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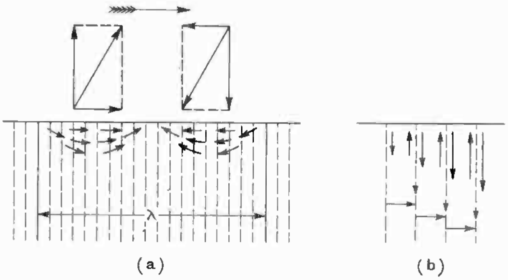
Editorial

Wireless Waves at the Earth's Surface

IN 1916 a paper was published showing how many skin-effect problems could be solved by a relatively simple application of telephone transmission formulae to the propagation of power into the conductor. The application was simplified by picturing perfectly conducting infinitely thin layers embedded in the actual conductors normal to the flow of current, and serving as the fictitious transmission lines whereby the power was conveyed into the material. Now when wireless waves travel over the earth's surface, the earth takes the place of one of the conductors of a transmission line, and, like the conductor, carries currents which are confined more or less to the surface. It is a case of skin effect and the question arises whether it can be treated in the same way. It undoubtedly can, but not to the same high degree of accuracy because of the much higher resistance of the soil as compared with copper and the resulting deeper penetration. When electromagnetic waves of the type radiated from an ordinary vertical aerial travel over the surface of the earth, the electric field is not vertical but has a horizontal component, and this component has the same value just below the surface as it has just above it. The wave is associated with currents in the earth somewhat as shown in Fig. 1 (a). If these currents flowed horizontally the phenomenon would not be affected by the insertion of very thin vertical plates of conducting material, as shown dotted, provided that they were normal to the direction of propagation, as would be the case if they consisted of concentric cylinders about the transmitter. If the penetration into the soil is an appreciable fraction of the wavelength, the currents will no longer be approximately horizontal, and the conducting plates will affect their paths, causing them to be split up into a series of horizontal currents between the plates and vertical currents in the plates as shown in Fig. 1 (b). If we assume the plates to be close together, say 1 cm. apart, infinitely thin, and perfectly conducting, the approximation to the actual current distribution will be close unless the depth of penetration is a considerable fraction of the wave-



(a) (b)

Fig. 1.

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length. Two adjacent plates may now be regarded as the conductors of a transmission line whereby electromagnetic waves are being transmitted vertically downwards into the earth, and the ordinary telephone transmission formulae can be applied to such a line.* If the plates are assumed to be 1 cm. apart, the p.d. at the sending-end, i.e. at the earth's surface, will be $\mathcal{E}_h$, the horizontal component of the electric field in volts per cm. The conductor resistance we assume to be zero. If we consider 1 cm. normal to the paper in Fig. 1 (a) we are evidently concerned with the propagation down a vertical column of soil 1 cm. square. The inductance L per cm. $= 4\pi/10^9$ henry, the capacitance $C = \kappa/(4\pi \,.\, 9 \,.\, 10^{11})$ farad, and the leakance $G = 1/\rho$, where κ and ρ are respectively the dielectric constant and specific resistance of the soil.

The sending end impedance of such a line is given by the formula

$$Z = \sqrt{\frac{R + jX}{G + jB}} = \sqrt{\frac{X}{\sqrt{G^2 + B^2}}}\ \underline{/\tfrac{1}{2}\tan^{-1}G/B}$$

where $X = \omega L$ and $B = \omega C$.

The current I in our fictitious conductor at the earth's surface is $\mathcal{E}_h/Z$ and lags behind $\mathcal{E}_h$ by an angle ϕ where $\tan 2\phi = G/B$. The power transmitted into the column of soil and dissipated in it is equal to $\mathcal{E}_h I \cos\phi$,

that is, to $\mathcal{E}_h^2 \sqrt{\dfrac{\sqrt{(G^2 + B^2)} + B}{2X}}$; by substituting the above values for G, B and X the dissipated power per square cm. of earth's surface can be easily calculated for any values of f, κ and ρ.

To calculate the depth of penetration we apply the attenuation formula e^{-px} If we put this equal to 0.25 the value of x thus determined will be the depth at which the horizontal field and current have fallen to a quarter of the surface value. Since $R = 0$, the standard formula

$$2p^2 = \sqrt{(R^2 + X^2)(G^2 + B^2)} + RG - XB$$

reduces to

$$2p^2 = X(\sqrt{G^2 + B^2} - B)$$
$$= XB\left(\sqrt{1 + \frac{G^2}{B^2}} - 1\right).$$

To take an example we assume that $f = 10^7$ c/s so that $\lambda = 30$ metres, $\kappa = 5$ and $G = 2.78 \times 10^{-5}$, corresponding to a specific resistance of 36,000 ohms. $X = \omega L = 2\pi \,.\, 10^7 \,.\, 4\pi \,.\, 10^{-9} = 0.08\pi^2$. $B = \omega C = 2\pi 10^7 \,.\, 5/(4\pi \,.\, 9 \,.\, 10^{11}) = 2.78 \times 10^{-5}$. We have chosen values such that $G = B$, so that $\tan 2\phi = G/B = 1$ and $\phi = 22.5$ degrees.

If $e^{-px} = 0.25$, $px = 1.386$

and in our case

$$2p^2 = XB(\sqrt{1+1} - 1) = 0.414XB$$
$$= 0.414 \times 0.08\pi^2 \times 2.78 \times 10^{-5}$$
$$= 9 \times 10^{-6}$$
$$\therefore p = 0.0021$$

and $x = 1.386/0.0021 = 650$ cm.

Hence with the assumed soil constants and frequency, the earth currents are reduced to a quarter of their surface value at a depth of 6.5 metres, that is 0.22 of the wavelength.

In Fig. 1 (b) three adjacent columns are shown and it will be seen that each conductor carries the opposing currents of two adjacent columns. If $\mathcal{E}_h$ were identically the same for both columns, the currents would cancel, that is to say there would be no vertical currents but only horizontal ones. When $\mathcal{E}_h$ is not the same there will be resultant vertical currents in the conductors, causing variations in the accumulated electric charges at the surface which are proportional to the vertical component $\mathcal{E}_v$ of the electric field that ends on them.

The upper curve in Fig. 2 shows the distribution of $\mathcal{E}_h$ over the wavelength at a given

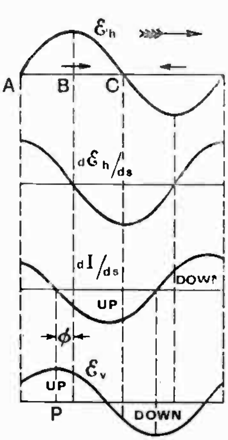

Fig. 2.

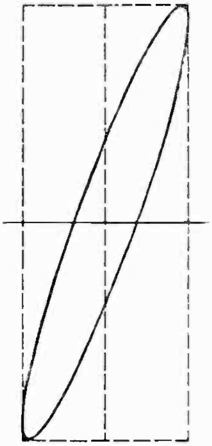

Fig. 3.

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* See "The Application of Telephone Transmission Formulæ to Skin-effect Problems." *J.I.E.E.*, 54, p. 473, 1916.

moment; it is moving from left to right with the velocity of light or slightly less. The second curve shows the distribution at the same moment of $d\mathcal{E}_h/ds$ where s is distance measured in the direction of propagation over the earth's surface. The third curve shows dI/ds which is the resultant current in the vertical conductors at the surface; since I lags behind $\mathcal{E}_h$ by the angle ϕ, dI/ds lags behind $d\mathcal{E}_h/ds$ by the same angle. From A to C $\mathcal{E}_h$ is towards the right, i.e. outwards or positive; from A to B $\mathcal{E}_h$ is increasing and tending to produce a downward resultant current in the conductors as shown in Fig. 1 (b), but this current lags by an angle ϕ as shown in the third curve dI/ds. If we consider the point P we see that for the last half-cycle it has been the seat of an upward resultant current so that the positive charge on the surface at P has just reached its maximum, and with it the upward vertical electric field $\mathcal{E}_v$ in the air, which therefore lags by the angle ϕ behind the horizontal field $\mathcal{E}_h$.

If q be the surface density of the charge in practical units, i.e. the quantity in coulombs collected per cm. on the upper edge of the conductor, and $\mathcal{E}_v$ the field in volts per cm. then $\mathcal{E}_v = 4\pi q \cdot 9 \times 10^{11}$.

$\mathcal{E}_h$ being distributed sinusoidally over the wave length, the maximum value of $d\mathcal{E}_h/ds$ will be $2\pi\hat{\mathcal{E}}_h/\lambda$, and the maximum value of dI/ds will be $2\pi\hat{\mathcal{E}}_h/\lambda|Z|$. This will be the maximum value of the resultant vertical current in the conductor. The accumulated charge q at any point will vary sinusoidally with the frequency f and will have a maximum value of $2\pi\hat{\mathcal{E}}_h/\omega\lambda|Z|$; but $\omega\lambda/2\pi = 3 \cdot 10^{10}$.

Hence $\hat{\mathcal{E}}_v = 4\pi \cdot 9 \cdot 10^{11} \cdot \hat{q}$

$$= \frac{4\pi \cdot 9 \cdot 10^{11}}{3 \cdot 10^{10}} \cdot \frac{\hat{\mathcal{E}}_h}{|Z|} = 120\pi \frac{\hat{\mathcal{E}}_h}{|Z|}$$

Taking as an example the same constants as before, we have

$$X = 0.08\pi^2 \text{ and } G = B = 2.78.10^{-5}$$

so that

$$|Z| = \sqrt{\frac{X}{\sqrt{G^2+B^2}}} = \sqrt{\frac{0.08\pi^2 \times 10^5}{\sqrt{2} \times 2.78}} = 142 \text{ ohms}$$

and $\hat{\mathcal{E}}_v/\hat{\mathcal{E}}_h = 120\pi/142 = 2.66$.

Hence the vertical component has an amplitude 2.66 times the horizontal component, behind which it lags by 22.5 degrees.

The locus of the resultant field vector is therefore an ellipse as shown in Fig. 3.

If $\mathcal{E}_h = 1$ volt per cm. $I = \frac{1}{142}$ ampere and the power transmitted into and dissipated in each sq. cm. column of soil

$$= 1 \times \frac{1}{142} \times \cos 22.5^\circ = 0.924/142 = 0.0066$$

watt. If $\mathcal{E}_h = 1$ millivolt per cm. the power will be 0.0066 microwatt.

It is interesting to calculate this power in another way. If we assume the ellipse to be replaced by its major axis, the field sweeping over the surface of the earth will have this constant direction, and we can apply Poynting's theorem and calculate the power arriving on each square centimetre of the earth's surface. The field strength $\mathcal{E} = 2.84\,\mathcal{E}_h$ and it is inclined at an angle θ such that $\cos\theta = 0.33$. If $\mathcal{E}$ were in electrostatic units, the energy in a cubic cm.—electric plus magnetic—would be $\mathcal{E}^2/4\pi$ ergs, but as $\mathcal{E}$ is in volts per cm. it is $\mathcal{E}^2/4\pi \cdot 9 \cdot 10^4$ ergs. If $\mathcal{E}$ is the r.m.s. value, this will be the mean value of the energy density throughout the wave. It will be seen from Fig. 4 that the energy falling on 1 sq. cm. of surface is that in $\cos\theta$ sq. cm. of wave front, and, assuming the wave to travel normal to $\mathcal{E}$ with the velocity of light, we have for the power in watts or joules per second

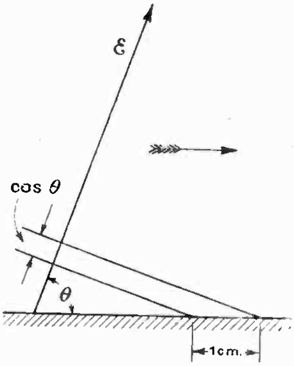

Fig. 4.

$$\frac{\mathcal{E}^2}{4\pi} \cdot \frac{1}{9 \times 10^{11}} \cdot 3 \times 10^{10} \cdot \cos\theta = 0.00705\,\mathcal{E}_h^2$$

If we assume, however, that 3×10^{10} cms. per second is the horizontal velocity of the wave, which we really assumed previously when we put $f\lambda = 3 \times 10^{10}$ and measured λ horizontally, the velocity normal to $\mathcal{E}$ will be reduced to $3 \times 10^{10} \times \sin\theta$ and as $\sin\theta = 0.94$, we shall obtain for the power $0.00705 \times 0.94 = 0.0066\,\mathcal{E}_h^2$ watt which agrees exactly with the value calculated by the other method. G. W. O. H.

Frequency Modulation*

Its Production by Phase Shifting the Side Bands of an Amplitude Modulated Wave

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SUMMARY.—A harmonic analysis is performed of the general case of a frequency modulated wave produced by phase shifting the side bands of an amplitude modulated wave by a given angle ϕ and it is shown that a phase shift of 90° will give least harmonic distortion. If this phase shift ϕ is made to vary sinusoidally at the modulation frequency, it is shown that the harmonic distortion may be made very small.

Introduction

RADIO communication is usually maintained between two stations by means of amplitude modulated waves in which the frequency is kept constant and the amplitude is varied at the modulation frequency.

It is now well known that radio communication can be established using either frequency or phase modulation, and in this case the amplitude is kept constant and the frequency or the phase of the wave is varied at the modulation frequency, according to the type of modulation used. It is quite obvious that these latter types of modulation must be closely related since a change in frequency implies a change of phase.

It will be useful to consider these types of modulation more in detail before proceeding further.

The displacement of an amplitude modulated wave is given by the relation

$$e_a = A(1 + m \sin pt) \sin (\omega t + \theta) \quad .. \quad (1)$$

where

A is the mean amplitude of the modulated wave.

p is $2\pi \times$ modulation frequency.

ω is $2\pi \times$ carrier frequency.

m is the amplitude modulation index.

θ is the arbitrary phase angle.

The frequency of the carrier wave is obtained by differentiating the phase $(\omega t + \theta)$ with respect to time and dividing by 2π. No apology is made for the inclusion of the trivial result since the method of obtaining it is important, and reference will be made to it frequently.

The displacement of a frequency modulated wave is given by

$$e_f = A \sin (\omega t + m_f \sin pt + \theta)$$

where m_f is the frequency modulation index and is equal to the ratio of the change in frequency from the mean frequency to the modulation frequency or $\frac{\Delta\omega}{p}$.

The frequency at any time t is obtained as before and is

$$\frac{1}{2\pi} \frac{d}{dt} (\omega t + m_f \sin pt + \theta)$$

$$\text{or} \qquad \frac{\omega}{2\pi} + \frac{m_f p}{2\pi} \cos pt \qquad .. \qquad .. \quad (2)$$

Thus the frequency varies sinusoidally about the mean frequency $\frac{\omega}{2\pi}$, the maximum frequency excursion being $\frac{m_f p}{2\pi}$ or $\frac{\Delta\omega}{2\pi}$. It will be noted that the frequency excursion is independent of the modulation frequency.

The displacement of a phase modulated wave is represented by

$$e_p = A \sin (\omega t + m_p \sin pt + \theta)$$

where m_p is the phase modulation index, and is the maximum phase shift in radians from the mean phase $(\omega t + \theta)$. The instantaneous frequency is

$$\frac{1}{2\pi} \frac{d}{dt} (\omega t + m_p \sin pt + \theta) = \frac{\omega}{2\pi} + \frac{m_p p}{2\pi} \cos pt$$

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

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This again represents a sinusoidal variation of frequency about the mean frequency, but this time the maximum frequency excursion is $\frac{m_p p}{2\pi}$ and since m_p is no longer inversely proportional to p as it was in the case of frequency modulation the frequency excursion will increase lineally with the modulation frequency.

The difference, therefore, between frequency and phase modulation lies in the modulation index, and it is possible to produce frequency modulation by phase modulating a wave provided that the modulation is first "distorted" by passing it into a network whose response is inversely proportional to frequency.

Conversely phase modulation may be produced by frequency modulating a wave provided the modulation is passed through a network having a response which rises lineally with frequency.

The former of these methods is used by E. H. Armstrong for producing frequency modulation from a phase modulating system, and as the systems which will be discussed here produce phase modulation, the modulation index will have to be altered in order to change this to frequency modulation.

Case (1) Side Bands Phase Shifted with Respect to Carrier by a Fixed Angle

The displacement of an amplitude modulated wave has been dealt with in equation (1) and this may be expanded to the well-known side band form.

$$e_a = A \sin \omega t + \frac{Am}{2} \cos (\omega - p)t - \frac{Am}{2} \cos (\omega + p)t$$

The arbitrary phase angle is here considered to be zero for the sake of brevity.

If the phase of the side bands is advanced by an angle ϕ the displacement becomes

$$\begin{aligned} e_a &= A \sin \omega t + \frac{Am}{2} \cos \{(\omega - p)t + \phi\} - \frac{Am}{2} \cos \{(\omega + p)t + \phi\} \\ &= A \sin \omega t + Am \sin (\omega t + \phi) \sin pt \\ &= A\{(1 + m \cos \phi \sin pt) \sin \omega t + m \sin \phi \sin pt \cos \omega t\} \\ &= C \sin (\omega t + \psi) \end{aligned}$$

$$\text{where } C = A\{(1 + m \cos \phi \sin pt)^2 + (m \sin \phi \sin pt)^2\}^{\frac{1}{2}} \quad .. \quad (3)$$

$$\psi = \tan^{-1} \frac{m \sin \phi \sin pt}{1 + m \cos \phi \sin pt} \quad .. \quad (4)$$

This represents a wave which is both amplitude and phase modulated since both the amplitude C and the phase ψ are functions of pt.

If ϕ is made zero as would be expected

$$\psi = 0$$

$$C = A\,(1 + m \sin pt)$$

If ϕ has any value other than zero ψ becomes a function of pt and the wave is phase modulated. The amplitude modulation is distorted, but this is of no importance since this modulation may be removed by limiting the wave at the lowest trough of the modulation so that its amplitude will be constant.

The phase modulation may be changed to frequency modulation by distorting the modulation so that the modulation index is inversely proportional to the modulation frequency. Replacing, therefore, m by $\frac{mk}{p}$ the wave equation now becomes

$$e_a = I \sin \left(\omega + \tan^{-1} \left[\frac{\frac{mk}{p} \sin \phi \sin pt}{1 + \frac{mk}{p} \cos \phi \sin pt} \right] \right)$$

where B is the limited amplitude of the wave.

The instantaneous frequency is

$$\frac{1}{2\pi} \frac{d}{dt} \left\{ \omega t + \tan^{-1} \left[\frac{\frac{mk}{p} \sin \phi \sin pt}{1 + \frac{mk}{p} \cos \phi \sin pt} \right] \right\}$$

$$= \frac{1}{2\pi} \left\{ \omega - \frac{\alpha p \sin \phi \sin pt}{1 + 2\alpha \cos \phi \sin pt + \alpha^2 \sin^2 pt} \right\}$$

$$\text{where } \alpha = \frac{mk}{p}.$$

The latter term of the above equation should be of the form $\frac{m_f p}{2\pi} \cos pt$ as shown in (2) for this to be true frequency modulation. The fact that these terms are not alike indicates the presence of distortion, and the amplitudes of the various harmonics present

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will be given by a Fourier analysis of

$$\frac{\alpha p \sin \phi \sin pt}{1 + 2\alpha \cos \phi \sin pt + \alpha^2 \sin^2 pt}$$

this is shown to be (Appendix 1)

$$\left\{p \sum_{0}^{\infty} \frac{2n\,!}{2^{2n} n!\,(n+1)!} \alpha^{2n+1} \sin (2n+1)\phi \right\} \cos pt$$

$$-\left\{2p \sum_{1}^{\infty} \frac{(2n-1)\,!}{2^{2n-1}(n-1)!\,(n+1)!} \alpha^{2n} \sin 2n\phi \right\} \sin 2pt$$

$$-\left\{3p \sum_{1}^{\infty} \frac{2n\,!}{2^{2n}\,(n-1)!\,(n+2)!}\,\alpha^{2n+1}\right.$$

$$\left.\sin (2n+1)\,\phi\right\} \cos 3\,pt$$

$$+\left\{4p \sum_{2}^{\infty} \frac{(2n-1)\,!}{2^{2n-1}\,(n-2)!\,(n+2)!}\,\alpha^{2n} \sin 2n\phi\right\}$$

$$\sin 4\,pt$$

$$+\left\{5p \sum_{2}^{\infty} \frac{2n\,!}{2^{2n}(n-2)!\,(n+3)!}\,\alpha^{2n+1}\right.$$

$$\left.\sin (2n+1)\phi\right\} \cos 5\,pt + \ldots \text{etc.} \ldots \quad (5)$$

The amplitudes of the various harmonics are, of course, given by the coefficients of cos pt, sin 2 pt, etc. An examination of this series shows that two kinds of distortion will be present :—amplitude distortion since the coefficients of cos pt, sin 2 pt, etc., involve terms in α and hence in m, which have power greater than unity :—harmonic distortion since a single modulation frequency $\frac{p}{2\pi}$ gives rise to an infinite series of harmonics. It might be noted that if ϕ is $\frac{n\pi}{2}$ the even harmonics vanish.

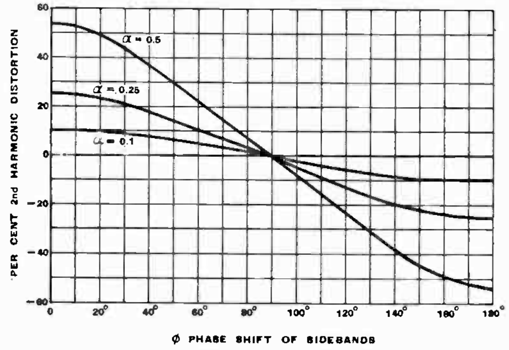

Fig. 1.

Harmonic Distortion

The ratio of the amplitudes of the second harmonic to that of the first is given by

$$\frac{2 \sum_{1}^{\infty} \frac{(2n-1)\,!}{2^{2n-1}\,(n-1)!\,(n+1)!}\,\alpha^{2n} \sin 2n\phi}{\sum_{0}^{\infty} \frac{2n\,!}{2^{2n}\,n!\,(n+1)!}\,\alpha^{2n+1} \sin (2n+1)\phi}$$

α may only vary in the range $0 < \alpha < 1$ and the second (5) harmonic distortion is plotted with respect to ϕ for values of α in this range in Fig. 1.

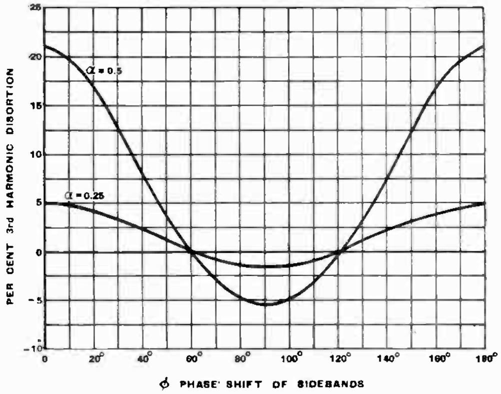

Fig. 2.

The fraction of 3rd harmonic present is given by

$$\frac{3 \sum_{1}^{\infty} \frac{2n\,!}{2^{n}\,(n-1)!\,(n+2)!}\,\alpha^{2n+1} \sin (2n+1)\phi}{\sum_{0}^{\infty} \frac{2n\,!}{2^{2n}\,n!\,(n+1)!}\,\alpha^{2n+1} \sin (2n+1)\phi}$$

The 3rd harmonic distortion (Fig. 2) is almost zero for phase shifts of 60° and 120°, but is quite small even at the maximum (90°) for values of α less than 0.5.

