencies of Its Molecule].—Richardson. (*Nature*, 15th April 1939, Vol. 143, pp. 638–639.)

3021. PRACTICAL ASPECTS OF WIDE-BAND AMPLIFIER DESIGN [for Biological Research, etc.].—Everest. (*See* 2859.)

Some Recent Patents

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS

500 865.—Tone-control networks for a low-frequency amplifier, particularly for reducing mains "hum."

F. J. Chart (assignee of M. G. Clay). Convention date (U.S.A.) 24th November, 1937.

502 579.—Amplifier with a negative feed-back impedance designed to increase the frequency range over which a straight-line response is secured.

E. L. C. White and M. G. Harker. Application date 22nd October, 1937.

502 595.—Amplifier and coupling circuit for a two-way loud-speaker system.

J. Levy. Convention date (Germany) 26th October, 1937.

AERIALS AND AERIAL SYSTEMS

500 360.—Method of energising a transmitting aerial so as to reduce "fading" effects.

Marconi's W.T. Co. and S. Aisenstein. Application date 7th August, 1937.

501 843.—Spaced arrangement of aerials, particularly for television, in which a directional effect is used to improve the signal-to-noise ratio.

E. C. Cork and J. L. Pawsey. Application date 26th June, 1937.

502 460.—Wireless aerial consisting of a tapered rod covered with a thin coating of metal.

G. de Monge. Convention date (Belgium) 30th October, 1937.

502 648.—Method of mounting and insulating a rod or dipole aerial, and of protecting it from lightning.

Telefunken Co. Convention date (Germany) 26th October, 1937.

DIRECTIONAL WIRELESS

503 005.—Direction-finding system in which the "dots" and "dashes" received from a rotating-beam transmitter are separately counted to give the bearing line.

C. Lorenz Akt. (addition to 447 707). Application date 19th August, 1938.

503 278.—Mast structure for a short-wave aerial "array" of radiators giving a uniform field in the horizontal plane.

E. C. Cork and J. L. Pawsey. Application date 15th March, 1938.

503 428.—Rotating condenser arrangement for applying the necessary phase-displacement to the currents in a directional wireless system of the overlapping-beam type.

Aga-Baltic Radio Akt. Convention date (Sweden) 26th November, 1936.

503 471.—Cathode-ray tube for indicating "off-course" deviations when an aeroplane is "homing" on to a wireless transmitting station.

Telefunken Co. Convention date (Germany) 8th October, 1937.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

501 644.—Selective arrangement of two circuits coupled through reactive means, operating in phase-opposition, to reject adjacent-channel interference.

Marconi's W.T. Co. (communicated by Radio Corporation of America). Application date 30th July, 1937.

501 692.—Receiver with push-button tuning, having one or more auxiliary buttons to allow tuning by manual control on selected wave-bands.

W. J. Brown. Application date 14th February, 1938.

501 760.—Receiving set in which the "fidelity" response is automatically controlled by the extent of interference present in the ether at any time.

Marconi's W.T. Co.; O. E. Keall; and N. M. Rust. Application date 4th September, 1937.

501 890.—Preventing damping of the input circuit by the rectifying-stage of an ultra-short-wave receiver.

Philips Lamp Co. Convention date (Germany) 10th July, 1937.

501 891.—Superhet circuit adapted to receive radiated or wired-wireless signals, at will, by switching a common local-oscillator valve.

C. Lorenz Akt. Convention date (Germany) 23rd July, 1937.

502 248.—Screened-grid valve circuit arranged to provide a convenient method of varying the selectivity of a wireless receiver.

F. T. Lett. Application date 14th July, 1937.

502 251.—Variable-inductance tuning system for a superhet receiver, with means to ensure accurate "tracking."

P. R. Mallory & Co. Inc. Convention date (U.S.A.) 8th August, 1936.

502 562.—Automatic volume control derived from a variable coupling, without detuning, and without using variable-mu valves.

L. W. Meyer (communicated by Philips' Lamp Co.). Application date 19th July, 1937.

502 834.—Tuning control with fine and coarse gearing and with means for automatically shutting-out interstation "noise."

The General Electric Co. and A. Bloch. Application date 27th September, 1937.

503 044.—Amplifier circuit in which both positive and negative feed-back is used to give the input valve a high, and the output valve a low anode resistance.

The British Thomson-Houston Co. Convention date (U.S.A.) 30th January, 1937.

503 083.—Amplifying circuit with negative feed-back applied through components of non-linear resistance, in order to control or vary the gain.

Standard Telephones and Cables and R. A. Meers. Application date 28th September, 1937.

