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Editorial

Reflection and Absorption of Electromagnetic Waves by Dielectric Strata

WHEN an electromagnetic wave impinges on a sheet of dielectric material some of the energy is usually reflected, some absorbed and some transmitted into the space beyond. If anyone were asked what would be the result of backing the dielectric with a metal reflecting sheet, thus preventing the transmission of waves beyond the sheet, they would almost certainly reply that the reflected wave would thereby be strengthened. That this is not necessarily the case is shown in a recently published paper.* In a given case in which the dielectric was a sheet of asbestos cement (a semi-conducting dielectric), 1 cm thick, the wavelength 13.5 cm, and the angle of incidence and reflection 20° to the normal, the intensity of the reflected wave was reduced to 1/7th of its former value when a metal reflector was placed on the back of the sheet.

To obtain an idea of the conditions which can cause the reflected wave to be reduced to a very small value when the reflector is in position, we may consider the case of the normal incidence of a plane wave and adopt the device which we introduced many years ago† of picturing fictitious transmission lines which in no way interfere with or modify the wave but enable one to use the ordinary transmission line formulae. In Fig. 1 is shown in section the vertical slab of semi-conducting dielectric with a metal sheet on the right-hand face. If plane waves are travelling from left to right they will not be modified by the horizontal conductors which we imagine to be present, and, if the waves are polarised with the electric field vertical, the conductors can be pictured as wide horizontal strips of perfectly conducting material. Such a transmission line between parallel strips lends itself to very simple calculation. We assume that they are 1 cm apart and we need only consider 1 cm perpendicular to the paper, so that we fix our attention upon the energy travelling horizontally along a column 1 cm square, through space with a relative permittivity of unity and zero conductivity until we come to the slab of material of permittivity κ and

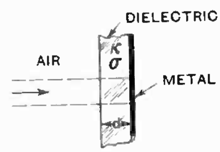


Fig. 1.

* Dällenbach and Kleinsteuber, *Hochfrequenztechnik*, May, 1938, p. 152.

† *Electrician*, 71, p. 965, 1913; also Dec. 26, 1913. *Journal Inst. of Elec. Eng.*, 54, p. 473, 1916.

conductivity σ. After travelling in this distance d the wave strikes the metal plate which we assume to have infinite conductivity. Such a line in air has an inductance L per cm of $4\pi . 10^{-9}$ henry and a capacitance C per cm of $1/(4\pi . 9 . 10^{11})$ farad. Its characteristic impedance $Z_0 = \sqrt{L/C} = 120\,\pi$ ohms. This gives the relation between the voltage and the current at any point and thus for the power P transmitted per sq. cm we have in air

$$P = VI = \frac{V^2}{120\pi} = \frac{\hat{v}^2}{240\pi} \text{ watts,}$$

and since the lines are 1 cm apart $\hat{v} = \hat{\mathcal{E}}$ where $\mathcal{E}$ is the electric field strength in volts per cm.

Now let us assume that the thickness of the slab is exactly a quarter of the wavelength λ' in the material, then, since the "lines" are short-circuited by the reflecting plate, the portion within the slab constitutes a quarter-wave resonator. Owing to the conductivity of the material energy will be dissipated in the slab. The watts lost in each cubic centimetre will be $\mathcal{E}^2/\rho$ or $\mathcal{E}^2\sigma$ where $\mathcal{E}$ is the R.M.S. volts per cm, which at the surface of the slab is the same as that in the air, but which falls off sinusoidally to zero at the metal plate. The average power per cm³ dissipated throughout the material will be $\hat{v}^2\sigma/4$, and therefore, if the thickness of the slab is $\lambda'/4$, the power dissipated in the column of 1 sq. cm cross section and $\lambda'/4$ cm long will be $\hat{v}^2\sigma\lambda'/16$ watts. If this be exactly equal to the power arriving in the wave, the energy will be dissipated as fast as it arrives and there will be no reflected wave. Hence the condition for no reflected wave whatever is that

$$\frac{\hat{v}^2}{240\pi} = \frac{\hat{v}^2\sigma\lambda'}{16} = \frac{\hat{v}^2\sigma\lambda}{16\sqrt{\kappa}} \quad \text{or } \sigma\lambda = \frac{8\sqrt{\kappa}}{377},$$

where λ is the wavelength in air.

Hence, to obtain no reflected wave under these conditions with a material of given σ and κ we must use a wavelength λ of $\sqrt{\kappa}/47\sigma$ cm and make the material into a slab of thickness $1/188\sigma$ cm where σ is the reciprocal of the specific resistance in ohms per cm cube. The thickness could, however, be any odd multiple of the quarter wavelength, the corresponding wavelengths being given by the formula

$$\lambda = \frac{\sqrt{\kappa}}{47\sigma\,(1, 3, 5, \text{etc.})},$$

the thickness of the slab being still $1/188\sigma$ cm.

This treatment of the problem is only a rough approximation since it neglects the fact that the wave cannot suddenly change from a progressive wave in air to a stationary wave in the slab, but must exist to some extent as a progressive wave in the latter, in order to transmit any energy into it. Calculation shows, however, that it gives a close approximation to the actual conditions if the material has a high value of κ; in this case the energy of the stationary wave is large compared with the dissipated energy.

If the thickness d of the layer be gradually changed, keeping λ, σ and κ constant, minima of the reflected wave will occur whenever $d = (1, 3, 5, \text{etc.})\ \lambda/4\sqrt{\kappa}$. This experiment is easily performed with water as the semi-conducting dielectric, as it is only necessary

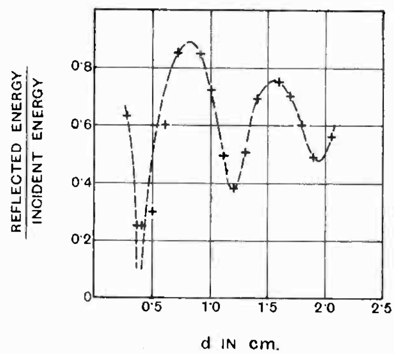


Fig. 2.

to vary the depth of a layer of water in a metal tray and measure the reflection from waves impinging approximately vertically on to the water. Such experiments have been performed by W. Pupp with a wavelength of 13.5 cm and the results are shown in Fig. 2. Putting $\lambda = 13.5$ and $\kappa = 77$, the calculated minima should occur when

$$d = \frac{47}{188} \cdot \frac{13.5}{\sqrt{77}}\ (1, 3, 5, \text{etc.})$$

$$= 0.384,\ 1.152,\ 1.92 \text{ cm, etc.}$$

The agreement is seen to be remarkably good.

Similar agreement has been obtained in the case of mixtures of quartz-sand with iron and carbon powder.

If an electromagnetic wave impinges on a sheet of dielectric free from losses and with no metal reflector it will pass through without reflection if the thickness is exactly half a wavelength in the dielectric, assuming that the medium on both sides is the same. That this is so can be shown as follows: Let the permittivities of the media on the two sides be κ_1 and κ_3 and that of the dielectric κ_2 and let the corresponding characteristic impedances be Z_{01}, Z_{03}, and Z_{02}. These are the impedances which the three sections of the transmission line would appear to have if they were infinitely long, and in the present case of no losses they are simply equal to the corresponding values of $\sqrt{L/C}$. In Fig. 3, the line to the right of B could be replaced by a resistance equal to Z_{03} across the lines at B, and the apparent impedance at A of the line of length d so terminated would be

$$\frac{Z_{03} + Z_{02} \tanh ad}{1 + \dfrac{Z_{03}}{Z_{02}} \tanh ad}$$

where $a = \sqrt{ZY} = j\omega\sqrt{L_2C_2}$.

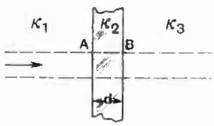


Fig. 3.

Since the velocity of the wave in the dielectric is $\frac{1}{\sqrt{L_2C_2}}$, the wavelength is $1/f\sqrt{L_2C_2}$ and therefore if $d = \lambda'/2$, the product $ad = j\pi$, and $\tanh ad = j \tan \pi = 0$.

The apparent impedance at A is therefore equal to Z_{03} which is the same as Z_{01}. Hence the impedance at A is just the same as if the dielectric were removed and the line extended to infinity in air; there is therefore no reflection. The same is true if d is equal to any multiple of the half wavelength.

Another interesting case is that in which κ_1 and κ_3 are different, and the thickness of the slab an odd multiple of a quarter wavelength; there will then be no reflection if $\kappa_2 = \sqrt{\kappa_1\kappa_3}$. We then have

$$\tanh ad = j \tan \pi/2 = j\,\infty$$

and the above expression for the apparent impedance at A reduces to Z_{02}^2/Z_{03}. For this to be equal to Z_{01}, and thus give the condition for no reflected wave, we must have $Z_{02} = \sqrt{Z_{01}Z_{03}}$.

In addition to their general interest these problems have a practical application in the determination of the height of aircraft by reflection of waves from the surface of the earth which consists of strata of different electrical properties. The paper to which we have referred is, in fact, followed by another on somewhat similar lines contributed from the Electrophysical Department of the German Aviation Experimental Research Station. In this it is stated that it has been found that in determining the height from the strength or from the phase of the reflected signal, very great inconsistencies are met with under conditions which are identical except for the nature of the earth's surface. The theoretical formulae developed agree with those to which we have referred, and the practical experiments were on similar lines, the wavelength being 14 cm produced by a Barkhausen transmitter with a parabolic reflector. The observations agreed so well with the calculated variations that the authors felt justified in applying the formulae to the practical case in which the wave-length is taken as 1.5 metres. Four cases were worked out viz., dry sand on very wet soil, dry sand on damp soil, ice on water, and water on asphalt, the last named having the semi-conductor of high permittivity on top and the good insulator underneath. In all cases curves somewhat similar to Fig. 2 were obtained. The problems which we have considered above are highly idealised but they may serve as an introduction and indicate the line of attack on the more general problem. G. W. O. H.

The Impulsive Theory of the Hexode Frequency Changer*

By L. H. Bedford, M.A.

SUMMARY.—The operation of the Hexode Frequency Changer is examined by means of an impulsive theory. The latter is of somewhat general application and is presented in a tentative manner without any attempt at condensation of the mathematics. The results obtained are quite in accordance with those of the sinusoidal theory, and the value of the present treatment resides in (*a*) A somewhat physically instructive view-point on the problem discussed, and (*b*) The presentation of a theory of potential general utility.

IN the hexode frequency-changer the signal-grid-controlled space current is modulated by the voltage applied by the local oscillator to the final grid. If both signal and oscillator voltages are sinusoidal and small enough to allow us to ignore curvature of the valve characteristics, then the whole frequency-changing action is expressed by the equation

$$\cos pt \cos qt = \tfrac{1}{2}\{\cos(p+q)t + \cos(p-q)t\} \qquad \ldots \quad \ldots \quad (1)$$

In general the conditions above mentioned are severely violated; in particular, the oscillator voltage is so high as to over-run the valve characteristic and maintain a condition of current cut-off for a substantial portion of the oscillator cycle. In these circumstances it is fully possible to develop a theory by Fourierising the anode current wave form which results from application of the oscillator voltage alone (i.e. in the absence of a signal), and then applying equation (1) to the various harmonics in turn.

In the present study an alternative treatment is attempted in which the sinusoidal theory is abandoned in consideration of the viewpoint that the current wave form approximates more to a repetitive impulse than to a sinusoid.

The impulsive function, which is in a sense the derivative of the Heaviside unit function, is already well known. The repetitive impulse function has also been used, but has not, as far as the writer is aware, been subjected to any formalised notation. To an appropriate definition and nomenclature we may therefore proceed :—

The function contemplated is the limiting case of that indicated in Fig. 1, in which the width of the non-zero portions of the wave form is made to approach zero, whilst their height approaches ∞ in such a way

Fig. 1.

Fig. 2.

that the area under the non-zero portions remains finite. The function may then be pictorially represented as in Fig. 2.

In this figure it must be recognised that the height depicted by the vertical lines is the *area* under the corresponding loops in Fig. 1; the corresponding ordinates in Fig. 1 being infinite.

From the appearance of the function as expressed in Fig. 2, and from other quite accidental considerations, we may conveniently assign the name " Line Function."

For definition we may write :—

lin $pt = 0$ for all values of pt other than

$$(2n + \tfrac{1}{2})\pi - \epsilon < pt < (2n + \tfrac{1}{2})\pi + \epsilon,$$

$$\text{and} \quad \int_{(2n+\frac{1}{2})\pi-\epsilon}^{(2n+\frac{1}{2})\pi+\epsilon} \text{lin}\,\theta\, d\theta = 2\pi,$$

the whole statement being taken to the limit as $\epsilon \rightarrow 0$.

The definition has been so arranged that the infinities in lin θ occur co-phased with the positive unity values of sin θ.

* MS. accepted by the Editor, April, 1938.

We may conveniently, and with some abbreviation, define the corresponding "coline" function by

$$\text{col}\, pt = 0 \text{ for } pt \neq 2n\pi$$

and $\text{col}\, pt \to \infty$ for $pt = 2n\pi$, with the same restriction on the nature of the infinity.

In the above definition n is any integer, and p is the "angular frequency" of the cycle. The latter term we shall abbreviate to "afrequency." [It is felt that any etymological objection to this term must be waived in consideration of its usefulness.]

Having set up the above notation, we may now proceed to the treatment of the hexode mixer in which we idealise the circumstances to the extreme of the condition known as "flick excitation." In other words, we assume that the oscillator drive is great enough to hold the current cut off for all but an infinitely small fraction of the cycle.

Assuming a signal afrequency p and an oscillator afrequency q, we may write for the anode current the expression

$$I(1 + \epsilon \cos pt)\, \text{col}\, qt.$$

We have therefore to devote attention to the product $\cos pt\, \text{col}\, qt$.

The significance of this product may conveniently be approached graphically.

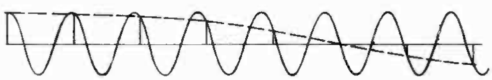


Fig. 3.

The state of affairs is indicated in Fig. 3, in which the oscillator is shown as having the lower frequency. Thus the oscillator impulse finds the signal voltage progressively later and later in phase. We may construct the following table :—

t		Signal Voltage
0	.. ..	1
$\frac{2\pi}{q}$	.. ..	$\cos 2\pi \frac{p}{q}$
$\frac{4\pi}{q}$	.. ..	$\cos 4\pi \frac{p}{q}$, etc.

It may now be seen by inspection that the values in the second column are equal to the time-corresponding values of the expression $\cos (p - q)t$. For :—

t .. $\cos (p - q)t$

0 .. 1

$$\frac{2\pi}{q} \;..\; \cos (p - q)\frac{2\pi}{q} = \cos \left(2\pi\frac{p}{q} - 2\pi\right) = \cos 2\pi\frac{p}{q}$$

$$\frac{4\pi}{q} \;..\; \cos (p - q)\frac{4\pi}{q} = \cos \left(4\pi\frac{p}{q} - 4\pi\right) = \cos 4\pi\frac{p}{q},$$

etc.

Hence we may write the important equation

$$\cos pt\, \text{col}\, qt = \cos (p - q)t\, \text{col}\, qt \quad .. \quad (2)$$

The significance of this equation is worth some consideration. In the first place we may note that for $qt \neq 2n\pi$ the equation conveys no information whatever, other than the affirmation $0 = 0$. For $qt = 2n\pi$ it makes the statement

$$\cos pt = \cos (p - q)t.$$

The equation thus states that if a phenomenon expressed by $\cos pt$ is observed only for infinitely short intervals at afrequency q, it is indistinguishable from the phenomenon $\cos (p - q)t$. Thus, in view of the process which it accurately describes, we may term equation (2) "The Stroboscopic Equation."

The above remarks, and particularly Fig. 3, indicate that the curve $\cos (p - q)t$ is, in an engineering rather than a mathematical sense, the envelope of the "curve" $\cos pt\, \text{col}\, qt$. It is thus physically evident that $(p - q)$ is one of the afrequencies in the spectrum of $\cos pt\, \text{col}\, qt$; but it is not obvious what other components are present. That an attempt to make a normal Fourier analysis of $\cos pt\, \text{col}\, qt$ is not likely to be successful will be realised when it is noted that $\frac{2\pi}{p - q}$ is not necessarily the period of the function, which indeed is not periodic at all unless p and q happen to be rationally related.

A suggestion as to the likely frequency components comes however from the process of treating the stroboscopic equation as a reduction formula, from which we obtain

$$\cos pt\, \text{col}\, qt = \cos (p - sq)t\, \text{col}\, qt \quad .. \quad (2a)$$

s being any integer, positive or negative.

The validity of this equation is immediately checked by noting that we are concerned only with times $qt = 2n\pi$, and that for such times $\cos (p - sq)t = \cos pt$.

Whilst this may indicate the likelihood of components of afrequency $(p - sq)$, it does not establish their existence, nor does it establish the absence of any component other than this series. To determine this point fully we may look for the presence of an afrequency ω by means of a *generalised* Fourier process.

Suppose that we are given a function $f(t)$ of unknown period which we suspect of containing sinusoidal components. To test for the presence of an arbitrary afrequency ω we may examine the expression

$$\frac{1}{T}\int_0^T f(t) \frac{\sin}{\cos} \omega t \, dt,$$

taking the limit as $T \to \infty$. The absence of any particular component will be indicated by a zero value of the limit.

In the present case, therefore, we have to consider

$$\lim_{T\to\infty} \frac{1}{T}\int_0^T \cos pt \operatorname{col} qt \frac{\sin}{\cos} \omega t \, dt.$$

Putting $\omega = (p - sq)$, we have

$$\lim_{T\to\infty} \frac{1}{T}\int_0^T \cos pt \operatorname{col} qt \frac{\sin}{\cos} (p - sq)t \, dt$$

$$= \lim_{T\to\infty} \frac{1}{T}\int_0^T \operatorname{col} qt \cos pt \frac{\sin}{\cos} pt \, dt.$$

This expression has the value zero for the upper alternative and the value $\frac{1}{2}$ for the lower. We therefore infer that all of the terms $\cos (p - sq)t$ are present, and in equal amplitude, and we reach the equation

$$\cos pt \operatorname{col} qt = \sum_{-\infty}^{\infty}{}_s \cos (p - sq)t \quad .. \quad (3)$$

Equation (3) is the impulsive counterpart of equation (1) in the sinusoidal theory. Another way of deriving equation (3) would have been simply to Fourierise the expression $\operatorname{col} qt$ and apply equation (1) term by term. The present method of treatment is thought, however, to show much more clearly the physics of the matter, and in particular, to stress the rather beautiful stroboscopic aspect of the case.

It may be appropriate at this stage to point out that if we are interested in the precise treatment of the practical case in which the wave form of the no-signal current is intermediate between the cosine and the coline we have a choice of two methods. From the impulsive view-point we should regard the wave form as built up of a series of coline functions of one single frequency, but varying in phase and amplitude, and we should develop a superposition theorem by which to compound the solutions. From the sinusoidal aspect we should merely Fourierise the no-signal current and apply equation (1). The latter view-point indicates that we should in all circumstances arrive at a result $\sum_0^\infty a_s \cos (p \pm sq)t$, of which the R.H.S. of equation (3) is a special case.

We may now consider certain applications of the above theory.

(1) *The Conversion Conductance.*

The anode current being denoted by $I(1 + \epsilon \cos pt) \operatorname{col} qt$, we may note first of all that the mean current is I, and that the amplitude of the wanted difference-frequency current is ϵI. If the oscillator drive is removed and the valve set up by adjustment of the oscillator grid-voltage to a steady current I, we may measure the mutual conductance of the valve as seen by the signal grid. Denoting this by m,

$$I\epsilon \cos pt = mV_s \cos pt.$$

Hence the difference-frequency current is mV_s, and the conversion conductance is m.

Contrast this with the case of a sinusoidally modulated current. In this case we write the anode current as

$$I(1 + \epsilon \cos pt)\,(1 + \epsilon' \cos qt).$$

I is again the mean current and $I\epsilon = mV_s$. The amplitude of the difference-frequency current is $\frac{1}{2}\epsilon\epsilon' I$, and the conversion conductance is $\frac{1}{2}\epsilon' m$. The maximum value of the conversion conductance obtained with this type of excitation is thus $\frac{1}{2}m$, this corresponding to a linear characteristic modulated to cut-off. The value $\frac{1}{2}m$ for the conversion conductance is a classic in the literature, and it is interesting to observe that we improve on it to the extent of 100 per cent. by going to full flick excitation.

(2) *The Unwanted Frequencies.*

In the expression $\sum_{-\infty}^{\infty} \cos(p - sq)t$, all the terms except that corresponding to $s = 1$ are in general unwanted frequencies. An exception to this statement is the case in which it is desired to receive "on an oscillator harmonic." In this event equation (3) informs us that in the case of complete flick excitation reception is equally efficient on any harmonic *including the fundamental.* This somewhat surprising result can be grasped physically by referring to Fig. 3, from which it may be seen that the same "envelope" is obtained if we take only every 2nd, 3rd, or rth impulse into account.

In the superheterodyne receiver the possibility of reception on oscillator harmonics is, however, usually more of a drawback than an advantage, since it opens up a whole series of possibilities of "second channel" interference.

If f_1 is the frequency of the wanted signal, f_2 that of the oscillator, assumed higher, and $f_3(=f_2 - f_1)$ the intermediate frequency, then it is usual to consider $f_1 + 2f_3$ as the second channel frequency. The above theory indicates, however, that, on account of non-sinusoidal current modulation by the oscillator, the following is the complete series of receivable frequencies:—$sf_2 \pm f_3$, s being a positive integer. For $s = 1$, this gives the wanted frequency $f_2 - f_3$, and the image frequency $f_2 + f_3$. For $s = 2$ we get $2f_2 + f_3$ and $2f_2 - f_3$. The latter expression equals $2f_1 + f_3$, so that it is seen that when the signal frequency is less than the intermediate frequency, there is an interfering frequency closer than the normal image.

The superheterodyne receiver is subject to yet a third form of interference which is not considered in the above. This arises at frequencies in the vicinity of a very strong signal. In these circumstances the strong carrier, even after some attenuation by the mis-tuning of the pre-selector circuits, is still able to produce a voltage on the signal grid of the hexode which is large enough to produce harmonics by valve characteristic curvature. The anode current accordingly takes the form

$$I \operatorname{col} qt(a_0 + a_1 \cos pt + a_2 \cos 2\,pt + \ldots)$$
$$= I\{a_0 \operatorname{col} qt + a_1\Sigma_s \cos(p - sq)t$$
$$+ a_2\Sigma_s \cos(2p - sq)t + \ldots\}$$

Accordingly we are faced with the introduction of spurious signals of the type $a_r \cos(rp - sq)$, r being any positive integer > 1, and s any integer or zero.

Suppose now that f_0 is the frequency of a strong signal, and f_3 the intermediate frequency, and that we seek to tune in a station of frequency f in the neighbourhood of f_0. The values of f defined by

$$|rf_0 - s(f + f_3)| = f_3$$

represent the centre points of the "squeak" ranges.

Standard Frequency Transmissions

USING a power of 20 kW the American National Bureau of Standards station, WWV, transmits signals for frequency calibration on Tuesday, Wednesday and Friday of each week except legal holidays. Three carrier frequencies are used and the times of transmission are as follows:—3 p.m. to 4.30 p.m. on 5,000 kc/s; 5 p.m. to 6.30 p.m. on 10,000 kc/s; and 7 p.m. to 8.30 p.m. on 20,000 kc/s, all times being G.M.T. The Tuesday and Friday transmissions are unmodulated C.W. except for one-second standard time short-pulse modulated signals at 1,000 c/s.

On Wednesday the carrier is modulated to 30 per cent. using a standard audio tone of 1,000 c/s. The frequencies transmitted by WWV have an accuracy better than one part in five million.

The Properties of a Resonant Circuit Loaded by a Complex Diode Rectifier *

By F. C. Williams, M.Sc., D.Phil.