A particularly interesting case occurs when $\phi = 90°$ since this is employed by E. H. Armstrong in his frequency modulation system. It will be seen that this side band shift of 90° happens to be the one where the second harmonic is zero, although third harmonic distortion will be a problem if α is large, that is, if the original amplitude modulation index m is large.

If the above value for ϕ is substituted in expression (5) the frequency excursion

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becomes

$$\frac{1}{2\pi}\left[\left\{\alpha p-\frac{\alpha^3 p}{4}+\frac{\alpha^5 p}{8}-\frac{5\alpha^7 p}{64}\ .\ .\right\}\cos pt+\left\{\frac{\alpha^3 p}{4}-\frac{3\alpha^5 p}{16}+\frac{9\alpha^7 p}{64}-\frac{7\alpha^9 p}{64}\ .\ .\ .\right\}\cos 3pt.+\text{etc.}\right]$$

The amplitude characteristic of the fundamental is shown for a side band phase shift of 90° in Fig. 3, where it will be seen that the departure from linearity is small except in cases where the modulation index approaches unity.

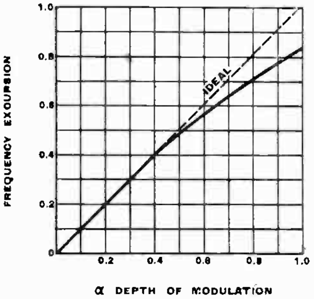

Fig. 3.—*Modulation characteristic of Armstrong system of frequency modulation.*

Case (2) where ϕ is a Function of Time

Referring to equation (3), it will be seen that if $\cos\phi = -m/2 \sin pt$ then amplitude of the wave becomes constant and equal to A. The amplitude modulation has thus been removed from the wave without recourse to limiting. The wave equation therefore becomes

$$e_a = A\sin\left(\omega t+\tan^{-1}\left\{\frac{m\sin pt\sqrt{1-\frac{m^2}{4}\sin^2 pt}}{1-\frac{m^2}{2}\sin^2 pt}\right\}\right)$$

The phase modulation term

$$\psi=\tan^{-1}\left\{\frac{m\sin pt\sqrt{1-\frac{m^2}{4}\sin^2 pt}}{1-\frac{m^2}{2}\sin^2 pt}\right\}$$

is obtained by substituting

$$\cos\phi=-\frac{m}{2}\sin pt \text{ in } (4)$$

and may be simplified to

$$\psi=\cos^{-1}\left(1-\frac{m^2}{2}\sin^2 pt\right)$$

The frequency excursion thus becomes

$$\frac{1}{2\pi}\frac{d}{dt}\left(\omega t+\cos^{-1}\left(1-\frac{m^2}{2}\sin^2 pt\right)\right)$$

$$=\frac{\omega}{2\pi}-\frac{1}{2\pi}\frac{mp\cos pt}{\left\{1-\frac{m^2}{4}\sin^2 pt\right\}^{\frac{1}{2}}}$$

This form of modulation is a type of phase modulation since the frequency excursion

$$\frac{1}{2\pi}\frac{mp\cos pt}{\left(1-\frac{m^2}{4}\sin^2 pt\right)^{\frac{1}{2}}}$$

increases with the modulation frequency $\frac{p}{2\pi}$, and it is necessary to replace m by $\alpha=\frac{mk}{p}$ to convert this frequency modulation. As before the distortion terms will be given by a Fourier analysis of

$$\frac{\alpha p\cos pt}{\left(1-\frac{\alpha^2}{4}\sin^2 pt\right)^{\frac{1}{2}}}$$

This is shown to be Appendix (2)

$$\left\{p\sum_0^\infty\frac{2n\,!}{2^{2n}\,n!\,(n+1)\,!}\,\frac{\alpha^{2n+1}}{4^n}\,\frac{1,3,5\ .\ .\ .\ 2n+1}{2,4,6\ .\ .\ .\ 2n}\right\}\cos pt$$

$$-\left\{3p\sum_1^\infty\frac{2n\,!}{2^{2n}\,(n-1)\,!\,(n+2)\,!}\,\frac{\alpha^{2n+1}}{4^n}\,\frac{1,3,5\ .\ .\ 2n+1}{2,4,6\ .\ .\ 2n}\right\}\cos 3\,pt$$

$$+\left\{5p\sum_2^\infty\frac{2n\,!}{2^{2n}\,(n-2)\,!\,(n+3)\,!}\,\frac{\alpha^{2n+1}}{4^n}\,\frac{1,3,5\ .\ .\ .\ 2n+1}{2,4,6\ .\ .\ .\ 2n}\right\}\cos 5\,pt+\ .\ .\ .\ \text{etc.}$$

Expanding the first few terms this gives

$$\left(\alpha p+\frac{\alpha^3 p}{32}+\frac{3\alpha^5 p}{1024}\ .\ .\ .\right)\cos pt-\left(\frac{\alpha^3 p}{16}+\frac{9\alpha^5 p}{1024}\ .\ .\ .\right)\cos 3\,pt+\left(\frac{15\alpha^5 p}{10240}+\ .\ .\ .\right)\cos 5\,pt+\text{etc.}$$

Both amplitude and harmonic distortion are present as in the previous case, and as this system of frequency modulation will be more difficult to carry out than, say, the Armstrong system, which only involves fixed phase shifts for the side bands, it is necessary that it should have definite advantages before its adoption could be recommended. Jaffe* has shown that in the Armstrong system of modulation the third harmonic distortion will amount to about 17 per cent. for values of m approaching 1. This depth of modulation will produce a phase shift of 45°. Practically the only distortion present in the system outlined above is third harmonic distortion and this is given very nearly by $\frac{\alpha^3 p}{16/\alpha p}$ or $\frac{\alpha^2}{16}$. Thus the third harmonic distortion only amounts to about 7 per cent. when $\alpha = 1$, yet the maximum phase shift is $\cos^{-1}\frac{1}{2}$ or 60°.

Hence, this system produces larger phase shifts and less distortion than any system of frequency modulation in which the side bands are shifted by a constant angle. The third harmonic distortion will decrease with frequency since α is inversely proportional to p. Hence if the third harmonic distortion is 7 per cent. at, say, 50 cycles ($\alpha = 1$), it will only be $7\left(\frac{50}{400}\right)^2 = .11$ per cent. at 400 cycles. Amplitude distortion is small since the terms involving powers of greater than unity are small. This modulation characteristic is shown in Fig. 4.

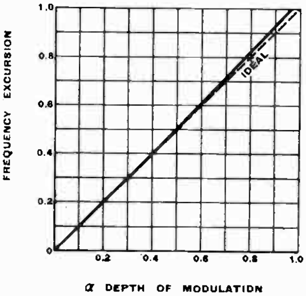

Fig. 4.—Modulation characteristic for system of frequency modulation in which the phase of the side band is shifted at the modulation frequency.

In conclusion, it may be pointed out that further distortion will be present than is indicated here in frequency modulation produced by phase shifting the side bands by a fixed angle, because it has been assumed that it is possible to remove the amplitude modulation from a wave simply by limiting at the lowest trough of modulation. In point of fact this is not so, since the width of the limited peak at the limiting potential will be dependent on the peak height, and hence the widths of the limited peaks will vary with the amplitude modulation. If such a wave is then passed through subsequent circuits in the transmitter having only a finite band width, some of the original amplitude modulation will be restored.

I must express my indebtedness to Mr. D. Weighton for checking the mathematical analysis in this article.

APPENDIX I

$$\frac{\alpha p \sin\phi \sin pt}{1 + 2\alpha\cos\phi\sin pt + \alpha^2\sin^2 pt}$$

$$= \frac{d}{dt}\tan^{-1}\left\{\frac{\alpha\sin\phi\sin pt}{1 + \alpha\cos\phi\sin pt}\right\}$$

$$= \frac{d}{dt}\tan^{-1}\left(\frac{\beta\sin\phi}{1 + \beta\cos\phi}\right)$$

where $\beta = \alpha\sin pt$

If $\psi = \tan^{-1}\frac{\beta\sin\phi}{1 + \beta\cos\phi}$

then

$$\beta\sin\phi = k\sin\psi \quad \ldots \quad (6)$$

$$1 + \beta\cos\phi = k\cos\psi \quad \ldots \quad (7)$$

where $k = (1 + 2\beta\cos\phi + \beta^2)^{\frac{1}{2}}$

Equations (6 and (7) give

$$1 + \beta e^{j\phi} = ke^{\psi}$$

$$= e^{\log k} . e^{j\psi}$$

$$\log(1 + \beta e^{j\phi}) = \log k + j\psi$$

Equating imaginary quantities,

$$\psi = \beta\sin\phi - \frac{\beta^2}{2}\sin 2\phi + \frac{\beta^3}{3}\sin 3\phi \ldots$$

Replacing β by $\alpha\sin pt$

$$\psi = \alpha\sin pt\sin\phi - \frac{\alpha^2\sin^2 pt}{2}\sin 2\phi + \frac{\alpha^3\sin^3 pt}{3}\sin 3\phi \ldots$$

Substituting

$$\text{Sin}^{2n+1} pt = \frac{(2n+1)!}{2^{2n} n!\,(n+1)!}\left\{\sin pt - \frac{n}{(n+2)}\sin 3pt + \frac{n(n-1)}{(n+2)(n+3)}\sin 5\text{pt} \ldots\right\}$$

$$\text{Sin}^{2n} pt = \frac{2n!}{2^{2n-1} n!\,n!}\left\{\frac{1}{2} - \frac{n}{n+1}\cos 2pt + \frac{n(n-1)}{(n+1)(n+2)}\cos 4pt \ldots\right\}$$

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* *Proc. Inst. Rad. Eng.*, April, 1938, p. 475.

and differentiating gives

$$\frac{d\psi}{dt} = \frac{\alpha p \sin\phi \sin pt}{1 + 2\alpha \cos\phi \sin pt + \alpha^2 \sin^2 pt}$$

$$= \left\{ p \sum_0^\infty \frac{2n\,!}{2^{2n}\, n\,!\ (n+1)\,!}\ \alpha^{2n+1} \sin(2n+1)\phi \right\} \cos pt$$

$$- \left\{ 2p \sum_1^\infty \frac{(2n+1)\,!}{2^{2n-1}\,(n-1)\,!\,(n+1)\,!}\ \alpha^{2n} \sin 2n\phi \right\} \sin 2\,pt$$

$$+ \text{ etc.}$$

APPENDIX II

$$\left(\frac{1}{1 - k^2 \sin^2 pt}\right)^{\frac{1}{2}} = 1 + \frac{k^2}{2} \sin^2 pt + \frac{1,\,3}{2,\,4} k^4 \sin^4 pt$$

$$+ \frac{1,\,3,\,5}{2,\,4,\,6} k^6 \sin^6 pt \ \ldots\ldots\ldots$$

or putting $k = \frac{\alpha}{2}$

$$\frac{1}{\left(1 - \frac{\alpha^2}{4} \sin^2 pt\right)^{\frac{1}{2}}} = 1 + \frac{1}{2}\frac{\alpha^2}{4} \sin^2 pt + \frac{1,\,3}{2,\,4}\frac{\alpha^4}{4^2} \sin^4 pt$$

$$+ \frac{1,\,3,\,5}{2,\,4,\,6}\frac{\alpha^6}{4^3} \sin^6 pt$$

$$\frac{\alpha p \cos pt}{\left(1 - \frac{\alpha^2}{4} \sin^2 pt\right)^{\frac{1}{2}}} = \alpha p \cos pt + \frac{1}{2}\frac{1}{4} \alpha^3 p \cos pt \sin^2 pt$$

$$+ \frac{1,\,3}{2,\,4} \cdot \frac{1}{4^2} \alpha^5 p \cos pt \sin^4 pt \ \ldots$$

Substituting

$$\text{Sin}^{2n} pt \cos pt = \frac{2n\,!}{2^{2n}\, n\,!\ n\,!} \left\{ \frac{1}{(n+1)} \cos pt \right.$$

$$- \frac{3n}{(n+1)(n+2)} \cos 3\,pt$$

$$\left. + \frac{5n(n-1)}{(n+1)(n+2)(n+3)} \cos 5\,pt \ \ldots \right\}$$

gives

$$\frac{\alpha p \cos pt}{\left(1 - \frac{\alpha^2}{4} \sin^2 pt\right)^{\frac{1}{2}}}$$

$$= \left\{ p \sum_0^\infty \frac{2n\,!}{2^{2n}\, n!\ (n+1)\,!}\ \frac{\alpha^{2n+1}}{4^n}\ \frac{1,\,3,\,5 \ldots (2n-1)}{2,\,4,\,6\ \ldots\ 2n} \right\} \cos pt$$

$$- \left\{ 3p \sum_1^\infty \frac{2n\,!}{2^{2n}\,(n-1)\,!\ (n+2)\,!}\ \frac{\alpha^{2n+1}}{4^n}\ \frac{1,\,3,\,5 \ldots (2n-1)}{2,\,4,\,6\ \ldots\ 2n} \right\} \cos 3\,pt$$

$$+ \left\{ 5p \sum_2^\infty \frac{2n\,!}{2^{2n}\,(n-2)\,!\ (n+3)\,!}\ \frac{\alpha^{2n+1}}{4^n}\ \frac{1,\,3,\,5 \ldots (2n-1)}{2,\,4,\,6\ \ldots\ 2n} \right\} \cos 5\,pt + \ \ldots \text{ etc.}$$

Radio Interference Suppression

New and Revised B.S. Specifications

A NEW specification of the British Standards Institution on Anti-Interference Characteristics and Performance of Radio Receiving Equipment prescribes the general conditions to be complied with in the design of radio receiving equipment, and gives guidance on the method of installing such equipment and interference suppression devices with the object of minimising the effects of radio interference. One section is devoted to the characteristics and performance of anti-interference aerial systems, whilst another deals with community aerials. The methods of eliminating interference from the electric supply mains and means of protection against atmospheric electricity are described in this specification, B.S. 905.

The main interest of the revised specification, B.S.613, which relates to components for radio interference suppression devices (excluding devices for traction, marine and other special equipment), lies in the appendices. Two entirely new appendices have been added dealing respectively with shock and earth leakage considerations, and with wiring and maintenance. It is understood a separate specification dealing with the suppression of radio interference on board ship, which is excluded from this one, is in the course of preparation.

Copies of these specifications may be obtained from The British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1, price 2s. 3d. each, post free.

Mathematical Tables

THERE is in the United States an organisation sponsored by the Bureau of Standards known as "Project for the Computation of Mathematical Tables," of which the Technical Director is Dr. A. N. Lowan, of 475, Tenth Avenue, New York City. The aim of the organisation, which has been in existence since January 1, 1938, is "to compute mathematical tables of fundamental importance in mathematics, physics, engineering, statistics and related sciences." They have already published tables giving the first ten powers of integers from 1 to 1000, and the ascending and descending exponentials for various ranges and intervals to 15 decimal places or more. Many other tables are in preparation or under consideration. Among those in process of publication are tables of $Si(x)$, $Ci(x)$ and $Ei(x)$, and on comparing their figures with those given by K. Tani in his tables published in Tokio in 1931, they have discovered a number of errors in the latter and have circulated a list of corrections.

Anyone specially interested in such tables, including those of radiation, electronic, or probability functions, and desirous of obtaining copies should communicate with Dr. Lyman J. Briggs, Director, National Bureau of Standards, Washington, D.C.

G. W. O. H.

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Band-Spreading*

Its Effect on the "Tuning Rate"

By F. H. Woodbridge

The conformity of some conventional circuits to straight-line-frequency tuning is considered; and a particular circuit is suggested which admits of simple design by graphical methods.

BAND-SPREADING may be defined as the deliberate limitation of the frequency range covered by a tuning unit, in order to facilitate the process of tuning. In practice it is employed exclusively on the short and ultra-short waves since on the lower frequencies the ranges are automatically and effectually limited by using components with conventional values. To effect this deliberate limitation special circuits have been developed, and it is one purpose of this article to consider how such circuits affect what may be called the "tuning rate" of the unit—that is, the frequency range covered per unit of displacement on the tuning scale.

Clearly in any case this rate should be as nearly constant as is practicable over the whole band, because otherwise the frequencies will be unevenly spaced: one end of the scale will not be used with full effectiveness while at the other there will be unnecessary congestion of frequencies. This consideration applies with especial force to band-spreading circuits, since such congestion will run counter to the whole purpose of band-spreading. For example, at some point in the spectrum a simple tuning circuit of conventional design might cover a band of, say, 6 Mc/s; if a band-spreading circuit were substituted limiting the range to 2 Mc/s, but at the same time causing the tuning rate to vary overall by 9 or 10 to 1, then at one end of the scale (where the frequencies would be most crowded) there would be no improvement in tuning, while at the other the spreading would be altogether excessive. And this, it will be shown, is far from being an extreme case.

These considerations hold wherever use is to be made of the whole tuning scale. But where the band in question is so narrow that only part of the tuning scale is needed to cover it, changes in the tuning rate over the whole scale become less important. A case in point is the 14-metre broadcast band.

On analysis the tuning rate is seen to be the product of three independent factors, most easily expressed in mathematical terms. Let f be the resonant frequency, C_T the total effective capacitance, C the capacitance of the variable condenser, and θ the scale reading. Then we may express the tuning rate by $\frac{df}{d\theta}$ and we may analyse it thus: $\frac{df}{d\theta} = \frac{df}{dC_T} \cdot \frac{dC_T}{dC} \cdot \frac{dC}{d\theta}$. Though much of this analysis is of course common to the design of all tuning circuits, I make no apology for reviewing it all from this special standpoint.

First, by differentiating $f = \frac{1}{2\pi\sqrt{LC_T}}$ we have $\frac{df}{dC_T} = -2\pi^2 L f^3$. As the inductance will be constant over each band, $\frac{df}{dC_T}$ will vary as the cube of the frequency and therefore the importance of this source of variation depends on the width of the band relative to its position. Thus over the band 10-11 Mc/s the overall increase in $\frac{df}{dC_T}$ is only 33 per cent.: but over 2-4 Mc/s the increase would be eightfold.

$\frac{dC}{d\theta}$ depends on the design of the variable condenser. In short-wave work semi-circular vanes are now standard practice and in such cases $\frac{dC}{d\theta}$ is naturally constant. Indeed the use of shaped vanes to compensate for variation in other factors has practical

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

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disadvantages in multi-band tuners, since in each band a different degree of compensation may be needed ; so the present practice seems well-founded.

The factor $\frac{dC_T}{dC}$ is governed by the circuit and here we can draw a distinction between circuits with a fixed condenser in series with the tuning condenser, and those without.

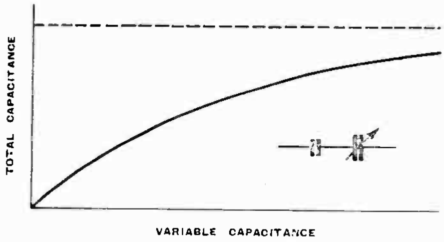

Fig. 1.

In the latter, whatever shunt capacitances may be present, $\frac{dC_T}{dC}$ will always be constant —though not necessarily equal to unity— and the problem of securing a reasonably constant tuning rate is correspondingly simplified. But in the former class, which comprises the majority of circuits, some variation in $\frac{dC_T}{dC}$ is to be expected, if only because the familiar asymptotic curve (Fig. 1) of such a series circuit shows a continuous change of gradient.

To consider this in more detail we may take Fig. 2 as a generalised circuit, where C_T is the total capacitance and the variable capacitance C ranges from zero to $C_{\max}$. (Physically C_2 may represent either an extra fixed condenser or simply the minimum capacitance of the variable whose maximum would then be $C_{\max} + C_2$.) Fixed shunt capacitances can be neglected in discussing these differential coefficients. Since (as can be seen from Fig. 1) $\frac{dC_T}{dC}$ falls steadily as C increases, we can measure the degree of its change by the ratio of its extreme values, namely ${\frac{dC_T}{dC}}_{C=0} : {\frac{dC_T}{dC}}_{C=C\max}$. Let this be r.

From $C_T = \frac{C_1(C + C_2)}{C + C_1 + C_2}$ we have

$$\frac{dC_T}{dC} = \frac{C_1^2}{(C + C_1 + C_2)^2}$$

and therefore

$$r = \frac{C_1^2}{(C_1 + C_2)^2} \cdot \frac{(C_{\max} + C_1 + C_2)^2}{C_1^2}$$

$$= \left[1 + \frac{C_{\max}}{C_1 + C_2}\right]^2$$

This shows that the greater $C_{\max}$ is compared with $(C_1 + C_2)$ the larger r becomes — rapidly. What does this mean in practice ? It would perhaps be unreasonable to insist on a value for r of less than 4, but even so we see that $C_{\max}$ should not exceed $(C_1 + C_2)$. By way of contrast consider a tuner consisting of a 0.0001μF variable (minimum 5 $\mu\mu$F) in series with a 10 $\mu\mu$F fixed condenser —a combination neither uncommon nor extreme. In such a case r equals 53.8 ! That is to say, even if we assume the other factors to be constant, the frequency calibrations will be over fifty times more crowded at one end of the scale than at the other, and any variation in $\frac{df}{dC_T}$ will be in the same sense, thus still further increasing the disparity.

Steps should therefore be taken to minimise this effect, but to indicate suitable methods from this general treatment is difficult. The proportioning of values must depend primarily on the bands required and attempts to reduce r must take second place. In practice, any circuit on the lines of Fig. 2 will have an extra capacitance in parallel with that network, and this complicates analysis since adjustment of this shunt capacitance, as well as of C_1 and C_2, may be the means used to select the different bands. The relative band-width depends on the ratio between the extreme values of the total effective capacitance in the circuit, but the presence of the shunt capacitance makes it impossible to say more than that this ratio will certainly be less—by an indefinite amount—than the corresponding ratio for the network of Fig. 2 taken by itself. Now this latter ratio

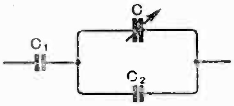

Fig. 2.

$$\frac{C_1(C_{\max} + C_2)}{C_{\max} + C_1 + C_2} \cdot \frac{C_1 + C_2}{C_1 C_2}$$

may be written as

$$\frac{1+\frac{C_{\max}}{C_2}}{1+\frac{C_{\max}}{C_1+C_2}} \quad \text{or} \quad \frac{1+\frac{C_{\max}}{C_2}}{\sqrt{r}} .$$

From this it may be seen that (i) to keep this ratio high and r low C_1 should be given a relatively high value; (ii) to lower the ratio and r at the same time, C_2 should be increased. (An increase in the shunt capacitance of course reduces the band-width without altering r, but this capacitance is used mainly to control the position of the band and is therefore not independently adjustable.) Note that the popular method of reducing band-width is to reduce C_1, rather than increase C_2, and this by contrast causes an *increase* of r. One might perhaps design an unconventional circuit in which, as the shunt capacitance was progressively reduced for the higher frequency bands, *larger* condensers were switched in at C_2 to limit the corresponding band-widths.