503 133.—Tuning condenser with magnetic control for automatically de-tuning a superhet set to the extent necessary to avoid interference from overlapping signals.

H. J. Parrish. Application date 31st July, 1937.

503 459.—Coupling arrangement designed to minimise losses in a class B push-pull amplifier.

C. Lorenz Akt. Convention date (Germany) 6th July, 1937.

503 469.—Mains-driven wireless set in which the anode voltage applied to the amplifiers is varied in accordance with the signal strength.

Radiowerk Horny Akt. Convention date (Austria) 13th September, 1937.

503 496.—Controlling and supervising the performance of automatic frequency-control as applied to a superhet set.

Marconi's W.T. Co. and J. D. Brailsford. Application date 5th October, 1937.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

501 741.—Method of treating the luminescent screen of a cathode-ray tube so as to increase its resistance to burning.

Marconi's W.T. Co. Convention date (U.S.A.) 29th August, 1936.

501 802.—Cathode-ray television transmitter in which the photo-electric "cells" of a mosaic-screen are separated from the "storage" or condenser layer in the form of powdered iron mixed with insulating material.

C. Lorenz Akt. Convention date (Germany) 29th August, 1936.

501 816.—Cathode-ray television receiver in which the scanning stream is used to vary the transparency of a screen so that the received picture can be projected through it on to a larger screen outside the tube.

F. J. G. van den Bosch. Application date 3rd September, 1937.

501 919.—Amplifying the electron image of a picture to be televised by utilising the principle of secondary emission.

H. G. Lubszynski and W. S. Brown. Application date 5th August, 1937.

501 931.—Magnetic focusing system for the electron stream of a cathode-ray tube.

The British Thomson-Houston Co. Convention date (U.S.A.) 11th September, 1936.

501 966.—Method of "mixing" the signals derived from different scanning-devices in a television transmission system.

A. D. Blublein and R. E. Spencer. Application date, 7th June, 1937.

502 024.—Mosaic-cell screen in which the effective sensitivity is varied in order to prevent "space-charge" distortion on television.

W. Heimann. Convention date (Germany) 10th September, 1936.

502 098.—Television system in which direct-current and very low-frequency signal-components are specially treated or commuted.

Standard Telephones and Cables, and V. J. Terry. Application date, 10th September, 1937.

502 104.—Preventing the formation of detrimental negative charges on the fluorescent screen of a cathode-ray television receiver.

O. Klemperer. Application date, 11th Sept., 1937.

502 358.—System for televising in natural colours, by interlaced scanning, without the use of high-speed moving parts.

A. Carpmael (communicated by H. R. C. Van de Velde). Application date 14th September, 1937.

502 351.—Means for preventing the persistence of a "defocused" spot on the fluorescent screen of a cathode-ray television receiver after the set has been switched off.

Baird Television and D. V. Ridgeway. Application date 14th September, 1937.

502 509.—Mechanical scanning-system in which the usual single fixed "slit" is replaced by a number of slits, each co-operating with the same set of holes.

The General Electric Co. and D. C. Espley. Application date 3rd January, 1938.

502 615.—Electric wave-filter for a television amplifier designed to give a high combination of band-pass and stage gain.

W. S. Percival (addition to 475 490). Application date 22nd September, 1937.

502 696.—Construction of stationary mirror-ring for television scanning in which all the mirrors are held in place by end-pressure.

E. Traub. Application date 5th October, 1937.

502 796.—Cathode-ray tube in which a number of independent streams are produced for "multiple-spot" scanning in television.

J. D. McGee. Application date 23rd August, 1937.

502 830.—Circuit for producing saw-toothed oscillations for scanning in television.

Marconi's W.T. Co. Convention date (U.S.A.) 26th September, 1936.

502 975.—Optical system for projecting an image on to an electron-emitting surface in a cathode-ray tube for transmitting television signals.

W. D. Wright. Application date 1st October, 1937.

503 025.—Television system in which large-sized pictures are built up from individual sections, each of which is reproduced by a different cathode-ray tube and then combined on a common viewing-screen.

E. N. Muller. Convention date (Luxembourg) 1st October, 1936.

503 026.—Means for accurately mounting and spacing the mirror-elements on a rotating drum used for television scanning.

E. Traub. Application date 5th October, 1937.

503 074.—Method of mounting and spacing the control and focusing electrodes in a cathode-ray tube.

Pye Radio and G. Liebmann. Application dates 25th August, 1937 and 9th June, 1938.

503 087.—Method of separating synchronising-impulses from picture signals in a television receiver.