(Manchester University)

SUMMARY.—This paper reports the continuation of some recently described researches into the properties of a rectifier stage comprising a resonant circuit loaded by a diode rectifier. The present contribution extends the analysis developed for simple rectifiers to the general case where the rectifier is biased and has an R.C. coupling circuit to facilitate connection to a subsequent amplifier. It is shown that bias of either sign will lead to distortion at some level of carrier input; with bias omitted distortionless rectification of all modulations of less than 95 per cent. depth is possible. Selectivity and sharpness of tuning are again found to be governed by different parameters. It is shown that A.V.C. rectifiers should be designed to yield distortionless rectification or the signal output will be distorted. A concluding section discusses the application of the circuit to modulation.

Table of Contents

(1) Introduction

In two recent papers the author has discussed the properties of a resonant circuit loaded by a diode peak rectifier.† It has been shown that the non-linearity of the rectifier inhibits consideration of the circuit and rectifier separately; the properties of the two are interdependent, and valid analysis can be based only on a consideration of the combination. The discussion so far attempted has related to simple unbiased rectifiers having no provision for coupling to an amplifying stage. The present paper is devoted to a discussion of these more complicated, but necessary, circuits.

Before proceeding with the discussion of such complex rectifier stages, it is of interest to review briefly the already established properties of the simple type. The relevant circuit is Fig. 1 with E_b equal to zero. The first paper [1] discussed the free oscillations resulting when the circuit is momentarily energised only: i, the supply current, being zero. It was found that a normal damped oscillation resulted in all cases. If the

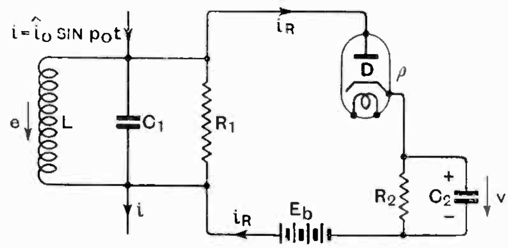


Fig. 1.

rectifier time constant (R_2C_2) exceeded that of the resonant circuit ($2R_1C_1$) the time constant governing the decay of oscillation amplitude was that of the resonant circuit. With $R_2C_2 < 2R_1C_1$ the time constant of decay was less than $2R_1C_1$ to an extent dependent on C_2/C_1 and R_2/R_1. In both cases the frequency of the oscillation approximated very closely to the resonant frequency of the circuit. The decay time constant was found to be inconsistent with the "effective input resistance" $R_2/2$ usually ascribed to peak rectifiers. Non-linearity of the rectifier arm was shown to cause this "effective resistance" to hold only in the steady state and with an e.m.f. of constant amplitude applied to the rectifier; under all other circumstances it was shown to be

* MS. accepted by the Editor, April, 1938.

† The term "peak rectifier" here relates to the well-known combination of a diode valve with an associated resistance capacitance load circuit (see Fig. 1, D, R_2 and C_2), the circuit parameters being supposed such that the steady voltage across the load is closely equal to the peak forward voltage applied to the rectifier.

an inadequate representation of the rectifier. Thus earlier discussions of behaviour with varying input amplitudes were invalid, since they made use of this supposed effective resistance. A new analysis was developed and applied to the "free oscillation" problem. Good agreement with experiment was found.

The second paper [2] discussed the response of the combination to modulated signals. It was found that there existed a difference between the "tuning curve" (defined as the curve relating the peak value of the circuit voltage to the frequency of the drive current, whose amplitude was held constant) and the "selectivity curve" (defined as the curve relating the amplitude of the beat note produced by the interference of two input signals to the frequency difference between them. The larger signal was supposed of constant frequency equal to the circuit resonant frequency, the smaller was of adjustable frequency: both amplitudes were supposed constant). With linear circuits the two curves are necessarily identical. The difference was again ascribed to non-linearity of the rectifier arm. For the tuning curve the effective input resistance $R_2/2$ is relevant. For the selectivity curve it is not, for the rectifier input amplitude is then a function of time. The degree of "side band cutting" with modulated inputs was shown to be governed by the selectivity curve. It was found that whereas, by suitable choice of parameters, selectivity could be made either greater or less than that inherent to the resonant circuit itself, the tuning was essentially broader. The conditions necessary to ensure distortionless reproduction of modulated signals were also set out. An accurate knowledge of the behaviour of rectifying stages, both as regards selectivity and freedom from distortion, is of considerable importance in radio communication: extension of the analysis summarised above to the more complicated rectifier circuits used in practice is therefore desirable. The present paper discusses such extension. It also discusses the application of the circuit to the inverse process, modulation.

(2) Steady State Conditions

The circuit to be considered first is shown in Fig. 1; it represents a resonant circuit shunted by a biased diode rectifier. The combination is supplied with an alternating drive current $i = \hat{\imath}_0 \sin p_0 t$ (where $p_0/2\pi$ is the resonant frequency of the circuit): let the resulting p.d. across the combination be $e = \hat{e}_0 \sin p_0 t$ as shown. The resistance R_1 represents the circuit losses. V is the output voltage of the rectifier, supposed freed from components of frequencies equal to or greater than $p_0/2\pi$.

It is a well-known property of peak rectifiers that V is only slightly less than the peak forward e.m.f. applied to the rectifier, accordingly,

$$V = a(E_b + \hat{e}_0)^* \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where a approximates to unity provided R_2 is many times greater than the slope resistance of the rectifier. It has been shown [1] that the important component† of the current i drawn by the rectifier from the source is the fundamental of value,

$$i_R = 2A_0 \sin p_0 t \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where A_0 is the current entering the load circuit R_2C_2 supposed freed from components of frequency $p_0/2\pi$ or greater. In this case $A_0 = V/R_2$, hence,

$$i_R = 2V/R_2 \sin p_0 t \quad \ldots \quad \ldots \quad (3)$$

The net current entering the resonant circuit is $(i - i_R)$, (see Fig. 1), thus the assumed p.d. across the circuit is evaluated by the equation

$$e = \hat{e}_0 \sin p_0 t = R_1(i - i_R).$$

It can be shown from (1) and (3) that

$$\hat{e}_0 = \beta R_1(\hat{\imath}_0 - 2aE_b/R_2) \quad \ldots \quad \ldots \quad (4)$$

with $$\beta = \frac{1}{1 + 2aR_1/R_2} \quad \ldots \quad \ldots \quad (5)$$

Thus the peak potential difference, $\hat{e}_0$, across the coil is a linear function of $\hat{\imath}_0$ if E_b is held constant, and a linear function of

* In this expression a is a function of $\hat{e}_0/E_b$, but it can be shown that a approaches unity provided R_2 is much greater than the valve slope resistance: the dependence of a on $\hat{e}_0/E_b$ is marked only when $\hat{e}_0/E_b \to 0$: such dependence will be neglected, a being taken as constant as in the earlier papers. Cases where (1) is invalid are discussed later.

† The rectifier current consists of a d.c. component with a superposed harmonic series. The resonant circuit responds dominantly to the fundamental component: hence in assessing the circuit voltage e the others are neglected. (See Bib. 1 for full discussion.)

E_b if $\hat{\imath}_0$ is held constant. There is a limit to the validity of (4), however, for if $2aE_b/R_2$ were greater than $\hat{\imath}_0$, $\hat{e}_0$ would apparently have negative values; such values are, of course, impossible. In practice as $2aE_b/R_2$ approaches $\hat{\imath}_0$ the resulting low values of $\hat{e}_0$ inhibit discontinuous rectifier operation, and continuous conduction in the valve ensues. The resonant circuit is then shunted by the comparatively low valve slope resistance ρ, and very small positive values of $\hat{e}_0$ result: thus to the first order (4) may be conditioned by the statement that

$$\hat{e}_0 = 0 \text{ except when } \hat{\imath}_0 > 2aE_b/R_2 \quad \ldots \quad (4a)$$

As $\hat{\imath}_0$ is increased from zero, $\hat{e}_0$ will remain zero until (4a) is satisfied.

Further, if E_b is negative, (5) suggests a positive value of $\hat{e}_0$ with $\hat{\imath}_0$ zero: however, with E_b negative rectifier operation is suspended when $\hat{e}_0$ is less than $|E_b|$ (see Fig. 1). Hence (4) applies only when

$$\hat{e}_0 > (-E_b) \quad \ldots \quad \ldots \quad \ldots \quad (4b)$$

With lower values of $\hat{e}_0$ the rectifier is effectively isolated from the circuit, the anode never swinging positive with respect to the cathode, hence with this régime,

$$\hat{e}_0 = R_1\hat{\imath}_0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4c)$$

Equations (4)–(4c) have been tested experimentally. The results are shown in Fig. 2 where $\hat{e}_0$ is plotted as a function of $R_1\hat{\imath}_0$, $\hat{\imath}_0$ being the variable. Curve a was taken with the valve cathode cold and relates to the circuit only (equation 4c). Curves b, c, d and e relate to the combination; curve b was taken with negative bias, curve c with zero bias, and the remainder with positive bias.

Curves b, c, d and e all exhibit long parallel portions in accordance with (4). The mean slope of these curves is 1/1.64 of the slope of curve a. This corresponds with $a = 0.89$ in equation (5). Using this value of a the lines on the figure have been calculated from equations (4) (4a) and (4b). These are in good agreement with the plotted experimental points. Exact agreement cannot be expected on account of the curvature of the valve characteristic; this causes the experimental results to show a smooth transition rather than the predicted discontinuities.

The form of the negative bias curve is well known, but it is believed that the result with positive bias has not previously been noted: it appears at first rather surprising that finite values of input current should be incapable of producing an appreciable potential difference across the circuit. It may be noted from the curves of Fig. 2 that the discontinuities found with biased rectifiers introduce a possible source of distortion with modulated signals: this will be discussed more fully later.

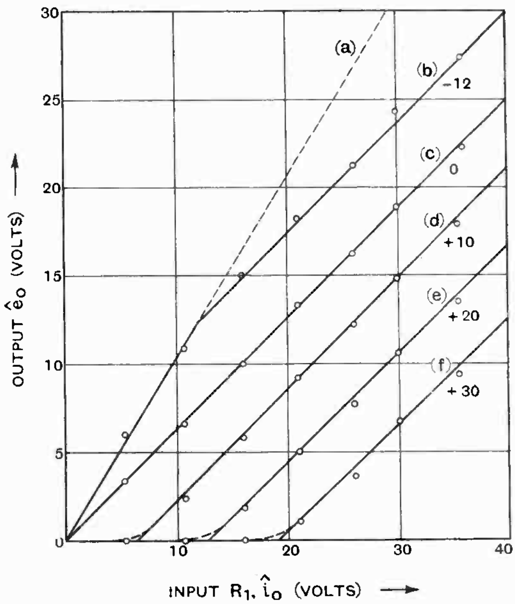


Fig. 2.—*Input-output characteristic with various values of bias. Curve (a), circuit only; curves (b), (c), (d), (e) and (f) relate to the combination with $E_b = -12$, $0 + 10$, $+20$, $+30$ volts respectively. The full lines show the expectation.*

Negative bias is often used to "delay" the response of the rectifier. These curves show that positive bias can also be used to provide the delay, and that then the voltage across the circuit itself is also "delayed." There may be some application for this property in A.V.C. circuits or in circuits designed to yield zero output during tuning operations.

(3) Response to Modulated Signals

The circuit now to be considered is shown in Fig. 3.

It differs from Fig. 1 only in that now $i = \hat{\imath}_0 (1 + K \cos \omega t) \sin p_0 t$ and R_3 and C_3 have been added to facilitate connection to a subsequent amplifying stage. R_3 and C_3 exert no influence on the steady state response discussed in section (2). If distortionless rectifier operation is assumed equation (1) is still valid but is now written

$$V_1 = a(E_b + \hat{e}) \quad \ldots \quad \ldots \quad \ldots \quad (1a)$$

and it must be noted that now $\hat{e}$ has a time variation dictated by the modulation of i. With such assumption it is shown in appendices 1 and 2 that if $R_3C_3 \gg 2\pi/\omega$

$$e = \hat{e} \sin p_0 t$$

where

$$\hat{e} = \beta R_1\left(\hat{\imath}_0 - \frac{2aE_b}{R_2}\right) + \frac{\gamma R_1 K \hat{\imath}_0}{\sqrt{1 + \alpha^2 T^2 \omega^2}} \cos(\omega t - \theta) \quad \ldots \quad (6)$$

and

$$\alpha = \frac{1 + aC_2/C_1}{1 + \dfrac{2aR_1(R_2 + R_3)}{R_2R_3}} \quad \ldots \quad \ldots \quad (7)$$

$$\beta = 1/(1 + 2aR_1/R_2) \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$\gamma = \frac{1}{1 + \dfrac{2aR_1(R_2 + R_3)}{R_2R_3}} \quad \ldots \quad \ldots \quad (8)$$

$T_1 = 2R_1C_1$ = the time constant of the resonant circuit .. .. .. (9)

and

$$\tan\theta = \alpha T_1 \omega \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

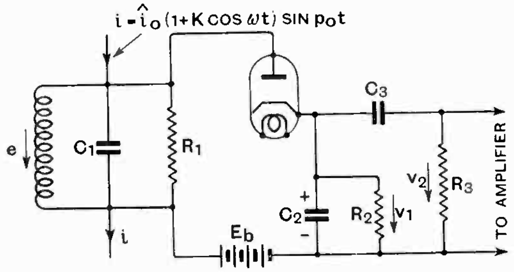


Fig. 3.

If now the amplitude $\hat{e}$ is split into two components, a steady value $\hat{e}_0$ (the "carrier" component) and an oscillating component $\hat{e}_m$ (the "modulation" component),

$$\hat{e}_0 = \beta R_1(\hat{\imath}_0 - 2aE_b/R_2) \quad \ldots \quad \ldots \quad (4d)$$

and

$$\hat{e}_m = \frac{\gamma R_1 K \hat{\imath}_0}{\sqrt{1 + \alpha^2 T_1^2 \omega^2}} \quad \ldots \quad \ldots \quad (11)$$

The resulting signal output across R_3 is then,

$$v_2 = a\hat{e}_m(\cos\omega t - \theta) = \frac{a\gamma R_1 K \hat{\imath}_0}{\sqrt{1 + \alpha^2 T_1^2 \omega^2}} \cos(\omega t - \theta) \quad \ldots \quad (11a)$$

Equation (11) shows that even with low modulation frequencies, $(\alpha T_1 \omega \ll 1)$, the modulation response is not that which would be deduced from the steady state characteristics of Fig. 2; it is less than that value in the ratio γ/β. This results from the presence of R_3 and C_3, these do not influence the steady state response, and the relevant value of the resistive component of the rectifier load circuit is then R_2. With low frequency modulations, however, the relevant resistance component is R_2 in parallel with R_3, for the analysis has supposed the impedance of C_3 negligible at all modulation frequencies. This difference between the "A.C. load" and the "D.C. load" was first discussed by Kilgour and Glessner[3]; fuller discussion, relevant to the rectifier alone, will be found in their paper.

The parameters which define the sensitivity, the tuning curve, the modulation response curve, and the selectivity curve of the combination, can be deduced from the results of sections (2) and (3) by a method exactly parallel with that adopted in the earlier paper[2] relating to rectifiers with E_b zero and R_3 infinite: the results only will be given here.

The sensitivity is now determined by γ, not β, see equations (11), (11a) and (8); it is greatest when R_2 and R_3 are much greater than R_1. The tuning curve again depends on β and has a band width (as defined in the earlier paper) given by $1/(\beta T_1)$ in terms of ω.

The modulation and selectivity curves are again defined by α, see equations (11) and (7), but the relevant value of α is modified by the introduction of R_3: $R_2R_3/(R_2 + R_3)$ replaces the R_2 of the earlier analysis. The band width is $1/(\alpha T_1)$.

Thus as before connection of a rectifier to a resonant circuit essentially reduces sensitivity and broadens tuning, but the modulation and selectivity band width may be either decreased or increased by such connection according as α is greater or less than unity.

The analysis has been tested experimentally by noting the ratio of the modulation depth of $\hat{e}$ to the modulation depth of $\hat{\imath}$; termed K_0 and K respectively. From (4d) and (11)

$$K_0 = \frac{\hat{e}_m}{\hat{e}_0} = \frac{\gamma K}{\beta\left(1 - \frac{2aE_b}{R_2\hat{\imath}_0}\right)\sqrt{1 + \alpha^2 T_1^2\omega^2}} \quad .. \quad (12)$$

whence

$$\frac{K_0}{K} = \gamma / \left\{\beta \cdot \left(1 - \frac{2aE_b}{R_2\hat{\imath}_0}\right)\sqrt{1 + \alpha^2 T_1^2\omega^2}\right\} \quad (12a)$$

The experimental method was similar to that described in the earlier paper: the results are shown in Fig. 4. The dotted

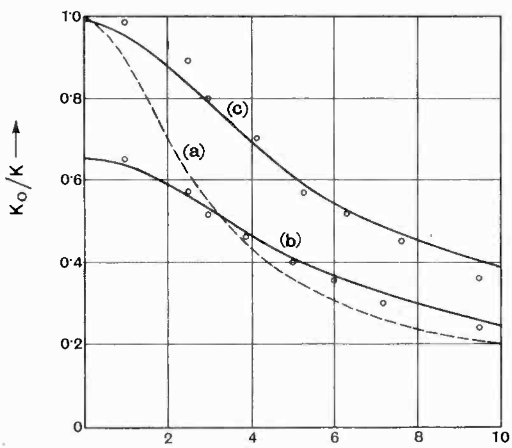


Fig. 4.—*Change of modulation depth as a function of frequency. Curve (a), circuit only; (b), combination with zero bias; (c) combination with positive bias. The full lines are calculated curves.*

curve, a, refers to the circuit only, the relevant equation is (12a) with $\alpha = \beta = \gamma = 1$ and $E_b = 0$; it was used to determine R_1. Curves (b) and (c) refer to the combination and show the expectation according to (12a) with E_b zero, and $E_b = +12$ volts respectively. The plotted points show the experimental results.

The discrepancies are due partly to interelectrode capacitance in the diode: when this factor is allowed for in the manner outlined elsewhere,* much better agreement results. Further, the difficulties of measuring modulation depth accurately are considerable; these difficulties account for the spread of the observed values about their mean line. If the values of the various parameters are deduced from these mean lines and allowance is made for interelectrode capacitance the agreement is excellent; see Table I.

* Bib. (1).

TABLE I.

Parameter	Calculated Value	Observed Value
γ/β	0.65	0.67
α	0.627	0.61
$\gamma/\beta\left(1 - \frac{2aE_b}{R_2\hat{\imath}_0}\right)$	1.005	0.98

These results are thought to be sufficient to verify the analysis.

Fig. 4 shows quite clearly that the modulation depth at all frequencies is reduced by the coupling circuit R_3C_3. The increase of modulation depth due to positive bias is also illustrated. Equation (12a) shows that if E_b were negative the modulation depth would decrease, such decrease has also been checked. Apart from any possible applications, these mechanisms may have in the adjustment of the modulation depth of existing signals, they have an important bearing on the conditions necessary to distortionless rectification: this is considered in the next section.

(4) Conditions for Distortionless Rectification

It has been shown[4] that a diode rectifier of the type here considered will operate without distortion provided

$$\frac{\left(1 + \frac{E_b}{\hat{e}_0}\right)^2}{K_0^2} \geqslant \left(1 + \frac{R_2}{R_3}\right)^2 + R_2^2 C_2^2 \omega^2.$$

Introducing K_0 from equation (12) this reduces to

$$\frac{1}{\gamma^2 K^2}\left\{\frac{E_b}{R_1\hat{\imath}_0} + \beta\left(1 - \frac{2aE_b}{R_2\hat{\imath}_0}\right)\right\}^2 (1 + \alpha^2 T_1^2\omega^2)$$
$$\geqslant \left(1 + \frac{R_2}{R_3}\right)^2 \left(1 + \frac{R_2^2 C_2^2 \omega^2}{\left(1 + \frac{R_2}{R_3}\right)^2}\right) \quad .. \quad (13)$$

This will be satisfied for all values of ω if

$$\alpha T_1 \geqslant \frac{R_2 C_2}{1 + \frac{R_2}{R_3}} \quad .. \quad .. \quad (14a)$$

and

$$\frac{1}{\gamma K}\left\{\frac{E_b}{R_1\hat{\imath}_0}+\beta\left(1-\frac{2aE_b}{R_2\hat{\imath}_0}\right)\right\} \geqslant \left(1+\frac{R_2}{R_3}\right). \quad (14b)$$

This expression shows that with negative bias there will always be some value of $\hat{\imath}_0$ below which distortion enters with a given value of K: with $K = 1$ it occurs with all values of $\hat{\imath}_0$. It also suggests that positive bias will not introduce distortion; this is untrue for (14b) does not include the possibility of distortion due to continuous conduction in the diode, as discussed in section (2) and leading to proviso (4a). Such distortion occurs whenever the circuit voltage $\hat{e}$ approaches zero; thus a sufficient criterion of freedom from it is $K_0 \leqslant 1$. It follows from (12a) that whatever the value of K, K_0 will exceed unity for some value of $\hat{\imath}_0$, and distortion will ensue.

Thus any biased rectifier must of necessity distort with some value of input signal $\hat{\imath}_0$ whether E_b be positive or negative: thus the suggestion* that positive bias may assist in providing distortionless rectification is of no practical value. This result may also be inferred from Fig. 2.

The suggestion was based on a consideration of the rectifier only and did not envisage the discontinuities exhibited by the combination and described in section (2).

This statement is at variance with recommendations recently made by W. T. Cocking [5] who states that the value of the positive bias need be chosen only with regard to the maximum carrier level to be accommodated. His discussion, however, relates to the rectifier only and does not envisage the discontinuities associated with the combination and illustrated in Fig. 2.

The type of distortion introduced by bias is well illustrated by the oscillograms of Fig. 5. These refer to the oscillating p.d. developed across the circuit with a sinusoidally modulated input current. Conditions were such that condition (14a) was always satisfied and condition (14b) was satisfied for a small range of E_b in the vicinity of zero. Oscillogram (a) shows the undistorted oscillation with zero bias, (b) shows the result of applying negative bias, (c) shows the result with positive bias. The general form of (b) and (c) can be inferred from the curves of Fig. 2 relevant to maintained inputs: the exact geometry cannot be so inferred, however, even for very low frequency modulations, except when R_3 is infinite. Exact estimation of the wave shape is somewhat complicated and will not be attempted; it is sufficient to note that bias should never be applied to diode rectifiers if distortion is to be avoided for all values of input carrier.

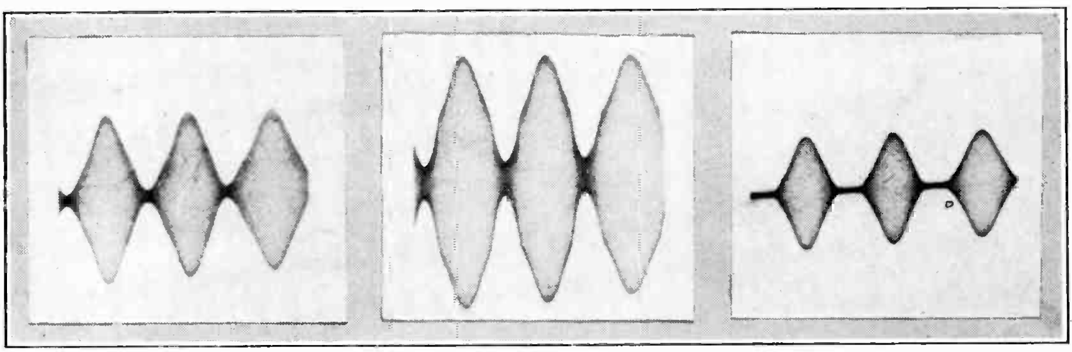
Accordingly condition (14b) becomes, with $E_b = 0$,

$$\frac{\beta}{\gamma K} \geqslant \left(1+\frac{R_2}{R_3}\right)$$

or from (5) and (8)

$$K \ngtr \frac{1+\dfrac{2aR_1/R_3}{1+2aR_1/R_2}}{1+R_2/R_3}$$

* See for example Bib. (4).