Enough has been said to show the possible drawbacks to series condenser circuits. An alternative method which deserves some attention is to limit the effectiveness of the tuning condenser as required by tapping it across part only of the coil and thus reducing its effective value by—approximately—the square of the tap ratio. This device not only avoids any variation in $\frac{dC_T}{dC}$ but may also be turned to the positive advantage of economy in components. In Fig. 3 a fixed condenser of appreciable size is put in parallel with the variable, so that the one switch determines not only the width but also the position of the bands. A single-pole switch and two fixed condensers will thus do the work of a double-pole switch and two *sets* of condensers in the series condenser circuit. Where more than two bands are concerned the single switch does not indeed permit of a completely free choice of band limits, but in practice an acceptable compromise can usually be achieved.

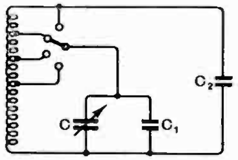

Fig. 3.

Inspection of Fig. 3 (C is assumed as before to vary from zero to $C_{\max}$) shows that if, for example, C_2 is negligibly small, alteration of the tap will alter the frequency limits in identical proportion, and therefore the width of the band will vary directly with its position in the spectrum; while if C_2 has an appreciable size, the bands will be relatively smaller at the higher frequencies, though not necessarily absolutely so.

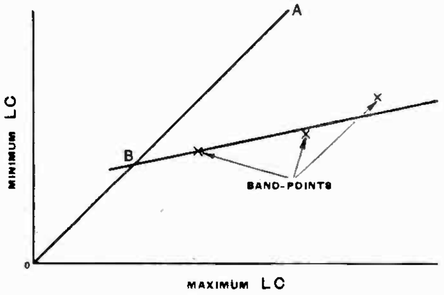

Fig. 4.

But the properties of the circuit will emerge more clearly if we consider the principles of its design. In the first place, the inductance will be a constant factor in all computations covering the use of a single coil, and its evaluation may well be left to the last, when it can be chosen to harmonise our other requirements with independent factors such as residual capacitances. The main calculations can thus conveniently be done in terms of the product LC rather than in absolute capacitances.

The limits of the bands required can be expressed in these terms and then on a graph, the co-ordinates of which measure the maximum and minimum LC values of particular bands; each band may be represented and determined by one fixed point (Fig. 4). All such points will necessarily lie on one side of the line OA bisecting the angle between the axes. It can be shown that on such a graph the locus of the points corresponding to the bands which can be selected by varying the coil-tap is a straight line, the gradient and position of which are determined by the mutual proportions of the capacitances C_1, C_2, $C_{\max}$.

For let y be the minimum and x the maximum value of LC for any band, and p the fraction of the coil tapped by the switch. Then we have

$$y = L(p^2 . C_1 + C_2) \text{ and}$$

$$x = L(p^2 . \overline{C_1 + C_{\max}} + C_2)$$

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i.e.
$$y - LC_2 = p^2 LC_1 \text{ and}$$
$$x - LC_2 = p^2 L(C_1 + C_{max}).$$

Therefore
$$\frac{y - LC_2}{x - LC_2} = \frac{C_1}{C_1 + C_{max}}.$$

That is, the locus of these points is a straight line passing through the point (LC_2, LC_2) with a gradient of $\frac{C_1}{C_1 + C_{max}}$, the ratio of the minimum/maximum values of $(C + C_1)$. The point (LC_2, LC_2) will be at the intersection of the line and the " bisector " *OA*—at *B*— since its co-ordinates are equal.

Hence we have an easy method of evaluating our constants. Plot the required band-points. As they will not in general lie exactly in a straight line, draw a line as nearly through them as possible and produce it to cut *OA*. The co-ordinates of this intersection give us LC_2, while the gradient of the line $\left(\text{equal to } \frac{C_1}{C_1 + C_{max}}\right)$ gives the ratio of C_{max} to C_1. What these values are actually to be (or rather the values of LC_1, LC_{max}, since we are still working in terms of *LC*) depends on the point along the line at which we choose to make p equal to unity—to raise the tap to the top end of the coil—since it is at this point that the transferred values of these condensers become equal to their real values. Normally this point will correspond to the lowest band required and so the values of LC_1, $L(C_1 + C_{max})$ can be read directly from the graph as the excess of the co-ordinates at this point over the co-ordinates of the lower end of the line at *B*. All that remains is to fix a value for *L* that takes into account such factors as the *L/C* ratio, residual capacitances and so on. In many cases it will be found best to let C_2 consist solely of the self-capacitances of the various components.

There seems no reason why p should be kept less than unity for all the bands worked : to increase it above unity is tantamount to using a larger coil and tapping down C_2 (and with it the valve input) or rather that part of it not due to self-capacitance in the coil or switching arrangements. This device might be useful in some circumstances, e.g., where the values of C_1, C_{max}, are otherwise limited, perhaps by their use with another coil.

BOOK REVIEWS

Telephony: Supplement to Volume II.

By T. E. HERBERT, M.I.E.E., and W. S. PROCTOR, A.M.I.E.E. Pp. 97. 83 illustrations. Published by Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2. Price 3s. 6d.

This volume is a welcome addition to Volume II (Automatic Telephony) and extends the already wide field covered by the main work to include 2,000 type selector circuits.

In Chapter I there are about 20 pages and 16 illustrations dealing with group and final selector circuits of the 2,000 type. In addition to containing comprehensive circuit descriptions, this chapter serves to bring out the changes in circuit design that have been introduced in conjunction with the new type of selector mechanism. It also includes a description of the method by which balanced tones are applied. For mechanical details and mounting arrangements of the 2,000 type selector reference should be made to Appendix I of Volume II.

The remainder of the volume deals with the Unit Automatic Exchanges Nos. 13 and 14. The trunking and circuit aspects of these units are well explained together with the use of these exchanges in a tandem capacity. Other features including the use of route-restricting and route-discriminating equipment have also been described. Finally there is a short section dealing with the principles of the inductor tone generator.

The work has been well produced and adequately illustrated, its layout following the lines of the main work. In this volume, however, nearly all illustrations are either trunking or circuit diagrams; no photographs have been included. The fact that most of the circuits have been dissected so as to enable facilities to be dealt with separately should be of great assistance to the student.

C. G. G.

Television

By V. K. ZWORYKIN, E.E., Ph.D., and G. A. MORTON, Ph.D. Pp. 646+xi. Published by John Wiley and Sons, Inc., New York, U.S.A. Obtainable from Chapman and Hall, Ltd., 11, Henrietta Street, Covent Garden, London, W.C.2. Price 36s.

This book is divided into four parts of greatly differing lengths. The first deals with fundamental physical principles and covers in some detail electron emission, fluorescent materials, electron optics and vacuum practice, including pumps and plumbing.

Part II covers the principles of television, while Part III—the longest—deals with the " component

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elements of an electronic television system." The book concludes with a section on the RCA—NBC Television Project.

The treatment is very thorough, and although it is largely mathematical adequate physical explanations are by no means absent. The book aims at being complete in itself in the sense that it deals not merely with television but with the related subjects of electron optics and electron emission. These sections are fairly comprehensive, but the information given naturally does not approach in quantity or in detail that which is to be found in books devoted solely to them. While useful in giving the reader a good background of electron technique for understanding the characteristics of television cameras, the designer of such devices will be likely to want additional information.

Part II, dealing with television equipment, is the longest and begins with a chapter on the fundamentals of picture transmission. The treatment of resolution and scanning is extremely comprehensive and contains information not commonly found in books on television. A general discussion of the characteristics of transmitters and receivers follows and includes a mathematical treatment of single- and double-sideband operation. Succeeding chapters deal with pick-up and reproducing devices, starting with the Niphow dish and leading up to the Iconoscope which, together with the receiving tube, is allotted no less than 129 pages.

Amplifiers and saw-tooth oscillators are then treated, and although the former are dealt with adequately the latter receive less attention than they deserve. Only a few of the commonly used circuits are described and certainly justice is not done to the gas-triode. In fact, the whole subject of time-bases and deflection systems is rather cursorily treated. This is a weak point in an otherwise excellent book.

The characteristics of receiver circuits are also dealt with in a manner which tends to be somewhat brief. There are many forms of intervalve coupling in R.F. and I.F. amplifiers which one feels should have been treated in a comprehensive book of this nature. The general tendency is to gloss over the problems of the receiver and quite a number of systems in use in this country are not even mentioned.

The book, however, is an extremely good one and should prove very helpful to all who are seriously interested in the technical aspects of television. It is unusually free from errors and is remarkable for the number of references to other literature, among which the English are well represented. W. T. C.

Radio at Ultra-High Frequencies

Published by RCA Institutes Press, 75, Varick Street, New York, U.S.A. Pp. 448+vi.

This book is unusual because it is not for sale! It is available without charge, but only to subscribers to the *RCA Review*.

It contains 19 pages on ultra-high frequencies below 300 Mc/s and 4 pages on frequencies above this figure. In addition, summaries of 26 papers in the former category and 5 in the latter are included. The authors of these papers are engineers of the RCA Laboratories and most of the articles have already appeared in the *RCA Review*, *Electronics*, or *Proceedings of the I.R.E.*; in fact, only two have been previously unpublished. These two are "A New Method for Measurement of Ultra-High Frequency Impedance," by Stuart W. Seeley and William S. Barden, which occupies 22 pages, and "Simple Antennas and Receiver Input Circuits for Ultra-High Frequencies," by R. S. Holmes and A. H. Turner, which occupies 11 pages.

The papers cover transmitting methods and equipment, propagation, including frequency-modulation, relaying, measurement, and reception. A good deal of useful information on aerials is included.

The book forms a handy reference manual, for it is undoubtedly convenient to have so much material on ultra-high frequency apparatus collected into one volume. The papers are, however, rather specialised and the gaps between them are so wide that one cannot consider it in any way a text-book. W. T. C.

Photo-Electric and Selenium Cells

(Second Edition). By T. J. Fielding. Pp. 163, Figs. 83. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 7s. 6d.

This is the second edition of a book first published and reprinted in 1935. The advances made since then in the design and application of light-sensitive cells have necessitated considerable revision of and addition to the original text.

The practical nature of the book has been maintained throughout. It is intended mainly for the experimenter and for those to whom the science of photo-electricity is as yet an unexplored field.

After a brief introduction to the types and principles of operation of photo-electric cells follow chapters on various practical applications, together with associated apparatus such as valve amplifiers, relays, etc. An entirely new chapter has been added on "Time Delay Circuits." The book concludes with a short chapter on the latent possibilities of the photo-electric cell. It is a well-written book and makes very interesting reading.
S.O.P.

Principles of Television Engineering

By Donald G. Fink. Pp. 541+xii. Published by McGraw-Hill Publishing Co., Ltd., Aldwych House, London, W.C.2. Price 33s.

While the field covered by this book is exceedingly great, the author has wisely confined his more detailed discussions to subjects appertaining strictly to television and has avoided the common error of attempting to include everything in equal measure. Thus, electron optics, which is now itself a highly specialised subject, is dealt with less thoroughly than, for instance, the theory of scanning. This is as it should be, for while all television workers should know something of electron optics, relatively few need have a detailed knowledge because only this few have the facilities for electron tube construction.

Image analysis is dealt with very thoroughly as are also the fundamentals of television cameras.

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Focusing and deflection are dealt with and the form of the vision signal is very well treated. There are chapters dealing with V.F. amplification, carrier transmission, image reproduction, broadcast practice and receiver practice.

The general treatment is mathematical, but this side is by no means overdone, for there are entirely adequate explanations given of the points brought out and the reader is not left to ferret them out for himself from among a mass of equations. The discussion of single- *v.* double-sideband systems is particularly good and the author makes out a good case for the single-sideband system which has been adopted in the U.S.A.

The examples are, of course, all drawn from American practice, which differs considerably from the British. There is, however, one case where one would not expect there to be any difference and this is the value of current which is dangerous to human life. The author quotes this as being about 150 mA., but in this country it is more often taken as being in the neighbourhood of 20 mA. Possibly Americans have an immunity to electric shock far in excess of that prevailing here!

The least satisfactory parts of the book are those dealing with deflection, time-bases, and sync separation methods. Only the more common American systems are described and many of the widely used British arrangements are barely mentioned.

In spite of these minor defects the book is a very good one and can be recommended to all engaged on television work. It includes some excellent illustrations of image defects.

W. T. C.

Problems in Applied Physics

IT has been decided to extend the facilities of the Institute of Physics' panel of consultants, in an endeavour to assist professional men who in the present circumstances find themselves confronted with problems in applied physics of which they have not had previous experience. Enquirers, who should apply to the secretary of the Institute of Physics at The University, Reading, will be put into touch with physicists who are most likely to be able to offer practical suggestions. The subjects which can be dealt with cover all branches of pure and applied physics, including, for example, physical measurements and testing, the design and supply of scientific instruments for special purposes, and the control of processes by physical means.

New Colour Codes for Resistors and Fixed Condensers

IN the "Recommended War Standards" for the colour coding for resistors and fixed condensers, recently issued by the Radio Manufacturers' Association, alternative methods of marking resistors are given. They are (1) the body, end and dot (or, band) method; (2) the four-band method.

Markings to indicate percentage tolerances above and below the previously accepted standard of 10 per cent. are now included in the resistor code, which also covers a wider range of values than formerly.

The colour coding for small tubular, cylindrical or elongated rectangular fixed condensers is on the same basis as that recommended for resistors, but includes the designation of the D.C. voltage rating.

A band or dot of colour to designate the tolerance only of the resistance or capacitance may be used if desired on a resistor or condenser that has its value indicated by a numerical marking.

The Industry

WE have received from Standard Telephones and Cables, Ltd., an illustrated booklet describing the H.S.1 and H.S.2 general-purpose short-wave transmitters, which are equally suitable for fixed stations or mobile units. A leaflet giving summarised characteristics of the Type KR1 six-frequency blind approach receiving equipment has also been received.

E. K. Cole, Ltd., inform us that communications to the Radio Sales, Lamp Sales, Thermovent Sales, Moulding Sales, Export Sales, Publicity, Accounts and Secretarial departments, should, until further notice, be addressed to Green Park Hotel, Aston Clinton, Bucks.

Wild Barfield Electric Furnaces, Ltd., have now moved to new premises at Watford By-Pass, Watford, Herts.

Amplitude, Frequency and Phase Modulation

IN the editorial note which followed the letter from Mr. Dale Pollack on p. 353 of the August issue, the bar, which, as stated in the text, should have been above the second term of the last formula, was omitted. The formula should read $\sin(\omega_0 + \delta\overline{\hat{\omega}\sin pt})t$.

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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

3278. Hyperfrequency Waves and Their Practical Use.—L. Brillouin. (*Journ. Franklin Inst.*, June 1940, Vol. 229, No. 6, pp. 709–736.)

(1) What does hyperfrequency mean? (2) Some characteristics of hyperfrequency waves (and the possibility of storing-up energy in a resonator, and afterwards radiating this energy). (3) Former experiments by Clavier & Darbord (Lympne/St. Inglevert). (4) Dielectric cables (particularly the work of the author with Clavier). (5) Theory of dielectric cables. (6) Rectangular cross-section. (7) Circular and elliptical cross-sections.

3279. Research on Wave Guides and Electromagnetic Horns: Report III—Electromagnetic Waves passing through Curved Wave Guides.—Morimoto. (*See* 3400.)

3280. The Wave Configurations of Travelling Electromagnetic Fields produced in a Long Hollow Cylinder [Analytical Treatment of *E* Wave (but applicable also to *H* Wave): Equations for Critical Frequencies (System as a Type of High-Pass Filter): Nodal Configurations: etc.].—H. Iwakata. (*Nippon Elec. Comm. Eng.*, Jan. 1940, No. 19, pp. 178–181.)

3281. Theory of Resonance in Micro-Wave Transmission Lines with Discontinuous Dielectric [Lecher Wires: Wave Guides].—H. R. L. Lamont. (*Phil. Mag.*, June 1940, Vol. 29, No. 197, pp. 521–540.)

"In a recent paper King [3429 of 1937] has described a method of measuring dielectric constants at ultra-high frequencies. The theory was developed of a stationary-wave system on a pair of Lecher wires, these being surrounded for part of their length by a solid or liquid dielectric and for the remainder by air. The interesting mathematical result obtained seems to merit more exhaustive treatment, and to provide such is the object of the first part of this paper. Incidentally, misconceptions [" neglect of second boundary effect "] by previous authors [17 of 1935, 3100 of 1938 (both on measurement of soil constants: *see* also 3282, below) and 1933 Abstracts, p. 207 (Seeberger: dispersion in liquids)] seem to remain uncorrected, and these will be pointed out.

"The second part deals with the introduction of a slab of dielectric in a hollow-tube resonant line of the form investigated by Barrow, Southworth, and Carson, Mead, & Schelkunoff. The two characteristic types of wave form are studied, and it is shown how each is affected by the dielectric" [it is shown that the decrease in resonant length caused by the introduction of the dielectric cylinder is a function of the position of this cylinder: the form of the function is essentially similar to that for the parallel-wire system, but has important differences. For the *E* wave there is an important special case where for a definite wavelength the shift remains constant for all positions of the dielectric].

3282. Input Impedance of H.F. Parallel-Wire Transmission Lines immersed in an Absorbing Medium.—Banerjee. (*See* 3403.)

3283. Absorption of Radio Waves by a Thin Water Shell [and Its Employment to Improve the Directivity of a Radiator: Theory of Perfect Absorbing Body].—Morita. (*See* 3401.)

3284. Anomalous Dispersion and Absorption of Electric Waves in Solutions of Amino-Acids and Dipeptides [and the Effect of Molecular Size: Polarisation by Deformation or Orientation?].—J. B. Bateman & G. Potapenko. (*Phys. Review*, 15th June 1940, Vol. 57, No. 12, p. 1185.)

3285. Mobile Field-Strength Recordings of 49.5, 83.5, and 142 Mc/s Ultra-Short Waves from Empire State Building, New York: Horizontal and Vertical Polarisation [Former gives Stronger

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Average Field, also Less Variation in Cities but More Variation in Country (owing to Its Higher Maximum Values): Lowest Frequency gives Strongest Average Signal in City, Highest in Country (both Horizontal Polarisation, Equal Powers): etc.].—G. S. Wickizer. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 387–398.)

3286. On Variations in Transit Time of Wireless Signals on the Short Wave [Apparent Mean Velocity 281 000 km/s (compared with 252 000 km/s for Long Wave): Experimental Formula: Velocity increased by 15% over Path through Polar Region, increased on Dark Nights, decreased with Increase of Frequency (10% for Change from 8 Mc/s to 18 Mc/s): etc.].—M. Miyadi. (*Rep. of Rad. Res. in Japan*, [dated] Oct. 1939, Vol. 9, No. 1, pp. 1–8.)

3287. The Velocity of Propagation of Wireless Waves over the Ground [Cambridge/Chelmsford Measurements (60 km) on 166 m Wave, by Short Wave-Train Method: Velocity within 6 or 7% of That of Light: Results of Colwell, Hall, & Hill cannot be Correct: No Inconsistency between Frequency-Change Results (Mandelstam & Papalexi) and Short Wave-Train Results].—F. T. Farmer & H. B. Mohanty. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 456–463.)

3288. The High-Frequency Conductivity of an Ionised Medium in the Presence of an External Transverse Magnetic Field.—B. N. Singh & B. D. Sinha. (*Sci. & Culture*, Calcutta, May 1940, Vol. 5, No. 11, pp. 716–717.)

For previous work *see* 2635 of 1939. Using the complete expression for the conductivity, the present writers give curves for the values of the collision frequency giving maximum conductivity, as a function of p_T (both frequencies being expressed as fractions of the angular frequency p) for four different values of p_0^2/p^2, namely 0.5, 1.0, 1.1, and 1.5, for comparison with the curve obtained by Appleton & Booharivalla (423 of 1936) from the approximate expression to which the full equation reduces on the assumption of very small ionic density (an assumption which, however, " does not always hold good in the ionosphere "). The curves show that as the ratio p_0^2/p^2 increases towards unity, " the smaller is the value of p_T for which the conductivity becomes maximum at a collision frequency equal to zero." At unity, two values of collision frequency giving maximum conductivity occur when p_T/p is less than $\frac{1}{2}$. " It would be interesting to investigate which of them gives the greater conductivity and whether this double value . . . occurs only for $p_0^2/p^2 = 1$ or for a certain range on both sides of this value." For values of p_0^2/p^2 equal to or greater than unity, the conductivity never becomes maximum for zero value of the collision frequency. For p_0^2/p^2 greater than unity, the conductivity becomes maximum for higher values of collision frequency and after a certain value of p_0^2/p^2 the nature of the curve changes, the downward bend disappears, and a continuous increase is indicated.

" Conductivity . . . in the present case attains infinite values only when it is maximum at collision frequency equal to zero. For a given value of p_T^2 (lying between 0 and p^2) this occurs when $p_T^2 = p^2 - p_0^2$. This expression, when put as $p_0^2 = p^2 - p_T^2$, corresponds to the fourth condition of reflection pointed out by R. N. Rai [*see* Bajpai & Mathur, 3980 of 1937]. For this value of p_0^2, in the presence of a transverse magnetic field, the conductivity of the ionised medium would be infinity if the collision frequency is zero. Even if the collision frequency is not actually zero but has a small value, the conductivity would be sufficiently great to resemble the case of metallic reflection. Under these conditions the smaller the value of collision frequency, the greater will be the conductivity of the ionised medium and hence the better the chances of reflection."

3289. Normal and Abnormal Region-E Ionisation [through the Sunspot Cycle].—E. V. Appleton & R. Naismith. (*Proc. Phys. Soc.*, 1st May 1940, Vol. 52, Part 3, pp. 402–415.)

Normal-E character figure confirmed as proportional to ultra-violet intensity, but different relations are required to relate u.v. emission to mean sunspot numbers in the two halves (rising and falling) of the cycle: relative levels of normal and abnormal regions: abnormal-E ionisation probably due to irregular corpuscular agency (penetrating power 1 cm in air at N.T.P.): the problem of reconciling this solar control with frequent occurrence (probably predominating over normal ionisation) at night.

3290. The Application of Ionospheric Data to Radio-Communication Problems: Part I [Absorption- and Electron-Limitation: the (P', f) Relations for Normal & Oblique Incidence: Trajectories of Waves Obliquely Incident: Development of Direct Method of calculating Maximum Usable Frequency reflected by Thick " Parabolic " Layer, for Short & Long Distances: Method of deducing Thickness of " Parabolic " Layer from Vertical-Incidence Results].—E. V. Appleton & W. J. G. Beynon. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 518–533.)

3291. The Vertical Distribution of Ionisation in the Upper Atmosphere.—C. L. Pekeris. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 205–211.)

From the author's summary:—" Some transformations are given of the de Groot-Appleton formula to facilitate its use for determining the distribution of ionisation with height from equivalent height data . . . A formula is derived for determining the vertical distribution of electron-collision frequency from simultaneous measurements of the reflection-coefficient as a function of frequency ": it would seem that accurate measurements of this "offer an effective method of exploring the upper atmosphere."

3292. Measurements of the Reflection-Coefficient as a Function of Frequency, for determining the Vertical Distribution of Electron-Collision Frequency.—Pekeris. (In paper dealt with in 3291, above.)

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3293. Recombination and Electron Attachment in the F_2 Layer of the Ionosphere [Disappearance of Electrons by Negative-Ion Formation, as well as by Pure Recombination, raises F_2 Level above That where Electron Production is a Maximum: etc.].—F. L. Mohler. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1071: summary only.)