Marconi's W.T. Co. Convention date (U.S.A.) 30th September, 1936.

503 106.—Open mesh knitted-wire elastic "screen," which may be sensitised for photo-electric emission, or else used as an accelerating-electrode in a cathode-ray tube.

Farnsworth Television Inc. Convention date (U.S.A.) 31st October, 1936.

503 179.—Time-base circuit in which a mechanically-moving relay is used to separate the "line" and "frame" synchronising impulses in television or still-picture systems.

Philips Lamp Co. Convention date (Germany) 30th August, 1937.

503 327.—Scanning system in which the picture to be televised is analysed into "lines" of irregular shape, so as to ensure secrecy.

S. L. Clothier and H. C. Hogencamp. Convention date (U.S.A.) 6th October, 1936.

503 419.—Television receiver fitted with a viewing screen which can be rotated or adjusted relatively to the cabinet.

Marconi's W.T. Co. and A. A. Linsell. Application date 5th October, 1937.

503 426.—Means for adjusting or centring the "spot" on the fluorescent screen of a cathode-ray tube.

E. L. C. White. Application date 12th October, 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

501 859.—Means for equalising the "surface-load" on the anode of a valve of the magnetron type.

Ideal Werke Akt. Convention date (Germany) 17th December, 1936.

502 013.—Method of modulating signals in which the value of the carrier-wave component is automatically regulated by the amplitude of the signal.

J. C. Stewart. Convention dates (New Zealand) 6th June, 24th July, and 5th November, 1936.

502 814.—Carrier-current system for signalling over traffic-control or other low-frequency circuits.

Standard Telephones and Cables ; W. N. Roseway ; and F. C. Wright. Application date 24th September, 1937.

503 429.—Remote control and interlocking relay for a combined transmitting and receiving set.

Standard Telephones and Cables (assignees of Bell Telephone Manufacturing Co.) Convention date (Belgium) 28th December, 1936.

503 443.—Modulating system in which the anode voltage applied to the power amplifier is automatically varied in accordance with the amplitude of modulation.

C. Lorenz Akt. Convention date (Germany) 13th January, 1937.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

501 726.—Electron multiplier with an electron-optical focusing-structure formed of two coaxial elements each in the shape of the frustrum of a cone.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 24th October, 1936.

501 740.—Electrode arrangement for filtering and regulating the discharge stream through an electron-multiplier operated either by deflection or velocity control.

Gluhlampen und Elektrizitats Akt. Convention date (Germany) 28th August, 1936.

502 310.—Pentode type of valve with auxiliary screening-plates arranged between the grids at points of low electron concentration.

Philips Lamp Co. Convention date (Germany) 14th June 1937.

502 472.—Arrangement and spacing of the target electrodes in an electron-multiplier.

Baird Television and J. A. Colls. Application date 17th September, 1937.

502 528.—Electron multiplier in which the target electrodes are combined with auxiliary plates which form a spiral channel for the electron stream.

Electrical Research Products Inc. Convention date (U.S.A.) 31st August, 1937.

502 976.—Arrangement and assembly of the "target" electrodes in an amplifying device of the electron-multiplier type.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 24th October, 1936.

503 126.—Arrangement of the focusing electrodes in a cathode-ray tube.

Pye and G. Liebmann. Application date 25th August, 1937.

503 221.—Arrangement of, and method of mounting the electrode system in a valve with a metal envelope.

Telefunken Co. Convention date (Germany) 1st September, 1936.

503 314.—Spacing and grouping of the secondary-emission electrodes in an electron multiplier.

F. J. G. van den Bosch (divided out of 500 189). *Application date 3rd July,* 1937.

SUBSIDIARY APPARATUS AND MATERIALS

501 691.—Piezo-electric relay of high sensitivity for repeating electric impulses.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 16th March, 1937.

502 051.—Optical system for a high-powered lamp suitable for use in television.

The General Electric Co. and D. C. Espley. Application date 2nd November, 1937.

502 075.—Method of mounting a piezo-electric crystal oscillator.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 30th October, 1937.

502 181.—Electron discharge device designed to give an incandescent indication of the value of an applied voltage, particularly suitable for use as a visual tuning indicator.

Marconi's W.T. Co. (communicated by Radio Corporation of America). Application date 14th September, 1937.

502 499.—Capacity coupling for very high frequency circuits designed to allow both the "sense" and the degree of coupling to be varied.

Telefunken Co. Convention date (Germany) 19th September, 1936.

502 593.—Low-resistance "resonator" unit applied to a valve for handling ultra-short waves.

Telefunken Co. Convention date (Germany) 3rd July, 1937.