(a) (b) (c)

Fig. 5.—*Oscillograms of the oscillating p.d. across the resonant circuit showing distortion due to bias. (a) zero bias, (b) negative bias, (c) positive bias.*

which can be written as

$$K \ngtr \frac{1 + R_2/R_3\left(\frac{1}{1 + R_2/2aR_1}\right)}{1 + R_2/R_3} \quad .. \quad (15)$$

In general, the maximum value of K will be unity: it may approach that value at any frequency if the aerial is coupled directly to the rectifying stage; if there are intermediate selective circuits it will approach unity only at low frequencies. If such modulations are not to infringe (15) the ratios R_2/R_3 and $R_2/2aR_1$ must both be small.

If $R_2/2aR_1$ is made small sensitivity is lost, for γ is then small (see eqn. (8)); a suitable value would be $R_2/2aR_1 = 1$. If then R_2/R_3 is made equal to 1/10 input modulation depths up to 95 per cent. can be accommodated at all frequencies. These appear suitable ratios to adopt for practical purposes, for γ is then approximately $\frac{1}{2}$ and R_3 need not be unduly large. Since R_1 is usually about 100 $k\Omega$, suitable values of R_2 and R_3 are 200 $k\Omega$ and 2 $M\Omega$ respectively. If the sensitivity (γ) were increased by increasing R_2, undesirably high values of R_3 would be required to give distortionless rectification, of an equal modulation depth.

The choice of C_2 is governed by condition (14a) which may be rewritten

$$R_2C_2 \ngtr 2R_1C_1\left(1 + \frac{R_2}{R_3}\right) \cdot \frac{1 + aC_2/C_1}{1 + \frac{2aR_1(R_2 + R_3)}{R_2R_3}}$$

which is a little more than satisfied provided

$$R_2C_2 \ngtr 2R_1C_1 \quad .. \quad .. \quad .. \quad (16)$$

In the interests of high selectivity it is best to make $R_2C_2 = 2R_1C_1$, for α increases with R_2C_2: if $R_3 \gg R_2$ this is very nearly the highest permissible value of R_2C_2. It may be noted that if these values are adopted distortion will occur only at low modulation frequencies, for condition (14a) is more than satisfied, and as ω increases some point will be reached where (13) is satisfied for all greater values of ω for all values of K less than unity. This is especially true when the rectifier is preceded by a selective amplifier for then the relevant upper limit of K with the higher values of ω will be less than unity on account of side band cutting in the R.F. amplifier. Thus if any distortion occurs it is likely to be confined to low modulation frequencies.

The penalties for infringing either of the conditions (14a) and (14b) are severe. They have been fully discussed elsewhere and need only brief mention here. If (14b) is infringed distortion will probably be confined to low modulation frequencies; the wave form of $\hat{e}$ is then similar to that obtained with negative bias (Fig. 5b), for there is a portion of the modulation cycle during which rectifier operation is completely suspended. The rectifier output does not follow the envelope of $\hat{e}$ continuously, it follows the envelope for all amplitudes above the discontinuity, but is sensibly constant with amplitudes below the discontinuity. There results a "flat bottomed" sinusoid of output, oscillograms of which were given in the earlier paper.[4] If (14a) is infringed distortion occurs chiefly at high frequencies and is of the well-known form in which the descending branch of a sinusoidal modulation is replaced by an exponential segment. Oscillograms of such distortion are also given in the paper quoted above.

(5) Application to A.V.C. Circuits

In many rectifier stages two diode rectifiers are connected across the resonant circuit; one provides the signal output and the other provides bias for the variable μ H.F. stages. The signal diode is often designed with reasonable care, but the same is not true of the A.V.C. diode. It is usually provided with a negative bias in order to obtain delayed control. This practice is unsound, for the analysis of the preceding sections shows that with signals of low intensity the A.V.C. rectifier will distort; the modulation cycle being divided into alternate intervals during one of which the rectifier operates whilst during the other the rectifier is sensibly isolated from the circuit. If it were only the A.V.C. rectifier output that was distorted no distortion of the signal would be introduced, but with such discontinuous operation the oscillating p.d. generated across the circuit is distorted. This is illustrated by the oscillograms of Fig. 5. This distorted envelope will be recorded by the signal diode. Assessment of the distortion is too complicated to be attempted.*

* K. R. Sturley (*Wireless Engineer*, January, 1937, p. 15) has attempted the comparable problem relating to a band pass filter. He treated the filter as a pure resistance and used the invalid representation of the rectifier load as pure resistance.

It is, however, quite evident that if good quality is required some means other than negative bias should be used to give the delay. Also the A.V.C. rectifier should be designed as carefully as the signal rectifier to avoid other forms of distortion included in condition (13). The principles stated in the last section are equally applicable to A.V.C. diodes. It may be noted that delay achieved by means of positive bias is equally unsuitable, for similar reasons.

(6) Application to Modulation

The relation found between $\hat{e}_0$ and E_b in section (2) suggests that the circuit might well be used as a modulator: the exact linearity there found indicates that really distortionless modulation should result. The necessary circuit modifications are shown in Fig. 6.

The modulating voltage v_m (supposed sinusoidal) is introduced in series with E_b: i is now of steady amplitude and the coupling components R_3C_3 are omitted.

The complete analysis of this circuit is exceedingly laborious, but it can easily be shown* that with distortionless rectifier operation there results across the circuit a p.d. of the form

$$e = \{\hat{e}_0 + \hat{e}_m \cos(\omega t + \phi)\} \sin p_0 t$$

where

$$\hat{e}_0 = \beta R_1\left(\hat{\imath}_0 - \frac{2aE_b}{R_2}\right) \quad \ldots \quad \ldots \quad (4)$$

and $\hat{e}_m$ and ϕ are functions of v_m, ω, R_2, R_1, T_2 and T_1. ($T_2 = R_2C_2$, $T_1 = 2R_1C_1$). The quantitative evaluation of $\hat{e}_m$ and ϕ is simple only when $R_2C_2 = 2R_1C_1$, and then

$$\hat{e}_m = \frac{2aR_1/R_2\hat{v}_m}{1 + 2aR_1/R_2} = \beta \,.\, 2aR_1/R_2\hat{v}_m \quad \ldots \quad (17)$$

and

$$\phi = 0 \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

It follows from (17) that modulation will be distortionless, for β and $2aR_1$ are independent of v_m; further, there will be no relative loss of the higher frequency modulations for β is independent of ω: the circuit is thus "aperiodic."

Further, if (4), (17) and (18) are substituted in the equation for e, it becomes, in terms of peak value of e

$$\hat{e} = \beta R_1\left\{\hat{\imath}_0 - \frac{2a}{R_2}(E_b - \hat{v}_m \cos \omega t)\right\} \quad \ldots \quad (19)$$

If this is compared with (4) and the discussion in section (2), $(E_b - \hat{v}_m \cos \omega t)$ being read for E_b, it follows that the static characteristics, relating $\hat{e}$ to the bias, there developed still apply. That such should be the case with low values of ω is obvious, for $(E_b - \hat{v}_m \cos \omega t)$ is now the net bias. That they apply irrespective of ω is due to the already noted "aperiodic" property of the circuit.

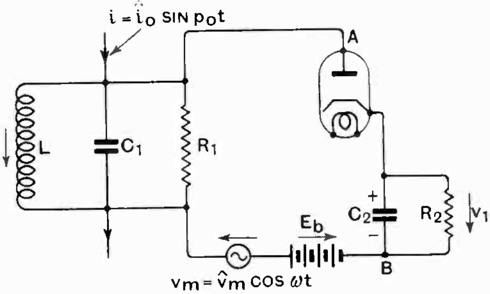


Fig. 6.

These results hold only if rectifier operation is distortionless. With low values of ω the limits set out in section (2) are relevant, i.e.

$$E_b - \hat{v}_m \cos \omega t \not> \frac{R_2}{2a}\hat{\imath}_0 \quad \ldots \quad \ldots \quad (19a)$$

from (4a), and

$$\hat{e} \not< -(E_b - \hat{v}_m \cos \omega t) \quad \ldots \quad (19b)$$

from (4b)

It follows from (19a) that

$$\hat{v}_m \not> \frac{R_2}{2a}\hat{\imath}_0 - E_b, \ (\cos \omega t = -1) \quad (20a)$$

and from (19b)

$$\hat{v}_m \not> + E_b + \hat{e}, \ (\cos \omega t = +1)$$

which, substituting for $\hat{e}$ and β from (19) and (5), becomes

$$\hat{v}_m \not> E_b + R_1\hat{\imath}_0 \quad \ldots \quad \ldots \quad \ldots \quad (20b)$$

Maximum permissible $\hat{v}_m$ will coincide with equality of these limits, one of which sets the permissible positive and the other the permissible negative swing of v_m.

* See App. (3).

Hence for maximum modulation amplitude,

$$\frac{R_2}{2a}\hat{\imath}_0 - E_b = E_b + R_1\hat{\imath}_0$$

which reduces to

$$E_b = \tfrac{1}{2}R_1\hat{\imath}_0\left\{\frac{R_2}{2aR_1} - 1\right\} \quad .. \quad (21)$$

Substitution in (19) yields, after reduction,

$$\hat{e} = \beta R_1\left\{\frac{\hat{\imath}_0}{2\beta} + \frac{2a}{R_2}\hat{v}_m \cos \omega t\right\} \quad .. \quad (22)$$

The corresponding maximum value for $\hat{v}_m$ is $\frac{1}{2} R_1\hat{\imath}_0\left(1 + \frac{R_2}{2aR_1}\right)$ from (20a) and (21), and hence, substituting in (22), with maximum modulation,

$$\hat{e} = \frac{R_1\hat{\imath}_0}{2}(1 + \cos \omega t) \quad .. \quad .. \quad (23)$$

That is, 100 per cent. modulation is just achieved.

The choice of R_2 will be set by the diode used; it must be high enough to give a high value of a, but the lower it is made the smaller the required modulation input $\hat{v}_m$. R_1 will be set by the consideration that the maximum value of $\hat{e}$ ($R_1\hat{\imath}_0$, with $\cos \omega t = 1$) lies within the permissible anode voltage swing of the valve (for instance a pentode) which supplies the drive $\hat{\imath}_0$.

In fact, 100 per cent. modulation depth will not quite be achieved on account of the curvature existing at low values of $\hat{e}$ (see Fig. 2 and sect. (2)).

With higher modulation frequencies the distortion limit is reached at lower modulation depths, and the process of sect. (4) must be applied. It is first necessary to evaluate the voltage applied to the rectifier between the points A and B in Fig. 6, it is,

$$v_r = e + E_b - v_m$$

The envelope of this is, from (22),

$$\hat{v}_r = \beta R_1\left(\frac{\hat{\imath}_0}{2\beta} + \frac{2a}{R_2}\hat{v}_m \cos \omega t\right) + E_b - \hat{v}_m \cos \omega t$$

$$= \frac{R_1\hat{\imath}_0}{2} + \frac{\beta\, 2aR_1}{R_2}\hat{v}_m \cos \omega t + E_b - \hat{v}_m \cos \omega t$$

$$= \left[\frac{R_1\hat{\imath}_0}{2} + E_b\right]\left[1 + \frac{\beta\frac{2aR_1}{R_2} - 1}{\frac{R_1\hat{\imath}_0}{2} + E_b}\hat{v}_m \cos \omega t\right]$$

The modulation depth of this is

$$K_e = \frac{\beta\,.\,\frac{2aR_1}{R_2} - 1}{\frac{R_1\hat{\imath}_0}{2} + E_b}\hat{v}_m$$

which, substituting for β and E_b from (5) and (21), reduces to

$$K_e = -\frac{2\hat{v}_m}{\left(1 + \frac{R_2}{2aR_1}\right).\,R_1\hat{\imath}_0}{}^{*} \quad .. \quad (24)$$

The condition for distortionless operation given at the beginning of section (4) still holds, but E_b in that equation must be put equal to zero since we have now included E_b in the evaluation of K_e, hence, for no distortion, we require,

$$\frac{1}{K_e^2} \nless 1 + R_2^2C_2^2\omega^2 \ (R_3 = \infty) \quad .. \quad (25)$$

We require to know, however, not the limit of K_e but the limit of K, the modulation depth of the output voltage, and from (22),

$$K = \frac{\hat{v}_m \beta 4a/R_2}{\hat{\imath}_0}$$

which, substituting for β from (5) can be rewritten,

$$K = \frac{2\,\hat{v}_m}{R_1\hat{\imath}_0\left(1 + \frac{R_2}{2aR_1}\right)}$$

Comparison with (24) shows that $K = K_e$, and hence (25) becomes

$$K \ngtr \frac{1}{\sqrt{1 + T^2\omega^2}} \quad .. \quad (26)$$

where $T = 2R_1C_1 = R_2C_2$.

The permissible modulation depth of the output thus decreases with increasing modulation frequency.

It is interesting to compare this result with that achieved by the normal method of grid, or suppressor grid, modulation. Here the rectifier would be omitted and the drive current $\hat{\imath}$ would be modulated. With unity modulation depth of $\hat{\imath}$ the modulation depth of the output voltage, due to side band cutting (see sect. (3)), would be

$$K = \frac{1}{\sqrt{1 + T^2\omega^2}}$$

* The negative sign can be ignored, it relates only to the phase of the modulation.

Comparison with (26) shows that the available modulation depth at the higher frequencies is the same in the two cases, but in the diode case it is achieved without modification of the modulation depth of higher frequency components, and without introducing a lagging phase angle. The peak output obtainable with $K = 1$ and $\cos \omega t = 1$ is the same in both cases since at this limit the rectifier is not operating and the two circuits are effectively identical.* More power is needed to perform the modulation in the diode case, since modulation occurs on the anode side, and more D.C. power is drawn by the supply pentode since it is fully driven throughout the modulation cycle. It seems, however, that there may be applications in low power modulation circuits or in television work where the aperiodic nature of the modulation outweighs these disadvantages. The disadvantages are inherent to the circuit, since it is essentially an "absorption modulator."

A more advanced circuit based on the present principle has been developed in which the limitation of modulation depth at high frequencies is avoided. It is at present being fully investigated, and the author hopes to describe it in a future article. The principle is covered by a Patent.

(7) Conclusions

It is concluded that the sensitivity, modulation response and selectivity of a resonant circuit loaded by a complex rectifier obey the same laws as are relevant to a resonant circuit loaded by a simple rectifier, except that new parameters α, β and γ replace the earlier parameters α and β. The conditions necessary for distortionless rectification are correspondingly more complex, but if bias be omitted they can be reduced to easily satisfied rules stated in section (4): it is also shown that bias of either sign is always liable to introduce distortion at some level of input signal. It is shown that the design of the A.V.C. rectifier demands the same care as the design of the signal rectifier, and that accordingly "delay bias" should be omitted for best results. Where such delay is essential it can be achieved with either negative or positive bias: in the latter case, the signal applied to the rectifier is also "delayed" and quiet tuning results.

The circuit is equally applicable to modulation and offers the unique advantage of being aperiodic to the modulation frequency provided the time constants of the resonant circuit and the rectifier load are equal: further, the modulation characteristic is inherently linear and very pure modulation can be achieved. The output obtainable compares favourably with that obtained with grid or suppressor grid modulation.

(8) Acknowledgments

The research here described was performed in the Electro-Technics Department of Manchester University. The author is indebted to Professor R. Beattie for the facilities provided, and to Mr. W. Makinson, M.Sc. for assistance with the experimental work.

Appendix 1

Fig. 7 illustrates a biased rectifier supplied with a modulated oscillation. With distortionless rectification :—

$$v_1 = a(E_b + \hat{e}_0(1 + M \cos \omega t))$$

and if $R_3C_3 \gg 2\pi/\omega$

$$v_2 = a\hat{e}_0 M \cos \omega t.$$

The components of the rectifier current i which are either steady or of modulation frequency are given by the expression,

$$A_0 = C_2 \frac{dv_1}{dt} + \frac{v_1}{R_2} + \frac{v_2}{R_3}$$

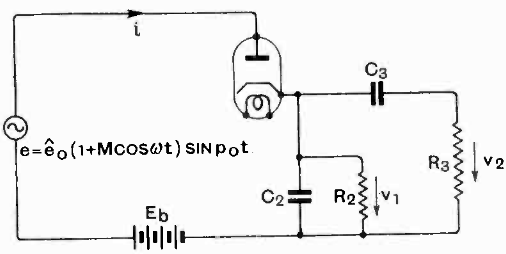


Fig. 7.

And from equation (2) the important R.F. component of rectifier current is $i_R = 2A_0 \sin p_0 t$

$$= \left[-2C_2 M a\hat{e}_0 \omega \sin \omega t + \frac{2(R_2 + R_3)}{R_2 R_3} \cdot aM\hat{e}_0 \cos \omega t + \frac{\hat{e}_0 2a(1 + E_b/\hat{e}_0)}{R_2} \right] \sin p_0 t.$$

* See eqn. (23) with $\cos \omega t = 1$. The output voltage is $R_1 \hat{\imath}_0$, i.e., the value relevant to the circuit without the rectifier shunt.

Appendix 2

Referring to Fig. 8, let a current i be injected such that there appears across the circuit a p.d.

$$e = \hat{e}_0\{1 + M \cos \omega t\} \sin p_0 t$$

where $p_0 = 1/\sqrt{LC}$.

Let i_R and i_C be components of i as shown. Then it follows from Appendix 2 of an earlier paper (2) that i_C

$$= \hat{e}_0 \left\{ \frac{1}{R_1} + \frac{M \cos \omega t}{R_1} - 2C_1 \omega M \sin \omega t \right\} \sin p_0 t$$

But $i = i_C + i_R$, hence by adding the above equa-

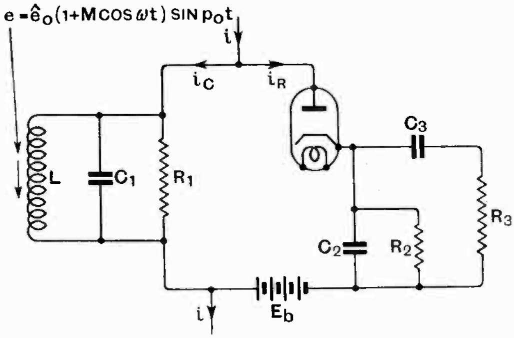


Fig. 8.

tion term by term to that obtained for i_R in Appendix 1,

$$i = \left[\frac{\hat{e}_0}{R_1} + \frac{2a\hat{e}_0(1 + E_b/\hat{e}_0)}{R_2} + \hat{e}_0 \left[\frac{1}{R_1} + 2a\left(\frac{R_2 + R_3}{R_2 R_3}\right)\right] M \cos \omega t - 2\hat{e}_0(C_1 + aC_2)M\omega \sin \omega t\right] \sin p_0 t$$

$$= \left[\left(\frac{\hat{e}_0}{\beta R_1} + \frac{2aE_b}{R_2}\right) + \frac{\hat{e}_0 M}{\gamma R_1} \sqrt{1 + \alpha^2 T_1^2 \omega^2} \cos(\omega t + \theta)\right] \sin p_0 t$$

where :—

$$\beta = \frac{1}{1 + 2aR_1/R_2}$$

$$\alpha = \frac{1 + aC_2/C_1}{1 + \dfrac{2aR_1(R_2 + R_3)}{R_2 R_3}}$$

$$\gamma = \frac{1}{1 + \dfrac{2aR_1(R_2 + R_3)}{R_2 R_3}}$$

$T_1 = 2R_1C_1$ = the time constant of the resonant circuit

and $\theta = \tan^{-1} \alpha T_1 \omega$

If now the origin of time be changed such that $t = t' - \theta/\omega$, i can be written in the form

$$i = [\hat{i}_0 + K\hat{i}_0 \cos \omega t^1] \sin p_0(t' - \theta/\omega)$$

where

$$\hat{i}_0 = \frac{\hat{e}_0}{\beta R_1} + \frac{2aE_b}{R_2} \quad \text{and} \quad K = \frac{\hat{e}_0 M}{\gamma R_1} \frac{\sqrt{1 + \alpha^2 T_1^2 \omega^2}}{\hat{i}_0}$$

Whence the original equation $e = \hat{e}_0 (1 + M \cos \omega t)$ can be rewritten after some reduction as :—

$$e = \left[\beta R_1\left(\hat{i}_0 - \frac{2aE_b}{R_2}\right) + \frac{\gamma R_1 K \hat{i}_0}{\sqrt{1 + \alpha^2 T_1^2 \omega^2}} \cos(\omega t' - \theta)\right] \sin p_0\left(t' - \frac{\theta}{\omega}\right).$$

Hence, modifying the phase of the carrier, the potential difference across the circuit resulting from the injection of a current

$$i = \hat{i}_0(1 + K \cos \omega t) \sin p_0 t$$

is

$$e = \left[\beta R_1\left(\hat{i}_0 - \frac{2aE_b}{R_2}\right) + \frac{\gamma R_1 K \hat{i}_0}{\sqrt{1 + \alpha^2 T_1^2 \omega^2}} \cos(\omega t - \theta)\right] \sin p_0 t$$

Appendix 3

(See Fig. 6 of text.)

Due to some unspecified form of v_m let the variation of peak potential applied to the rectifier (between A and B) be

$$\hat{e} = \hat{e}_0(1 + M \cos \omega t)$$

Both the steady and varying components in this expression are partly bias and partly H.F. terms.

The important component of rectifier current is then, from App. 3 of an earlier paper (2)

$$i_R = \frac{2a\hat{e}_0}{R_2}\left[1 + M\sqrt{1 + T_2^2\omega^2} \cos(\omega t + \theta)\right] \sin p_0 t$$

where $\tan \theta = T_2 \omega$.

The net current entering the circuit is thus

$$i - i_R = \left(\hat{i}_0 - \frac{2a\hat{e}_0}{R_2}\right) \left[1 - \frac{(2a\hat{e}_0/R_2)M}{\hat{i}_0 - 2a\hat{e}_0/R_2} \sqrt{1 + T_2^2\omega^2} \cos(\omega t + \theta)\right] \sin p_0 t$$

There results a p.d. across the circuit given by App. 2 of the already quoted paper ; it is,

$$e = R_1\left(\hat{i}_0 - \frac{2a\hat{e}_0}{R_2}\right)\left[1 - \frac{(2a\hat{e}_0/R_2)M}{(\hat{i}_0 - 2a\hat{e}_0/R_2)} \frac{\sqrt{1 + T_2^2\omega^2}}{\sqrt{1 + T_1^2\omega^2}} \cos(\omega t + \theta - \phi)\right] \sin p_0 t \quad \text{.. (i)}$$

where $\tan \phi = T_1 \omega$.

Thus the instantaneous bias potential e_b, which is equal to the difference between the peak voltage applied to the rectifier and the peak voltage developed across the circuit, is

$$e_b = \hat{e}_0(1 + M \cos \omega t) - R_1\left(\hat{i}_0 - \frac{2a\hat{e}_0}{R_2}\right) \left[1 - \frac{2a\hat{e}_0/R_2 \,.\, M}{\hat{i}_0 - 2a\hat{e}_0/R_2} \frac{\sqrt{1 + T_2^2\omega^2}}{\sqrt{1 + T_1^2\omega^2}} \cos(\omega t + \theta - \phi)\right] \quad \text{.. .. (ii)}$$

This can be expressed in the form

$$e_b = E_b + \hat{v}_m \cos(\omega t + \psi) \quad \ldots \quad \ldots \text{(iii)}$$

Hence a sinusoidally modulated wave (eqn. i) results from the application of sinusoidally varying bias (eqn. ii): the quantitative relation can be derived by substituting for $\hat{e}_0$ and M in equation (i) in terms of E_b and $\hat{v}_m$ by comparison of (ii) and (iii), but the process is very laborious: we shall consider only the special case when $T_1 = T_2$. Then $\theta = \phi$ and (ii) becomes

$$e_b = \hat{e}_0 - R_1\left(\hat{i}_0 - \frac{2a\hat{e}_0}{R_2}\right) + M\left(\hat{e}_0 + \frac{2a\hat{e}_0 R_1}{R_2}\right) \cos \omega t$$

i.e. in eqn. (iii)

$$E_b = \hat{e}_0 - R_1\left(\hat{i}_0 - \frac{2a\hat{e}_0}{R_2}\right) \quad \text{or } \hat{e}_0 = \frac{E_b + R_1\hat{i}_0}{1 + 2aR_1/R_2}$$

$$\hat{v}_m = M\left(\hat{e}_0 + \frac{2a\hat{e}_0}{R_2}\right) \quad \text{or } M = \frac{\hat{v}_m}{\hat{e}_0(1 + 2aR_1/R_2)}$$

$$\psi = 0.$$

Substitution in (i) then yields the coil p.d. as

$$e = \beta R_1 \left\{\hat{i}_0 - \frac{2aE_b}{R_2}\right\} \left\{1 + \frac{(2a/R_2)\hat{v}_m}{\beta\{\hat{i}_0 - 2aE_b/R_2\}\{1 + 2aR_1/R_2\}} \cos \omega t\right\} \sin p_0 t$$

$$= \{\hat{e}_0 + \hat{e}_m \cos \omega t\} \sin p_0 t$$

Where :—

$$\hat{e}_m = \frac{(2aR_1/R_2)\hat{v}_m}{\{1 + 2aR_1/R_2\}}$$

and $\hat{e}_0 = \beta R_1 \left(\hat{i}_0 - \dfrac{2aE_b}{R_2}\right)$

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Correspondence

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

Noise of Frequency Changer Valves

To the Editor, The Wireless Engineer.