3294. A Rigorous Theory of the Recombination of Both Small and Large Ions in Gases at High Pressures.—W. R. Harper. (*Phil. Mag.*, May 1940, Vol. 29, No. 196, pp. 434–448.)

3295. Production of Atomic Metastable States by Photoionisation and Recombination, *and* Photoionisation and Recombination of O Atoms [Quantum-Mechanical Calculation: Production of Metastable O Atoms Very Improbable, at least in Terrestrial Atmosphere].—Yamanouchi, Kotani. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 468: p. 468.) *See* also *ibid.*, pp. 491–492 (excitation by electron collision).

3296. Cross-Section of Atomic Oxygen for Elastic Collision with Electrons, and Region F Absorption [Computation by Quantum Mechanics: Ramsauer Effect exhibited, and Its Importance in Interpretation of Absorption Processes: Collisional Frequency in Region F, calculated from Curve, agrees with Mean Value from Radio Measurements (unlike Values from Gas Kinetic Cross-Section)].—Mitra, Ray, & Ghosh. (*Nature*, 29th June 1940, Vol. 145, p. 1017.)

The agreement of radio results for Region E with those obtained from gas kinetic cross-sections of N_2 and O_2 is due, the writers point out, to the accidental coincidence of these values with those derived by quantum mechanics (*see* 3459 of 1938). A fuller account of the present work will appear elsewhere.

3297. Researches on the Conditions of Excitation of the Various Band Systems of the Molecule of Neutral and Ionised Nitrogen.—R. Bernard. (*Ann. de Physique*, Jan./Feb. 1940, Ser. 11, Vol. 13, pp. 5–77.) For previous work *see*, for example, 3465 of 1939 and 477 of February.

3298. Excitation Functions of Nitrogen Bands and Their Bearing on Auroral Problems.—B. Rypdal & L. Vegard. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 459.)

3299. Pressure Effect on Infra-Red Absorption [and the Writers' New Method of Determining the Height of Atmospheric Ozone: Laboratory Measurements show that Line Broadening in the Infra-Red is Proportional to Square Root of Pressure].—J. Strong & K. Watanabe. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1049.)

3300. Six-Month Period of Terrestrial Magnetic Activity and Its Relation to the F_2 Layer of the Ionosphere [Solar-Activity Increase involves Positive Charge on Sun, Negative on Planets: Calculation of Maxima of Magnetic Disturbance: etc.].—H. Nagaoka. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 461.)

3301. Layer "G" [Tomsk Ionosphere Station repeatedly observes Existence of Reflecting Layer above F_2 Layer, with Effective Height fluctuating from 400 to 650 km: Majority of Reflections (over Periods of ½ to 4 or 5 Hours) appear during, or a Few Hours before, a Magnetic Storm: Lower Boundary Sharp by Day, Diffuse by Night: Critical Frequencies slightly above Those of F_2].—A. Likhachev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 25, 1939, pp. 590–592: in English.)

3302. Study of the Ionosphere at Shanghai: Measurement of the Reflection Coefficient of the Ionised Regions.—P. Lejay. (*Comptes Rendus*, 11th March 1940, Vol. 210, No. 11, pp. 381–385.) A long paper on these observations was dealt with in 2148 of June.

3303. Papers on the Ionosphere at Huancayo, Peru, *and* Annual Variations of the Critical Frequencies of the Ionised Layers at Tromsö during 1939, *also* The Ionosphere at Watheroo, Western Australia.—Wells & Coile: Harang: Parkinson & Prior. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 155–165: pp. 167–168: pp. 169–172.)

3304. Characteristics of the Ionosphere at Washington, D.C., March 1940, with Predictions for June 1940 [including Severe Ionospheric Storm of 24th March: No "Well-Defined Period of about 26 Hours" between Intense Sudden Ionospheric Disturbance and Beginning of Storm: etc.].—Gilliland & others. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 236–238.)

3305. Elements of the Physical Theory of Meteors [Collision with Air Molecules: Heating: Evaporation & Deceleration].—B. J. Levin. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 5, Vol. 25, 1939, pp. 371–374: in English.)

"Observational data relating to these dependences [eqns. 6a & b] . . . fully contradict the hypothesis of the prevailing of light gases at the height of 100–140 km." "From eqn. 13 it follows that the mass of iron meteors disappearing at a height of about 80 km ('ordinary' meteors) must be of the order of 10^{-2} gm."

3306. Aeroplane Radio Communication during Dellinger Phenomenon [Conclusion that Propagation of Short Waves from Aeroplanes, at Distances less than 500 km, depends on Direct or Directly Diffracted Waves].—K. Umeda. (*Rep. of Rad. Res. in Japan*, [dated] Oct. 1939, Vol. 9, No. 1, Abstracts p. 1.) *See* also 922 of March.

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3307. Spots on the Sun [and Their Correlation with Earth Currents & Radio Disturbances: Bell Laboratories' Ground-Potential Records, etc.].—A. L. Durkee. (*Bell Lab. Record*, June 1940, Vol. 18, No. 10, pp. 305–309.)

3308. Solar Activity [and Associated Magnetic Storms: 1936/1939].—H. W. Newton & A. L. Narayan. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 455.)

3309. On the Stability of Sunspots [from Greenwich Data on Group Recurrence, 1874/1935].—M. S. Eigenson. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 25, 1939, pp. 584–586: in English.)

It is concluded that the general character of recurrence in two neighbouring cycles (*e.g.* 1889/1900 and 1901/1912) is very constant, varying sharply in passing from one pair of neighbouring cycles to the following. "This phenomenon possibly represents the pair-wise connection of cycles in the double cycle of Hale's solar activity."

3310. On the Localisation of Centres of Geoactive Radiation in the Sun's Active Regions [Probable Centre of Troposphere-Active Radiation generally about 15° West of Region of Highest Concentration of Spots, but occasionally to East (when Centres of Magnetically Active & Troposphere-Active Radiations coincide, giving Observed Coincidences between Geomagnetic & Tropospheric Rhythms].—B. M. Rubashev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 25, 1939, pp. 587–589: in English.)

3311. Reality of Periodicities [found by Fourier Analysis of Observations of Solar Constant: Statistical Treatment].—H. R. Hulme: Abbot. (*Nature*, 22nd June 1940, Vol. 145, p. 979.) "Hulme regards his results as indicating not that the periodicities are real but that the [random] fluctuations persist over a number of 10-day intervals . . ."

3312. Energy in the Solar Ultra-Violet [Report of Five Years' Work at Mount Wilson Observatory].—E. Pettit. (*Nature*, 29th June 1940, Vol. 145, p. 1026: summary only.) *See* also *Sci. Abstracts*, Sec. A, 25th June 1940, p. 457.

3313. Rotation of Solar Corona as determined from the Apparent Displacements in Its Structure, *and* The Inner Corona on June 19th 1936: Investigation of Coronal Structure and Changes occurring in the Corona and Chromosphere.—Vsesviatsky & Bugoslavskaja. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 5, Vol. 25, 1939, pp. 362–366: pp. 367–370: in English.)

3314. Cosmic Ray Intensities in Relation to Cyclones and Anticyclones.—Nishina & others. (*Nature*, 20th July 1940, Vol. 146, p. 95.)

3315. Cosmic Rays give Hint on Upper-Air Weather [Intensities fluctuate with Different Air-Mass Conditions over Japan].—(*Sci. News Letter*, 15th June 1940, Vol. 37, No. 24, p. 377.)

3316. On Space Closure of Periodic Orbits in the Field of a Magnetic Dipole [and Possible Advances in the Ring Theory of Magnetic Storms and in the Determination of Distribution of Cosmic Rays].—O. Godart. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1062–1063: summary only.) For previous work *see* 3076 of 1939, 945 of March, and 1342 of April.

3317. Principal Magnetic Storms [Jan./March 1940, Sitka, Cheltenham, Tucson, Huancayo, Apia, Watheroo: Oct./Dec. 1939, Alibag, Capetown].—(*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 226–234.)

3318. Studies of the Secular Variations of Terrestrial Magnetism: I—Secular Variations deduced from Biot's Theory, *and* On the Intersection of Isolines [in the Construction of Magnetic Charts].—P. P. Lazarev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 1, Vol. 25, 1939, pp. 26–29: pp. 30–31: in French.)

3319. A Significance-Test for Ellipticity in the Harmonic Dial [representing Fourier Coefficients from Harmonic Analysis of Observations of Periodic or Quasi-Periodic Phenomena (Atmospheric Tides, Magnetic Variations, etc.)].—J. W. Mauchly. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 145–148.)

3320. Wide-Range Magnetograph at Washington, D.C.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 213–214.)

3321. The Interior of the Earth [and the Earth's Magnetic Field: Discussion].—E. Teller & M. A. Tuve. (*Science*, 28th June 1940, Vol. 91, pp. 621–623.) At the Washington Conference on Theoretical Physics.

3322. On a Proposed Thermoelectric Origin of the Earth's Magnetism [Objection based on Weakness of Coriolis Force].—Inglis & Teller: Elsasser. (*Phys. Review*, 15th June 1940, Vol. 57, No. 12, pp. 1154–1155.) *See* 2155 of June and back references.

3323. Physical Representation of the Geomagnetic Field.—A. G. McNish. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1088: summary only.)

"Interpretation of this model leads to the beliefs that (1) at least a considerable portion of the earth's magnetism (the residual field) originates at a lesser depth than the central core revealed by seismological evidence, and (2) secular change involves this residual field and therefore is due to changes taking place between the surface of the earth and the surface of the central core."

3324. On the Screening Effect of Wire Cages.—Kontorovich. (*See* 3407.)

3325. Calculation of Driving-Point Impedance in Electromagnetic Field Problems [with Application to Forced, Steady-State Oscillations of Linear Antenna].—Stratton & Chu. (*See* 3404.)

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3326. An Alternative Treatment of the Attenuation of Waves in a Coil-Loaded Telephone Line [by Summation of Campbell's Infinite Series of Reflections: Good Agreement with Experimental Results: Some Conclusions].—G. H. Metson. (*Journ. I.E.E.*, July 1940, Vol. 87, No. 523, pp. 69–75.)

3327. A Method for Solving the Wave Equation in a Region with Perturbed Boundaries.—Feshbach & Clogston. (*See* 3457.)

3328. The Classical Theory of Shock and the Theory of a Propagated Discontinuity.—L. Thompson. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1058: summary only.)

"Both procedures are faulty in employing at some point the thermodynamics of equilibrium. The theory of discontinuity seems less vulnerable in this respect."

3329. On the Propagation of Motion in Viscous Materials.—L. Cagniard. (*Ann. de Physique*, May/June 1940, Ser. 11, Vol. 13, pp 239–265.)

3330. Propagation of Waves in Two Dimensions: *also* Solution of Cauchy-Dirichlet's External Problem for a Wave Equation in the Case of a Circle: *and* Propagation of Elastic Waves in Two Dimensions [with Future Application to Propagation within Three-Dimensional Space].—J. A. Mindlin. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 4, Vol. 25, 1939, pp. 280–284: pp. 285–288: pp. 289–292: in English.)

3331. A Comprehensive Theory of Light [Corpuscles vibrating (transversely to Propagation Path) while moving with Velocity of Light].—P. Fireman. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1060: summary only.) "Thus we would have a wave theory of light without ether . . a corpuscular theory accounting for all light phenomena."

3332. A Generalised Theory of the Concave Grating [Formula for Reflection & Diffraction, for Arbitrary Position of Luminous Point or of Image: Expressions for Aberration, etc.].—Beutler. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1073: summary only.)

3333. On the Diffraction at a Slit or Bar: Part I [Identical Integral Equation for Slit (when Electric Force is Parallel to Z Axis) and Bar (when Magnetic Force is Parallel to Z Axis): etc.].—W. Ignatowsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 5, Vol. 25, 1939, pp. 375–378.) Continuation of the work referred to in 2685 of 1939. For Part II see *ibid.*, No. 8, pp. 665–667.

3334. Note on "The Theory of Light-Scattering" [by Particles in Suspension in Liquids, etc.].—S. Parthasarathy: R. S. Krishnan. (*Phil. Mag.*, May 1940, Vol. 29, No. 196, pp. 515–516.)

3335. Haidinger's Rings in Non-Uniform Plates [such as give Newton's Rings: Transition from One to the Other Type of Interference Figure].—Raman & Rajagopalan. (*Phil. Mag.*, May 1940, Vol. 29, No. 196, pp. 508–514 & Plates.) Hitherto it has been considered that the two phenomena were mutually exclusive.

3336. The Doppler Effect from Moving Mirrors [would also give Null Result as regards Detection of Absolute Motion].—H. E. Ives. (*Journ. Opt. Soc. Am.*, June 1940, Vol. 30, No. 6, pp. 255–257.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3337. Recent Lightning Storms: III [particularly Those of July 1939 (Brighton, Scotland); Oct. & Nov. 1939; Frontal Type; etc.].—J. F. Shipley. (*Distribution of Electricity*, July 1940, Vol. 12, No. 139, pp. 383–387.) For previous parts *see* 2526 of July.

3338. Developments in Electric Surge Recording [by the Klydonograph].—J. L. Candler. (*Nature*, 22nd June 1940, Vol. 145, p. 982.) Note on I.E.E. paper based on E.R.A. Report Ref.S/T26.

3339. The Variation ot Sparking Potential with Initial Photoelectric Current [in connection with New Theory of Spark Discharge.]—J. M. Meek. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 547–558.) *See* 2524 of July.

3340. Protector Tubes for Power Systems [Survey of Eight Years' Experience].—Peterson & others. (*Elec. Engineering*, May 1940, Vol. 59, No. 5, Transactions pp. 282–291.)

3341. Analysis of Local Atmospheric-Electric Phenomena at College, Alaska.—Gish & Sherman. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 173–190.)

3342. Upper-Air Weather Soundings by Radio [Radio Sondes, Ground-Station Equipment: Accuracy of Observations: etc.].—Diamond & others. (*Elec. Engineering*, June 1940, Vol. 59, No. 6, Transactions pp. 321–328.)

3343. On the Contribution to the Ionisation at Sea-Level produced by the Neutrons in the Cosmic Radiation.—S. A. Korff. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 133–134.)

3344. The Diurnal Variation and Vertical Distribution of Atmospheric Condensation-Nuclei, *and* The Mobility-Spectrum of Atmospheric Ions.—E. A. Yunker. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 121–126: pp. 127–132.)

3345. Total and Uncharged Nuclei at Washington, D.C.—K. L. Sherman. (*Terr. Mag. & Atmos. Elec.*, June 1940, Vol. 45, No. 2, pp. 191–204.)

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PROPERTIES OF CIRCUITS

3346. A General Reciprocity Theorem for Transmission Lines at Ultra-High Frequencies [Reciprocity Theorem is Valid only if Induced E.M.Fs exhibit Cosine-Symmetrical Distribution or if Line is terminated in Its Characteristic Impedance].—R. King. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 223–225.) Applying the general coupling theorem dealt with in 2194 of June.

3347. Some Impedance Characteristics of Tapped Resonance-Line Circuits [relevant to Use as Frequency-Stabilising Elements in Ultra-Short-Wave Oscillators].—Willshaw. (*See* 3368.)

3348. An Investigation of the Telegraph Artificial Line.—P. A. Naumov. (*Elektrosvyaz*, No. 1, 1940, pp. 42–50: Russian only.)

Formulae are derived, and curves plotted, for determining the current in a two-section balancing network (Fig. 1), and the current in each section is discussed. It is concluded that a two-section network cannot be replaced by one of a single section.

3349. A Contribution to the Theory of the Diode Rectifier [applicable also to the Dry-Plate Rectifier].—H. Oplustil. (*T.F.T.*, March 1940, Vol. 29, No. 3, pp. 84–91.)

Author's summary :—" The characteristic curve of a diode rectifier, which in the literature is approximately represented by an exponential function, a straight line with a ' knee,' or one limb of a parabola, is represented in this paper by the space-charge characteristic [$i = K \,.\, e^{\gamma}$, with $\gamma = 1.5$]. On this assumption the rectification characteristic is worked out, and the influence of the resistances in the external circuit on the rectifying process and on its ' klirr ' factor [factor of non-linear distortion] is investigated."

The case of complete short circuit is considered first ; the exact solution on p. 86 is simplified to the approximate formulae of p. 87, and the calculated rectification characteristics for a Type AB1 diode, as a function of the repose-state bias E_0 for various carrier-frequency voltages, are seen in Fig. 5 (dotted) to agree well with the measured values, especially in the region of negative bias. The output circuit is then assumed to have a finite resistance R_a, short-circuited for the carrier and modulation frequencies by a by-pass condenser : its effect is to change the repose-state bias E_0 to the working bias E and to reduce the short-circuit current to the working current $I + \Delta I$. (For the open-circuit case where R_a is infinity the carrier-frequency voltage is equal to $-E$: this is the greatest displacement of the steady-state bias which can occur). The change to the working bias E leads to new values of fundamental-frequency amplitude and of input impedance (equations at top of p. 88). The case next examined is when the modulation frequency is no longer by-passed, so that the circuit contains also an a.c. resistance ; if this is assumed equal to the d.c. resistance R_a, then the Taylor series (p. 88, l-h column) contains terms representing the rectifying action of the carrier-frequency voltage, the additional action of the modulation-frequency voltage (small compared with the first otherwise a marked additional displacement of the working bias would occur, and with it a complicated disturbance of the rectifying process), the a.c. amplitude of the modulation frequency, and the a.c. amplitude of the first harmonic. The rest of this section is concerned largely with the derivation of formulae for the " klirr " factors, and with a discussion of these.

The final section deals with the influence of the internal resistance of the current source. If this is not zero (as has been assumed hitherto) it will be subjected to a voltage drop not only of the carrier frequency but also of its harmonics, and the consequent distortion of the carrier frequency by the harmonics leads to considerable mathematical complications in the determination of the current function and its series development, since not only the amplitudes of the various harmonics have to be considered but also their phases. Simple relations are only obtainable for the case (not unimportant in practice) where the internal resistance is zero for the harmonics though not for the carrier.

3350. Power-Tube Performance as influenced by Harmonic Voltage.—Sarbacher. (*See* 3433.)

3351. Square-Wave Analysis of Linear Pulse Amplifiers.—R. D. Huntoon. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1068 : summary only.) *Cf.* Arguimbau, 3071 of August.

3352. Load-Rating Theory for Multi-Channel Amplifiers [for Carrier Telephony : for Design so that Inter-Channel Interference due to Amplifier Overloading may not be Serious].—B. D. Holbrook & J. T. Dixon. (*Elec. Engineering*, May 1940, Vol. 59, No. 5, Transactions pp. 265–272.)

3353. The Stability of Regenerative Circuits [Derivation of Nyquist's Criteria without Consideration of Behaviour to Transients, by assuming that Transfer-Constant Value has been attained by Quasi-Static Increase from Zero].—R. S. Rivlin. (*Wireless Engineer*, July 1940, Vol. 17, No. 202, pp. 298–302.)

" The mathematical objections to Brayshaw's method [881 of 1938] are avoided and the complete criteria of Nyquist are deduced as distinct from the limited criteria of Brayshaw."

3354. Simplified Surge-Generator Equations.—T. J. Higgins. (*Electrician*, 28th June 1490, Vol. 124, p. 450.)

3355. Electromechanical Analogies.—P. G. Bordoni. (*Alta Frequenza*, March 1940, Vol. 9, No. 3, pp. 133–161.)

Author's summary :—" The possibility of developing analogies between electrical circuits and mechanical systems is recognised, using the formal identity of the relations connecting electrical and mechanical quantities, and choosing conveniently the units in which these quantities are measured. It is sought to establish the number and nature of the possible analogies, and the types of electrical circuit to which they are applicable. Suggestions are made for the practical construction of mechanical models of the most general electrical circuits, and as an example the characteristics are given of a mechanical filter under steady and transitory conditions " [triple-pendulum band-pass filter, 0.744–

0.844 c/s band, corresponding to the circuit of Fig. 7, 744–844 c/s band].

3356. Calculation of Filter Circuits, etc., with the Help of the Working Transmission Equivalent [Betriebsübertragungsmass].—F. Wisgrill. (*T.F.T.*, March 1940, Vol. 29, No. 3, pp. 74–77.)

The writer begins by a condemnation of the methods—" costly in time and material "—of well-known workers in this field. Thus " in the theoretical improvement of the characteristic attenuation (Cauer) and above all in the theoretical smoothing of the characteristic impedance (Zobel) one sometimes goes so far that the theoretically sought-for gain (obtained at the price of a large number of circuit components) is smaller than the practical losses due to the unavoidable resistances and to the inaccuracy and instability of the final arrangement. Moreover, in many types of filter circuit (Zobel) there exist unavoidable dependencies between characteristic transmission equivalent and characteristic impedance, which can only be calculated with great difficulty and which often have an extremely unfavourable effect." The conclusion reached is that " in order to arrive at the best possible circuits, the calculations should be based, fundamentally and always, on the working transmission equivalent," which after all is, as a rule, the one and only thing that matters in practice.

The filter circuit (assumed to be symmetrical) is replaced by its equivalent bridge circuit, Fig. 1. In the general case of unmatched conditions ($Z/C = p$ = matching factor, where C is the terminating impedance) the working transmission equivalent $\mathfrak{g}_B$ is defined as the natural logarithm of the ratio {output current for the straight-through connection, *i.e.* without quadripole}/{output current with quadripole inserted}. If from this $\mathfrak{g}_B$ is subtracted the characteristic transmission equivalent $\mathfrak{g}$ ($= \log_e x/y$ in the matched condition —*see* eqns. 7 and 10), a residue is left which represents the influence of the imperfect matching, and which is named the " reflection transmission equivalent," $\mathfrak{g}_R$. Eqn. 15 gives

$$\mathfrak{g}_R = \log_e\{(p + 1)^2 - (p - 1)^2 e^{-2\mathfrak{g}}\}/4p,$$

and since this and the other formula $\mathfrak{g}_B = \mathfrak{g} + \mathfrak{g}_R$ involve nothing but C and the quadripole components, they are applicable not only to X-sections but also to T and pi sections, to chains of such sections, to interposed sections of overhead line or cable, and generally to any symmetrical linear quadripole. An obvious step is to represent eqn. 15 once and for all in the form of graphs for practical use; to do this certain assumptions are made which are either likely to be fulfilled in practical cases or capable of being corrected for subsequently. As an example of the use of such curves, a low-pass filter (Fig. 6) of two bridge-type sections is calculated, to give a working attenuation of 0.3 neper in the pass band and of over 4 nepers in the cut-off band.

3357. A Resistance-Compensated Band-Stop Filter [yielding Practically Infinite Attenuation at Predetermined Frequency even when Attenuation Band is Very Narrow: combining Desirable Characteristics of Ladder and Bridge Types].—H. Stanesby. (*P.O. Elec. Eng. Journ.*, July 1940, Vol. 33, Part 2, pp. 82–87.)

3358. The New GT Quartz Crystal with High Frequency-Constancy over Wide Temperature-Range [for Crystal Filters, etc.].—Mason. (*See* 3518.)

3359. Thermistors, Their Characteristics and Uses [Directly & Indirectly Heated Resistances having Large Negative Temperature Coefficient of Resistance: Use as Temperature- or Power-Measuring Device, Temperature-Compensating Device, L.F. Oscillator, etc.].—G. L. Pearson. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1065–1066: summary only.) *Cf.* 3184 of August.

3360. An Unstable Non-Linear Circuit [Iron-Cored Reactance shunted by Capacitance, in Series with an Impedance: Characteristics & Theory: Utilisation of Instability for Large Phase Shifts, Energy Conversion (Reciprocating Action for Contact-less Bells, etc.), Temperature Control, etc.].—C. M. Summers. (*Elec. Engineering*, May 1940, Vol. 59, No. 5, Transactions pp. 273–276.)

3361. Operational Treatment of a Circuit having an Iron-Cored Inductance Coil.—S. Kumagai. (*Electrot. Journ.*, Tokyo, April 1940, Vol. 4, No. 4, p. 93.)

3362. Balancing of D.C. Clicks [in Telephone Receiver: Experimental Investigation].—T. Sakamoto. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, p. 72.)

" When both currents are the same, the impulse becomes zero steeply; the larger the inductance, the smaller the impulse under unbalanced condition; and the larger the compensating current, the smaller the impulse for the same amount of current unbalancing."

3363. Inductor with Air-Gapped Magnetic Circuit [and the Existence of an Optimum Air-Gap in a Telephone Receiver, depending on Distribution of Magnetic Flux].—Marinesco: Glazier. (*See* 3444.)

TRANSMISSION

3364. The Electronic Valve with Velocity Modulation: Correction to Formula 5 [Bracket Misplaced].—Bethenod. (*Comptes Rendus*, 11th March 1940, Vol. 210, No. 11, p. 423.) *See* 1416 of April.

3365. On the Resonant Frequency [and Corresponding Field Value] of a Type of Klystron Resonator [Calculation by Approximation Method (using Ritz Variation Principle): Comparison with Barrow & Mieher's Measurements].—E. H. Smith. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1080: summary only.)

For these measurements see 2951 of August. Of the present paper, " probably the most useful results are the calculated field values, as these are difficult to measure experimentally and are useful in resonator design."

3366. The Influence of the Space Charge on the Focusing of Cathode Rays [Survey, & New Experimental Results].—W. Reusse & N. Ripper. (*T.F.T.*, March 1940, Vol. 29, No. 3, pp. 68–74.)

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Further development of the work dealt with in 3626 of 1939, which was particularly concerned with the determination of the distribution of the charge as it might occur in iconoscopes. Recently the matter has attained special importance in connection with velocity-modulated u.h.f. generators and amplifiers, and it is very desirable to know what electrode arrangement and what field relations will produce the best ray cross-section and will give the steepest possible "flank" to the charge distribution. After a survey of theoretical work from various sources the writers remark that to sum up from these results is difficult "because the assumptions from which the various authors start are all different. Thorough critical decisions will only be possible when more comprehensive experimental material is available. Approximate calculations lead, however, to the conclusion that an appreciable thickening of the ray, $\Delta = r/r_0 \approx 1.5$, occurs for an electron energy of 4 kv, a ray length of 50 cm, and a ray current of 1 mA or ray density of 1–10 mA/cm²."

The results of the investigation described in the previous paper are then enumerated, and the almost simultaneous work of Jacob (3625 of 1939) is outlined; reasons are given why the two sets of results cannot be compared. The rest of the paper describes the writer's new experimental measurements, using an improved form of his original apparatus in which the ray current could be checked between each measurement by swinging a Faraday cage (positively biased to avoid secondary emission) into the path of the ray. Fig. 9 shows typical oscillograms with the one-wire and two-wire arrangements (*see* previous abstract); from these, with the help of a photographic enlarger, the base-widths *f* (giving a true measure of the spot diameter) were determined. Fig. 11 gives the value of *f* as a function of the ray current (bottom axis) and ray density (top axis), for voltages of 2 and 4 kv: it shows that "over the whole of the current range down to a density of 0.4 mA/cm² [ray current about 0.5 μA] space-charge effects must play a rôle. It is seen also that with increasing ray voltage the spot diameter becomes smaller" [item 3b in the summary at the end seems ambiguously worded]. According to von Borries & Dosse (2947 of 1938) no thickening by space charge would be expected until the ray current passed about 50 μA: actually it is found to occur even when the ray current is only 0.004 μA (Fig. 12, for a smaller *B* aperture—see below).

The next point dealt with is the interesting question whether the focusing can be improved by diminishing the diameter of the spot-image aperture in the screen *B* ("3" in the electrostatic gun of Fig. 10). Fig. 14 gives the observed results: decreasing the diameter from 0.04 to 0.01 cm does decrease the value of *f* for a constant ray current, but not by as much as would be expected, probably because more of the total ray-electrons are dispersed at the edge of the smaller aperture and thus cause an added lack of sharpness. Fig. 16 shows the effect of decreasing the aperture of the stop in the middle of the cylinder 4 in Fig. 10: curve 1 is for no stop, curve 2 for a 6 mm-aperture stop, and curve 3 for a 4 mm aperture. This smallest aperture does actually improve the sharpness of focusing, partly by diminishing the spherical aberration of the image-forming lens 5, but also partly because, together with the setting free of low-velocity secondary electrons, the introduction of the small stop "upsets the charge distribution at that point of the ray so that the beam after leaving the stop possesses a non-uniform drop of charge density, which seeks to equilibrate itself."

Finally the writer examines the possibility of making the spot-image screen *B* (*see* above) act also as an apertured stop, by altering the pre-concentrating lens ("2" of Fig. 10), which supplies *B* with electrons, so that its focus falls short of *B*. This gives the ray in the main lens ("4" and "5" in Fig. 10) a smaller diameter, and reduces the spherical aberration (curve 2 of Fig. 18).

3367. An Extended Wavelength Spectrum of Oscillations in a Triode with Positive Grid [including Simultaneous Appearance of 3 Non-Harmonic Frequencies].—R. King. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1065: summary only.) For Wundt's work *see* 1931 Abstracts, pp. 94–95.

3368. Some Impedance Characteristics of Tapped Resonance-Line Circuits [relevant to Use as Frequency-Stabilising Elements in Ultra-Short-Wave Oscillators: Calculation of Resonant Conductance, and Susceptance Off Resonance, as Functions of Tapping-Point Position: Simple Equivalent Circuit for Frequencies near Resonance: Experimental Checks].—W. E. Willshaw. (*Phil. Mag.*, June 1940, Vol. 29, No. 197, pp. 572–585.) From the G.E.C. laboratories. The method of treatment is different from that used by Reed (3875 of 1938).

3369. A Method of measuring Frequency Deviation [*i.e.* Half the Total Excursion or "Swing" of a Frequency Modulator: based on Bessel-Function Variation of Amplitudes of Carrier & Side Frequencies: Carrier is Heterodyned to Beat Note and Filtered, so that Carrier Zero Points can be Observed].—M. G. Crosby. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 473–477.)

3370. Errata in "The Service Range of Frequency Modulation" [including Replacement of Four Signal/Noise *versus* Distance Diagrams].—Crosby. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, p. 504.) *See* 1644 of April.

3371. Modulation Circuit Theory [More General Solution of Ordinary *n*th Order Linear Differential Equation, easily applicable to Amplitude, Phase, or Frequency Modulation].—D. L. Jaffe. (*Journ. Franklin Inst.*, June 1940, Vol. 229, No. 6, pp. 779–782.) For the writer's analysis of the Armstrong frequency-modulator *see* 2711 of 1938.

3372. A New Broadcast Transmitter Circuit Design for Frequency Modulation [Modulation Characteristics are Independent of Carrier-Frequency Stability (Latter is ± 0.0025% without Use of Temperature Control].—J. F. Morrison. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 251: summary only.)

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3373. Variable-Resistance Device and Its Application, especially to the Frequency Modulation of a Quartz-Crystal Oscillator [for Frequency-Diversity Short-Wave Telegraphic Signalling, Frequency-Modulated Telephony, etc.].—I. Koga. (*Electrot. Journ.*, Tokyo, May 1940, Vol. 4, No. 5, pp. 99–107.)

Based on Amari's circuit in which the increase of a condenser in series with the crystal, and the increase of one in parallel with the crystal, give opposed effects on the amplitude but added effects on the frequency: the writer uses two indirectly heated triodes (with small capacitance between cathode and heating circuit) for the purpose. For telephony modulation, the method is only claimed to be suitable for not very deep modulation—when, however, the advantages of frequency modulation may not be so evident.

3374. Papers on Frequency Modulation.—Maeda: Pollack: Crosby. (*See* 3617/3619.)

3375. The Influence of Filter Shape-Factor on Single-Sideband Distortion [Optimum Conditions approached when Filter Slope in Region of Carrier Frequency is Zero: etc.].—J. C. Wilson & H. A. Wheeler. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 253: summary only.)

3376. Selective Sideband Transmission in Television [including Comparison with Double Sideband].—Kell & Fredendall. (*See* 3477.)

3377. Counting Words per Minute Electrically [Continuous Measurement of Keying Speed, for Classes, etc.].—M. J. Larsen. (*QST*, July 1940, Vol. 24, No. 7, pp. 30–31.)

3378. A Heterodyne Exciter: a Stabilised Frequency-Control Unit for Transmitters [Advantages: Construction].—W. R. Bliss & P. A. Bailey. (*QST*, July 1940, Vol. 24, No. 7, pp. 38–40 and 78, 80.)

3379. A Stabilised Variable-Frequency Oscillator: Design Considerations for High-Stability Transmitter Frequency Control.—G. M. Brown. (*QST*, July 1940, Vol. 24, No. 7, pp. 13–17 and 90..96.)

3380. The Limits of Inherent Frequency Stability [*i.e.* Extent to which the Frequency is Independent of Small Changes in Effective Valve Impedances: Desirable Basis on which to build Stable Oscillator, by adding Refinements in Design & Lay-Out of Components, Compensating Arrangements, etc.].—W. van B. Roberts. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 478–484.)

3381. The New GT Quartz Crystal with High Frequency-Constancy over Wide Temperature-Range.—Mason. (*See* 3518.)

3382. Quartz Crystals: Part II—Nature of Quartz and Manufacture of Crystals.—Baldwin. (*Gen. Elec. Review*, June 1940, Vol. 43, No. 6, pp. 237–243.) For Part I *see* 2967 of August.

3383. Tritet Crystal Oscillator [combining Function of Frequency Multiplier: Examination of Popular American Circuit as regards Suitability for Higher Powers (Beam Power Output Valve Type UY-807): Comparison with Pierce Circuit followed by Frequency Multiplier].—I. Koga & W. Yamamoto. (*Electrot. Journ.*, Tokyo, May 1940, Vol. 4, No. 5, pp. 110–115.) *See* Lamb, Abstracts, 1933, p. 502, and 1934, p. 34.

3384. A Different Portable-Emergency Transmitter: Simplified Design with the "Inverted" Amplifier [requiring No Fixed Bias or Neutralisation].—R. P. Austin. (*QST*, July 1940, Vol. 24, No. 7, pp. 36–37.) *See* Romander, 1934 Abstracts, p. 34: the grid is earthed and the cathode left "up in the air."

RECEPTION

3385. Panoramic Reception [and Its Advantages for Navigation, Monitoring & Measurement, Adjustment of Television & Frequency-Modulated Transmitters, etc.].—M. Wallace. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 253: summary only.) For this system of cathode-ray reception *see* 4386 of 1938 and back reference.

3386. Papers on Noise and Interference in Frequency- & Phase-Modulation Systems.—Maeda: Pollack: Crosby. (*See* 3617/3619.)

3387. An Acorn-Tube 112-Mc Converter.—M. P. Rehm. (*QST*, July 1940, Vol. 24, No. 7, pp. 41 and 104.)

3388. Design of Superheterodyne Intermediate-Frequency Circuits [Choice of I.F: Diode-Transformer Considerations: Coupled Tuned-Circuit Theory: Effect of Valve-Admittance Variations: Excessive Capacitive Coupling between Plate & Grid Windings of Transformer, as Additional Cause of Resonance-Curve Asymmetry: etc.].—F. E. Spaulding, Jr. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 485–495.)

3389. Rationalising Broadcast Receivers [Economy in Labour & Material: Suggestions for a "Total War" Plan: Three Basic Types of Valve: Mains Transformers & Smoothing Chokes saved: etc.].—J. A. Sargrove. (*Wireless World*, July 1940, Vol. 46, No. 9, pp. 338–342.)

3390. Broadcast Receivers for a Blitzkrieg [Requirements of Two Main Classes].—(*Wireless World*, July 1940, Vol. 46, No. 9, p. 325.)

3391. Kolster-Brandes Receivers for Export: Tropical Construction and Special Short-Wave Ranges, *and* Murphy Overseas Models: Modified Standard Receivers for Export.—(*Wireless World*, July 1940, Vol. 46, No. 9, p. 342: p. 344.)

3392. Test Report: the "Double-Decca" [Combined AC/DC and "All-Dry," with Short-Wave Reception on addition of Outside Aerial].—(*Wireless World*, July 1940, Vol. 46, No. 9, pp. 336–337.)

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3393. " Mulparvo " Portables [Weighing under 3 lb : Dry Batteries of Deaf-Aid Type].—(*Wireless World*, July 1940, Vol. 46, No. 9, pp. 329–330.)

3394. Nomograms for the Calculation of Mains Transformers in Low-Power Radiotechnical Apparatus [Receivers, Amplifiers, Small Transmitters].—C. Crescini. (*Radio e Televisione*, Jan./March 1940, Vol. 5, No. 4/5, pp. 184–189.) For the writer's book including similar nomograms for electroacoustic transformers *see* 1485 of April.

3395. British Standard Specification for Anti-Interference Characteristics and Performance of Radio Receiving Equipment for Aural and Visual Reproduction.—British Standards Institution. (*Specification No.* 905–1940, June 1940, 44 pp.)

3396. Corona in Oil as a Part of a Commercial-Frequency Circuit [and the Existence of Primary (Non-Oscillatory) and Secondary (Oscillatory) Corona : Back-Coupling Theory of Oscillating Condition].—Kimura & others. (*Electrot. Journ.*, Tokyo, April 1940, Vol. 4, No. 4, pp. 90–92.) Investigated by microphone/oscillograph records of supersonic emissions.

3397. Considerations on Some Incidents of Service in High-Tension Overhead Lines.—A. Pernier. (*L'Elettrotec.*, 25th March 1940, Vol. 27, No. 6, pp. 134–142.)

3398. Principles of Fault-Tracing : Part II—Applying Basic Ideas to Specific Cases.—W. H. Cazaly. (*Wireless World*, July 1940, Vol. 46, No. 9, pp. 320–323.) For Part I *see* 3003 of August.

3399. " Wireless Servicing Manual, 5th Edition " [Book Notice].—W. T. Cocking. (*Wireless World*, July 1940, Vol. 46, No. 9, p. 342.)

AERIALS AND AERIAL SYSTEMS

3400. Research on Wave Guides and Electromagnetic Horns : Report III—Electromagnetic Waves passing through Curved Wave Guides.—S. Morimoto. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, pp. 64–67.)

For Reports I & II *see* 1886 of May : for previous papers on curved guides *see* 1745 of May. For Buchholz's work, referred to here, *see* 2629 of 1939 : the reference to Kalähne's paper (on oscillations in a rectangular-section tube bent into a ring) is given as *Ann. der Physik*, 1939, whereas actually the date is 1905 (Vol. 18, pp. 92–127.)

3401. Absorption of Radio Waves by a Thin Water Shell [and Its Employment to Improve the Directivity of a Radiator for 25 cm Waves : Theory of Perfect Absorbing Body : Experiments with Containers filled with Salt Water].—K. Morita. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, pp. 67–71.) For the German papers referred to *see* 559 of 1939 and back references. For a fuller version of the present paper, including a new method of measuring the power factor of water, see *Rep. of Rad. Res. in Japan*, Oct. 1939, Vol. 9, No. 1, pp. 9–21.

3402. A General Reciprocity Theorem for Transmission Lines at Ultra-High Frequencies.—King. (*See* 3346.)

3403. Input Impedance of High-Frequency Parallel-Wire Transmission Lines immersed in an Absorbing Medium.—S. S. Banerjee. (*Indian Journ. of Phys.*, Feb. 1940, Vol. 14, Part 1, pp. 13–19.)

" The impedance of such lines for different lengths, when placed in air, has been worked out by various authors [Roder, 1933 Abstracts, p. 327 : Walmsley, 110 of 1937], but attention has not been directed to its effective value when the lines are immersed in an absorbing medium." Such lines, however, have been used by the writer and his collaborators for the determination of the electrical constants of an absorbing medium, such as soil and ionised gas, at ultra-high frequencies [2186, 3100, & 3839 of 1938 : *cf.* Smith-Rose & McPetrie, 17 of 1935]. " In the present paper the input impedance of parallel-wire h.f. transmission lines [in dry soil], a quarter-wavelength long, with open as well as short-circuited terminations, has been worked out mathematically and the values thus obtained have been verified experimentally. The results have been compared with those when there is no absorbing medium between the wires." The frequencies were from 31 to 114 Mc/s. " As the frequency is lowered till the attenuation constant goes below 3×10^{-2} the impedance of the lines with closed termination gradually increases and that of the line with open termination decreases." *Cf.* Lamont, 3281, above.

3404. Calculation of Driving-Point Impedance in Electromagnetic Field Problems [with Aplication to Forced, Steady-State Oscillations of Linear Antenna].—J. A. Stratton & L. J. Chu. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1080–1081 : summary only.)

The Rayleigh-Sommerfeld theory gives no clue to the relation between the amplitude of steady-state modes and the applied e.m.f. The writers discuss certain solutions of inhomogeneous field equations corresponding to arbitrary distributions of impressed e.m.f. ; finally the method is applied to an elongated prolate spheroid, the results giving the radiation resistance and reactance as a function of frequency and eccentricity, and the relative amplitudes of the modes excited by a specified e.m.f.

3405. The Radiation Resistance of a Spherical Oscillator excited by an External Electromotive Force.—A. G. Arenberg. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 25, 1939, pp. 593–595 : in French.)

Further development of the work dealt with in 1857 of May. " It is seen, by comparing formulae 4 & 5 with those for an elementary dipole, that the spherical oscillator considered is equivalent to a dipole whose length is $l = \lambda/\pi\sqrt{1 + m^2}$ [where $m = \lambda/2\pi a$]. It is evident that for relatively small dimensions of the oscillator ($a \ll \lambda/2\pi$ and consequently $m \gg 1$) formula 5 reduces to the form $R_\Sigma = 80\pi^2(2a/\lambda)^2$ ohms, which only differs from the ordinary formula for the radiation resistance of an elementary dipole in the replacement of the length l by the sphere diameter $2a$. For fairly large dimensions of the oscillator ($a \gg \lambda/2\pi$ and

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consequently $m \ll 1$) it follows from formula 5 that $R_\Sigma = 80$ ohms, which corresponds to the value of radiation resistance for a half-wave oscillator calculated by the formula for an elementary dipole (Fig. 1)."

The calculation of the radiation resistance is then considered from another viewpoint—that of the power at the terminals of the oscillator. The final formula 10 for the ratio of the external e.m.f. $E_e(\theta)$ to the current $I(\theta)$ which it excites (*i.e.* the radiation resistance referred to a unit of meridional length) is a complex expression, "showing that resonance, corresponding to a complete disappearance of the phase displacement between $E_e(\theta)$ and $I(\theta)$, cannot occur for any values of $m \gg 0$. Examination of formula 15 [*see* previous abstract, *loc. cit.*] shows that the value of $|I_m^2|$ has, nevertheless, a maximum for $m_1 = 0.855$. The maximum of power emitted from the oscillator corresponds, from equation 7, to the value $m_2 = 0.707$ (Fig. 1). The values m_1 and m_2, corresponding to the maxima of current and of power, do not coincide: this is due to the simultaneous change of the radiation resistance of the oscillator and of the current distribution."

3406. THE DESIGN AND CALCULATION OF DIRECTIVE DIPOLE AERIALS: PART II.—G. Barzilai. (*Radio e Televisione*, Jan./March 1940, Vol. 5, No. 4/5, pp. 161–176.)

For Part I *see* 1407 of April. The present part deals with the Fiumicino array for communication with Addis Ababa on a 19.60 m wave. The calculation of the aerial and its feeder (with matching transformer consisting of two parallel copper tubes, a quarter-wavelength long, with spacing adjustable from 4 to 40 cm) was carried out by the methods already described. Measured values on the completed system are also given on p. 169 and compared with those calculated. Some errors in Part I are corrected on p. 170.

3407. ON THE SCREENING EFFECT OF WIRE CAGES.—M. J. Kontorovich. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2195–2210.)

An approximate mathematical method is proposed for designing closed wire-mesh screens. It is assumed that the screen has the shape of a sphere and that it can be replaced, with the addition of certain compensating e.m.fs, by an equivalent sphere having a continuous surface. Equations (1) determining the system are written down and methods are indicated for solving these. A formula (22) is derived for determining the coefficient of screening η. Experimental measurements of η in the case of a screen having the shape of a parallelepiped have shown that the theory, although based on the spherical case, gives a sufficiently accurate answer for other shaped screens. In the appendix a formula (30) is derived for determining η in the case of a double screen system (one screen inside the other). For the writer's previous work *see* 492 of February.

3408. BRITISH STANDARD SPECIFICATION FOR ANTI-INTERFERENCE CHARACTERISTICS AND PERFORMANCE OF RADIO RECEIVING EQUIPMENT FOR AURAL AND VISUAL REPRODUCTION.—British Standards Institution. (*Specification No.* 905–1940, June 1940, 44 pp.)

3409. PORTABLE KINKS: USEFUL CIRCUIT AND ANTENNA IDEAS [for Conditions where Good Transmitting & Receiving Aerials are Unattainable].—H. W. Dreyer. (*QST*, July 1940, Vol. 24, No. 7, pp. 18–21 and 86.)

VALVES AND THERMIONICS

3410. ACCELERATION AND AVERAGE CROSS DRIFT OF ELECTRONS IN A MAGNETIC FIELD [from Momentum Considerations].—C. G. Smith. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1064: summary only.)

3411. THE HIGH-FREQUENCY CONDUCTIVITY OF AN IONISED MEDIUM IN THE PRESENCE OF AN EXTERNAL TRANSVERSE MAGNETIC FIELD.—Singh & Sinha. (*See* 3288.)

3412. INDUCED CURRENTS IN SPLIT CYLINDRICAL ELECTRODES BY MOVING CHARGES, *and* ELECTROSTATIC FIELDS INSIDE SPLIT CIRCULAR CYLINDRICAL ELECTRODES.—A. Okazaki. (*Electrotech. Journ.*, Tokyo, April 1940, Vol. 4, No. 4, pp. 83–87: pp. 87–90.)

(1) The induced currents produced on various kinds of cylindrical electrode by charges with circular motion are expressed by comparatively simple Fourier series, and the effective values of the currents in the fundamental and higher harmonic waves are obtained. "Although the above results may not exist in the strict sense in the case when the speed of the electric charges is very great, there is a close relation with the magnetrons which are very eagerly studied recently and it is hoped that this paper will serve to help to some extent those who are carrying out such studies." *See* also 1807 of May. (2) "In this paper, based on Green's reciprocity theorem, the electrostatic fields inside circular cylindrical electrodes, split into any two parts and also into $2n$ equal parts, are dealt with by means of an indirect method."

3413. THE ELECTRONIC VALVE WITH VELOCITY MODULATION: CORRECTION TO FORMULA 5.—Bethenod. (*Comptes Rendus*, 11th March 1940, Vol. 210, No. 11, p. 423.) *See* 1416 of April. A bracket was misplaced.