SIR,—Recently many papers have dealt with the question of shot noise in receiving valves. A marked discrepancy is still to be noted regarding measurements and theoretical computations dealing with the noise of frequency changer valves. We feel that the following considerations will serve to clarify the situation.

It is well known that the mean square value of noise output of amplifier valves is proportional to the bandwidth of the receiver. In frequency changer valves circumstances are more complicated, plate current and noise current being simultaneously modulated through the oscillator voltage. Noise spectrum will be heterodyned through the oscillator voltage and will generate beat frequency components. Thus the noise voltage on the plate circuit tuned to intermediate frequency will contain not only the amplified I.F. band of shot noise spectrum but also the beats of its two "R.F. bands." (In the case of I.F. being 100 ± 5 kc/s, local frequency being 330 kc/s we call "R.F. bands" of shot noise the components falling into the ranges 430 ± 5 kc/s and 230 ± 5 kc/s. Practically effects of oscillator harmonics may be neglected). While noise of amplifier valves originates from one band of noise spectrum, noise of F.C. valves is likely to be generated by three separate bands. Two tests described below seemed to contradict this assumption.

First test.—A fixed grid bias was applied to the injector grid (3rd grid in the case of a conventional hexode) and the noise output measured without oscillation. Then a voltage of oscillator frequency was superimposed and the noise measured again. The oscillator voltage did not appear to alter valve noise appreciably. (Frequently a slight reduction of noise was observed depending on the choice of working point). Published data of other authors seem to indicate the same result.[1] Therefore this test gives no indication of the appearance of additional noise components due to heterodyning the R.F. noise bands.

Second test.—We measured and plotted noise output *versus* injector grid bias (without applying oscillations). From this noise characteristic an average noise value may be determined. Assuming the same fixed grid bias and a superimposed A.C. voltage as used in the first test, a plot of mean square noise *versus* time was constructed and the mean square value of the noise current was averaged over one period of oscillation. This graphically determined average noise value was in striking agreement with the value of noise current measured in the first test with oscillation injected. As the noise output determined in the second test originated without doubt entirely from the I.F. band, the result of this test seemed to confirm the lack of R.F. noise bands.

Third test.—To check the measuring set and put circumstances clearly in evidence, the following arrangement was made. A pure resistance was inserted into the circuit of the signal grid of the same F.C. valve and the plate noise was measured in the same manner. In this case the noise was due partly to the Johnson effect of the resistance which is known to represent a noise source producing the same random noise as shot effect. The amount of noise originating from the resistance

[1] Rothe and Engbert: *Telefunkenröhre* H. 11, 206, 1937.

was isolated. The resistance was then shunted by a resonant circuit tuned successively to the I.F. band and the two R.F. bands. Determining the Johnson noise in each case we found that the sum of the mean square output values of these three bands gave exactly the mean square noise of the unshunted resistance.

The third test proves that with a constant noise source outside the valve the R.F. noise bands will be heterodyned. We have to account for the observed divergency in the case of shot noise.

Rothe and Engbert tried to explain the discrepancy by assuming that the shot noise resulting from mixing effects is so small (10–20 per cent. in comparison with the effect of I.F. components) that an appreciable increase would not be detected.

Our considerations lead us to a different view: In spite of the observation, that frequency mixing process does not produce additional noise, approximately 50 per cent. of the noise in commonly used F.C. valves is due to straight amplification of I.F. components of shot noise and 50 per cent. originates from heterodyning the R.F. noise components. This follows from a mathematical analysis. With the aid of a theorem of Fourier series it may be proved that when oscillator voltage is injected noise output arising from heterodyning action is exactly equal to the amount of reduction of I.F. noise components taking place simultaneously.

If the frequency of the local oscillator is low (say 50 c/s) compared with the bandwidth of I.F. circuits (say 10 kc/s) there is no reason to deal with new heterodyned bands. The observable mean square value of noise current is equal to $\frac{1}{T}\int_0^T \overline{i^2}\, dt$. ($\overline{i^2}$ is the mean square value of the I.F. component of noise current for a certain grid bias, T period of oscillation). If however the frequency of local oscillations is high compared with the bandwidth of I.F. circuits, the output voltage cannot follow the pulsations of the amplitudes of I.F. noise components. In this case the observable mean square value of noise current originating from I.F. noise components will be equal to $\left[\frac{1}{T}\int_0^T \sqrt{\overline{i^2}}\, dt\right]^2$. As the square of arithmetic mean value is smaller than the mean square value — $\left[\frac{1}{T}\int_0^T \sqrt{\overline{i^2}}\, dt\right]^2 < \frac{1}{T}\int_0^T \overline{i^2}\, dt$—*the noise originating from I.F. shot noise components will be smaller for fast oscillations than for slow ones.* This difference is equal to the amount of noise originating from the additional noise bands detected through heterodyning action, *the total noise output being independent of oscillator frequency and equal to* $\frac{1}{T}\int_0^T \overline{i^2}\, dt$.

Thus the graphic determination of the mean square noise output carried out in the second test corresponding to the investigated case of slow oscillation gives always the correct value of total noise. The described graphic method seems to be well suitable for further investigations owing to its simplicity.

We are indebted to Dr. Grünwald for his help in the mathematical treatment and Mr. Zakariás for his valuable advice regarding experimental procedure.

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Deflection Valves for Ultra-Short and Decimetre Waves

To the Editor, The Wireless Engineer.

SIR,—An article by Mr. Colebrook, which appeared in the April issue of *The Wireless Engineer* under the title "Ultra-Short and Decimetre Wave Valves" (page 198), and the subsequent letter from Mr. Harries, published on page 323 of the June issue, calls the attention of your readers to the work which has been carried out during recent years with the object of obtaining a deflection valve for ultra-short waves.

During the years 1931 to 1934 I made some experiments* with the object of solving this interesting problem. These experiments were described in an article printed in *Alta Frequenza*,† an abstract of which you published in your April, 1936, issue (No. 1348, page 209). Considering that Mr. Harries is interested to hear of any work in this line, I should like to call your attention to this article, which it seems to me Mr. Colebrook and Mr. Harries have not read, adding some considerations which may be of interest to your readers.

(1) The chief problem, in studying microwave tubes, lies in the fact that the electronic delay must not disturb the oscillatory mechanism.

This problem may be solved by reduction of the delay as obtained partly in acorn tubes or by making this delay uniform for every electron. For instance, in the latter case one can regulate the potentials so that the delay for all electrons is equal to one cycle. The valve then acts as an inertless relay. The deflection valve secures the uniformity of delay, since the deflection of the electronic jet does not involve a great variation of the longitudinal velocity of electrons. The advantages that arise from this fact are theoretically examined in my article, and are confirmed by the fact that the oscillatory mechanism of the magnetron and of the Barkhausen-Kurz type may be explained by a model of the deflection type.

(2) These advantages cannot be fully obtained since the secondary emission causes a supplementary delay in the absorption of the electrons in anodes, which is difficult to make uniform or to suppress.

As I have pointed out in my article this supplementary delay remains of the order of the 10^{-9} even if a suppression grid is employed, and in my opinion this is the chief reason why I have not obtained the expected results.

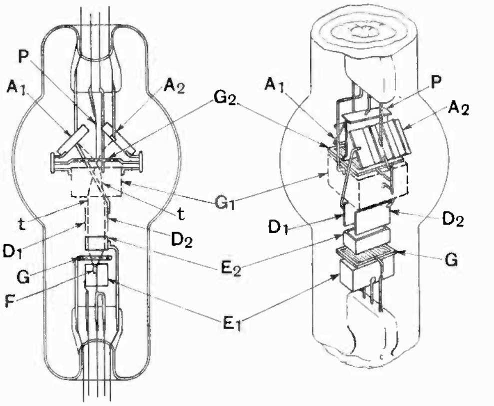
(3) In some models which I have constructed I

* In the Laboratory of the Wireless Institute of the Italian Army.

† U. Tiberio—"Il comando per deviazione nei tubi generatori di microonde." *Alta Frequenza*, 1935, Vol. IV, page 714.

obtained a powerful beam, making it in the form of a plane blade and employing a convenient structure and position for the accelerating grids. This is in accordance with the results spoken of by Mr. Harries in his article on page 110 of *The Wireless Engineer*, April, 1936. For instance, a tube, of which I give the design, gave:

$$I_a = 30 \text{ mA}. \quad G_m = 2 \text{ mA/V}.$$



Longitudinal section and general view of an experimental tube of the deflection control type.

In this tube the cathode is a rectilineal powerful filament, the beam being generated by the assistance of a negative electrode E_1 and a positive accelerating grid G. The further acceleration, and the concentration of the beam, in the form of a well-defined blade, was obtained by the electrode E_2, the deflection plates D_1 and D_2 and the screen grid G_1. The suppressor grid G_2 and the earthed plate P helped to cut the beam in two parts, which fell on the two anodes, and to repel the secondary electrons.

(4) The complete elimination ot the secondary delay may be obtained by means of a technique opposite to that employed in ordinary pentodes. Instead of repelling the secondaries against anodes it is probably preferable to eliminate them by means of an auxiliary electrode maintained at a higher constant potential. This is a procedure similar to that followed in dynatrons. If the secondaries are double the primaries, the anode current is equal to the impinging current of the jet, but in the opposite sense (positive instead of negative), this current being completely unaffected by the secondary delay. A number of secondaries still greater will increase the mutual conductance.

(5) As a conclusion, I express these two criterions suggested to me by experience, and which I hope will prove useful to experimenters working in this direction.

(*a*) To produce the electronic jet it is necessary to abandon the classical oscillographic technique and make the jet in the form of a plane blade so that a high efficiency long cathode may be employed. It is more interesting to obtain a powerful jet than a high deflectional sensibility.

(*b*) Another fundamental criterion is to obtain uniformity of delay. To do so it is necessary to make the electronic trajectories as parallel as possible, reducing the secondary delay, or eliminating it by the means I have already mentioned in paragraph 4.

(6) In his historical résumé Mr. Harries mentions even the earliest studies from those made by Von Lieben to those by Alfvèn. These studies do not take into consideration certain problems which arise when the deflection tube is employed in microwave bands.

The idea of employing the electron gun of the oscillographic device for the production of deflection amplifying tubes is too general and simple a matter. Therefore it seems to me that these earliest studies cannot be considered as pioneers in our field.

The studies of problems which are substantially related to microwaves—the compensation of the delay, the control impedance and the production of long powerful beams—are the work of recent years. Experimenters have been fully convinced of the benefits of the deflected beam conception, after the studies from which it results that the oscillators of the magnetron and B-K type can be interpreted as "Deviation" type tubes, and after the possibilities of the "deviation control" obtained by means of deflected beams, had been theoretically explored. So far as I am aware my article was the first to be written according to these conceptions.

The articles by Mr. Colebrook, Mr. Harries (although Mr. Harries' article in *The Wireless Engineer*, April, 1936, makes no mention of the microwave problems) and by myself will probably be sufficient to furnish your readers with a good picture of this question.

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Book Reviews

Direct and Alternating Current Potentiometer Measurements

By D. C. Gall. Pp. 231 + XIV. 109 Figs. Chapman and Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 15/-.

This forms one of a series of monographs, the avowed object of which is to enable engineers, advanced students and others to obtain authoritative works on special and important subjects which are either ignored or inadequately dealt with in standard text-books. The author of the book under review is certainly an authority on this subject and no one could write with more intimate knowledge of it from the point of view of a manufacturer who has done much to develop the most up-to-date types of potentiometer. The first chapter deals with that important accessory, the standard cell; the Clark cell is mentioned but attention is confined to the Weston type which has superseded it. There is a tendency to say the same thing in a different way within two or three lines, for example, on p. 3: "The internal resistance of the cells is of the order of 1,000 ohms" and "one microampere will probably lower the voltage by a millivolt due to the internal resistance"; and on p. 5 "a 1-ohm resistance in the present international units becomes 1.00048 ohms in absolute units," and "one absolute ampere through an international ohm will give a voltage 480 microvolts high of the absolute volt." In each case the second statement is a corollary of the first and may impress the fact more indelibly on the mind of the student. Chapters II and III deal with the principles and construction of the d.c. potentiometer in its various forms, and chapter IV with its applications. A special type is described which has been developed to meet the requirements of the Electricity Supply (Meters) Act 1936. Surely the saving of space by writing "microhms per centimetre³" is hardly sufficient to justify it, in addition to which, cm³. is the recognised abbreviation of cubic centimetres and not of a centimetre cube. Kirchhoff is robbed of a letter on p. 8, on p. 26 there is a reference to Rs which should be RB, and on p. 34, the reference to Thompson is, we suspect, intended for Thomson afterwards Lord Kelvin. Such little slips are hard to avoid. Chapter V is devoted to galvanometers with special reference, of course, to their application to potentiometer measurement. The various types of a.c. potentiometers are described in Chapters VI and VII, and their uses in the following four chapters. The Drysdale, Larsen, Campbell-Larsen, Pedersen and the author's own type, are all fully described and discussed. When the author leaves his own special field and described such things as the Weston photo-electric potentiometer, he is not so successful. It is the current and not the variation in current, as stated on p. 26, which is a measure of the unknown voltage, and an increase of the potential drop in R_4 causes a raising and not a lowering of the cathode potential of V as stated on p. 27. The author is not always very happy in his choice of symbols; on page 119, for example, i appears to do duty for instantaneous, steady, and root-mean-square values, all within four lines. The many important applications of the a.c. potentiometer to the calibration of meters and instrument transformers, the measurement of iron loss, etc., are all fully discussed, and special attention is paid to the subject of harmonics in magnetisation. On p. 195 we are told that "one of the most successful means adopted for supplying the a.c. potentiometer and the apparatus under calibration is to use a smooth core rotary converter excited from batteries of ample capacity, the former being mechanically coupled to a synchronous motor fed from the frequency controlled National Grid System." It is not clear why or how the rotary converter is employed unless it happens to be the only suitable smooth-core machine available and is run as a generator and not as a converter.

In the chapter dealing with the vector representation of Alternating Currents, the author is somewhat unorthodox in his references to numerical quantities and vectors. He says: "If E_R is a numerical quantity, E_1 will be given in its vector components in relation thereto," and then refers to "the vector relationship between I and E_R." The underlying misconception is found at the foot of page 208 where it is stated that "Treating E_R as a numerical value is really the same as fixing its phase at zero or fixing the co-ordinate system," but on the previous page we read: "The voltage at the relay of admittance Y_R is E_r and the current I_R. Both are numerical values," and therefore presumably both have their phase "fixed at zero," which is obviously impossible. After struggling with these two or three pages for a long time, we were compelled to pass on and leave the question—what is a numerical value? unanswered. On p. 204 "Bleck" should be "Blech."

The book is very well illustrated and every chapter is provided with a very extensive bibliography to which references are made in the text.

With the exception of the two or three points which we have criticised, the book is excellent and can be recommended to anyone who has to use the potentiometer or is interested in allied electrical measurements. G. W. O. H.

Engineering Electronics

By Donald G. Fink. Pp. 358. 217 Figs. McGraw Hill Publishing Co., Aldwych, London, W.C.2. 1938. Price 21s.

The first application of an electronic device was the X-Ray tube (Rontgen, 1895), and although it was almost immediately put to practical use by the surgeon, it was not used to any extent by the engineer for many years. Some twenty years ago, the valve, or high-vacuum tube, became the indispensable tool of the wireless engineer, and it is still the most familiar and widespread electronic application; but in the last ten years or so many other applications of electron technique have become prominent, such as the gas-filled tube (*e.g.* Thyratron, Mercury arc rectifier), the photo-electric cell, and the electronic light-source (*e.g.* Neon sign, Sodium lamp).

In *Engineering Electronics* the author has collected information on all these subjects, "to meet the needs of the practising engineer who has a good foundation in electricity, but who has no specific training in electronic concepts and methods." He has succeeded in his aim, "to steer a course between simple descriptions of equipment on the one hand, and elaborate technicalities on the other."

Like all Gaul, the book is divided into three parts. Part I, "Physical Electronics," gives a general description of the nature and behaviour of the electron in vacuo and in gases, and of its control by electric and magnetic fields, a necessary preliminary to the understanding of particular devices and their applications. This is for the most part clear and easy to follow, though it is surely unnecessary, in writing for the "practising engineer" in 1938, to omit proofs of formulae with the comment "it can be shown by calculus that . . ." One can always "skip" the proof, but its absence when required, perhaps in a hurry, detracts from the value of the book as a work of reference. In the introductory chapter the statement that "each electron is considered to *possess* an electric charge" is misleading; surely the electron does not *possess*, but simply *is*, an electric charge, as correctly stated on page 20.

Part II, "Electron Tubes," describing their construction and characteristics, is perhaps the most valuable part of the book. The chapter on vacuum tubes, though much of it will be familiar to the wireless engineer, contains matter which is not elsewhere available in convenient collected form, and includes typical characteristic curves for different varieties of valve (all American types, but not essentially different from European valves). Another chapter deals with "Gas-filled thermionic electron tubes" (including mercury-vapour tubes), but no convenient brief name for these, analogous to the English "valve" or American "tube," seems yet to have evolved. (The convenient and expressive "*Thyratron*" having been appropriated, in this country at any rate, to the products of one particular manufacturer, is not available; though in most laboratories the term *Thyratron* is used, quite illegally, to denote any triode filled with mercury vapour, quite irrespective of the name of the manufacturer; as distinct from the tube filled with inert gas, such as Neon or Argon, for which there seems no name other than the far from dignified *Gas-bottle*). This chapter contains much that will be of interest and almost immediate use, as do the following chapters on the interaction of light and electricity, as exemplified by Photoelectric cells of various sorts, and electronic light sources; there is here collected in one place information on various devices, some of which are perhaps as yet rather beyond the boundaries of the everyday experience of the wireless engineer, but which are of rapidly increasing importance.

Part III deals with applications, and contains descriptions and skeleton circuit diagrams indicating how the types of electron tubes described in Part II have been applied to Electric Communication, and to Industrial Control. While these are intentionally not fully detailed specifications for the construction of particular instruments, the suggestion of principles adopted will be of use as indicating the lines on which experiments may profitably be conducted to derive apparatus for the performance of specific duties.

The whole is plentifully illustrated with clear diagrams and graphs, and each chapter concludes with a set of numerical examples which can be worked by the student (answers are given in an appendix), and with Bibliographies which suffer from a defect all too common in American works, namely the omission of references to anything published outside the United States. True, there are a few references, perhaps half a dozen in all, to English publications, but there is no reference of any kind to France, Germany or indeed any other country. C. R. C.

Negative Ions

By H. S. W. Massey. Pp. 105 + xiv, 19 Figs. Cambridge University Press. Price 6s.

This is one of the first of a series of Cambridge Physical Tracts, of which about a dozen are in preparation. They are being written by those actively engaged in research and are described as "personal interim reports of important work in progress." The author of this tract is in the Mathematical Physics Department of Queen's University, Belfast, but the work itself is experimental and "anything savouring of elaborate mathematics" has been relegated to small type. There are five chapters dealing respectively with negative atomic ions, negative molecular ions, modes of formation of negative ions, detachment of electrons from negative ions, and negative ions in glow discharges and in the upper atmosphere. This small volume provides in a very handy form a well-written resumé of all that has been done in this subject. Numerous references are given to original papers. One of the difficulties of such a task is the avoidance of the use of words the meaning of which may be known to the initiated, but which convey little or nothing to those for whom the book is presumably intended. We are told, for example, in the opening paragraph of the introduction that the ions must be regarded as forming clusters of considerable size by *solvation*. We turned to the index in vain and the nearest that the dictionary provided was "to solve = to loosen or separate the parts," which does not sound very conducive to the formation of clusters. We fear, however, that this sort of thing is unavoidable in a tract written on a highly specialised field of research by one deeply immersed in it. What is avoidable, however, is the statement on p. 1 that "the potential difference between C and A was 3,000 volts" when in the Figure to which it refers it is marked 6,000 volts. G. W. O. H.

The Industry

THE properties of the various steels (including aluminium alloys) used in the manufacture of permanent magnets are described in a booklet issued by Darwins, Ltd., Fitzwilliam Works, Sheffield.

Particulars of a newly-introduced series of Raytheon voltage regulators with output power capacities of from 25 watts upwards, are obtainable from Claude Lyons, Ltd., 40, Buckingham Gate, London, S.W.1.

Coil-winding machines, hand and power driven, including automatic and semi-automatic types, are described in leaflets issued by the Eta Tool Co., 18, Metcalfe Street, Leicester.

A 43 per cent. increase in the amount paid out in grants is recorded in the 1938 Year Book of the Electrical Industries Benevolent Association. Applications for tickets (price 25/- each) for the Association's Annual Ball, to be held on November 22nd at Grosvenor House, Park Lane, London, W., should be addressed to the E.I.B.A. at 6, Southampton Street, Holborn, London, W.C.1.

The radio installation for the newly launched *Queen Elizabeth*, to be fitted by the International Marine Radio Co., Ltd., will be of an even more comprehensive nature than that with which the *Queen Mary* was equipped by the same company. Extended facilities for passenger radiotelephonic calls are to be provided.

A Note on Asymmetric Side-Band Phase Distortion

By W. E. Benham

JOHNSTONE AND WRIGHT* have established that harmonic distortion of the modulation envelope (i.e. of the detected signal) can arise, even in the complete absence of non-linear devices, as a result of side-band phase distortion. A necessary condition for such harmonic production is that an asymmetry shall exist in the phase angle of any pair of side bands with respect to the carrier. In other words, the mean phase angle $(\theta+\phi)/2$ shall differ from zero, θ, ϕ being the phase angles of the side bands with respect to the carrier.

It can be shown * that, in virtue of the phase angles assumed for the side bands, the received modulating e.m.f. is by the action of the phase shift changed from the value

$$V_0\left(1 + \frac{V_m}{V_0}\cos qt\right)$$

to the value

$$V_0\left[1+2\frac{V_m}{V_0}\cos(\theta+\phi)/2\,.\cos\{qt+(\theta-\phi)/2\} + \frac{V_m^2}{V_0^2}\cos^2\{qt+(\theta-\phi)/2\}\right]^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (1)$$

where V_0, V_m are amplitudes of carrier, modulation voltage respectively.

It appears from this expression that the percentage second harmonic distortion is given approximately by

$$P(h_2) = 25\frac{V_m}{V_0}\sin(\theta+\phi)/2\,.\tan(\theta+\phi)/2\,\% \quad \ldots \quad \ldots \quad (2)$$

the third and higher harmonic being small in comparison with the second. By a graphical method, Professor Howe found,† in the case $(\theta+\phi)/2 = 45°$, $V_m/Vo = 1/2$:—

$$P(h_2) = 10.86\,\% \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

whereas the figure quoted by Johnstone and Wright is 22 %, i.e. just double this value. By the approximate equation (2) the value comes out still less at

$$P(h_2) = 8.85\,\% \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

The example chosen is an extreme one, and corresponds to both side bands leading, or both lagging, with respect to the carrier. By way of illustration, we might have in the case of Fig. 5 of the previous article ‡, a carrier frequency of 37.2 Mc/s and side bands of frequencies in the neighbourhood of (37.2±2.7) Mc/s. Referring to the frequencies marked as parameters on the loop, it will be seen that the phase angle is zero for f35.63 and for f40 Mc/s. Thus the frequencies (37.2±2.7) Mc/s both lead the carrier in phase by an angle of just over 30°. Taking 50 % modulation $\left(\frac{V_m}{V} = \frac{1}{2}\right)$ equation (2) then gives, taking $(\theta+\phi)/2 = 30°$,

$$P(h_2) = 3.6\,\%, \text{ say } 5\,\% \quad \ldots \quad \ldots \quad (4)a$$

It would appear that harmonic distortion represented by (4)a represents the utmost that is likely to arise from the cause under discussion as a result of either double or single side band working, when using the bandpass coupling designed in accordance with curve (*d*), Fig. 7 of the previous paper ‡.

* See Bibliography 3 of the article "Aerial Coupling Systems for Television" in the October issue.

† *The Wireless Engineer*, Oct., 1936, Vol. 13, No. 157, pp. 517 and 518.

‡ "Aerial Coupling Systems for Television," p. 555 of the last issue.

N.P.L. Directorship

THE Lord President of the Council has released Professor R. H. Fowler, O.B.E., F.R.S., at his own request for reasons of health, from the engagement to assume the Directorship of the National Physical Laboratory on 1st October, 1938, in succession to Dr. W. L. Bragg, O.B.E., D.Sc. To the vacancy thus created, the Lord President has appointed Dr. C. G. Darwin, M.C., Sc.D., F.R.S., Master of Christ's College, Cambridge. For the period until Dr. Darwin can assume his duties, the Lord President has decided that the office of Director shall be held by Sir Frank Smith, K.C.B., C.B.E., Sec.R.S., the Secretary of the Department of Scientific and Industrial Research. Correspondence should be addressed as hitherto to the Director, National Physical Laboratory, Teddington, Middlesex.

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

4208. Electromagnetic Waves in Elliptic Hollow Pipes of Metal [Theory giving Field Configurations, Critical Frequencies, Velocities of Propagation, and Attenuations for Six Lowest-Order Waves: Special Case of Circular Cross-Section: Stability of Waves in It for Small Deformation of Cross-Section].—L. J. Chu. (*Journ. of Applied Physics*, Sept. 1938, Vol. 9, No. 9, pp. 583–591.)

4209. Ultra-High-Frequency Transmission along Cylindrical Conductors and Non-conductors [History since 1893 (J. J. Thomson), followed by a Survey of the Mathematical Analysis].—H. W. Droste. (*TFT*, June & July 1938, Vol. 27, Nos. 6 & 7, pp. 199–205 & 273–279: to be contd.)

4210. Dispersion and Absorption [of Ultra-Short Waves] in Polar Substances [Short Survey of Present Knowledge: Reasons for Experimental Critical Wavelength in Liquids often being Shorter than Calculated Value: the Effect in Gases]; *also* Frictional Dispersion of the Dielectric Constants of Organic Liquids [Wavelengths 350 m to 14 cm].—P. Debye & W. Ramm: Plötze. (*Nuovo Cimento*, April 1938, Vol. 15, No. 4, pp. 226–231: in German: *Naturwiss.*, 15th July 1938, Vol. 26, No. 28, pp. 460–461.)

4211. Irregular Variations in the Propagation of Short [and Ultra-Short] Waves over Transoceanic Distances.—H. A. Hess. (*Funktech. Monatshefte*, Aug. 1938, No. 8, pp. 225–233.)

Observations at Pieskow during the summer of 1937 are now added to the writer's previous reports (2059, 2851, & 3589 of 1937, and 1736 of May). They include a daily series of observations in August on the 10.75 m harmonic from the Japanese short-wave station JNJ (Figs. 3–5), which is compared with American results.

4212. A Study of the Penetration of Radio Waves [2–40 Mc/s] into Reinforced-Concrete Buildings.—Eastman, Swarm, & Harrold. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 792: short summary only.)

4213. Short-Wave Reception in Limestone Caverns.—Doborzynski. (*See* 4311.)

4214. Abnormal Ionisation in the E Region of the Ionosphere.—J. A. Pierce. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 892–908.) The full paper, a summary of which was dealt with in 3110 of August.

4215. Further Reports on 56-Megacycle DX, *and* Interpreting 1938's 56-Megacycle DX: Ionosphere Conditions deduced from Long-Distance Amateur Work on Five Metres [Connection between "Abnormal" E Ionisation and 1200–1400 km Contacts: Two or More "Jumps"].—R. A. Hull: J. A. Pierce. (*QST*, Sept. 1938, Vol. 22, No. 9, pp. 21–22 and 113: pp. 23–24 and 72.)

4216. A Study of the F Region of the Ionosphere [in Winter, 1936: Increase in Electron Density at Night: Separate Existence of F_1 Region until Some Hours after Sunset: "Solar Theory of Upper-Atmospheric Ionisation is Inadequate"].—R. R. Bajpai & B. D. Pant. (*Indian Journ. of Phys.*, May 1938, Vol. 12, Part 3, pp. 211–222.)

4217. Commercial Communication with Short Radio Waves, and Ionospheric Studies recently carried out at Various Places on the Earth [Present Frequencies used in Long-Distance Daylight Communications in Northern Hemisphere during Autumn, Spring, and Winter should be Increased 1.5 or 2 Times, with Consequent Reduction in Necessary Power: Dellinger Fade-Outs overcome without Use of Long Waves].—K. Ohno. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts pp. 1–2.) For previous work *see* 2449 of 1937.

4218. The Propagation of the Sky Wave (Wavelengths 200–2000 Metres).—Archanguelsky, Leoushin, & Pabo. (*Nauchno-Tekhnicheski Sbornik* [in Russian], No. 10, 1935, pp. 36–47.)

Authors' summary :—" In this article the results of an experimental study on the sky-wave propagation in the night-time, for wavelengths 200 to 2000 metres, are given. On the basis of a sufficient number of measurements, a relation is established between the propagation constant of a sky wave (E_{med}/E_0), in the complete shadow, and the distance, azimuth and wavelength. For the calculation of the intensity of the field of a sky wave in the complete shadow, field-voltage curves are given in function of the distance (up to 6000 km) for 1 kw of emitted power." The title of this periodical may be rendered " Collected Scientific & Technical Works " (of the Leningrad Institute of Communications).

4219. Critical Frequency Measurements of Wireless Waves Reflected Obliquely from the Ionosphere [and the Question of the Lorentz Term].—F. T. Farmer, C. B. Childs, & A. Cowie. (*Proc. Phys. Soc.*, 1st Sept. 1938, Vol. 50, Part 5, No. 281, pp. 767–775.)

" Experiments are described which compare the F-region skip frequency, for transmission between two distant stations, with that calculated from the normal-incidence characteristics on a simple ray theory." A pulse transmitter was used at each end of the oblique trajectory to correct for horizontal variations of ionisation. " The results show that the theory, which neglects the earth's magnetic field, is very nearly correct for the ordinary wave over a transmission distance of about 500 km. The precise disagreement is determined, and it is believed that if an accurate theory be developed the results will indicate whether or not the Lorentz term should be included in the analysis." For previous work *see* 437 of 1937.

4220. The Relation between Ionospheric Transmission Phenomena at Oblique Incidence and Those at Vertical Incidence.—G. Millington. (*Proc. Phys. Soc.*, 1st Sept. 1938, Vol. 50, Part 5, No. 281, pp. 801–825.)

Author's abstract :—This paper gives a modification for a curved earth of Martyn's theorems [1727 of 1935], relating oblique-incidence ionospheric phenomena with observed conditions at vertical incidence. The theorems in their modified form are shown to hold, as regards both equivalent frequency and absorption, for a relatively thin layer above the earth's surface. It is assumed that the ionic density has the same vertical gradient everywhere between the transmitter and receiver, and that the effect of the earth's magnetic field can be neglected. Methods of allowing approximately for these two factors are discussed. A set of transmission curves is derived, with which the skip frequency at any given distance from the transmitter can be obtained graphically from an observed $P'f$ curve at vertical incidence. Similar curves are given for deducing equivalent heights and angles of elevation at oblique incidence, together with graphs of the maximum receivable frequency at extreme distances and the maximum distance of single-hop transmission, as functions of the height of the layer. The application of the theorem is thus reduced, for the benefit of engineers, to a simple technique of using a number of standard curves in conjunction with a given $P'f$ curve.

4221. Reflection of Atmospherics by the Ionosphere.—Laby & others. (*See* 4247.)

4222. Characteristics of the Ionosphere at Washington, D.C., May, 1938 [Loss of Sporadic-E Reflections at Beginning of Fade-Out could not be due to Absorption ; believed due to Destruction of Characteristic Sharp Reflecting Boundary].—Gilliland, Kirby, & Smith. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 909–913.)

4223. Characteristics of the Ionosphere at Washington, D.C., June 1938 [and a " Tentative Picture " of an Ionosphere Storm : First, or Violent Phase, principally in Auroral Zone ; Second, or Moderate Phase, much longer in Duration and spreading from Auroral Zone towards Equator].—Gilliland, Kirby, & Smith. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 1033–1036.)

4224. The Nature of the Ionosphere Storm [Turbulent and Moderate Phases : Disintegration of Normal Ionospheric Stratification in Auroral Zone, followed by Expansion and Diffusion of Higher F Region in Latitudes removed from Auroral Zone].—S. S. Kirby, N. Smith, & T. R. Gilliland. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 234.)

4225. The Effect of Catastrophic Ionospheric Disturbances on Very Long Waves [*e.g.* 15.15 km Wavelength].—Budden. (In the work dealt with in 4105 of October : a paper on the subject will appear soon.)

4226. The Relation between Radio-Transmission Path and Magnetic-Storm Effects [Relationship between Proximity of Path to Magnetic Pole and Signal Stability during Magnetic Disturbances, based on Reception of European Signals in Long Island and in Puerto Rico : Superiority, by about 8 db, of Latter Reception].—G. W. Kenrick, A. M. Braaten, & J. General. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 831–847.)

4227. Radio Fade-Outs, Auroras, and Magnetic Storms [of 20–22nd and 24–26th Jan. 1938 : Observation Data from New Zealand : in High Latitudes Radio Fade-Out may be due to Ultra-Violet Radiation or to Ionisation by Particle Radiation causing Auroras].—F. W. G. White, H. F. Skey, & M. Geddes. (*Nature*, 13th Aug. 1938, Vol. 142, p. 289.)

4228. Changes in the Ionosphere on the Occurrence of Aurora Borealis.—B. Beckmann, W. Menzel, & F. Vilbig. (*TFT*, July 1938, Vol. 27, No. 7, pp. 245–251.)

A defence of the writers' conclusions (2669 of

July: *see* also 3467 of September) against the opposed hypothesis, brought forward by Dieminger & Plendl (2668 of July), of lateral reflection by a northerly slanting ion front.

4229. Solar Eruptions and Ionospheric Disturbances [At Least 80 per cent. of All Fade-Outs are caused by Solar Eruptions of Ultraviolet Light between 600 and 1000 AU: Increase of Ionisation below E Region].—M. Waldmeier. (*Naturwiss.*, 12th Aug. 1938, Vol. 26, No. 32, pp. 533–534: short note on paper in *Zeitschr. f. Astrophysik*, Vol. 14, 1937, p. 229.)

4230. The Preparation and Properties of Auroral Afterglows [in Pure Nitrogen: Nomenclature of Five Stages of Discharge: Ozone, Nitric Oxide, Cyanogen, Lewis-Rayleigh, Auroral].—J. Kaplan. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 176–178.)

4231. Production of Highly Vibrating Molecules [in Nitrogen Afterglow showing Night-Sky Spectrum], *and* Where does the Light of the Night Sky Originate? [Experiments on Nitrogen Afterglows suggest Most Radiation originates in Lower Regions of Upper Atmosphere].—J. Kaplan. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 230: pp. 241–242: abstracts only.)

4232. Existence of the Bands 2963, 2977 in Night-Sky Spectra [supported by Afterglow Spectrum: Origin at Low Level in Atmosphere: Light of Night Sky resembles Chemiluminescence producing Afterglows].—J. Kaplan. (*Nature*, 27th Aug. 1938, Vol. 142, p. 395.)

4233. Observation of the Varying Intensity of the Green Ray in the Light of the Night Sky.—Wassmuth & others. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 19, 1938, pp. 405–407: in French.)

4234. On the Rôle of Galactic Matter in the Phenomenon of the Zodiacal Light.—B. Fessenkoff. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 6/7, Vol. 19, 1938, pp. 451–452: in French.)

4235. Motion Picture Polarigraph for Sky Light Investigations.—W. M. Cohn. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 241: abstract only.)

4236. Method of calculating Coefficients characterising Atmospheric Turbidity: Variations of This Turbidity in the Neighbourhood of Shanghai [Absorption of Solar Energy by Atmosphere containing Dust Particles].—P. Lejay. (*Comptes Rendus*, 29th Aug. 1938, Vol. 207, No. 9, pp. 439–442.)

4237. Study of the Atmospheric Absorption [and Calculation of the Ozone-Layer Thickness] according to Observations made at Montezuma, 1920/1930, by the Smithsonian Institution.—T. Kiu. (*Journ. de Phys. et le Radium*, July 1938, Series 7, Vol. 9, No. 7, pp. 297–307.)

4238. Carbon Dioxide Content of Stratosphere at 18 Miles' Height only 5 Parts in 100 000 Less than at Surface.—Regener. (*Sci. News Letter*, 13th Aug. 1938, Vol. 34, No. 7, p. 104.)

4239. The Propagation of Sound in the Atmosphere.—Waetzmann & others. (*See* 4390.)

4240. The Transmission Constants of Overhead Lines [Calculations explaining Absorption Peaks due to Neighbouring Lines].—H. Kaden & H. Kaufmann. (*E.N.T.*, July 1938, Vol. 15, No. 7, pp. 210–217.)

4241. Operational Solution of the [Inhomogeneous] Wave Equation [in Three Dimensions: Use of Laplace Transform].—L. A. Pipes. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 333–340.)

4242. On Wave-Motion for Infinite Domains [Integration of General Differential Equation of Wave Motion for One, Two, and Three Dimensions, with Given Initial Conditions: Vibration of Infinite String, Inhomogeneous Equation for One, Two, Three Dimensions].—A. N. Lowan. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 340–360.)

4243. "Contribution à la Théorie du Principe des Ondes enveloppes de Huygens" [Book Review].—J. van Mieghem. (*Rev. Gén. de l'Élec.*, 27th Aug. 1938, Vol. 44, No. 8, p. 226.) One of the collection published by the Belgian Institute of Radio-Scientific Researches.

4244. The State of Polarisation of the Penetrating [Light] Wave at More than Limiting Incidence [derived from Simple Relation to State of Polarisation of Totally Reflected Wave].—G. Salvatore. (*Nuovo Cimento*, March 1938, Vol. 15, No. 3, pp. 139–144.)

4245. Rayleigh Waves [Interaction of Air and Ground: Problem of Flat Earth and Homogeneous Atmosphere: etc.], *and* Coulomb's Function.—H. Bateman. (*Proc. Nat. Acad. Sci.*, Aug. 1938, Vol. 24, No. 8, pp. 315–320: pp. 321–325.)

4246. Paper for the Chemical Recording of Electric Currents and for Styctography, *and* Active Coherers for Styctography [for the Mapping of H.F. Fields].—Z. A. Iofa. (*Journ. of Techn. Phys.* [in Russian], Nos. 10 & 11, Vol. 8, 1938, pp. 915–919 & pp. 1040–1047.)

(1) Investigation of suitable solutions for impregnating paper for this type of recording (*see* 2664 of July). (2) Coherers have been developed which

can be used for styctography without the necessity for a d.c. voltage across the sensitised paper. The preparation of paper for this type of coherer is also described.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

4247. REFLECTION OF ATMOSPHERICS BY THE IONOSPHERE [Oscillographs indicate that *all* Atmospherics are reflected at Ionosphere: Possible Deduction of Ionospheric Reflection Height and Distance of Lightning generating Atmospheric: Reflection of Long Waves occurs below Short-Wave Boundary of E Region].—T. H. Laby, F. G. Nicholls, A. F. B. Nickson, & J. J. McNeill. (*Nature*, 20th Aug. 1938, Vol. 142, pp. 353–354.) For previous work *see* 2881 of 1937.

4248. PRELIMINARY STUDY OF ATMOSPHERIC PARASITES USING THE CATHODE-RAY OSCILLOGRAPH [Two Types of Oscillograms: (1) Short Single Wave, (2) Longer Oscillatory Curve, beginning simultaneously with Lightning].—H. Hubert & J. Barberon. (*Comptes Rendus*, 17th Aug. 1938, Vol. 207, No. 7, pp. 400–402.)

4249. THE APPLICATION OF THE STUDY OF ATMOSPHERIC PARASITES TO METEOROLOGY.—R. Bureau. (*Génie Civil*, 10th Sept. 1938, Vol. 113, No. 11, pp. 226–229.)

4250. ELECTRICAL CHARGE DISTRIBUTION IN THUNDERCLOUDS [and the Existence of Two Distinct Types of Thundercloud, One associated with Considerable Amount of Rain and the Other Not: Simpson's Theory and the Reason for the Contradictory Results of Schonland and Others].—A. K. Dutta. (*Sci. & Culture*, Calcutta, Aug. 1938, Vol. 4, No. 2, pp. 67–72.)

4251. SKY DARKENING ASSOCIATED WITH A SEVERE THUNDERSTORM [Curve of Brightness].—D. R. Barber. (*Nature*, 20th Aug. 1938, Vol. 142, p. 359.)

4252. MULTIPLE LIGHTNING STROKES: II [Great Preponderance of Negative Direct Strokes: No Evidence for Reversal of Polarity between First and Succeeding Discharges: etc.].—K. B. McEachron. (*Elec. Engineering*, Sept. 1938, Vol. 57, No. 9, pp. 510–512.) Further development of the work referred to in 670 of 1935. *See* also Sporn & Gross, *ibid.*, pp. 525–526 and subsequent Discussion.

4253. EFFECTS OF THE LENGTH OF LIGHTNING WAVES ON INDUCED OVER-VOLTAGE IN ARMATURE WINDINGS.—J. Ohkohchi & K. Takeo. (*Electrot. Journ.*, Tokyo, Sept. 1938, Vol. 2, No. 9, pp. 209–214.)

4254. THE PENETRATION OF SURGES INTO WINDINGS [Theory].—E. Hallén. (*Arch. f. Elektrot.*, 15th Aug. 1938, Vol. 32, No. 8, pp. 515–537.)

Author's summary:—It is proposed to base the calculation of the over-voltage phenomena due to an arbitrary incident wave, for all kinds of windings, on certain impedance and distribution functions which can be measured once for all with valve circuits. For this purpose potential expressions are found in which the normal voltage distribution and the superposed over-voltage phenomenon occur separately. The latter is probably very little affected by the magnetic properties of any iron bodies present. The functions referred to are determined by a purely theoretical method for a simple coil and inserted into the potential expressions. The appearance of the surge phenomena can then be discussed.

4255. THE MECHANISM OF THE POSITIVE AND NEGATIVE POINT CORONAS IN AIR AT ATMOSPHERIC PRESSURE.—G. W. Trichel. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 242: abstract only.)

4256. THE DIURNAL VARIATION OF ATMOSPHERIC CONDENSATION NUCLEI [causes Variation in Local Component of Earth's Potential Gradient].—N. E. Bradbury & H. J. Meuron. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 242: abstract only.)

4257. STUDY OF PHASE IRREGULARITIES OF THE DIURNAL COMPONENT OF THE TERRESTRIAL ELECTRIC FIELD [Possible Effect of Semi-Diurnal Component], *and* FORM OF THE SEMI-DIURNAL VARIATION OF THE EARTH'S ELECTRIC FIELD, IN THE CASES WHEN THE PHASE OF THE DIURNAL COMPONENT IS PERTURBED.—R. Guizonnier. (*Comptes Rendus*, 8th & 17th Aug. 1938, Vol. 207, Nos. 6 & 7, pp. 372–374: pp. 403–404.)

4258. ELECTRIC FIELD AND RADIATION OF THE ATMOSPHERE [First Results of a Series of Simultaneous Measurements of Field at Ground Level and Light from the Sky at Periods around Sunrise and Sunset: Special Apparatus: Indications of Correlation suggesting a Common Cause].—E. Medi. (*La Ricerca Scient.*, 15th/31st Aug. 1938, Series 2, 9th Year, Vol. 2, No. 3/4, pp. 139–147.)

4259. HEAVY ELECTRONS ORIGINATE HIGH IN UPPER ATMOSPHERE: FLIGHT INTO SUB-STRATOSPHERE [25 000 Feet] ENABLES SCIENTISTS TO STUDY PENETRATING COMPONENTS OF COSMIC RAYS.—M. Schein & V. C. Wilson. (*Sci. News Letter*, 27th Aug. 1938, Vol. 34, No. 9, p. 131.)

4260. HEAVY ELECTRONS IN COSMIC RAYS [Secondary (or Ternary, etc.) Particles produced by the Penetrating Component of Cosmic Radiation as Result of Some Kind of Interaction with Matter].—Veksler & Dobrotin. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 6/7, Vol. 19, 1938, pp. 479–482: in English.)

4261. COSMIC RADIATION AND MAGNETIC STORMS IN JANUARY, APRIL, AND MAY, 1938 [Cosmic Radiation Variations running Parallel to Strong Magnetic Disturbances].—E. G. Steinke & A. Sittkus. (*Naturwiss.*, 15th July 1938, Vol. 26, No. 28, pp. 461–462.)

4262. I. GENERAL THEORY OF THE EARTH'S SHADOW EFFECT OF COSMIC RADIATION [Reduced Motions of Charged Particle in Meridian Plane of Magnetic Dipole: Topological Features of Allowed Cones in Presence and Absence of Impenetrable Earth]: II. THE SIMPLE SHADOW CONE OF COSMIC RADIATION [Summary of Properties of Trajectories].—E. J. Schremp. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 153–157: 158–162.)

4263. THE DETERMINATION OF THE METEOROLOGICAL CONDITIONS OF THE ATMOSPHERE BY THE USE OF RADIO-SOUNDING BALLOONS.—H. A. Thomas. (*Proc. Roy. Soc.*, Series A, 5th Aug. 1938, Vol. 167, No. 929, pp. 227–250.)

From author's summary:—"In this method a signal of fixed radio frequency is employed and each meteorological instrument produces a continuous variation of modulation frequency. . . . The pressure- and temperature-measuring instruments are both arranged to produce variation of modulation frequency without the use of mechanical linkages. The cost of the apparatus is comparatively low, and reproduction in large quantities is possible. The results obtained from a number of experimental ascents are analysed and it is shown that a high degree of reliability and accuracy is obtainable."

4264. ELECTROLYTIC RESISTORS FOR DIRECT-CURRENT APPLICATIONS IN MEASURING [or controlling] TEMPERATURES [primarily for Radio-Meteorographs, but capable of Other Applications owing to Stability, Large Temperature-Coefficient, and Low Capacitance & Inductance].—Craig. (*Journ. of Res. of Nat. Bur. of Stds.*, Aug. 1938, Vol. 21, No. 2, pp. 225–233.)

4265. NEW METHOD OF SENSITIVE TEMPERATURE AND PRESSURE MEASUREMENTS [giving Remote Indication: Mercury Capillary short-circuiting Varying Length of Thin Resistance Wire].—S. Zamenhof. (*Acta Physica Polonica*, Fasc. 1, Vol. 7, 1938, pp. 1–4: in English.)