3414. A NEW ULTRA-HIGH-FREQUENCY TETRODE AND ITS USE IN A 1-KILOWATT TELEVISION SOUND TRANSMITTER [Two deliver 1 kW of Carrier Output at 108 Mc/s, in RCA Type S-1 Transmitter].—A. K. Wing, Jr., & J. E. Young. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 253: summary only.)

3415. ON SOME THEOREMS OF THE PERTURBATION THEORY, AND PARTICULARLY ON THEIR APPLICATION IN THE THEORY OF NON-STATIONARY PROCESSES IN ELECTRONIC VALVES.—G. A. Grünberg. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 1, Vol. 25, 1939, pp. 22–25: in German.)

"In the perturbation theory two different types of problem are encountered, the first demanding the determination of the disturbed motion for infinitely long times, while in the second only certain finite time-intervals are involved. To the first type, for instance, belong the questions of the stability of the motion; to the second, very many problems in applied physics, of which we shall here consider only the theory of the rapidly changing processes in valves, where the electrons are exposed

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to the action of the field only during their transit time through the system. Here the voltage under whose influence the motion takes place consists of a constant component on which is superposed a varying voltage small in comparison; the case is thus one of the second type, and the initial conditions for the undisturbed and the disturbed motions ('U.M.' and 'D.M.') coincide. For the (generalised) coordinates of the D.M., therefore, we can put $x_i = x_i^0 + u_i$, where x_i^0 represents the U.M. and u_i, if the disturbing force is sufficiently small, remains arbitrarily small during the whole (finite) time of motion.

"We give here some theories which make possible the solution of such questions; although primarily intended for treating problems of the second type, they can, with slight alterations, be applied to those of the first group. These and related problems we intend to investigate more closely elsewhere, where the method will be further explained and illustrated by a large number of examples." In the present note the examples given are a cylindrical and a spherical diode (*see* 1790 of 1936 and 4357 of 1938 & back reference).

3416. A Contribution to the Theory of the Diode Rectifier.—Oplustil. (*See* 3349.)

3417. Current Division in Plane-Electrode Triodes [More Accurate Formula than Those of Lange and Tellegen: Nomograms for Effective Grid Radius and Current-Division Factor: Experimental Confirmation (within 2 or 3%): Grid Currents in Typical Valves can be Reduced (without reducing μ or S) by Change of Electrode Dimensions: etc.].—K. Spangenberg. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 226–236.) A summary was dealt with in 598 of February.

3418. Equivalent Electrostatic Circuits for Vacuum Tubes [Triode represented by Three Capacitances in Star: Method extended to Multi-Grid Valves: Practical Uses].—W. G. Dow. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 247: summary only.)

3419. Note on Paper on "Calculation of Triode Constants" [Position of Equivalent Diode Plane, given by Equation XIII, assumed to be Constant at Any Grid Bias: New Equation showing Variation with V_g].—S. Rodda: Fremlin. (*Phil. Mag.*, June 1940, Vol. 29, No. 197, pp. 601–603.) *See* 3166 of 1939.

3420. Fluctuations in Space-Charge-Limited Currents at Moderately High Frequencies: Part II—Diodes and Negative-Grid Triodes.—D. O. North. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 441–472: to be contd.)

For Part I (Introduction, by Thompson) *see* 1421 of April. "Beginning with the steady-state description of a diode showing a Maxwell-Boltzmann distribution of emission velocities, the theory is founded upon a determination of the new steady state which results from the injection of a small additional emission comprised of electrons of a specified velocity."

3421. Small Fluctuations in the Space-Charge-Limited Electron Current from a Fine Tungsten Wire [in Balanced Space Charge Method of detecting Very Small Positive-Ion Currents: Cause & Elimination of the Fluctuations: Small Traces of Gas increase Work Function].—H. W. Berry & R. N. Varney. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1063–1064: summary only.)

3422. The Mechanism of Electron Space Charge Neutralisation by Positive Ions [Direct Proof of Trapping of Spiralling Positive Ions in Potential Trough formed by Thermal Emission of Electrons].—H. Karr & R. N. Varney. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1064: summary only.)

3423. Characteristics of Thermionic Rectifiers at High Voltage [and the Effect of Screening the Electron Path between Filament & Anode: Experimental Investigation].—K. Miyazaki. (*Electrotech. Journ.*, Tokyo, April 1940, Vol. 4, No. 4, p. 95.)

The current flowing in an insulated rectifier circuit is plotted against the driving voltage, for three different values of the voltage to which (through a separate transformer) the whole circuit is raised. The strong "grid" effect of this voltage, in the type of tube where the electron path is completely open to the container walls, is progressively reduced when this path is more and more screened.

3424. Rectilinear Electron Flow in Beams [according to Well-known Space-Charge Equations, in Beams surrounded by Charge-Free Space, given by Special Electrode Design: Use in Electron Guns].—J. R. Pierce. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1080: summary only.) For previous work *see* 1419 of April.

3425. Investigation of Dynatron Hysteresis at Low Frequencies [extended below 26 c/s: Loops due to "Field-Inhibited" & "Field-Assisted" Secondary Emission from Charged Layers on Plate Surface].—P. L. Copeland & J. M. Kubert. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1065: summary only.)

3426. Temperature Effects on the Secondary Emission from Pure Metals [Coefficient changes abruptly by 1% at Point of Magnetic Transformation (Iron & Cobalt) but not even by 0.3% (Nickel): etc.].—D. E. Wooldridge. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1080: summary only.)

3427. On the Mechanism of Secondary Emission of Electrons from Composite Surfaces.—Timofeev. (*See* 3495.)

3428. On the Production of Low-Voltage Secondary-Electron Multipliers with Copper/Sulphur/Caesium Layers.—Badikova: Kubetski. (*See* 3494.)

3429. Design and Performance of an Electron Diffraction Camera [for Study of Photo- and Secondary-Electron-Emissive Surfaces].—J. E. Ruedy: R.C.A. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1073: summary only.)

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3430. Additional Experimental Evidence of a Periodic Deviation from the "Schottky Line."—W. B. Nottingham. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1080: summary only.) *Cf.* 3035 of August.

3431. Field Emission from Tungsten Single Crystals [Crystallographic Directions of High Emission: the Variation with Work Function: etc.].—J. H. Daniel. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1079–1080.) For the work of Müller and of Nichols *see* 542, 3313, & 4119 of 1937; 1428 of April, & footnote (1): 2266 of June.

3432. Electrolytic "Polishing" of Tungsten.—Peterson, Guarino, & Coomes. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1081: summary only.) Further work on the process dealt with in 3966 of 1939.

3433. Power-Tube Performance as influenced by Harmonic Voltage [Power-Output & Over-All Efficiency increased (for Class C Amplifier) by Introduction of Third-Harmonic Voltage in Correct Phase: etc.].—R. I. Sarbacher. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 252: summary only.)

3434. Water and Forced-Air Cooling of Vacuum Tubes with External Anodes, *and* Large Air-Cooled Tubes in 50-Kilowatt Transmitters.—Mouromtseff, Moran. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 251: p. 251: summaries only.) *See* also Harmon, *ibid.*, p. 248.

3435. Rationalising Broadcast Receivers [Suggestions for a "Total War" Plan: Three Basic Types of Valve: etc.].—J. A. Sargrove. (*Wireless World*, July 1940, Vol. 46, No. 9, pp. 338–342.)

3436. Development and Production of the New Miniature Battery Tubes [Decrease in Size without Increase in Cost: Efficient Operation on 45 Volts].—N. R. Smith & A. H. Schooley. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 496–502.) About 2 inches long and under $\frac{3}{4}$ inch diam. *See* also 1431 of April: for still smaller valves, 2593 of July.

3437. The Heating of Thin Molybdenum Films in a High-Frequency Electric Field [Frequency 30 Mc/s: Effects of Varying Glass Temperature during Deposition: of Contamination of Glass: Effect of Electron Bombardment: etc.]—Wright. (*Proc. Phys. Soc.*, 1st March 1940, Vol. 52, Part 2, pp. 253–265.) From the M.O. Valve Company.

DIRECTIONAL WIRELESS

3438. Panoramic Reception [and Its Advantages for Navigation, etc.].—Wallace. (*See* 3385.)

3439. The RCA "Omnidirectional Radio Range Beacon" for Aircraft [with Ultra-Short-Wave Beam revolving 60 Times per Second and Omnidirectional "Flash" when Beam points North: Direct Visual Indication of Bearing].—D. G. C. Luck. (*Science*, 12th July 1940, Vol. 92, Supp. p. 7; *Sci. News Letter*, 13th July, Vol. 38, No. 2, p. 29.)

3440. Amateur D.F: Design of a Simple Direction-Finder [with Residual "Vertical Effect" balanced out by Differential Condenser].—A. Black. (*Wireless World*, July 1940, Vol. 46, No. 9, pp. 316–319.) For its use, *see* August issue, pp. 357–359.

3441. The Use of a Cathode-Ray Oscillograph in an Inductor Tele-Compass.—L. A. Goncharski. (*Automatics & Telemechanics* [in Russian], No. 6, 1939, pp. 85–96.)

A brief description is given of an inductor-type course-indicating device ("Pioneer," Fig. 1) and the defects of such systems are discussed. This is followed by a description of a system in which the induction principle is utilised to give actual compass readings, which are observed on a cathode-ray indicator (Fig. 2). The theory of the system is described, and it is pointed out that the bearings given are free from errors due to inclination of the aeroplane. Further, if the oscillograph is replaced by an electron commutator (Fig. 6), the system can be used as an automatic course-stabiliser.

3442. The Sound-Absorbing Properties of Some Common Out-Door Materials [Gravel, Turf, Snow, etc.].—G. W. C. Kaye & E. J. Evans. (*Proc. Phys. Soc.*, 1st May 1940, Vol. 52, Part 3, pp. 371–379.) Some of the results are compared with those of Ernsthausen & von Wittern, 1095 of March, and Eisner & Kruger, 1933 Abstracts, p. 629.

ACOUSTICS AND AUDIO-FREQUENCIES

3443. Iron-Cored Coils of High Efficiency [for Lower Audio-Frequencies up to 2000 c/s: Low Losses of Permalloy Cores utilisable only if Air Gap is provided: "Optimum" Gap for Any Given Frequency (Distinct from "Optimum-Gap Effect" in Coils with Superposed A.C. & D.C., which is an Effect on Incremental Permeability): Frequency Characteristic depends on Value of Gap: Ferrocart & Gecalloy as Examples of Same Principle: etc.].—G. F. Partridge. (*Phil. Mag.*, May 1940, Vol. 29, No. 196, pp. 485–494.) For previous work *see* 310 & 1097 of 1937.

3444. Inductor with Air-Gapped Magnetic Circuit [and the Existence of an Optimum Air-Gap in a Telephone Receiver, depending on Distribution of Magnetic Flux].—M. G. Marinesco: Glazier. (*Wireless Engineer*, July 1940, Vol. 17, No. 202, p. 297.) Prompted by the editorial referred to in 2212 of June, and quoting the writer's work (1934 Abstracts, p. 621.)

3445. Electrodynamic Moving-Coil Microphones.—(*Alta Frequenza*, March 1940, Vol. 9, No. 3, pp. 184–186.)

Based on the papers of Wente & Thuras, Marshall & Romanov (1932 Abstracts, pp. 43 & 101: 3829 of 1936), Lauffer (3188 of 1939), and Turnbull & Clark (Marconi-EMI: 4514 of 1939).

3446. Crystal Structure of Rochelle Salt [Approximate Positions for All the Atoms].—C. A. Beevers & W. Hughes. (*Nature*, 20th July 1940, Vol. 146, p. 96.)

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3447. Contour Vibrations of a Rectangular Rochelle-Salt Plate, *and* Thickness Vibrations of a Rochelle-Salt Plate.—Takagi, Miyake, Sakamoto. (*See* 3521.)

3448. Vibrations of Free Square Plates: Part II—Compounded Normal Modes.—M. D. Waller. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 452–455.) For Part I *see* 174 of January.

3449. New Gramophone Pick-Up with Feather-Weight Sapphire "floating" along Groove, controlling Light-Beam by Paper-Thin Aluminised Mirror.—D. Grimes: Philco. (*Sci. News Letter*, 22nd June 1940, Vol. 37, No. 25, pp. 387–388.)

3450. Multiphone Working [Distinction between Multiphone, Conference, & Broadcast Facilities: Scope & Applications of Multiphone: Apparatus].—E. W. Ayers & H. E. Stevens. (*P.O. Elec. Eng. Journ.*, July 1940, Vol. 33, Part 2, pp. 60–62.)

3451. Broadcast Music in Workshops.—(*Engineer*, 12th July 1940, Vol. 170, pp. 31–32.)

3452. A Voice-Operated Relay for Use on Long-Distance Private Wires.—A. Fairweather. (*P.O. Elec. Eng. Journ.*, July 1940, Vol. 33, Part 2, pp. 66–70.)

3453. Electromechanical Analogies.—Bordoni. (*See* 3355.)

3454. McClure Model ACA 16 Amplifier: 3-Stage 15-W Push-Pull Unit for A.C. Mains.—(*Wireless World*, July 1940, Vol. 46, No. 9, p. 329.)

3455. An Alternative Treatment of the Attenuation of Waves in a Coil-Loaded Telephone Line.—Metson. (*See* 3326.)

3456. The Clasiscal Theory of Shock and the Theory of a Propagated Discontinuity.—Thompson (*See* 3328.)

3457. Calculation of Acoustic Waves with Irregular Boundaries, *and* A Method for Solving the Wave Equation in a Region with Perturbed Boundaries.—R. H. Bolt: Feshbach & Clogston. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, pp. 1057: p. 1058.)

(i) Examples are calculated, in good agreement with recent experiments (678 of February). (ii) Application of perturbation methods to the solution of partial differential equations (acoustic or electromagnetic) with particular boundary conditions on a surface slightly deformed from some regular shape for which the exact solutions are known.

3458. Sound-Energy Density in an Enclosure excited by a Directional Source [with Application to Auditorium with Sound-Reinforcing System].—J. M. Suharevsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 1, Vol. 25, 1939, pp. 16–21: in English.)

3459. Room Noise at Telephone Locations: II [Relative Importance of Major Noise Sources].—D. F. Seacord. (*Elec. Engineering*, June 1940, Vol. 59, No. 6, pp. 232–234.) For I *see* 3998 of 1939.

3460. Effect of Paint on the Sound Absorption of Acoustic Materials.—V. L. Chrisler. (*Journ. of Res. of Nat. Bur. of Stds.*, May 1940, Vol. 24, No. 5, pp. 547–553.)

3461. The Sound-Absorbing Properties of Some Common Out-Door Materials [Gravel, Turf, Snow, etc.].—Kaye & Evans. (*See* 3442.)

3462. The Decibel in High-Frequency Technique [with Examples regarding Sensitivity & Amplification of Superheterodyne Receiver, Design of A.F. Amplifier, Microphone Output, Selectivity, Directive Aerials].—C. G. Keel. (*Bull. Assoc. suisse des Élec.*, No. 9, Vol. 31, 1940, pp. 206–209: in German.)

3463. The Question of Sound Radiation Pressure [Discussion of Contradiction between Rayleigh's and Schaefer's Results: Discrepancy due to Different Choice of Integration Constant: New Derivation of Pressure Effects].—G. Richter. (*Zeitschr. f. Physik*, No. 3/4, Vol. 115, 1940, pp. 97–108). *See* 186 of January. On pp. 109–110 Schaefer agrees as to the choice of the integration constant.

3464. The "Vu" and the New Volume Indicator.—S. Brand. (*Bell Lab. Record*, June 1940, Vol. 18, No. 10, pp. 310–314.) *See* also 1472 of April.

3465. Contribution to the Study of the Performance of Electrostatic Wattmeters.—Francini: Perucca. (*See* 3534.)

3466. Beat-Frequency Oscillator [Type T.F. 602].—Marconi-Ekco. (*Journ. of Scient. Instr.*, May 1940, Vol. 17, No. 5, p. 131.)

3467. The Residue, a New Component in Subjective Sound Analysis.—J. F. Schouten. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, pp. 489–490.)

3468. Hearing-Test Machines at the World's Fairs.—F. A. Coles. (*Bell Lab. Record*, June 1940, Vol. 18, No. 10, pp. 290–291.) For an analysis of the results *see* 1055 of March.

3469. The Paradox of Voice Teaching.—W. T. Bartholomew. (*Journ. Acous. Soc. Am.*, April 1940, Vol. 11, No. 4, pp. 446–450.)

3470. Recent Work in Experimental Phonetics [General Account of Vowel Wave-Patterns, Formants, Intonation, etc.].—E. G. Richardson. (*Nature*, 1st June 1940, Vol. 145, pp. 841–843.)

3471. Resonant Frequencies and Damping Constants of Resonators involved in the Production of Sustained Vowels "Oh" and "Ah."—D. Lewis & C. Tuthill. (*Journ. Acous. Soc. Am.*, April 1940, Vol. 11, No. 4, pp. 451–456.)

3472. Observations on Edge Tones [Experiments on Tones heard when Air issuing from Slit strikes Parallel Wire: Same Nature as Edge Tones: Significance of Observations for Edge-Tone Theories].—Lenihan & Richardson. (*Phil. Mag.*, April 1940, Ser. 7, Vol. 29, No. 195, pp. 400–406.)

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3473. Auto-Vibrations of the Harmonica Reeds, and the Production of Sound.—B. Konstantinov. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 9, 1939, pp. 1820–1831.)

3474. The Propagation of Supersonics in Liquids [Method using Hot-Wire Amplitude-Detector for exploring Stationary-Wave System between Radiator & Reflector: No Velocity Dispersion: Attenuation Constants].—E. G. Richardson. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 480–488.)

3475. An Optical Method for the Measurement of Ultrasonic Absorption, *and* Ultrasonic Velocity and Absorption in Liquids.—E. C. Gregg, Jr : G. W. Willard. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1053: p. 1057: summaries only.)

3476. Dispersion of Supersonic Waves in Cylindrical Rods [and the Absence of the "Dead Zone"].—G. S. Field: Shear & Focke. (*Phys. Review*, 15th June 1940, Vol. 57, No. 12, p. 1188.) Prompted by the paper dealt with in 2309 of June.

PHOTOTELEGRAPHY AND TELEVISION

3477. Selective Sideband Transmission in Television [Reproduction of Detail (Unit Function & Narrow-Line Details, etc.) as a Function of Modulation Factor and Ratio of Vestigial Sideband to Transmitted Sideband: Comparison with Double Sideband Transmission: etc.].—R. D. Kell & G. L. Fredendall. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 425–440).

3478. Television Control Equipment for Film Transmission [at W2XVT: Table of Causes of Faulty Reproduction: Promising Results in Flicker Elimination by Receiver "Remembering Characteristic" instead of by Vision Retentivity: Test Pictures of 441- *versus* 625-Line Resolution].—R. L. Campbell. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, p. 108: summary only.)

3479. Lenticulated Film makes Pictures with Depth: can be used in Ordinary Amateur's Camera.—Winnek. (*Sci. News Letter*, 15th June 1940, Vol. 37, No. 24, pp. 378–380.)

3480. A New Method for Television Image Transmission [the DuMont Proposals].—DuMont. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, pp. 91–93.) *See* also 2314 of June and 2654 of July.

3481. Two-Way Television over Single Pair of Wires [Alternation by "Blanking-Out" Amplifiers].—Zworykin. (*Science*, 12th July 1940, Vol. 92, Supp. p. 7.) Paragraph on U.S.A. Pat. No. 2 206 654.

3482. Television over Telephone Lines.—A. G. D. West. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, p. 106.) Summary of an article in *Kinematograph Weekly*.

3483. Some Thoughts on Television Pick-Up Technique [Details of Apparatus & Procedure, and Comparison with Film Studio Technique].—G. Goebel. (*T.F.T.*, March 1940, Vol. 29, No. 3, pp. 77–81: to be concluded.)

The scope of this paper is best indicated by some quotations. Thus after discussing the focusing of an ordinary film camera, the writer continues:—"Similarly with a super-iconoscope, owing to the short focus and the high sensitivity of the tube, direct focusing on the photocathode (as has been tried for earlier pick-up cameras) is prohibited on the grounds mentioned above. The method, commonly employed with films, of focusing by means of a tape measure and the graduated camera scale is difficult to use in television because of the continuity of action. The television camera of the future should therefore be provided with a high-precision optical range-finder coupled to the camera lens" [instead of the usual method of focusing on the ground-glass screen of the coupled view-finder]. "The adjustment of the iris diaphragm must be readable from behind as well as from the same side as the range adjustment," but "its drive by means of a double set of gearing seems to me unnecessary." Unconditionally, however, a modern television camera must be provided with completely satisfactory arrangements for "close-ups" (up to 0.5 m), since it is just by his power of interposing sudden surprising "close-ups" that the television playwright scores over his stage confrère. "Above all, the television camera lacks a gadget to allow the insertion, in front of the lens, of masks, trick lenses, diffraction gratings, and so on, and simultaneously to screen the lens from the direct light from the lamps behind and above the décor." The need is stressed for the development of a hand camera, or at any rate one that can be worked by hand while supported on the operator's chest.

3484. Television Studio Technique [as practised in N.B.C. Studios: Comparison with Motion-Picture Technique, and the Special Difficulties & Differences: the Prime Importance of Coordination & Timing: etc.].—A. W. Protzman. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 399–413.)

3485. Television Lighting [N.B.C. Equipment & Technique].—W. C. Eddy. (*R.C.A. Review*, April 1940, Vol. 4, No. 4, pp. 414–424.) *See* also 2660 of July.

3486. In Search of a Technique for Television [Television Accompaniment to Music (Three-Dimensional Shapes & Pattern Designs, etc.): Pre-Editing Control: Presentation Formulae for Televised News].—L. Lye. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, pp. 95–100.) Including a description of a suitable visual accompaniment to a jazz band.

3487. The Business Side of Television.—Kersta. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, pp. 100–104.) *See* 2655 of July.

3488. Television—the Unknown Quantity.—S. Griffis. (*Radio e Televisione*, Jan./March 1940, Vol. 5, No. 4/5, pp. 200–201: in English.) Paramount Pictures' views: this company has "taken its first exploratory steps through the DuMont Company."

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3489. "Principles of Television Engineering" [Book Review].—D. G. Fink. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 255.)

3490. An Efficient Ultra-High-Frequency Unit for the Amateur Television Transmitter [Crystal-Controlled 112-Mc/s Output for Video or Voice Modulation].—L. C. Waller. (*QST*, July 1940, Vol. 24, No. 7, pp. 32–35 and 96.) For the equipment referred to in 3090/3091 of August (Sherman).

3491. The Implosion of Cathode-Ray Tubes.—Smyth. (*Journ. Television Soc.*, No. 4, Vol. 3, 1940, pp. 93–94.) *See* 1101 of March.

3492. The Influence of the Space Charge on the Focusing of Cathode Rays.—Reusse & Ripper. (*See* 3366.)

3493. Photoconductivity in Zinc Silicates [with & without Manganese Activator].—Hill & Aronin. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1090: summary only.)

3494. On the Production of Low-Voltage Secondary-Electron Multipliers with Copper/Sulphur/Caesium Layers.—T. N. Badikova: Kubetski. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2163–2173.)