PROPERTIES OF CIRCUITS

4266. DISCUSSION ON "THERMAL FLUCTUATIONS IN COMPLEX NETWORKS" [and a Proposed Theorem in terms of a "Current Representation" of Fluctuations comparable with Williams's in terms of a "Voltage Representation": Reply].—D. A. Bell: F. C. Williams. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 432–433.) For Williams's paper *see* 433 of February; for his previous paper (footnote p. 433) *see* 4069 of 1936, and for a later paper, 3872 of October.

4267. FEEDBACK IN LOW-FREQUENCY AMPLIFIERS.—C. G. Mayo & H. D. Ellis. (*World-Radio*, 23rd Sept. 1938, Vol. 27, pp. 10–11.)

4268. THE LINEAR CHARACTERISTICS OF A SIMPLEX FEEDBACK AMPLIFIER.—K. Kobayashi. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, pp. 1–20.) *See* 3892 of October.

4269. WIDE-BAND AMPLIFIER FOR HIGH-FREQUENCY WIRE BROADCASTING.—Buchmann & Barthel. (*See* 4615.)

4270. A HIGH-EFFICIENCY GRID-MODULATED AMPLIFIER.—Terman & Woodyard. (*See* 4300.)

4271. HIGH-FREQUENCY CORRECTION IN RESISTANCE-COUPLED AMPLIFIERS.—Herold. (*See* 4469.)

4272. CIRCUIT DESIGN AND ITS RELATION TO TUBE PERFORMANCE.—L. C. Hollands. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 811: summary only.)

4273. CONSIDERATIONS ON THE SYNCHRONISATION OF OSCILLATORS [particularly the Saw-Tooth Relaxation Oscillator for Time Bases].—Fubini-Ghiron. (*See* 4306.)

4274. STABILISED - FEEDBACK OSCILLATORS.—Stevenson. (*See* 4308.)

4275. THEORY OF THE DIODE VOLTMETER [applicable also to Receiver Detector for Carrier Wave].—Aiken. (*See* 4530.)

4276. ON THE BEHAVIOUR OF RESISTORS AT HIGH FREQUENCIES [and a Further Use of Howe's Theory to give, by Measurements of Resistances, the Distributed Capacities: Some Measurements on Resistors on Italian Market: Little Influence of Type of Winding].—P. Pontecorvo: Hartshorn. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 500–501.) Prompted by Hartshorn's paper, 4106 of October. *See* also 4277, below.

4277. THE EFFECT OF THE DISTRIBUTED CAPACITY ON THE BEHAVIOUR OF RESISTORS AT HIGH FREQUENCIES.—Pontecorvo. (*Alta Frequenza*, Aug./Sept. 1938, Vol. 7, No. 8/9, pp. 570–581.)

See also 4276, above. Author's summary:—"According to Howe's theory, a resistor may be considered as a short-circuited line with constant series resistance and constant parallel capacity per unit length. The ratio R_f/R_{cc} (= r.f. resistance/d.c. resistance) is a function of the parameter $f.l.C.R_{cc}$. Howe's theory has been tested by Hartshorn [4106 of October] by r.f. measurements of resistance and by evaluation of the factor $l.C = C_d$, which is liable to be difficult in the case of capacitance less than 1 microfarad.

"It is shown that the difficulty may be avoided by a simple graphical method which consists in using $f.R_{cc}$, instead of $f.l.C.R_{cc}$, as a parameter. From the results of a series of measurements on a set of resistors of Italian manufacture, the value of C_d is calculated; Howe's theory is found to be very closely followed, and the dependence of the electrical properties of the resistor on its geometrical dimensions is discussed."

4278. Voltage-Regulated Impedances [the Use of an Amplifier Valve of High Internal Resistance and Widely-Adjustable Slope (Hexode) as a Practically Loss-Free Variable Condenser adjusted by Grid Bias].—R. Feldtkeller. (*TFT*, June 1938, Vol. 27, No. 6, pp. 205–210.) For AFC, the tuning of bridge circuits, the frequency variation of oscillators in h.f. and a.f. measurements, for telemetering, and other purposes.

4279. Time Constants for AVC Filter Circuits.—Sturley. (*See* 4315.)

4280. Crystal Band-Pass Filters.—Robinson. (*See* 4316.)

4281. Choke *versus* Condenser Input [for Smoothing Filter].—Scroggie. (*See* 4317.)

4282. The Use of Imaginary Notations for the Study of Transient Régimes, *and* On the Elementary Process of Calculation of Transient Régimes.—E. Fromy: R. Mesny. (*Bull. de la Soc. franç. des Élec.*, June 1938, Vol. 8, No. 90, pp. 541–567: pp. 568–570.)

4283. Calculation of Transients: a Simplified Method.—R. Feinberg. (*Electrician*, 16th Sept. 1938, Vol. 121, pp. 311–312.)

4284. Correction [to a Function assumed in the Theory of the Paper "Current Circuits with Inductances containing Iron"].—W. Taeger. (*Arch. f. Elektrot.*, 15th Aug. 1938, Vol. 32, No. 8, p. 554.) *See* 2693 of July.

4285. The Saturation Choke Coil as a Power Amplifier [Analysis: Design Data: Interrelation of Amplification Factor, Control Factor, Lag, etc: Power Amplification Factors of 15–20: Multi-Cascade Amplifiers].—G. R. Herzenberg. (*Automatics & Telemechanics* [in Russian], No. 2, 1938, pp. 35–46.)

4286. A Comparative Analysis of Dynamic and Static Electro-Magnetic Characteristics [Permissible Practical Use of Latter in place of Former for Well-Laminated Cores in Toroidal Coils].—V. I. Kovalenkov. (*Automatics & Telemechanics* [in Russian], No. 2, 1938, pp. 47–68.)

4287. Loci and Diagrams of the Leakage Transformer [Theory based on Fundamental Circuit: Loci for Various Loads: Practical Applications of Theory].—J. Kunte. (*Arch. f. Elektrot.*, 15th Aug. 1938, Vol. 32, No. 8, pp. 537–552.)

4288. A Method of designing Simulative Networks [for Particular Case of Transmission Lines: Zobel's Treatment of "Supplementary Network" ("Excess Simulator," correcting Impedance Deviation at Lower Frequencies) often leads to Negative Values: Simple New Treatment shows What Modification will yield Most Satisfactory Set of Positive Elements].—W. A. Edson. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 877–891.)

4289. Measuring [the Phase Shift and Current & Voltage Ratios of] Four-Pole Networks [terminated in Any Impedance: Practical Method].—J. L. Clarke. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 30 & 31.)

4290. Coupling Oscillations in Mechanical and Electrical Systems [Survey].—H. Awender & O. Lange. (*Funktech. Monatshefte*, Aug. 1938, No. 8, pp. 249–251: to be contd.)

4291. On the Law of Action and Reaction in the Electrodynamics of Stationary Circuits [Proof that Equality follows from Grassmann's Law].—M. Wolfke. (*Acta Physica Polonica*, Fasc. 1, Vol. 7, 1938, pp. 10–13: in German.)

TRANSMISSION

4292. The Virtual Cathode in the Magnetron [Theoretical Proof that Virtual Cathode, with Apparent Diameter a Function of Magnetic-Field Intensity, plays Important Part in Mechanism of "Type B" Oscillations in Split-Anode and Electron-Beam Magnetrons].—K. Okabe. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, pp. 21–25.) For "Type B" oscillations *see* 1823 of May and 521 of February, and for electron-beam magnetrons *see* 132 of January.

4293. Outputs of 100–400 Watts at 50–80 cm Wavelength obtained with Small Non-Water-Cooled Sectionalised Magnetron giving Type B Oscillations.—Owaki. (Mentioned in Okabe's paper, above—4292.)

4294. Obtaining Dwarf-Waves with Multi-Split-Anode Magnetrons [Periods roughly one *n*th of Electron Period ($n = 1, 2, 3$) obtained with Six- and Eight-Split Types].—K. Okabe. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, pp. 27–29.)

4295. The Mechanism of the Generation of Short-Wave Oscillations in the Magnetron [Short Survey].—H. Klinger. (*Funktech. Monatshefte*, Aug. 1938, No. 8, pp. 245–248.)

4296. Kinds of [Micro-Wave] Oscillations and Wavelengths produced by B-Type Parallel-Wire Oscillator.—S. Ohtaka. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 296–297: summary only.) *See* also 1826 of May.

4297. Considerations on the Optimum Dimensioning of Bifilar Lines at [Ultra-] High Frequencies.—Poledrelli. (*See* 4342.)

4298. "Transmission-Line" Modulation for High-Fidelity Television.—Parker. (*See* 4447.)

4299. Some Recent Developments in Frequency Modulation at 40 Megacycles.—E. H. Armstrong. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 806–807: summary only.)

4300. A HIGH-EFFICIENCY GRID-MODULATED AMPLIFIER [using Impedance-Inverting Quarter-Wave Transmission Line as in Doherty System, but giving High-Level Modulation with Its Advantages while requiring only Small Modulating Power: Efficiencies of 65 to 80%: Negative Feedback easy to Apply (Fewer R.F. Stages than in Low-Level System): etc.].—F. E. Terman & J. R. Woodyard. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 929–945.)

4301. HIGH-EFFICIENCY MODULATION SYSTEM [Positive Peaks dealt with by Load Line Modification (by Modulation-Controlled Absorber returning Absorbed Power to D.C. Supply Source), Negative Peaks by Grid Modulation: D.C./Carrier Conversion Efficiencies 50–60% for Average Valves].—R. B. Dome. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 963–982.)

4302. A PHASE-OPPOSITION SYSTEM OF AMPLITUDE MODULATION [Comparison of Input Power required, for Unmodulated Carrier Power of 100 kW, in High-Level Class A, Low-Level with Premodulation, High-Level Class B, Chireix "Outphasing," and Doherty Systems: Influence of Rates for Electric Power: a New "Phase-Opposition" System with Constantly Excited Carrier Generator and Sideband Generator with Excitation changed 180° in Phase according to Phase of Modulation].—L. F. Gaudernack. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 983–1008.)

4303. WIDE-BAND AMPLIFICATION AND MODULATION IN THE HIGH-FREQUENCY POWER TRANSMITTER [and the Important Influence of the Sending-End-Impedance Characteristic of the Plate-Circuit Band-Pass Filter on the Deformation of Wave Form: Grid Excitation and the Effect of the Distorted Wave Form of the Grid Current].—Y. Kikuti. (*Electrot. Journ.*, Tokyo, Sept. 1938, Vol. 2, No. 9, p. 220.)

4304. CORRECTION TO "THE CARRIER-CURRENT SUPPRESSION IN MODULATION CIRCUITS."—V. Aschoff. (*TFT*, June 1938, Vol. 27, No. 6, p. 238). *See* 2712 of July.

4305. A SINGLE-TUBE "FLOATING NEEDLE" VOLUME INDICATOR, *and* AUTOMATIC ADJUSTMENT FOR MODULATION INDICATOR.—H. C. Likel: R. W. Carlson. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 38 and 40: pp. 40 and 42.)

4306. CONSIDERATIONS ON THE SYNCHRONISATION OF OSCILLATORS.—E. Fubini-Ghiron. (*Alta Frequenza*, July 1938, Vol. 7, No. 7, pp. 459–464.)

"The subject of the synchronisation of oscillators has been much studied but, if attacked from the point of view of the non-linear theory of oscillations, presents serious analytical difficulties. Very interesting contributions to the subject have appeared for comparison recently in the literature [Carrara, 1816 of May, and Rocard, 2252 of June: for a subsequent paper *see* 3522 of September]. Carrara, abandoning the traditional path inspired by purely analytical conceptions, has succeeded in obtaining noteworthy results by the skilful utilisation of new physical conceptions. Rocard, on the other hand, has dealt with the particular case of the non-linear oscillator and has been able to give, for this, the complete analytical form of the solution. The results obtained from examination of the second case, and the apparent analogy of certain conclusions, have made me think it would not be wholly profitless to communicate certain considerations relating to another special case—that of the saw-tooth oscillator [relaxation-oscillation circuit using a thyratron] employed for a cathode-ray-tube time base . . ." The treatment is a simple one, and the theoretical conclusions are confirmed qualitatively by experiment. For low voltages the agreement is within about 20%, for high voltages the comparison is made difficult by the presence of numerous harmonics.

4307. TRANSIENT FREQUENCY VARIATION OF CRYSTAL OSCILLATOR.—Koga & Shoyama. (*See* 4518.)

4308. STABILISED-FEEDBACK OSCILLATORS [Frequency Constancy, under Changes of Potentials or of Cathode Temperature, treated on Lines of Recent Studies of Feedback Amplifiers: Conditions for Stability in Terms independent of Circuit Configurations and applicable to Certain Dissipative Circuits as well as to purely Reactive Systems].—G. H. Stevenson. (*Bell S. Tech. Journ.*, July 1938, Vol. 17, No. 3, pp. 458–474.)

4309. SELECTING THE BEST METHOD OF APPLYING NEGATIVE FEEDBACK TO VARIOUS TYPES OF TRANSMITTERS.—L. S. Bookwalter. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 792: summary only.)

4310. AUDITORY PERSPECTIVE ON A SINGLE CARRIER.—Sandstedt. (*See* 4617.)

RECEPTION

4311. SHORT-WAVE RECEPTION IN LIMESTONE CAVERNS.—D. Doborzyński. (*Hochf:tech. u. Elek:akus.*, Aug. 1938, Vol. 52, No. 2, pp. 67–69.)

For previous work *see* 1712 of 1936. Data of reception experiments in a damp limestone cavern are here given which show that short waves can be received after they have penetrated a depth of about 30 m of limestone rock, though they are absorbed and weakened to some extent. The results agree with those of Fritsch (4273 of 1936).

4312. NOISE IN RECEIVING SETS [Introduction of Concepts "Noise Voltage" and "Specific Noise Voltage": Explanation of Experimental Determination of Specific Noise Voltage: Variation of Noise Resistance as Function of Aerial Signal: Permissible Ratio and Noise Graphs].—M. Ziegler. (*Philips Tech. Review*, July 1938, Vol. 3, No. 7, pp. 189–196.)

4313. TELEDYNAMIC CONTROL BY SELECTIVE IONISATION WITH APPLICATION TO RADIO RECEIVERS.—S. W. Seeley, H. B. Deal, & C. N. Kimball. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 813–830.) The full paper, a summary of which was dealt with in 934 of March: *see* also 1389/1391 of April.

4314. SOME DEVELOPMENTS IN PRESELECTORS AND ELECTRIC TUNERS [including a Tuner with a Number of Notched Discs clamped on Rotor connected to Variable Condenser and actuated by Latches driven by Magnets].—H. F. Elliott. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 793: summary only.)

4315. TIME CONSTANTS FOR AVC FILTER CIRCUITS [Mathematical Investigation, up to Three Stages, with Experimental Confirmation: Series and Parallel Networks—Latter superior to Former, giving Lower Charge & Discharge Time Constants for Same Filtering Action: etc.].—K. R. Sturley. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 480–494.)

4316. CRYSTAL BAND-PASS FILTERS [Band-Pass Circuits "of Almost Ideal Characteristics" for Broadcast Receivers: using Two Crystals (of Different Resonance Frequencies) in Bridge Circuit].—Robinson. (*Wireless World*, 15th Sept. 1938, Vol. 43, pp. 251–253.) A short anonymous résumé of Robinson's early and recent work: "more information on this new development" is promised.

4317. CHOKE *versus* CONDENSER INPUT [for H.T. Smoothing Filter: Advantages of Choke Circuit for Many Applications such as Transmitters and High-Efficiency Amplifiers].—M. G. Scroggie. (*Wireless World*, 8th Sept. 1938, Vol. 43, pp. 224–226.)

4318. VARIABLE-INDUCTANCE TUNING APPLIED TO AUTOMOBILE-RADIO REMOTE CONTROL [using Displacement of Powdered-Iron Core along Coil Axis].—W. L. Dunn. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 800: summary only.)

4319. VARIABLE INDUCTANCE TUNING [American System].—W. N. Weeden: Ware. (*Wireless World*, 15th Sept. 1938, Vol. 43, pp. 244–246.) *See* also 1387 of April & 2293 of June.

4320. IRON POWDER CORES: THEIR USE IN MODERN RECEIVING SETS [Reason for Comparative Reluctance of English Designers to employ Them: Some Lines of Design (particularly for I.F. Filters and Push-Button Tuning): Trimming: etc.].—E. R. Friedlaender. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 473–479.)

4321. DISTRIBUTION OF MAGNETIC FLUX IN AN IRON POWDER CORE [Non-Uniform Distribution due to Eddy Currents can only be Appreciable at Wavelengths below about 6 m, for Insulated Particles: Small Trimming Effect of Brass Insert at Centre must be due to Imperfect Insulation, leading to Groups of Particles].—G.W.O.H: Friedlaender. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 471–472.) Editorial investigation prompted by a statement in Friedlaender's article (4320, above). The paper by Austin & Oliver (3570 of September) is referred to.

4322. COILS WITH POWDERED-IRON CORES [Survey, including the Optimum Permeabilities for Various Frequency Ranges (from $50\mu_0$ and over for Frequencies below 10 kc/s, to $20-2\mu_0$ above 100 kc/s)].—Kersten. (*Elektrot. u. Masch:bau*, 21st Aug. 1938, Vol. 56, No. 34, p. 441: summary only.) For other papers by the same writer *see* 2377 & 2381 of 1937 and 496 of February.

4323. DIVERSITY RECEPTION AT HOME.—R. H. Tanner. (*Wireless World*, 1st Sept. 1938, Vol. 43, pp. 194–196.)

4324. CONTRAST EXPANSION AND ITS APPLICATION [System using Low-Impedance Triode as Lower Limb of Potentiometer].—L. Colston-Jones & G. C. Bocking. (*Wireless World*, 22nd Sept. 1938, Vol. 43, pp. 272–275.) From the Tungsram laboratories.

4325. THE AEG BROADCAST RECEIVERS FOR 1938/1939, *and* THE TUNING OF THE BROADCAST RECEIVER [and Automatic Tuning Correction].—W. Hering: B. Freystedt. (*AEG-Mitteilungen*, Aug. 1938, No. 8, pp. 429–435: pp. 435–439.)

4326. PARIS RADIO SHOW [Push-Button Tuning—Opposing Views: Sets with R.F. Amplifier in Separate Small Case (with Tuning Knobs & Dial) fitting into Space in Set and connected by 15 ft. Cable rolled on Reel: etc.].—(*Electrician*, 9th Sept. 1938, Vol. 121, p. 283.)

4327. WHAT'S NEW IN RADIO SETS [Circuit and Mechanical Features of Receivers for End of 1938 and 1939].—(*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 8–13 and 55.) Preselection ("time tuning"); the "beamascope" frame aerial; chassis design; Philco's remote control; stabilised components make AFC less necessary; etc.

4328. RECEIVERS UNDER THE TITLE "COMBINED APPARATUS FOR RADIOPHONY [Broadcasting] AND TELEDIFFUSION" [Wire Broadcasting]: OFFICIAL REPORT OF TESTS.—(*Bull. Assoc. suisse des Élec.*, No. 19, Vol. 29, 1938, pp. 539–540.)

4329. THE *Wireless World* COMMUNICATION RECEIVER [13 Valves, 5.2–2000 m Range in 8 Bands: Output 7 Watts].—(*Wireless World*, 25th Aug., 1st & 8th Sept. 1938, Vol. 43, pp. 164–169, 199–203, 229–233.)

4330. OLYMPIA SHOW REPORT, *and* OLYMPIA SHOW REVIEW.—(*Wireless World*, 25th Aug. & 1st Sept. 1938, Vol. 43, pp. 172–183: pp. 207–217.)

4331. PLASTICS FOR [Cabinets of] RADIO RECEIVERS.—H. Chase. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 20–21 and 24.)

4332. ELECTROLYTIC CONDENSERS [Conclusions from Measurements on Commercial Types for Receivers].—Chrétien. (*See* 4576.)

4333. LIABILITY TO INTERFERENCE OF BROADCAST RECEIVER INSTALLATIONS IN THE NEIGHBOURHOOD OF TRAMWAYS.—W. Gerber & H. Kölliker. (*Bull. Assoc. suisse des Élec.*, No. 17, Vol. 29, 1938, pp. 454–456: in German.)

"On the foundation of measurements of the pick-up powers of the installations, in the signal field and in the interference field, the writers study by statistical methods the interference relations in the neighbourhood of urban tramway lines, thus creating a first basis of discussion on the permissible interference voltages on these lines." For previous work *see* 1407 of April.

4334. NOTE ON THE EXPERIMENTAL STUDY AND MEASUREMENT OF INDUSTRIAL INTERFERENCE.—E. Fromy. (*L'Onde Élec.*, Aug./Sept. 1938, Vol. 17, No. 200/201, pp. 373–383.)

Methods hitherto adopted show the imperfections which have already caused their abandonment for the analogous measurements in the permanent régime and which are particularly serious for the purpose in question, since the mode of action of parasites on a receiver is very different from that of an undamped wave and very little is known about it. The problem, therefore, seems to remain in its entirety, and the writer turns for its solution to the methods which have proved their worth in the usual measurements of undamped or modulated waves. He is thus led: (1) to the construction of a calibrated generator producing waves of a type comparable with that of industrial parasites; *i.e.*, damped periodic waves of known and controllable characteristics; (2) to the use of this generator according to a technique identical with the ordinary measurements in the permanent régime, either by itself or in conjunction with an ordinary generator, to study the behaviour of a receiver in the various practical conditions of service; and (3) to the measurement of the level of a parasite by substituting for the unknown parasite the calibrated interference-generator adjusted so as to produce, on whatever receiver is employed, the same apparent effect: the receiver characteristics playing no part in the result of the measurement.

The interference-generator circuit is shown in Fig. 1; it consists of an oscillatory circuit LC whose condenser is periodically charged from the d.c. source E and discharged through L, by a 50 c/s vibrator V. At each discharge a damped sinusoidal voltage (adjustable over a wide frequency range) is obtained, all of whose characteristics are known from the calibration of the LC circuit, and whose magnitude can be reduced in known ratios, so as to range from perhaps 50 volts to a few microvolts, by a capacitive potentiometer as shown in the figure, or by a similar arrangement of resistances. The whole circuit is enclosed in a screened case.

4335. SENSITIVITY TO MAINS DISTURBANCES OF UNIVERSAL-CURRENT RECEIVERS, FOR LOW-FREQUENCY DISTURBING VOLTAGES.—A. Dennhardt. (*Hochf:tech. u. Elek:akus.*, Aug. 1938, Vol. 52, No. 2, pp. 63–67.)

The fundamental circuit used for these measurements is shown in Fig. 1; an additional audio-frequency voltage is fed in through the d.c. mains and adjusted to give a constant low acoustic intensity from the loudspeaker. The d.c. mains used had no audio-frequency component with noticeable effect on the results. Figs. 2–6 give curves of the stability towards disturbances of various receivers; the "disturbance sensitivity" is taken as the minimum of the stability curve. Practical deductions from these curves as to the properties of the receivers used are drawn in § IV; the effect of rectifier-fed mains on the universal-current receiver is discussed in § IV 3b. It is concluded that in future special consideration must be given to the provision of smoothing devices on the rectifier.

4336. ELECTRICAL INTERFERENCE WITH RADIO RECEPTION [with Extensive Bibliography and an Appendix on the Theory of Signal/Noise Ratio in Ideal Receivers].—A. J. Gill & S. Whitehead. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 345–386: Discussion pp. 386–394.) Summaries were referred to in 2305 of June and 2742 of July.

4337. RADIO INTERFERENCE—LOCATION, SUPPRESSION, AND CONTROL.—H. O. Merriman. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 805–806: summary only.)

4338. THE 7TH NATIONAL CONGRESS ON PROTECTION AGAINST RADIOELECTRIC INTERFERENCE.—M. Adam. (*Génie Civil*, 13th Aug. 1938, Vol. 113, No. 7, pp. 142–145.)

4339. AEG INTERFERENCE-QUENCHING CONDENSERS FOR HIGH REQUIREMENTS.—H. Kvätz. (*AEG-Mitteilungen*, Aug. 1938, No. 8, pp. 442–443.)