In the multi-stage secondary-electron multipliers proposed by Kubetski (2495 of June) [Ag]-Cs_2O-Cs layers deposited on glass were originally used. These layers do not, however, possess sufficient thermal stability, and leakage (inter-electrode conductivity) often takes place in the tubes. Research was therefore carried out on [Cu]-Cs_2S-Cs layers, and a report on this is given in this paper. The preparation of the layers is described in detail and results of experiments are shown in a number of curves and tables. It appears that by the methods described tubes having a sensitivity of 1–5 A/lm at 750 V and 0.1–0.3 A/lm at 500 V can be produced; that is, a considerable reduction in the voltage applied to the tube can be obtained. At the same time the secondary-electron emission from the new layers, and their stability at high temperatures (200–250°C), are higher than is the case with any other known emitter. The effect of leakage is completely eliminated with these layers.

3495. On the Mechanism of Secondary Emission of Electrons from Composite Surfaces [of Caesium-Oxygen Type].—P. V. Timofeyev [Timofeev]. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 1, Vol. 25, 1939, pp. 11–15: in English.)

For previous work *see* 1050 *bis* of 1937 and 2888 of 1938. "Assuming that the large secondary emission from complex emitters is mainly a result of the extraction of electrons from the emitter by positive charges which are formed on its surface during bombardment of it by a beam of primary electrons, we come to the following conclusion.

"The magnitude of the secondary emission from composite surfaces is mainly determined by the time of recombination of positive ions T and by the magnitude K which characterises the average number of electrons which are extracted by unit charge in unit time. It is quite clear that the magnitudes K and T are determined by the electrical conductivity of the intermediate layer. It follows immediately from this that secondary emission from complex emitters depends both on the nature and on the relative quantity of particles of metals and their compounds which enter into the composition of the intermediate layer."

3496. Design and Performance of an Electron Diffraction Camera [for Study of Photo- and Secondary-Electron-Emissive Surfaces].—J. E. Ruedy: R.C.A. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1073: summary only.)

3497. External Photoelectric Effect in Semiconductors [Yields from Cu_2O for Wavelengths near Threshold: Discrepancies with Fowler's Theory (for Metals): Photoelectrons probably come from First Filled Band (Fermi Distribution) of Allowed Energy States: etc.].—R. J. Cashman. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1090: summary only.)

3498. Effect of High-Frequency Oscillation on the Photoelectric Current [Increase of Current from Photocell on Superposition of Very High Frequency Oscillation of a Few Volts].—T. Terada. (*Jap. Journ. of Phys., Trans. & Abstracts*, No. 2, Vol. 13, 1939/1940, p. 90.)

The effect depends on the intensity of illumination and on the frequency of the oscillatory voltage, but is nearly independent of temperature; presumably it is partly, at least, due to disturbance of the negative charge accumulated in front of the cathode. It is suggested that the critical frequency of the electrons in the cell is about 2.14 Mc/s. *Cf.* 3304 *bis* and end of 4201, both of 1938.

3499. Optical and Magnetic Properties of Magnetite Suspensions: Surface Magnetisation in Ferromagnetic Crystals [and Grove's 1845 Magneto-Optic Effect: Ferromagnetic Colloid Patterns on Ferromagnetic Crystal Surfaces].—L. W. McKeehan: Heaps. (*Phys. Review*, 15th June 1940, Vol. 57, No. 12, pp. 1177–1178.) *See* 3101 of August and back references.

3500. A Type of Light Valve for Television Reproduction [Suspension of Disc-Shaped Particles in Insulating Liquid].—J. S. Donal, Jr., & D. B. Langmuir. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 246–247: summary only.)

3501. A System of Large-Screen Television Reception based on Certain Electron Phenomena in Crystals [Principle, Construction, & Applications of the "Skiatron"].—A. H. Rosenthal: Scophony. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 203–212.) A long paper on the device dealt with in 2328 of June.

3502. British Standard Specification for Anti-Interference Characteristics and Performance of Radio Receiving Equipment for Aural and Visual Reproduction.—British Standards Institution. (*Specification No.* 905–1940, June 1940, 44 pp.)

3503. "Television Receiving Equipment" [Book Review].—W. T. Cocking. (*Wireless Engineer*, July 1940, Vol. 17, No. 202, p. 309.)

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3504. Vector-Response Indicator [Cathode-Ray Apparatus giving Magnitude & Phase Angle as Function of Frequency: for Television Amplifiers, etc.]—Loughlin. (*See* 3525.)

3505. An Einthoven String-Galvanometer/Amplifier System for the Investigation of Photovoltaic Effects.—Vanselow & others. (*Review Scient. Instr.*, June 1940, Vol. 11, No. 6, pp. 202–203.)

MEASUREMENTS AND STANDARDS

3506. Theory of Resonance in Micro-Wave Transmission Lines with Discontinuous Dielectric [with Application to Lecher-Wire Methods of measuring Soil Constants, etc.]—Lamont. (*See* 3281.)

3507. Input Impedance of H.F. Parallel-Wire Transmission Lines immersed in an Absorbing Medium.—Banerjee. (*See* 3403.)

3508. Dielectric Research at Ultra-High Frequencies with a New Method [Material inserted in Closed End of Pipe or Coaxial Line: Travelling Detector (with Probe pointing into Pipe through Slot) explores Position & Magnitude of Nodes & Antinodes: Results with 5.9 cm Wave].—S. Roberts & A. von Hippel. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1056: summary only.)

3509. A New Method of Measuring the Power Factor of Water.—Morita. (In paper dealt with in 3401, above.)

3510. The Dielectrometer: an Instrument for measuring Conductances and Dielectric Properties at 100 Megahertz [Concentric-Tube Antiresonant Circuit loaded by Admittance under Measurement: Susceptance-Variation & Frequency-Variation Methods: Some Results on Coils, Resistors, & Dielectrics: etc.].—D. L. Hollway. (*Journ. Inst. Eng. Australia*, March 1940, Vol. 12, No. 3, pp. 79–90.)

3511. Vacuum-Tube Voltmeter for Use in the Reactance-Variation Method [of measuring Dielectric Losses at High Frequencies: Use of One Space-Charge-Grid Tetrode to avoid Difficulties in Matching the Two Usual Valves, and Instability in Balancing due to Irregular Disturbances of Filament Emission].—M. Kanno. (*Electrotech. Journ.*, Tokyo, May 1940, Vol. 4, No. 5, p. 119.)

3512. Report on Wave Form in Dielectric Power-Factor Measurements [with Definitions & Discussion of Form, Deviation, Distortion, & Crest Factors, etc.].—AIEE Committee. (*Elec. Engineering*, June 1940, Vol. 59, No. 6, pp. 255–256.)

3513. A Note on a Method of determining Refractive Index by Microscope [for Solids, Liquids, or Gases].—A. G. Chowdri. (*Sci. & Culture*, Calcutta, May 1940, Vol. 5, No. 11, pp. 719–721.) Applicable also to the determination of the temperature variation of the index.

3514. "Physico-Chemical Methods" [Book Review].—J. Reilly & W. N. Rae. (*Phil. Mag.*, May 1940, Vol. 29, No. 196, pp. 517–518.) "A necessary addition to the library of any well-equipped laboratory."

3515. The Limits of Inherent Frequency Stability [Desirable Basis on which to build Stable Oscillator].—Roberts. (*See* 3380.)

3516. A Method of measuring Frequency Deviation [of a Frequency Modulator].—Crosby. (*See* 3369.)

3517. Variable-Resistance Device and Its Application, especially to the Frequency Modulation of a Quartz-Crystal Oscillator.—Koga. (*See* 3373.)

3518. A New Quartz-Crystal Plate, designated the GT, which produces a Very Constant Frequency over a Wide Temperature Range [Strong Oscillator in Range 60–1000 kc/s: Not More than 1 Part in a Million Change over 100°C Range: for Filters, Unattended Receiving Equipments, etc.].—W. P. Mason. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 220–223.) For previous reference *see* 1819 of May.

3519. Oscilloscope Patterns of Damped Vibrations of Quartz Plates, and *Q* Measurements with Damped-Wave Amplitudes.—H. A. Brown. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 245–246: summary only.)

3520. Quartz Crystals: Part II—Nature of Quartz and Manufacture of Crystals.—Baldwin. (*Gen. Elec. Review*, June 1940, Vol. 43, No. 6, pp. 237–243.) For Part I see 2967 of August.

3521. Contour Vibrations of a Rectangular Rochelle-Salt Plate, *and* Thickness Vibrations of a Rochelle-Salt Plate.—Takagi, Miyake, Sakamoto. (*Electrotech. Journ.*, Tokyo, April 1940, Vol. 4, No. 4, pp. 95–96: May 1940, No. 5, p. 120.) For Koga's theory of thickness vibrations in quartz, applied in the second paper to Rochelle salt, *see* 1933 Abstracts, p. 50.

3522. Crystal Structure of Rochelle Salt [Approximate Positions for All the Atoms].—C. A. Beevers & W. Hughes. (*Nature*, 20th July 1940, Vol. 146, p. 96.)

3523. The Recording of the [Deutschlandsender] Standard Frequency of 1000 c/s at the Geodesic Institute at Potsdam [with Help of Crystal Clock of PTR Type: Apparatus: Daily Results Feb./Aug. 1939].—W. Uhink. (*Zeitschr. f. Instrumentkunde*, April 1940, Vol. 60, No. 4, pp. 107–112.) *Cf.* 3129 of August.

3524. An All-Electric Clock [Defects of Usual Synchronous-Motor Final Stage (for Thousandfold Increase in Period): Replacement by Three Multivibrators (each of a Single Triode-Pentode, with Injection on Suppressor Grid): Improved Regularity of Intervals].—P. Vigoureux & H. E. Stoakes. (*Proc. Phys. Soc.*, 1st May 1940, Vol. 52, Part 3, pp. 353–358.)

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3525. Vector-Response Indicator [Cathode-Ray Apparatus giving Direct Indication of Magnitude & Phase Angle (from Position of Bright Spot on Trace) of a Transmission as Function of Frequency: for Television Amplifiers, Frequency-Modulation Systems, etc.].—B. D. Loughlin. (*Elec. Engineering*, June 1940, Vol. 59, No. 6, Transactions pp. 355–357.)

3526. Panoramic Reception [for Monitoring & Measurement, Adjustment of Television & Frequency-Modulated Transmitters, etc.].—Wallace. (*See* 3385.)

3527. Distortion Meter for Telegraphic Signals [and Relay Testing] by the Stroboscopic Method.—F. Schiweck: Siemens & Halske. (*T.F.T.*, March 1940, Vol. 29, No. 3, pp. 81–84.)

3528. Balancing of D.C. Clicks [in Telephone Receiver: Experimental Investigation].—Sakamoto. (*See* 3362.)

3529. An Electrical Memory System for Rapid Null Measurements [Circuit combining Stability of A.C. and Rapid Time-Response of D.C. Amplifiers].—E. P. Bentley. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1065: summary only.)

3530. A Lock-In Amplifier for Alternating-Current Measurements [with Sharp Frequency Selectivity of Cosens Bridge Detector but with Added Advantages].—Michels & Curtis. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1065: summary only.) *See* Cosens, 511 of 1935.

3531. Square-Wave Analysis of Linear Pulse Amplifiers.—R. D. Huntoon. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1068: summary only.) *Cf.* Arguimbau, 3071 of August.

3532. A High-Frequency Square-Wave Generator [giving, *e.g.*, a One-Megacycle Wave of 35 Volts Amplitude and 2% Ripple].—W. E. Parkins & L. P. Smith. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1081: summary only.) Primarily for the separation of isotopes.

3533. Some Recent Developments in Impulse-Voltage Testing.—C. M. Foust & N. Rohats. (*Elec. Engineering*, May 1940, Vol. 59, No. 5, Transactions pp. 257–262: Discussion pp. 262–265.)

3534. Contribution to the Study of the Performance of Electrostatic Wattmeters [using the Perucca Two-Plates-&-Vane Electrometer].—G. Francini: Perucca. (*Alta Frequenza*, March 1940, Vol. 9, No. 3, pp. 162–169.)

See Perucca, 2929 of 1938, and footnote 1 on p. 163. The present writer examines the possibility of using this instrument as a wattmeter. Eqn. 4 shows that the sensitivity of the arrangement shown in Fig. 2 is very high when the apparatus under test has an impedance with a large active component. At low voltages (as in measurements on loud speakers) eqn. 5 shows that the consumption would be undesirably high. The apparatus is independent of frequency between fairly wide limits given by eqn. 6. In the range of acoustic frequencies, both theoretical and experimental results show that powers from 10 to some 50 mw can be measured within 1% at frequencies up to about 40 kc/s.

3535. Two New Electrical Measuring Instruments: a Compensator and a Voltage-Divider.—H. von Steinwehr. (*Zeitsch. f. Instrum:kunde*, April 1940, Vol. 60, No. 4, pp. 116–123.)

The compensator, for the measurement of small voltages, has a low resistance (as is necessary when the voltage source has a low internal resistance—*e.g.* thermojunctions) which is the same in all its three ranges (0.1, 0.01, and 0.001 v maximum); the current taken from the supply battery remains constant when the range is changed, so that there is no waiting for it to take up a new steady value. The potentiometer is based on the same principle,

SUBSIDIARY APPARATUS AND MATERIALS

3536. Ultra-High-Frequency Oscillography [Inversion Spectrograph: Ultradynamic Lissajous' Figures, Production & Analysis: Micro-Wave Oscillograph, with von Ardenne Electron Probe].—Hollmann. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. 213–219.) *See* also 2480 of 1939, 544 of February and 1977 of May. For Piggott's work, referred to, *see* 3488 of 1936.

3537. Vector-Response Indicator [Cathode-Ray Apparatus giving Direct Indication of Magnitude & Phase Angle].—Loughlin. (*See* 3525.)

3538. Vectographs: Images in Terms of Vectorial Inequality, and Their Application.—Polaroid Corporation. (*See* 3653.)

3539. Cathode-Ray Oscillographs: a Battery-Operated Unit [L.F. Oscillator Valve, Amplifier Triode, Transformer, & Half-Wave Diode, to give 1000 V or more with Conversion Efficiency around 40%: Negligible Ripple, Stable Spot].—Burgess. (*Wireless Engineer*, July 1940, Vol. 17, No. 202, pp. 296–297.)

3540. A Direct Visualiser for Two [Non-Recurrent] Transient Phenomena [using Persistent Cathode-Ray Screen and Alternate Action of Two Amplifiers (Period 0.5×10^{-4} Second: by Rectangular Wave Voltage from Multivibrator) supplying Single-Element C-R Tube].—Kurokawa & Tanaka. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, pp. 51–55.)

3541. Multiple Cathode-Ray Oscillograph for the Simultaneous Examination of Several Phenomena [Type 3 FVS 3/18 Tube with Three Independent Ray Systems, and Its Ancillary Equipment].—Tronconi & Gianfranceschi. (*Radio e Televisione*, Jan./March 1940, Vol. 5, No. 4/5, pp. 193–199.) Under Safar-Castellani patents.

3542. Wide-Range Oscilloscope [10 c/s to over 5 Mc/s: with Provision for Measurement of Signal Voltages: Rotatable Coordinate System for Phase Measurement: etc.].—General Electric. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, pp. ii, iv, & vi.)

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3543. The Use of a Cathode-Ray Oscillograph [or an "Electron Commutator"] in an Inductor Tele-Compass.—Goncharski. (*See* 3441.)

3544. "Cathode-Ray Oscillographs" [Book Review].—Reyner. (*Wireless Engineer*, July 1940, Vol. 17, No. 202, p. 309.)

3545. A New Electron Microscope [RCA Magnetic Type], *and* Stable Power Supplies for the Electron Microscope.—Marton, Banca, & Bender : Vance. (*Proc. Inst. Rad. Eng.*, May 1940, Vol. 28, No. 5, p. 250 : p. 253 : summaries only.) Resolving power "considerably better than 100 AU in preliminary tests."

3546. A New Electron Microscope [Magnetic Type, with New Features (Specimen Very Close to Objective Lens, Cooling for Specimen, etc.)].—Marton : R.C.A. (*Phys. Review*, 1st July 1940, Vol. 58, No. 1, pp. 57–60.) Using some of the principles dealt with in 328 of 1937.

3547. Types of Electron Microscopes [and Their Resolving Powers] : *also* Theoretical Foundations of Electron Optics : *and* Supermicroscopy [with Many Photographs].—Dorgelo : Kronig : Ruska. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 497.)

3548. Rectilinear Electron Flow in Beams [given by Special Electrode Design in Electron Guns].—Pierce. (*See* 3424.)

3549. The Influence of the Space Charge on the Focusing of Cathode Rays.—Reusse & Ripper. (*See* 3366.)

3550. The Resolving Power of the Magnetic Electron Lens used as a Beta-Ray Spectrometer [Calculation & Experiment : Conclusions].—Cosslett. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 511–517.)

3551. An Electron Diffraction Camera for the Study of Emissive Surfaces."—Ruedy : R.C.A. (*See* 3429.)

3552. A New Method of Microscopy in Ultra-Violet Rays [including a Method using a Fluorescent Screen, in Eyepiece, having Colours of Fluorescence strictly connected with Wavelength of the Incident Ultra-Violet Rays].—Brumberg. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 6, Vol. 25, 1939, pp. 473–476 : in English.)

3553. Depth of Focus of Microscope Objectives [Present Formulae give Values considerably Higher than Those found Experimentally].—Beadle. (*Nature*, 29th June 1940, Vol. 145, pp. 1018–1019.)

3554. A Non-Cartesian Treatment of Mirror, Refracting Surface, and Lens [based on Sign Convention involving Convergence & Divergence of Beams].—Irons. (*Proc. Phys. Soc.*, 1st May 1940, Vol. 52, Part 3, pp. 281–311.)

3555. The Use of Calculating Machines in Ray Tracing [in Optics : with Discussion], *and* Note on Optical Instruments of Symmetrical Construction.—Comrie : Smith. (*Proc. Phys. Soc.*, 1st March 1940, Vol. 52, Part 2, pp. 246–252 : pp. 266–268.)

3556. Decay of Luminescence in Certain Classes of Luminescent Substances, Al_2O_3Cr, CdI_2MnCl_2, Zn_2SiO_4Mn [Investigation by Special Phosphoroscope : Short-Time (Exponential) and Prolonged (Hyperbolic) Processes in Willemite : Effect of Temperature : etc.].—Aliavdin, Fedorov, & Levshin. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 2, Vol. 25, pp. 106–110 : in English.)

3557. Magnetism of Phosphors [Increase of Diamagnetism during Luminescence : Experiments on CaS-Bi Phosphor : Decay Process can be followed from Susceptibility Observations : Increase explicable as due to Larger Electron Orbits (supporting Lenard's Theory of Mechanism of Phosphorescence)].—Sibaiya & Venkataramiah. (*Current Science*, Bangalore, May 1940, Vol. 9, No. 5, 224–225.)

3558. Preparation of Fluorescent Calcite [excited by Ultra-Violet Light].—Fonda. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 466.)

3559. Longitudinal Vibrations of Ionic Crystals, *and* Electric Breakdown of Alkali Halides.—Lyddane, Teller, & others. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1084 : summaries only.) Further development of the work dealt with in 349 of January.

3560. A Cyclotron Ion Source with Retractable Filament [Filament changed without Loss of Vacuum].—Curtis. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1070 : summary only.)

3561. Soldered Metal to Glass or Porcelain Seals [Improved Results with Silver as Initial Coating].—Martin. (*Review Scient. Instr.*, June 1940, Vol. 11, No. 6, pp. 205–206.)

3562. Influence of a Longitudinal Magnetic Field on a Low-Pressure Arc [Experimental].—Cummings & Tonks. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1064 : summary only.) The theoretical treatment was referred to in 316 of January.

3563. The Force on the Cathode of an Arc [and Its Explanation as Reaction of High-Velocity Vapour Stream].—Risch. (*Phys. Review*, 15th June 1940, Vol. 57, No. 12, pp. 1181–1182.)

3564. Researches on the High-Frequency Discharge with External Electrodes.—Zouckermann. (*Ann. de Physique*, Jan./Feb. 1940, Ser. 11, Vol. 13, pp. 78–150.)

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3565. The Influence of Anode Material on a Stepped Discharge [High-Current Glow Discharge having Similar Characteristics to Low-Current Type].—Nomoto. (*Electrotech. Journ.*, Tokyo, May 1940, Vol. 4, No. 5, pp. 116–119.) *See* 794 of February for previous work.

3566. On Some Consequences of Our Simple Relation about Glow Discharge [the Empirically Obtained Relation $V - nu - V_0 = Bk^2$].—Kasiwagi. (*Jap. Journ. of Phys., Trans. & Abstracts*, No. 2, Vol. 13, 1939/1940, p. 85.)

3567. Reaction by Metastable Atoms and Lowering of Breakdown Voltage in the Noble Gases [Theory: Extension of Townsend's Theory].—Rogowski. (*Zeitschr. f. Physik*, No. 5/6, Vol. 115, 1940, pp. 257–295.)

3568. The Variation of Sparking Potential with Initial Photoelectric Current [in connection with New Theory of Spark Discharge].—Meek. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 547–558.) *See* 2524 of July.

3569. Characteristics of Thermionic Rectifiers at High Voltage [and the Effect of Screening the Electron Path].—Miyazaki. (*See* 3423.)

3570. A Contribution to the Theory of the Diode [and Dry-Plate] Rectifier.—Oplustil. (*See* 3349.)

3571. Magnesium/Copper-Sulphide Rectifier Battery Charger [*versus* Copper-Oxide Type, for Heavy Duties].—Rah: Kotterman. (*Elec. Engineering*, May 1940, Vol. 59, No. 5, p. 208.) Continuation of the argument referred to in 1614 of April.

3572. A Study of Copper-Oxide Rectifiers at Audio- and Super-Audio Frequencies.—Renne, Bogdanov, & Meskin. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2149–2155.)

Report on an experimental investigation of copper-oxide rectifiers, using discs of 2.8–7 mm diam. operating at frequencies from 1 to 60 kc/s. The main conclusions reached are: (1) The backward resistance decreases with frequency, the sharpest decrease taking place at approximately 10 kc/s; (2) when a sufficiently high negative bias is applied, the forward resistance approximates to the value obtained with d.c; (3) the average specific capacity of the discs is approximately 0.01–0.02 $\mu F/cm^2$; (4) the capacity decreases with frequency, and also when the negative bias is increased; and (5) the capacity is reduced, but the resistance increased, if the discs are cooled slowly after heat treatment.

3573. The Temperature Coefficients of Selenium Rectifiers.—Vitenberg. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2156–2162.)

Five selenium rectifiers of Russian manufacture (45 mm diam.) were tested at temperatures from + 8° to + 50°C, and two German rectifiers (SAF, 112 mm diam.) at temperatures from + 20° to + 50°C. On the basis of the results obtained. formulae (1) (3) and (5) are derived for determining respectively the temperature coefficients α_n (forward resistance), α_0 (backward resistance) and α_u (forward resistance with a constant d.c. bias). Formulae (2), (4) and (6) are also derived for determining the coefficients β_n, β_0 and β_u, which depend on the type of rectifier and load, and which are used in formulae (1), (3) and (5). All these formulae are similar to those derived by the author for copper-oxide rectifiers (2440 of June). Curves showing the variation of the beta coefficients with load are plotted, and in Figs. 5 & 7 a comparison is made between the curves β_n & β_0 for selenium rectifiers (lower curves) and the corresponding curves for copper-oxide rectifiers.