AERIALS AND AERIAL SYSTEMS

4340. THE DISTRIBUTION OF ULTRA-HIGH-FREQUENCY CURRENTS IN LONG TRANSMITTING AND RECEIVING ANTENNAE [Analysis with Experimental Confirmation on Wavelengths around 70 cm].—L. S. Palmer & K. G. Gillard. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 415–423.) *See* 2956 of 1937 for a letter to *Nature*.

4341. MULTIPLE REFLECTIONS BETWEEN TWO TUNED RECEIVING ANTENNAE [Analysis (with Experimental Confirmation on 80 cm Waves) in connection with Short-Wave Beam Systems with Idle Reflecting Wires: Extension of Previous Work by considering Multiple Reflections: These have Little Effect on Optimum Spacings but More on Current Magnitudes: Aerials which are Close together *do* affect Field in Each Other's Neighbourhood unless Joining Line is Perpendicular to Propagation Direction: etc.].—L. S. Palmer, W. Abson, & R. H. Barker. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 424–432.) For the previous paper *see* 1929 Abstracts, p. 634.

4342. CONSIDERATIONS ON THE OPTIMUM DIMENSIONING OF BIFILAR LINES AT [Ultra-] HIGH FREQUENCIES.—C. Poledrelli. (*Alta Frequenza*, July 1938, Vol. 7, No. 7, pp. 435–446.)

"To obtain from a bifilar line one of these optimum conditions [max. coefficient of resonance, max. coefficient of supertension, max. value of input impedance, or minimum losses], the geometrical dimensions must fulfil certain conditions which are to be found in many places in the literature. The methods employed for the execution of such calculations are substantially two: one, the more common, neglects the radiation losses, while the other [Reukema, 1829 of May] allows for it in an approximate way. The results of these two methods show notable differences between them. It is the object of the present work to vary, perhaps to improve (in the case of bifilar lines) the approximations at the basis of these calculations; to investigate the influence, on the final results, of changes in the simplifying assumptions and of the presence of elements which appear to be mere accessories (connecting leads, short-circuiting bars) unavoidable in actual practice; and finally to give, by such discussion, a clear idea of the limits of the approximations obtained. In order that the reader may quickly recognise the usefulness of such a discussion, Table I gives a collection of the formulae and data for a line resonating on a half wavelength (open and short-circuited) to give a maximum resonance coefficient at 300 Mc/s."

4343. THREE TYPES OF WIDE-BAND CABLE [and the Use of Very Flexible Waterproof Tubes of "Telconax"].—E. W. Smith. (*E.T.Z.*, 1st Sept. 1938, Vol. 59, No. 35, p. 948: summary only.)

4344. THE ELECTRICAL PROPERTIES OF A THREAD SUSPENSION OF THE CONDUCTOR IN H.F. CABLES.—Cords. (*See* 4466.)

4345. THE APPLICATION OF TRANSMISSION-LINE THEORY TO [Single-Turn] CLOSED AERIALS [Analytical Treatment (now being checked by Experiment) and Some Conclusions, of Interest in connection with Field-Strength Measuring Equipment for Short & Ultra-Short Waves, etc: Definition and Measurement of "Resonance Factor": etc.].—F. M. Colebrook. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 403–414.)

4346. RECEPTION OF B.B.C. TELEVISION AT 100 MILES [with Description of Aerial].—S. West. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 388–389.)

4347. SURFACE RADIATION FROM HORIZONTAL AERIALS AND MEASUREMENT OF THE ELECTRICAL CONSTANTS OF THE GROUND.—G. Latmiral. (*Alta Frequenza*, Aug./Sept. 1938, Vol. 7, No. 8/9, pp. 509–535.)

Author's summary:—"A horizontal dipole generates a surface radiation only if the ground lying under it is not a perfect conductor; the formulae for the calculation of the field generated at a distance are shown to be deducible from the reciprocity theorem (Part I). In order to extend the above theory and calculations to the case of an aerial of a given length, the concept of the 'effective length' of a horizontal aerial is introduced, and formulae are given for calculating it in various cases. These formulae are also shown to provide a method for measuring the e.m. constants of the ground (Part II). Finally, experimental results and practical considerations are considered with respect to the use of horizontal aerials and to the selection of the best wavelength for a given arrangement (Part III)." A fuller summary, in French, is given on the two pages following p. 656.

4348. AERIALS WITH PROGRESSIVE AND STANDING WAVES [the Recent Tendency to ascribe All the Merits to the Former ("Rhombic," and Its Complex Form, the "Musa"): Choice really largely dependent on Cost and Availability of Land: No Special Independence of Frequency, as often claimed].—J. Grosskopf. (*TFT*, June 1938, Vol. 27, No. 6, pp. 220–225.)

4349. THE MULTIPLE-UNIT STEERABLE ANTENNA FOR HORIZONTAL-PLANE DIRECTIVITY.—Bown: Feldman. (*See* 4622.)

4350. BROADCAST ANTENNAS [Common Practice in Vertical-Aerial Design: a New Method of Top Loading: Field Surveys].—N. D. Webster. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 796: short summary only.)

4351. COMPUTING ANTENNA HEIGHT [or, alternatively, Determining the Mode of Operation in Electrical Degrees when Height in Feet and Operating Frequency is known].—C. C. Jinks. (*Electronics*, July 1938, Vol. 11, No. 7, p. 30.)

4352. "L'ANTENNE RAYONNANTE" [Book Review].—P. Baudoux. (*Rev. Gén. de l'Élec.*, 27th Aug. 1938, Vol. 44, No. 8, p. 226.) One of the collection published by the Belgian Institute of Radio-Scientific Researches.

4353. VIBRATION OF POWER LINES IN A STEADY WIND: IV—NATURAL FREQUENCIES OF VIBRATION OF STRINGS WITH STRENGTHENED ENDS.—R. Ruedy. (*Canadian Journ. of Res.*, July 1938, Vol. 16, No. 7, Sec. A, pp. 138–148.)

4354. Regulations for Controlling the Earthing of Electrical Installations to Metal Water-Pipes and Water-Mains.—(*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 434–435.)

VALVES AND THERMIONICS

4355. The Causes for the Increase of the Admittances of Modern High-Frequency Amplifier Tubes on Short [25 m–0.5 m] Waves.—M. J. O. Strutt & A. van der Ziel. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 1011–1032.) A German version was dealt with in 524 of February. For later papers *see* 3211 of August, 3598 of September, and 3946 & 3947 of October.

4356. The Virtual Cathode in the Magnetron, *and* Obtaining Dwarf-Waves with Multi-Split-Anode Magnetrons.—Okabe. (*See* 4292 & 4294.)

4357. On the Operation of a Cylindrical Diode at High Frequencies.—G. Grünberg & A. Bliznjuk. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 8, 1938, pp. 798–811.) A German version was dealt with in 3210 of August.

4358. A High-Frequency Amplifier Tube of New Design [Type 1231 Pentode for Video Frequencies].—C. F. Miller. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 803–804: summary only.) A Hygrade Sylvania product.

4359. The Principles of the Pentode Valve [including the Use of Negative Feedback to obtain Characteristics similar but superior to Those of a Triode].—H. D. McD. Ellis. (*World-Radio*, 26th Aug. 1938, Vol. 27, pp. 16–17.)

4360. A New High-Mutual-Conductance, High-Frequency Amplifier Tube [RCA-1851].—A. P. Kauzmann. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 808: summary only.)

4361. Discussion on "Thermal Fluctuations in Complex Networks."—Bell: Williams. (*See* 4266.)

4362. Noise in Receiving Sets.—Ziegler. (*See* 4312.)

4363. Mixer Considerations.—C. R. Hammond. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 804–805: short summary only.)

4364. A Super-Sensitive Valve, Type RH-507, for Measurement of Nerve-Impulse Currents, etc.—Westinghouse Company. (*Scient. American*, Sept. 1938, Vol. 159, No. 3, p. 141: paragraph only.)

4365. New Valves for the Broadcasting Year 1938/39 [particularly the German "Steel" Valves and the "Red Series" from Austria].—C. Kerger. (*Funktech. Monatshefte*, Aug. 1938, No. 8, pp. 233–244.)

4366. Steel Valves in the New AEG-Super 88 WK.—G. Fellbaum. (*AEG-Mitteilungen*, Aug. 1938, No. 8, pp. 439–442.)

4367. New German Valves [Metal ("Harmonic" Series), and the Special Valves for the "Small" People's Receiver].—(*Wireless World*, 8th Sept. 1938, Vol. 43, pp. 227–228.) *See* also 3960 & 3961 of October.

4368. New Radio Valves of the Season 1938/1939.—(*Bull. Assoc. suisse des Élec.*, No. 18, Vol. 29, 1938, pp. 509–512: in German.)

4369. Short Cuts in Vacuum-Tube Design.—M. A. Acheson. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 810: short summary only.)

4370. Some Developments and Problems of Demountable-Tube Design.—C. V. Litton. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 795 & 809: short summaries only.)

4371. On the New Short-Wave 60 kW Vacuum Tube Type TW-530-B.—M. Kobayashi & H. Nishio. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 290–291: summary only.)

4372. Phenomena in Amplifier Valves caused by Secondary Emission [and Methods of Combating the Undesired Effects].—J. L. H. Jonker. (*Philips Tech. Review*, July 1938, Vol. 3, No. 7, pp. 211–216.)

4373. Secondary Emission of Beryllium [Measurements on Films prepared by Evaporation in High Vacuum: Maximum Secondary Emission Ratio for Pure Bulk Beryllium].—E. G. Schneider. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 185–188.)

4374. Papers on Secondary Emission.—(*See* under "Phototelegraphy & Television.")

4375. Normal Modes of Vibration of a Body-Centered Cubic Lattice [Theory: Application to Calculation of Specific Heat, Elastic Constants, etc., of Tungsten].—P. Fine. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 239–240: abstract only.)

4376. The Influence of Adsorption Films on Electron Emission and Ion Reflection in the Impact of Positive Caesium Ions on Tungsten.—Paetow & Walcher. (*See* 4484.)

4377. The Spontaneous Electron Emission occurring at the Electrodes as an After-Effect of Gas Discharges [Effect due to Surfaces and Adsorption Films: Excited by Discharge Photons] and the Field Electron Emission from Thin Insulating Films.—Paetow. (*Naturwiss.*, 29th July 1938, Vol. 26, No. 30, p. 497.)

4378. VARIATION OF FIELD ELECTRON EMISSION FROM POINTS WITH EFFECTIVE FIELD STRENGTH [Shape of Points determined with Electron-Optical Microscope and Field Strength calculated: Quantitative Test of Wave-Mechanical Field-Emission Theory].—R. Haefer. (*Naturwiss.*, 29th July 1938, Vol. 26, No. 30, p. 497.)

4379. A SEARCH FOR TEMPERATURE CHANGES ACCOMPANYING FIELD EMISSION AT HIGH TEMPERATURES [below Temperature of Thermionic-Emission Onset, only Small Proportion of Emitted Electrons share Thermal Energy of Metals Studied].—G. Fleming & J. E. Henderson. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 241: abstract only.) For previous work *see* 167 of 1936.

4380. THERMIONIC EMISSION FROM PLATINUM IN HYDROGEN AND OXYGEN [including the Influence of Pressure & Temperature and the Determination of the Work Functions].—S. Kalandyk. (*Acta Physica Polonica*, Fasc. 1, Vol. 7, 1938, pp. 68–80: in German.)

4381. DIFFRACTION OF ELECTRONS BY OXIDE-COATED CATHODES [Examination of Surfaces of Nickel Cathodes coated with Barium and Strontium Oxides: Electron-Diffraction Patterns in Various Cases].—J. A. Darbyshire. (*Proc. Phys. Soc.*, 1st Sept. 1938, Vol. 50, Part 5, No. 281, pp. 635–641.)

4382. CHANGE IN ELECTRON WORK FUNCTION ON ACTIVATION OF OXIDE CATHODES [Measurement: Increase of Emission on Activation caused by Decrease of Work Function: Emission Mechanism represented by Equation containing Internal and External Work Functions, of which probably only the Internal changes on Activation].—W. Heinze & S. Wagener. (*Zeitschr. f. Physik*, No. 3/4, Vol. 110, 1938, pp. 164–188.) For previous work *see* 994 of 1937.

4383. CONTACT POTENTIAL [Theory: Distinction between Galvani, Contact, Charging, and Volta Potentials: Equation defining Contact Potential: Measurement by Valve containing Tungsten and Tantalum Electrodes: Contact Potential equal to Difference between Work Functions].—B. Gysae & S. Wagener. (*Zeitschr. f. Physik*, No. 3/4, Vol. 110, 1938, pp. 145–163.)

DIRECTIONAL WIRELESS

4384. AN ELEVATED TRANSMITTER FOR TESTING DIRECTION FINDERS [as used at Radio Research Station, Slough, for Measurement of Polarisation Error: Wavelengths below 70 m: at Top of 70 ft Tower, with Rotatable Dipole Aerial].—R. H. Barfield. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 495–498.)

4385. THE APPLICATION OF TRANSMISSION-LINE THEORY TO CLOSED AERIALS [including the Greater Sharpness of Minimum given by a Large Frame].—Colebrook. (*See* 4345.)

4386. "PANORAMIC RECEPTION" MAKES POSSIBLE A NEW TYPE OF RADIO COMPASS [with Cathode-Ray Indicator].—M. Wallace. (*Aviation*, June 1938, Vol. 37, No. 6, p. 46.) *See* also 3975 of October.

4387. RADIO COMPASS FAIRCHILD RC4, *also* A NEW TYPE OF RADIO COMPASS (FRENCH PATENT NO. 810 257), *and* AVOIDANCE OF NIGHT EFFECT IN RADIO DIRECTION FINDING (FRENCH PATENT NO. 810 276).—Fairchild: Lepaute: De Bozas. (*Revue de l'Armée de l'Air*, March 1938, No. 104, pp. 342–344: pp. 345–347: pp. 347–350.)

4388. THE PRACTICAL USE OF RADIO AS A DIRECT AID TO LANDING APPROACH IN CONDITIONS OF LOW VISIBILITY.—R. S. Blucke. (*Journ. Roy. Aeronaut. Soc.*, June 1938, Vol. 42, No. 330, pp. 483–511.)

4389. A DIRECT-READING RADIO-WAVE-REFLECTION-TYPE ABSOLUTE ALTIMETER FOR AERONAUTICS.—S. Matsuo. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 848–858.) *See* 3974 of October.

ACOUSTICS AND AUDIO-FREQUENCIES

4390. THE PROPAGATION OF SOUND IN THE ATMOSPHERE [Remarks on the Theory, and Results of Aeroplane Tests (with Measurement of Aeroplane Noise and also of Shots from Aeroplane): Influence of Meteorological Conditions].—E. Waetzmann, J. Scholz, & H. Krüger. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 245–249.)

4391. THE PROPAGATION OF SOUND IN TUBES [in connection with Acoustical Delay Devices: Analysis and Experimental Investigation of Effect of Size of Bore on Distortion, etc.].—W. Bürk [Bürck] & H. Lichte. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 259–270.)

Authors' summary:—"The investigations show that for every size of bore there is a corresponding critical limiting frequency over which the transmission of sound is practically prohibited owing to extremely strong linear distortions (amplitude fluctuations) and long passage times. At the same time there occur, for lower frequencies also, strong non-linear distortions, since the overtones present may fall in zones of high tube radiation resistance, with consequent displacements in the sound-pressure relations in the tube which are unfavourable to the fundamental. If the bore of the tube is so diminished that the critical limiting frequency lies above the highest frequency involved, then a satisfactory transmission is impossible owing to the increased damping in the tube due to the reduced cross section." Attempts to eliminate or reduce the distortion at high frequencies by using sound waves which were practically plane and parallel to the axis are mentioned on p. 270: they were unsuccessful.

4392. ACOUSTIC DELAY CIRCUITS FOR LABORATORY USE, *and* ACOUSTIC ATTENUATORS.—A. C. Norwine: P. B. Flanders. (*Bell Lab. Record*, Aug. 1938, Vol. 16, No. 12, pp. 400–402: pp. 403–406.)

4393. A METHOD OF OBSERVING SOUND DECAY AND MEASURING REVERBERATION TIME [Over-All Gain of Amplifier made to Increase Exponentially with Time (by Suitable Valves and Use of Discharging Condenser to provide Bias): adjusted to match Average Rate of Decay of Reverberant Sound, so that Deviations from True Exponential Decay are observed directly as Decibel Differences].—W. N. Tuttle & H. W. Lamson. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, pp. 84–85: summary only.)

4394. ON SYNTHETIC REVERBERATION [for Sound Recording and Broadcasting: including the Fluorescent Film Tape and Magnetic Tape Systems].—S. J. Begun & S. K. Wolf. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 8–9.)

4395. MEASUREMENT OF ABSORPTION IN ROOMS WITH SOUND-ABSORBING CEILINGS [and Its Difficulties], *also* THEORETICAL INVESTIGATION OF THE ABSORPTION OF SOUND BY VIBRATING MATERIALS, *and* THE ABSORPTION OF VIBRATING PLATES.—J. R. Power: R. Rogers: H. W. Leedy. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 85: p. 85: p. 88: summaries only.)

4396. STUDIO AND TRANSMITTER-HOUSING CONSTRUCTION.—R. V. Howard. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 794: short summary only.)

4397. GERMAN REGULATIONS FOR INSULATION AGAINST NOISE IN DWELLINGS [and the Approved Testing Technique].—(*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 319–320.)

4398. NOISE-LEVEL CHART OF A BERLIN DISTRICT [taken with a Special Recording Noise-meter].—H. Kösters & others. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 310–313.)

4399. A CALIBRATOR FOR SOUND-LEVEL METERS [with Frequency Composition closely representing General Room Noise].—J. M. Barstow. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 86: summary only.)

4400. A MOVING-COIL PISTONPHONE FOR MEASUREMENT OF SOUND-FIELD PRESSURES.—R. P. Glover & B. Baumzweiger. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 86: summary only.) *See* also 4009 of October.

4401. STANDARD REQUIREMENTS FOR AUDIOMETERS.—W. F. Snyder. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, pp. 85–86: summary only.)

4402. VOLUME INDICATOR-ATTENUATOR [for Measurements on High-Gain Amplifiers and Transmitters].—S. G. Carter. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 22–24.)

4403. AN ADJUSTABLE TUNING FORK [with Design suitable for Calculation, permitting Assumption of Lumped Constants].—O. H. Schuck. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, pp. 86–87: summary only.)

4404. AN IMPROVED AUDIO-FREQUENCY OSCILLATOR [with Frequency determined by Resistance-Capacity Network free from Coils: Positive and Negative Feedback: 20–20 000 c/s in 3 Ranges].—W. R. Hewlett. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 793: short summary only.)

4405. MEASUREMENT OF HIGH-FREQUENCY CHARACTERISTICS ON CONCENTRIC CABLES LAID AT HIYOSHI, YOKOHAMA [" Silk-String " Cables (Central Conductor held by Silk String across Silicon-Copper Spiral): Frequency Range 0.5–5.0 Mc/s].—N. Shinohara. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts p. 5.) *See* also Cords, 4466, below.

4406. EFFECT OF PHYSICAL SIZE ON THE DIRECTIONAL CHARACTERISTICS OF UNIDIRECTIONAL AND PRESSURE-GRADIENT MICROPHONES.—F. Massa. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 85: summary only.)

4407. A MINIATURE DIRECTIONAL CONDENSER MICROPHONE FOR ACOUSTIC MEASUREMENTS.—F. J. Willig. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 85: summary only.)

4408. APPARATUS FOR THE CALIBRATION OF ELECTROSTATIC MICROPHONES [by the Audio-Frequency and also the Radio-Frequency Methods: Excellent Agreement between Results: Determination of the Constant F/v^2: Tests in a Vacuum, and the Effect of the Air Cushion].—E. Fano. (*Alta Frequenza*, July 1938, Vol. 7, No. 7, pp. 486–493.)

4409. FIELD CALIBRATION OF MICROPHONES.—G. S. Cook. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 86: summary only.)

4410. ABSOLUTE SOUND MEASUREMENTS IN LIQUIDS [including a Radiation-Pressure Apparatus applicable to Microphone Calibration for Secondary Standards].—E. Klein. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 86: summary only.)

4411. ELECTROACOUSTICS IN COMMUNICATION AND MEASURING TECHNIQUE [Survey of Recent Developments in Telephones and Microphones (including Special Microphones for Noisy and Windy Situations): Choice of Frequencies for Sound-Signalling over Various Distances through Air: Sound Analysis: etc.].—W. Janovsky. (*Bull. Assoc. suisse des Élec.*, No. 19, Vol. 29, 1938, pp. 522–530: in German.)

4412. NOTES ON THE IMPEDANCE OF A CARBON MICROPHONE [Impedance shown to be Identical with D.C. Resistance].—F. Offner. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 1009–1010.)

4413. ON THE MAXIMUM SENSITIVITY OF A MICROPHONE TRANSFORMER.—V. Iofe. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 8, 1938, pp. 903–905.)

4414. MAGNETIC SHIELDING OF TRANSFORMERS AT AUDIO FREQUENCIES [Theory and Experiment: Permalloy Cases: Effect of Air-Gap between Core and Shield: High-Efficiency Shields: etc.].—W. G. Gustafson. (*Bell S. Tech. Journ.*, July 1938, Vol. 17, No. 3, pp. 416–437.)

4415. A DUAL-COIL COMBINED LOUDSPEAKER-MICROPHONE [and Its Use in the Berlin/Munich Television-Telephone Service].—Ring. (*See* 4456.)

4416. OPTICAL ANALOGY OF A LOUDSPEAKER IN A REVERBERANT ROOM.—F. R. Watson. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 84: summary only.)

4417. LOUDSPEAKERS FOR THEATRES AND PUBLIC-ADDRESS APPLICATIONS.—D. Seibert. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 804: summary only.)

4418. LOUDSPEAKER CONSIDERATIONS IN FEEDBACK AMPLIFIERS [with Driving-Point Impedances of Typical Loudspeakers].—H. S. Knowles. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 794: short summary only.)

4419. THE BBC SOUND-RECORDING SERVICE.—A. E. Barrett. (*World-Radio*, 2nd, 9th, & 16th Sept. 1938, Vol. 27, pp. 16–17, 10–11, & 10–12.)

4420. EXPERIMENTS WITH A.C. ERASING ON MAGNETIC RECORDING [and a New Recording Method using a Weak H.F. Field (for Biasing) superposed on L.F. Speech-Current Field: Reduced Noise Level and Greatly Increased Output].—K. Nagai, S. Sasaki, & J. Endô. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts pp. 4–5.) For previous work *see* 558 & 559 of February.

4421. THE TRUE FREQUENCY CHARACTERISTIC IN SOUND-FILM RECORDING [as opposed to the Usual Characteristic obtained by Methods involving the Frequency Characteristic of a Reproducing Process].—W. Vox. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 302–309.)

4422. THE PRESENT POSITION OF SOUND-RECORDING TECHNIQUE, AND ITS APPLICATION IN GERMAN BROADCASTING.—H. J. von Braunmühl. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 250–258.)

4423. CORRECTIONS TO "RESEARCHES ON THE RECORDING AND REPRODUCTION OF SOUND BY THE 'B' INTENSITY PROCESS."—Steube. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, p. 320.) *See* 3996 of October.

4424. SUMMARIES OF PAPERS ON MOTION-PICTURE RECORDING, INCLUDING NOISE-REDUCTION METHODS [Matting, Pre- and Post-Equalisation, Push-Pull).—(*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 805.)

4425. A PEAK VOLTMETER [Quick Indication and Very Slow Return] USEFUL IN SOUND RECORDING.—H. Loughnane. (*Electronics*, Aug. 1938, Vol. 11, No. 8, p. 42.)

4426. THE MULTI-ELECTRODE COMPANDOR.—Mano, Naoi, & Ogura. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 291–292: summary only.)

4427. COMPRESSION AND EXPANSION IN SOUND TRANSMISSION.—Henriquez. (*See* 4618.)

4428. CONTRAST EXPANSION AND ITS APPLICATION.—Colston-Jones & Bocking. (*See* 4324.)

4429. THE "BINODON": THE CORRECT-VOLUME GRAMOPHONE AMPLIFIER IN VERY SIMPLE FORM [Economical Two-Stage Amplifier with Two Channels (High-Note & Low-Note): 4.5 Watts Output, or in Push-Pull Model up to 20 Watts].—E. de Gruyter. (*Bull. Assoc. suisse des Élec.*, No. 17, Vol. 29, 1938, pp. 466–467: in German.)