3574. An Investigation of the Wetting of Thin Layers of Metals obtained by Evaporation *in Vacuo*.—Ignatov. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2185–2194.) Experiments on iron, nickel, aluminium, zinc, silver, & gold, oxidised and non-oxidised; the effect of the thickness of the layer on the spreading of a drop of water was investigated.

3575. The Heating of Thin Molybdenum Films in a High-Frequency Electric Field [Frequency 30 Mc/s].—Wright. (*See* 3437.)

3576. Oxidation of Metals and the Formation of Protective Films.—Mott. (*Nature*, 29th June 1940, Vol. 145, pp. 996–1000.)

3577. The Nature of Anodically Deposited Oxide Layers on Aluminium Alloys [" Eloxal " Process].—Röhrig. (*Zeitschr. V.D.I.*, 30th March 1940, Vol. 84, No. 13, pp. 223–225.)

3578. Residual Active Layer in Electrolytic Condensers [persists Indefinitely: responsible for the Large Capacitances obtained: etc.], *and* Effect of Al_2O_3 Film upon Formation of Active Layer in Electrolytic Condensers.—Miyata. (*Sci. Abstracts*, Sec. A, 25th June 1940, Vol. 43, No. 510, p. 493: pp. 493–494.)

3579. Dielectric Constant of Moist Air [and the Variation of the Capacitance of an Air Condenser with Moisture Content: Equations, Curve, & Table].—Koga. (*Electrotech. Journ.*, Tokyo, May 1940, Vol. 4, No. 5, pp. 108–110.)

3580. A Subdivided Air Condenser embodying Split-Insulation Principle [Max. Capacity 24 000 cms].—Yarnold. (*Proc. Phys. Soc.*, 1st March 1940, Vol. 52, Part 2, pp. 197–198.) In a paper on the electrification of mercury indexes in their passage through tubes.

3581. Glass Fibre Electrical Insulation [Some Criticisms].—Wyman: Quarendon. (*Engineer*, 19th July 1940, Vol. 170, p. 44.) Also *ibid.*, 2nd August, p. 77.

3582. Glass Fibre as a Wire Covering [Details of " Lewcoglass "].—(*Electrician*, 12th July 1940, Vol. 125, p. 19.) *Cf.* 755, 3761, & 4149 of 1939; 811 of February, 2027 of May, & 2427 of June.

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3583. The Electrical Breakdown Strength of Glasses *versus* Crystals, as a Function of Temperature [Results supporting Explanation of Increase of Breakdown Strength with Temperature, in Alkali Halide Crystals].—von Hippel & Maurer. (*Phys. Review*, 1st June 1940, Vol. 57, No. 11, p. 1056: summary only.)

3584. Fluid Filling-Media for Electrical Apparatus [with Discussion].—Meyer. (*Journ. I.E.E.*, April 1940, Vol. 86, No. 520, pp. 313–326.) For previous references *see* 1207 of March.

3585. Insulation [Address to I.E.E. Section].—Warren. (*B.T-H. Activities*, May/June 1940, Vol. 16, No. 3, pp. 81–92: to be contd.)

3586. The Dielectrometer, and Other Papers on the Measurement of Properties of Insulators.—Hollway: Kanno: AIEE: Chowdri. (*See* 3510/3513.)

3587. Some Recent Developments in Impulse-Voltage Testing.—Foust & Rohats. (*See* 3533.)

3588. Generation of Rectangular Impulse Voltage [Extremely Good Shape obtained, at Much Higher Voltages than possible by Previous Methods, by Chopping the Wave Tail of Spark-Gap Surge Generator: Clear Photographed C-R Oscillograms obtainable without Blurring around Zero Point].—Gosho. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, p. 72.)

3589. Square-Wave Generators.—Cossors: General Radio. (*See* 3115 & 3116 of August.)

3590. On the Recording of Current Pulses by Slow Galvanometers [Importance of Lag Effect, *e.g.* in Microphotometric Traces: Practical Equations for Elimination of Errors].—Rogers. (*Review Scient. Instr.*, June 1940, Vol. 11, No. 6, pp. 198–199.)

3591. A Sensitive Method for the Determination of Moisture, applied to Electrical Insulating Materials [down to Values around 0.01%: Equilibrium Vapour-Pressure Method].—Vincent & Simons. (*Proc. Phys. Soc.*, 1st July 1940, Vol. 52, Part 4, pp. 489–500.) From Callender's Cable & Construction Company.

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3598. On the Screening Effect of Wire Cages.—Kontorovich. (*See* 3407.)

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3602. Iron-Cored Coils of High Efficiency [for Lower Audio-Frequencies up to 2000 c/s].—Partridge. (*See* 3443.)

3603. Inductor with Air-Gapped Magnetic Circuit [and Existence of Optimum Air-Gap in Telephone Receiver].—Marinesco: Glazier. (*See* 3444.)

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STATIONS, DESIGN AND OPERATION

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Thus "astronomical observations can be made at different times and recorded on the same surface so that by rapid rotation of the analyser small changes can be observed."

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3701. The Industrial Utilisation of the Electrochemical Condenser.—André. (*See* 3181 of August.)

3702. Impulse Rate Indicator [for Electrical Pulses or Mechanical Movements up to 10 000 c/s].—Southern Instruments. (*Journ. of Scient. Instr.*, May 1940, Vol. 17, No. 5, pp. 131–132.) Using trigger-circuit control of a resistance/capacity circuit.

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3706. ON THE ACTION OF THE ULTRA-HIGH-FREQUENCY ELECTRIC FIELD ON HYDROPHOBIC SOLS [and the Question of a Specific Action: Results with a 5 m Wave].—Eristawi & Barnabischwili. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 25, 1939, pp. 610–613: in German.)

"For a clearing-up of the quantitative side of the thermal and specific action of ultra-short waves, and also for the investigation of the degree of absorption of electromagnetic waves by the object traversed, one must be in possession of a practically convenient method of measuring the electrical parameters. Although a large number of researches have been devoted to the measurement of dielectric constants and conductivity for u.s. waves [references 12–17, which include the Lecher-wire methods dealt with in 283 & 832 of 1935], it must be remarked that not one of the existing methods can be considered completely satisfactory owing to technical difficulties. In this field the correct path has only recently been indicated [two references, 18 & 19, are given; these are to papers by Tatarinov and Dimitriev, both in the Russian *Journal of Experimental & Theoretical Physics*, for 1935 & 1938 respectively].

"In the present paper we consider the specific action of the u.h.f. field on the sols of zinc-potassium and manganese-potassium ferrocyanides. . . . The experiments were carried out as follows. Some samples of the sols of equal concentration were made and then heated to boiling point. After cooling, we brought two of the samples into the u.h.f. condenser field and irradiated them for about 4 hours. In this field the temperature of the sols rose from 14° to 19°. After the irradiation, cataphoretic measurements and potentiometric titrations were made, and the results compared with those of the control samples." Definite changes in the cataphoretic velocity and in the ζ-potential [p.d. between the sol particles and the continuous phase] were found to have been produced by the irradiation—decreases in the case of weak concentrations of the sols, and increases in the case of high concentrations. "The alteration of the ζ-potential and the displacement of the 'equivalence point' of the irradiated sol cannot be attributed to the thermal effect of the u.s. waves, since the increase of temperature thereby is unimportant. We are of the opinion that in the u.h.f. field the diffuse layer of the sol micelles alters its thickness, and this produces the formation of colloidal particles of various composition."

3707. ON THE QUESTION OF SPECIFIC ACTION OF ULTRA-SHORT WAVES [No Effect on Surface Tension (measured by Bubble-Pressure Method) in Condenser Field of a Strong 8.5 m Transmitter].—Theis. (*Physik. Berichte*, No. 7, Vol. 21, 1940, pp. 711–712.)

3708. UNIQUE OSCILLOGRAPHIC DEMONSTRATIONS [Mirror-Galvanometer/Phosphorescent-Screen Oscillograph for Biophysical & Other Phenomena].—Hoecker & Asher. (*Sci. Abstracts*, Sec. A, 25th May 1940, Vol. 43, No. 509, p. 426.) *See* also 3048 of 1938.

3709. RESEARCHES ON CERTAIN BIOLOGICAL EFFECTS OF A MAGNETIC FIELD.—Lenzi. (*La Ricerca Scient.*, March 1940, Year 11, No. 3, pp. 166–174.)

3710. RELAXATION OSCILLATIONS [General Study of Methods in relation to Mechanical, Electrical, & Biological Phenomena]. — Herrender-Harker. (*Am. Journ. of Physics* [formerly *Am. Physics Teacher*], Feb. 1940, Vol. 8, pp. 1–22.)

3711. ELECTRICITY ELICITED BY AN ORGANIC CHEMICAL PROCESS [Berzelius's Description of Discharge of Electric Organs, and Recent Researches on *Raja*, *Torpedo*, & *Gymnotus*].—Nachmansohn. (*Science*, 26th April 1940, Vol. 91, pp. 405–406.)

3712. ACCIDENTS DUE TO ELECTRICITY, IN SWITZERLAND, 1939.—Sibler. (*Bull. Assoc. suisse des Élec.*, No. 11, Vol. 31, 1940, pp. 249–254: in French.)

3713. ON THE THEORY OF LIESEGANG'S RINGS [as Result of Formation of Standing Electromagnetic Waves (between Micro-Waves & Infra-Red): Reflection from Border of Diffusion Field (*cf.* Wireless Waves & Heaviside Layer): etc.].—Shemiakin & Mikhalev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 3, Vol. 25, 1939, pp. 201–203: in English.)

3714. THE EFFECT OF ELECTRIC CURRENT ON THE GROWTH OF FUNGI [in connection with Protection of Wood: Good Effect with D.C., Less with A.C., Least of All with H.F. (1000 c/s)].—Hattori & Tamura. (*Electrotech. Journ.*, Tokyo, March 1940, Vol. 4, No. 3, pp. 58–63.)

3715. A NEW METHOD OF RENDERING A POISONOUS SNAKE HARMLESS [by Destruction of Portion of Poison Duct by 1 Mc/s Currents].—Jaros. (*Nature*, 29th June 1940, Vol. 145, p. 1025.)

3716. LOAD-RATING THEORY FOR MULTI-CHANNEL AMPLIFIERS [for Carrier Telephony].—Holbrook & Dixon. (*See* 3352.)

3717. CARRIER FREQUENCY SYNCHRONISATION [now becoming Necessary: Theory of Methods, Difficulties, Design Considerations].—Tucker. (*P.O. Elec. Eng. Journ.*, July 1940, Vol. 33, Part 2, pp. 75–81.)

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Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

521 408.—Construction of the horn and connecting tube or throat of an out-of-doors public-address speaker, to prevent damage by rain.

Standard Telephones and Cables and J. C. Curry. Application date 15th November, 1938.

521 476.—Construction of microphone intended to be operated by direct contact, *e.g.*, by the throat muscles of the person using it.

J. E. Pollak (communicated by Associated Electric Laboratories Inc.). Application date 21st November, 1938.

521 808.—Construction of loud speaker, particularly designed to facilitate centering the speech-coil relative to the magnetic system.

Philco Radio and Television Corporation (assignees of R. S. Fisher). Convention date (U.S.A.) 15th December, 1937.

521 810.—Construction and arrangement of the speech coil and former of a loud speaker of the electro-dynamic type.

Philco Radio and Television Corporation. Convention date (U.S.A.) 14th December, 1937.

AERIALS AND AERIAL SYSTEMS

520 782.—Aerial coupling arrangement for eliminating local interference.

Belling and Lee and F. R. W. Strafford. Application date, 27th October, 1938.

520 849.—Aerial system comprising a number of dipoles responsive to different frequencies which are harmonically related, for multi-band transmission or reception.

J. G. Maitland-Edwards. Application date 1st November, 1938.

521 711.—Method of mounting a television aerial half inside and half outside the roof of a house.

Kolster-Brandes and W. A. Beatty. Application date 22nd November, 1938.

522 492.—Frame aerial fitted with a core of powdered magnetic material to increase its "Q" factor and "pick-up" sensitivity.

Standard Telephones and Cables (communicated by W. J. Polydoroff). Application date 13th December, 1938.

DIRECTIONAL WIRELESS

520 609.—Direction finder which gives both visual and audible "bearing indications" by using two local reversing switches, one operated in equal periods, and the other in unequal periods.

A. Carpmael (communicated by the Telefunken Co.). Application date 15th November, 1938.

520 821.—Navigational beacon in which overlapping beams are radiated from open or closed aerials.

Soc. Industrielle des Products Loth. Convention date (Germany) 30th May, 1938.

522 129.—Automatic direction finder in which the signals received from a heart-shaped field are used to orientate either the frame aerial or the search-coil of an associated radiogoniometer.

Standard Telephones and Cables and E. W. Braendle. Application date 6th December, 1938.

522 345.—Arrangement and energisation of the radiating cables in leader-gear equipment for the blind landing of aircraft.

E. N. Dingley, Jr. Convention dates (U.S.A.) 21st February and 21st March, 1938.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

520 915.—Means for automatically controlling the output volume of a wireless set by the action of extraneous noise, e.g. the level of conversation in a cinema.

Kolster-Brandes and C. N. Smyth. Application date 4th Novemver, 1938.

521 183.—Spring-controlled arrangement for ensuring the correct positioning of the movable parts of a press-button tuning system.

Philips' Lamps. Convention date (Netherlands) 8th June, 1938.

521 209.—Push-button tuning system in which a manual control allows the selector buttons to have different predetermined tuning values on different wave-bands.

Kolster-Brandes and W. A. Beatty. Application date 11th November, 1938.

521 255.—Mechanical push-button system in which it is possible to select any desired frequency within the tuning range of the set.

Ferranti and A. W. Edwards. Application date 10th November, 1938.

521 262.—Means for removing undesirable frequency variations from an amplitude-modulated signal.

Ideal Werke Akt. Convention date (Germany) 10th November, 1937.

521 278.—Flexible-band and spring control for increasing the accuracy of a press-button tuning system of the mechanical type.

E. K. Cole and A. Shackell. Application date 11th November, 1938.

521 330.—Wave-band interlocking arrangement designed to facilitate tuning on the short-wave bands.

Philips' Lamps. Convention date (Netherlands) 11th May, 1938.

521 423.—Electrode arrangement for separating the two electron discharge paths in the "mixer" valve of a superhet set.

Marconi's W.T. Co. (assignees of E. W. Herold). Convention date (U.S.A.) 18th November, 1937.

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521 490.—Noise limiting arrangement for a wireless receiver which discriminates against any disturbance above a predetermined level.

A. A. Thornton (communicated by Philco Radio and Television Corporation). Application date 26th August, 1938.

521 710.—Remote control for varying the tuning and wave-band setting of a wireless receiver.

Kolster-Brandes and J. Arnold. Application date 22nd November, 1938.

521 721.—Receiving circuit for signals with a suppressed carrier-wave and means for generating locally and restoring the missing carrier-frequency.

Wired Radio Inc. Convention date (U.S.A.) 21st December, 1937.

521 762.—Electrode arrangement and method of operating a valve of the so-called "beam" or deflection type, particularly for frequency-changing in a superhet receiver.

The M-O Valve Co.; R. J. Ballantine; and E. G. James. Application date 25th November, 1938.

521 812.—Push-button tuning system in which the operative condition of each button is shown by the illumination of an associated opening or "window."

Philco Radio and Television Inc. (assignees of L. J. Woods). Convention date (U.S.A.) 13th December, 1937.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

520 824.—Circuit for generating linear saw-toothed oscillations for use in television scanning.

A. C. Cossor; L. H. Bedford; L. Jofeh and W. H. Stevens. Application date 10th May, 1938.

521 028.—Using a resistance of variable permeability to separate the line and frame synchronising impulses used in television.

W. Jones and Pye. Application date 10th November, 1938.

521 140.—Method of transmitting images, and particularly for reproducing them in natural colours.

P. Kremer. Application date 11th August, 1938.

521 154.—Method of scanning a continuously-moving film for television.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 24th December, 1937.

521 367.—Circuit for separating the frame and line synchronising impulses in a television receiver.

W. Jones and Pye. Application dates 16th November, 1938, *and 2nd January,* 1939.

521 409.—Means for ensuring linearity in the operation of a time-base cricuit controlling the magnetic deflecting system of a cathode-ray television receiver.

Kolster-Brandes and W. F. Tedham. Application date 15th November, 1938.

521 477.—System of television scanning in which the picture points are exposed to a photo-sensitive cell in progressive zones which are then progressively concealed.

I. L. Maguire. Convention date (Australia) 3rd December, 1937.

521 522.—Scanning system which allows a close-up or enlarged view of any part of a television picture to be shown (addition to 520 235).

Kolster-Brandes and C. N. Smyth. Application date 22nd November, 1938.

521 637.—Scanning system for a cathode-ray tube in which a varying bias is superposed on the deflecting voltage to increase the angle of swing (addition to 423 427).

Radio-Akt. D. S. Loewe. Convention date (Germany) 26th April, 1937.

521 638.—Scanning system for a cathode-ray tube in which an auxiliary voltage is used to improve the marginal sharpness of the reproduced picture. (addition to 423 427).

Radio-Akt. D. S. Loewe. Convention date (Germany) 20th *October,* 1937.

521 814.—Discriminator circuit for separating the frame from the line scanning impulses in television.

Kolster-Brandes and W. A. Beatty. Application date 25th November, 1938.

521 873.—Television system in which automatic gain-control voltages are derived from a multi-stage "brightness analyser."

Kolster-Brandes and W. A. Beatty. Application date 29th November, 1938.

521 984.—Television receiver in which the frame time-base is actuated, not by the frame impulse, but by an interruption thereof.

The General Electric Co. and G. W. Edwards. Application date 30th November, 1938.

521 992.—Construction of the mosaic-cell photo-electric screen used in a cathode-ray tube for developing television signals.

Marconi's W.T. Co. (assignees of R. B. Janes). Convention date (U.S.A.) 30th November, 1937.

522 139.—Construction and manufacture of the mosaic-cell electrodes used to produce television signals.

Baird Television and K. A. R. Samson. Application date 7th December, 1938.

522 165.—Time-base circuit for a television receiver in which means are provided to render the discharge tube more sensitive to the triggering effect of the synchronising impulses.

Kolster-Brandes; C. N. Smyth; and D. S. B. Shannon. Application date 2nd December, 1938.

522 195.—Cathode-ray television tube with means for accelerating the electron stream after it has passed through the deflecting plates.

Radio-Akt. D. S. Loewe. Convention date (Germany) 24th July, 1937.

522 245.—Method of producing a photo-electric mosaic screen and net-electrode as used for developing television signals (addition to 499 744).

Radio-Akt. D. S. Loewe. Convention date (Germany) 8th February, 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

521 139.—Carrier-wave signalling system utilising the so-called "pulse" method of modulation.

Standard Telephones and Cables (communicated by E. M. Deloraine and A. H. Reeves. Application date 1st November, 1938.

521 340.—Multi-channel carrier-wave signalling systems, particularly suitable for use with coaxial transmission-lines.

Telephone Manufacturing Co. and L. A. Paddle. Application date 15th August, 1938.

521 347.—Electron-multiplier adapted for high- and low-frequency amplification, and as a modulator.

Farnsworth Television Inc. Convention date (U.S.A.) 29th November, 1937.

521 559.—The use in a carrier-wave transmission system of two or more pilot currents for indicating line-conditions and for controlling gain.

Standard Telephones and Cables and B. B. Jacobsen. Application date 18th November, 1938.

521 719.—Circuit comprising saturated and unsaturated choke-coils arranged to have a negative-resistance characteristic and used for generating electric oscillations.

Westinghouse Brake and Signal Co.; S. A. Stevens; and A. H. B. Walker. Application date 23rd November, 1938.

521 720.—Multiplex signalling system utilising the single side-bands of a number of modulated carrier-waves, spaced apart by less than the width of one side-band.

Wired Radio Inc. Convention date (U.S.A.) 21st December, 1937.

522 132.—Modulating and demodulating arrangement for use with carrier-wave signalling systems.

Automatic Telephone and Electric Co. and T. B. D. Terroni. Application date 6th December, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

520 751.—Means for "gettering," and activating the light-sensitive cathodes of electron discharge tubes.

Marconi's W.T. Co. (assignees of E. A. Lederer). Convention date (U.S.A.) 30th October, 1937.

520 973.—Construction and disposition of the target and control electrodes in an electron-multiplier tube.

Marconi's W.T. Co. and E. W. B. Gill. Application date 5th November, 1938.

521 049.—Gas-proof jointings for fluid-cooled high-powered valves which can be taken to pieces for overhaul or repair.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 1st December, 1937.

521 077.—Construction and disposition of the target and other electrodes of an electron-multiplier tube.

Electrical Research Products Inc. Convention dates (U.S.A.) 26th November, 1937, *and 4th May*, 1938.

521 199.—Construction and disposition of the control electrodes in a valve of the electron-beam type.

J. H. O. Harries. Application dates 9th November and 1st December, 1938.

521 246.—Electrode system for the production and control of electron streams, particularly in valves of the electron-beam type.

J. H. O. Harries. Application date 9th November, 1938.

521 299.—Construction and disposition of the target and control electrodes in an electron-multiplier tube.

Farnsworth Television Inc. Convention date (U.S.A.) 29th November, 1937.

521 356.—Construction and arrangement of the magnetic deflecting-coils of a cathode-ray tube (addition to 495 016).

Marconi's W.T. Co. (assignees of A. Blain). Convention date (U.S.A.) 16th November, 1937.

521 407.—Method of supporting and separating the parallel strips or rods forming the grid electrode of a thermionic valve.

Standard Telephones and Cables and F. D. Goodchild. Application date 15th November, 1938.

521 424.—Electrode arrangement for reducing inherent capacity between the screening grid and anode of a short-wave valve.

Telefunken Co. Convention date (Germany) 18th November, 1937.

521 558.—Coating and disposition of the lead-in wires of a thermionic valve for handling very high frequencies.

Standard Telephones and Cables and A. I. Vangeen. Application date 18th November, 1938.

SUBSIDIARY APPARATUS AND MATERIALS

520 516.—Construction and arrangement of a magneto-strictive vibrator, particularly for use as a submarine sound-generator.

Electrical Research Products Inc. Convention date (U.S.A.) 11th November, 1937.

520 655.—Cathode-ray type of visual tuning indicator in which the beam is deflected to show the direction in which the circuits are "off tune."

Marconi's W.T. Co. (assignees of C. N. Kimball and E. I. Anderson). Convention date (U.S.A.) 12th May, 1938.

520 693.—Electric testing circuit designed to give a permanent record of variable quantities, such as the working characteristics of a thermionic valve.

Standard Telephones and Cables; D. H. Black and J. H. Fremlin. Application date 27th October, 1938.

520 778.—Using short waves for sounding operations, i.e., for detecting the presence of invisible aircraft, and for indicating the altitude of an aeroplane.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Application date 9th September, 1938.

520 842.—Frequency-changing circuit in which desired harmonics are derived from a distorted wave-form.

Ericsson Telephones and F. W. Hopwood. Application date 1st November, 1938.

520 882.—Amplifying circuit utilising electron-multiplier tubes.

Gluhlampen und Elektrizitats Akt. Convention date (Germany) 30th September, 1937.

521 006.—Switching arrangements particularly suitable for controlling ultra-short-wave circuits.

Standard Telephones and Cables and L. J. Heaton-Armstrong. Application date 8th November, 1938.

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