4430. AUTOMATIC EQUALISATION IN DISC RECORDING [compensating for Variation in Frequency Response with Changing Groove Radius].—G. J. Saliba. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 15–16 and 24.)

4431. PRACTICAL REMOTE AMPLIFIERS [for Remote Pick-Up for Outside Broadcasts].—R. W. Carlson. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 25 and 55.)

4432. FEEDBACK IN LOW-FREQUENCY AMPLIFIERS.—C. G. Mayo & H. D. Ellis. (*World-Radio*, 23rd & 30th Sept. 1938, Vol. 27, pp. 10–11: pp. 10–11.)

4433. LIFTING A FINGER AGAINST NOISE [Effect of Extraneous Noise on Intelligibility, and the Stopping of One Ear while Listening with the Other].—W. B. Snow. (*Bell Lab. Record*, Aug. 1938, Vol. 16, No. 12, pp. 418–420.)

4434. THE DEPARTURE OF THE OVERTONES OF A VIBRATING STRING FROM A TRUE HARMONIC SERIES [and a New Type of Monochord].—R. S. Shankland. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 87: summary only.)

4435. A STUDY OF THE TUNING OF PIANOS [Measurements by Chromatic Stroboscope, and Some Conclusions].—O. L. Railsback. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 86: summary only.)

4436. RECENT ADVANCES IN THE USE OF ACOUSTIC INSTRUMENTS FOR ROUTINE PRODUCTION TESTING.—B. Foulds. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 87: summary only.)

4437. AN OPTICAL HARMONIC ANALYSER [Specially Suitable for Speech and Music: Function represented by Variation in Density, or Width of Transparent Portion, of Photographic Film: 30 Harmonics measured in 1½ Minutes].—H. C. Montgomery. (*Bell S. Tech. Journ.*, July 1938, Vol. 17, No. 3, pp. 406–415.)

4438. Observations and Measurements on a New Apparatus for Sound Analysis [using Special Heterodyne Oscillator with Both Waves Strongly Distorted, giving a Series of Harmonic Note Frequencies which can be Superposed, Varied in Amplitude, etc: Investigations on Masking Effects, Connection between Changes in Timbre and Amplitude Changes in the Component Frequencies: etc.].—S. Nahrgang. (*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, pp. 284–301.)

4439. The Application of Negative Feedback to Harmonic-Analyser Design.—F. C. Cahill. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 809: title only.) *See* also 3727 of September.

4440. New Telegraph System uses Tone from Organ [96 Simultaneous Messages by Use of Tone Generators from Hammond Electric Organ].—Hammond. (*Sci. News Letter*, 13th Aug. 1938, Vol. 34, No. 7, p. 108.)

4441. "VDI-Jahrbuch 1938" [Book Review].—(*Akust. Zeitschr.*, Sept. 1938, Vol. 3, No. 5, p. 317.) The review deals only with the section on Acoustics.

4442. Papers on the Passage of Supersonic Waves through Thin Plates.—Bär: Levi & Nath. (*See* 4495.)

PHOTOTELEGRAPHY AND TELEVISION

4443. The Problem of Television in Colour: Part I [Pressler]—Fundamental Considerations on the Resolution of Coloured Television Images: Part II [von Ardenne]—On the Effect of the Decrease in Detail, for Coloured Images transmitted by the Same Frequency Band, as a Function of the Total Number of Elements, of the Value of the Viewing Angle, and of the Character of the Subject.—M. von Ardenne & H. Pressler. (*TFT*, July 1938, Vol. 27, No. 7, pp. 264–273.)

The writers conclude by mentioning a small-scale statistical test (verdicts of 10 viewers on projected images with various picture motives) which showed that the point of intersection of the voting curves for colour and for black-and-white lay at a line number of 350 for the latter when the subject had great richness of detail and an average colour content; for subjects with less detail the corresponding number was 250. "The foregoing investigation shows that even with the frequency band of today's television technique a change-over to coloured pictures would produce an improvement in the impression made."

4444. A New Television Film Projector [Non-Intermittent Type, operating with Instantaneous or Storage Pick-Up Tube (Farnsworth Dissector or Iconoscope): Two Overlapping Lens Discs and Spirally Slotted Selector Disc].—H. S. Bamford. (*Electronics*, July 1938, Vol. 11, No. 7, p. 25.)

4445. Present and Future Developments of Television in Europe [including a Dual-Ray Projection Tube and a Proposed French Shutter-Mosaic Screen for Lighted Rooms].—W. J. Polydoroff. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 800–801: summary only.)

4446. Electronics Television Pick-Up Tubes [and a Comparison of the Farnsworth Image-Dissector Type and the Zworykin Iconoscope (Cathode-Ray Scanner) Type].—W. Heimann. (*Funktech. Monatshefte*, Aug. 1938, No. 8, Supp. pp. 59–63.) For the writer's full investigation of the second type of camera *see* 1947 of May.

4447. A Unique Method of Modulation for High-Fidelity Television Transmitters ["Transmission-Line" Modulation: Modulation Frequencies up to 4–5 Mc/s for 441-Line Television (in Demonstration Model, up to 20 Mc/s on 200 Mc/s Carrier].—W. N. Parker. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 946–962.) Summaries were dealt with in 1971 of May and back reference.

4448. Reception of B.B.C. Television at 100 Miles [with Description of Aerial].—S. West. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 388–389.)

4449. British Television: a Review of the Past Year.—G. Cock. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 393–394: broadcast talk by the B.B.C. Director of Television.)

4450. The New Television Drive [in England].—(*Electrician*, 26th Aug. 1938, Vol. 121, pp. 225–226.)

4451. The RCA Television Project.—V. K. Zworykin. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 807: summary only.)

4452. RMA completes Television Standards [Serrated Type of Vertical Synchronising Pulse, Negative Modulation, Constant Black Level, and "Equalising Pulses"].—A. F. Murray. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 28–29 and 55.)

4453. The Present Status of Television.—A. V. Eastman. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 810: summary only.)

4454. French Television: Transmission Data of "Société Radio-Industrie" and Eiffel Tower ("Compagnie française de Télévision").—(*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, p. 394.)

4455. Television at the 1938 Great German Broadcasting Exhibition.—F. Ring. (*Funktech. Monatshefte*, Aug. 1938, No. 8, Supp. pp. 57–58.)

4456. OPENING OF THE BERLIN/MUNICH TELEVISION-TELEPHONE SERVICE [including a New Dual-Coil Loudspeaker serving also as Microphone, and avoiding Feedback Difficulties common with Loudspeaking-Telephone and Microphone Combinations].—F. Ring. (*Funktech. Monatshefte*, Aug. 1938, No. 8, Supp. pp. 58–59.)

4457. HOME CONSTRUCTED [Television] RECEIVERS: A TALK AND SUBSEQUENT DISCUSSION [" Straight " *versus* " Superhet " Amplifiers: Tuned Filters in Smoothing Network: etc.].—S. West & others. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 345–351.)

4458. A COMMERCIAL TELEVISION RECEIVER EMPLOYING A SMALL CATHODE-RAY TUBE [9 Inch Diameter Magnetic-Type Tube: the " Ultra " Receiver].—T. D. Humphreys. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 352–362: with bibliography and discussion.)

4459. A LABORATORY TELEVISION RECEIVER: II.—D. G. Fink. (*Electronics*, Aug. 1938, Vol. II, No. 8, pp. 26–29.) For I *see* 4027 of October.

4460. " TELEVISION RECEPTION TECHNIQUE " [Book Review].—P. D. Tyers. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, p. 390.)

4461. DISCUSSION ON AND CORRECTIONS TO " TELEVISION IMAGES: AN ANALYSIS OF THEIR ESSENTIAL QUALITIES."—L. C. Jesty & G. T. Winch. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 395–396: p. 396.) *See* 1949 of May.

4462. COAXIAL CABLE SYSTEM FOR TELEVISION TRANSMISSION.—M. E. Strieby. (*Bell S. Tech. Journ.*, July 1938, Vol. 17, No. 3, pp. 438–457.) *See* 3289 of August: *also* 1528 of April.

4463. THREE TYPES OF WIDE-BAND CABLE [and the Use of Very Flexible Waterproof Tubes of " Telconax "].—E. W. Smith. (*E.T.Z.*, 1st Sept. 1938, Vol. 59, No. 35, p. 948: summary only.)

4464. CONSIDERATIONS ON THE OPTIMUM DIMENSIONING OF BIFILAR LINES AT [Ultra-] HIGH FREQUENCIES.—Poledrelli. (*See* 4342.)

4465. THE MEASUREMENT OF PHASE DISTORTION IN WIDE-BAND TRANSMISSION CIRCUITS [*e.g.* Television Cables: by the Use of a Signal compounded from Three Frequencies, with Oscillographic Recording].—F. Ring. (*TFT*, June 1938, Vol. 27, No. 6, pp. 210–213.)

It is found advantageous to generate the composite signal at high frequencies and then to transpose down to the required band. Two of the components are taken from the signal generators 1 & 2 (Fig. 3) while the third is given by a generator 3 which is synchronised by both the first two frequencies F_1 & F_2 so as to give a rigidly phase-connected frequency $F_3 = F_1 \pm n(F_2 - F_1)$. With such a mixture of frequencies a signal can be produced with an envelope such as is shown in Fig. 1a, for a signal in which F_1 is the carrier frequency of 1 Mc/s, F_2 is 1.1 Mc/s and of half amplitude, while F_3 is 1.2 Mc/s of quarter amplitude. The envelope is altered in shape from the symmetrical " normal " curve of Fig. 1a (for instance to curve b or c of the same figure) by any phase displacement between the three component frequencies.

4466. THE ELECTRICAL PROPERTIES OF A THREAD SUSPENSION OF THE CONDUCTOR IN H.F. CABLES.—O. Cords. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 484: summary of VDE lecture.) *See* also 3292 of August. The leakance loss is now given as 0.09 neper/km (a misprint?) *See* also 4405, above, and 124 of January.

4467. COAXIAL CABLES: THEIR USE AT HIGH FREQUENCIES, PARTICULARLY FOR TELEVISION [Survey, with Table of Data of Some Types up to 1933: Lines of Development].—R. Bélus. (*L'Onde Élec.*, Aug./Sept. 1938, Vol. 17, No. 200/201, pp. 399–416.) Concluded from 4040 of October.

4468. TELEVISION V.F. [Video-Frequency] CIRCUITS [Detector, AVC, and Amplifier].—E. W. Engstrom & R. S. Holmes. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 18–21.) One of the series referred to in 3699 of September.

4469. HIGH-FREQUENCY CORRECTION IN RESISTANCE-COUPLED AMPLIFIERS [particularly for Television: Discussion of Russian Work on Circuit Calculation (Kharkevich, Braude): Method of Tellegen & Verbeck applied to analyse Various Correction Circuits: Tabular Summary].—E. W. Herold. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 11–14 and 22.)

4470. TELEVISION I.F. AMPLIFIERS [Solutions of Cocking's Stage-Gain Equation for Peak and Trough Frequencies: Criticism of Subsequent Equations: Reply].—L. Jofeh: Cocking. (*Wireless Engineer*, Sept. 1938, Vol. 15, No. 180, pp. 499–500.) *See* 4033 of October.

4471. ELECTROMAGNETIC DEFLECTION IN TELEVISION [and the Appearance of Very High Voltages on Line-Deflection Output Valve].—W. T. Cocking. (*Wireless World*, 22nd Sept. 1938, Vol. 43, pp. 264–266.)

4472. PRACTICAL ASPECTS OF WIDE-BAND TELEVISION-AMPLIFIER DESIGN.—F. A. Everest. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 793: short summary only.)

4473. MEASUREMENT OF SCANNING SPEEDS OF CATHODE-RAY TUBES.—Blok. (*See* 4540.)

4474. CIRCUIT SIMPLIFICATION IN PICTURE GENERATORS [for Demonstrations, Testing, etc: " Monotron " Tube and Its Circuits].—M. P. Wilder. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 802: summary only.)

4475. On the Screen Materials ["Luminous Paints"] for Television Cathode-Ray Tubes [Survey].—W. Reusse. (*TFT*, June 1938, Vol. 27, No. 6, pp. 232–237.) A postscript calls attention to the importance of von Ardenne's recent paper (2953 of July.)

4476. Luminescence and Its Application to Television [Kerr Memorial Lecture].—L. Levy & D. W. West. (*Journ. Television Soc.*, March 1938, Vol. 2, Part 10, pp. 337–344.) Including developments since the I.E.E. paper dealt with in 3489 of 1936 and back references.

4477. Papers on Luminescent Screens.—(*See* also under "Subsidiary Apparatus & Materials.")

4478. On the Internal Photoelectric Effect in Allochromatic Crystals [Survey, with 58 Literature References, of Work on Alkali Halide Crystals].—G. Gregoretti. (*Nuovo Cimento*, March 1938, Vol. 15, No. 3, pp. 193–208.)

4479. On Secondary Electron Emission.—S. Yu. Luk'yanov. (*Journ. of Tech. Phys.* [in Russian], Nos. 8 & 9, Vol. 8, 1938, pp. 671–690 & 767–789.)

A detailed discussion of secondary electron emission is presented, based on a survey of the contemporary literature on the subject: for an addendum see *ibid.*, No. 9, pp. 852–853. In the first part of the paper the secondary emission from pure metal surfaces is discussed and different experimental methods used in the investigation of this phenomenon are described. The results obtained by various investigators are summarised and shown in a number of tables and curves. The second part of the paper deals mainly with the secondary emission from composite surfaces; the effects of various factors, such as the temperature and illumination of the cathode, on the secondary emission, both from pure metal and composite surfaces, are also discussed in this part of the paper.

The paper is concluded by a survey of the technical applications of the phenomenon and among other examples a short description is given of the electron multiplier developed by Timofeev and designed not for current but for voltage amplification. A bibliography of 144 items classified under different headings is appended.

4480. An Investigation of the Secondary Electron Emission from Heated Dielectrics.—M. M. Vudynski. (*Journ. of Techn. Phys.* [in Russian], No. 9, Vol. 8, 1938, pp. 790–797.)

It is pointed out that certain difficulties in the study of the secondary electron emission from dielectrics could be obviated if the conductivity of the sample under observation were increased, and it is suggested that this could be achieved by raising the temperature. A description is given of the apparatus developed for this investigation and a report is presented on experiments conducted with samples of glass, mica, fluorite, NaCl, KCl, KI and KBr. It appears that the coefficient of secondary emission from dielectrics, when the temperature of these is raised to several hundreds of degrees Centigrade, is much higher than that for pure metals and in the case of NaCl and KCl is almost as high as for composite oxide-caesium surfaces. A theoretical interpretation of the experimental results so obtained is given.

4481. The Effect of Gases on the Secondary Emission from Certain Metals.—N. S. Khlebnikov. (*Journ. of Techn. Phys.* [in Russian], No. 11, Vol. 8, 1938, pp. 994–1013.)

For previous work see 4045 of October. Experiments were carried out in which was observed the secondary electron emission from pure surfaces of Be, Mg, and Ta, and also from these surfaces after treatment by gas (oxygen, hydrogen, and helium). The main conclusion reached in this investigation is that in the second case the secondary emission is considerably increased and that the value of this increase depends on the method by which the cathode is treated.

A theoretical interpretation of this phenomenon is presented and it is claimed that the views developed by the author help towards the understanding of the secondary emission not only from pure surfaces but also from composite surfaces. In particular it is claimed that these views compare favourably with the theory expounded by Timofeev.

4482. The Energy Distribution of Secondary Electrons Emitted from a Composite Caesium Cathode.—A. I. Pyatnitski. (*Journ. of Tech. Phys.* [in Russian], No. 11, 1938, pp. 1014–1022.)

For previous work *see* 3501 of 1936. An account is given of experiments in which the energy distribution of secondary electrons emitted from an Ag-Cs_2-Cs cathode was investigated. The results obtained are discussed and the main conclusions reached are as follows:—(1) The majority of secondary electrons leave the cathode with an energy of the order of a few volts only. (2) A considerable number of electrons leave the cathode with zero energy. (3) There are electrons "deficient" in energy which leave the cathode only with the aid of an auxiliary field. (4) The energy distribution of secondary electrons differs from that determined by Maxwell. This indicates that there are certain peculiarities in secondary emission.

4483. Certain Aspects of the Technology of Oxygen-Silver-Caesium Photocathodes.—N. S. Zaytsev & N. S. Khlebnikov. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 8, 1938, pp. 1023–1033.)

A report on experiments with Ag-Cs_2O-Cs cathodes, to investigate the effect of various factors on the fatigue, integral sensitivity, and sensitivity to infra-red of these cathodes. Particular attention was paid to the following factors: the thickness of the Ag_2O layer, the temperature at which the cathode was prepared, and the addition of caesium and silver to the Ag_2O layer of a finished cathode. The results obtained are shown in a number of curves and are discussed, and certain practical suggestions are made with regard to the manufacture of these cathodes.

4484. The Influence of Adsorption Films on Electron Emission and Ion Reflection in the Impact of Positive Caesium Ions on Tungsten [Increase in Electron Emission due to Their Emission from the Adsorbed Atoms: Ion Reflection chiefly influenced by Surface Work Function].—H. Paetow & W. Walcher. (*Zeitschr. f. Physik*, No. 1/2, Vol. 110, 1938, pp. 69–83.)

4485. Resistivity of Thin Films: Caesium.—B. Mukhopadhyaya. (*Sci. & Culture*, Calcutta, Aug. 1938, Vol. 4, No. 2, pp. 131–132.) Further development of the work referred to in 3388 of August. For Fuchs's paper, here mentioned, *see* 1601 of April.

4486. Secondary-Electron Emission from Nickel, Cobalt, and Iron as a Function of Temperature [No Evidence of Discontinuous Changes at Transformation Points].—L. R. G. Treloar & D. H. Landon. (*Proc. Phys. Soc.*, 1st Sept. 1938, Vol. 50, Part 5, No. 281, pp. 625–634.)

4487. Method of Production of Single-Crystal Split Metal Surfaces in a High Vacuum and Its Possibilities in the Investigation of Present Questions of Surface Physics [Surface Photoeffect, Optical Constants, Adsorption Phenomena, Secondary Electron Emission, Electron Diffraction].—W. Kluge. (*Physik. Zeitschr.*, 1st Aug. 1938, Vol. 39, No. 15, pp. 582–585.)

4488. Townsend Ionisation Coefficients in Argon Photo-Tubes.—W. S. Huxford. (*Phys. Review*, 15th Aug. 1938, Series 2, Vol. 54, No. 4, p. 313: abstract only.)

4489. The New "Positive" Barrier-Plane Photoelectric Effect and the New Barrier-Plane Photocell.—B. Kolomiez. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 19, 1938, pp. 383–384: in English.)

Hochberg & Sominsky have shown that if subjected to appropriate treatment thallium sulphide can have both "electron" and "hole" types of conductivity. In the latter case the barrier-layer photoeffect is similar to that of cuprous oxide or selenium. If however the thallium sulphide is in a state of "electron" conductivity, so that the electrons pass from the metal into the semiconductor, and the metal adjoining the barrier layer is charged positively and the semiconductor negatively, then the resulting photocell has very high technical properties. Preliminary measurements gave a sensitivity of 5000–6000 μA/lumen (ten times that of a selenium cell under same conditions) with an e.m.f. attaining 0.3 v.

4490. Angular Distributions of Recoil and Photoelectrons produced by 300 to 800 kV X-Rays in Nitrogen.—H. Trueblood & D. H. Loughridge. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 239: abstract only.)

4491. Photoelectric Long Wavelength Limit of Magnetised Iron [Change in Threshold Frequency of Iron due to Magnetic Field].—D. H. Loughridge & N. K. Olsen. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 239: abstract only.)

4492. The Wavelength Variation of the Nuclear Photoeffect from Measurements on Bromine and Copper.—W. Bothe & W. Gentner. (*Naturwiss.*, 5th Aug. 1938, Vol. 26, No. 31, p. 517.)

4493. On the Effect of a Magnetic Field upon Mercury Discharge Radiation [including the Practical Possibility of Light Modulation by means of an Inhomogeneous Magnetic Field].—V. Fabrikant. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 19, 1938, pp. 393–396: in English.)

4494. Contribution to the Study of the Electric and Magnetic Double Refraction of Liquids [Benzene and 20 Derivatives: Measurements over Wide Temperature Range (up to 200° C): Comparison of Results with Theory of Molecular Orientation and with Data on Kerr Effect and on Depolarisation of Diffused Light: etc.].—A. Goldet. (*Ann. de Physique*, July/Aug. 1938, Series 11, Vol. 10, pp. 103–172.)

4495. On Simple Special Cases in the Passage of Supersonic Waves through Thin Plates: Remarks on Three Papers by Bär, Reissner, and Walti, *and* On the Theory of the Passage of Supersonic Waves through a Solid Plate.—R. Bär: F. Levi & Nagendra Nath. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 11, 1938, pp. 397–407: pp. 408–431: in German.)

4496. A Method for Absolute Measurement of the Kerr Constants with Alternating Voltage [deduced from Theoretical Relations between Kerr Constants and Liquid Double Refraction due to Alternating Electric Field].—Y. Björnståhl. (*Physik. Zeitschr.*, 1st Aug. 1938, Vol. 39, No. 15, pp. 585–587.)

4497. Practical Application of Facsimile Broadcasting [and the Make-Up of the Material: the RCA Equipment for KGW].—H. C. Singleton. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 795: short summary only.)

4498. Newspapers by Radio [Survey of Present Position, including Costs].—R. D. Potter. (*Sci. News Letter*, 3rd Sept. 1938, Vol. 34, No. 10, pp. 154–155.)

MEASUREMENTS AND STANDARDS

4499. LIMITS OF APPLICABILITY OF THE DYNATRON AS A MEANS OF MEASUREMENT AT HIGH FREQUENCIES [Latmiral-Vecchiacchi Method of measuring Equivalent Resistances, Condenser and Coil Losses, etc., and a Modification extending the Useful Range to 50–150 Mc/s according to Type of Valve].—E. Viti. (*Alta Frequenza*, Aug./Sept. 1938, Vol. 7, No. 8/9, pp. 536/550.)

Author's summary :—The Latmiral-Vecchiacchi method for measuring parallel equivalent resistances by means of a dynatron [3117 of 1936] has certain limitations at high frequencies. The first of these is due to the fact that parallel to the measuring circuit there are necessarily the anode/cathode capacity of the valve, and a resistance equivalent to the dielectric losses : above a certain frequency the necessary correction would be too large.

Measurements may however be carried out at higher frequencies by means of a method based on the same principle. The use of the method involves the assumption that only the negative-conductance part of the anode/cathode admittance varies with the grid bias of the dynatron. For still higher frequencies the self and mutual inductances inside the valve must be taken into account ; the effects of these, together with the interelectrode capacities, are : (a) a retroactive coupling between the anode and the other electrodes, and (b) a variation in the positive-conductance component between anode and cathode, when the grid bias is varied. It is shown that for valves with secondary emission sufficient to reverse the anode current, and if the working point selected is that for which the current is zero, the retroactive coupling (a) does not modify the amplitude of the fundamental frequency of the oscillation, introducing only a negligible increase in the second-harmonic component. As the dynamic resistance is deduced from the equality of the oscillating voltage in two selected conditions, it may be concluded that the retroactive effect has no influence on the measurement.

The variation in the anode/cathode admittance (b) is calculated on the lines indicated by Strutt [524 of February] and it is found that, at the chosen zero-current working point, this also may be neglected. The method of measurement may therefore be used without errors due to these causes up to frequencies about a half the resonance frequency of the inner circuits of the valve, *i.e.* up to 50–150 Mc/s according to the type of valve.

4500. SYSTEMATIC MEASUREMENTS OF HIGH RESISTANCES [Italian, with Some of Other Makes] AT HIGH FREQUENCIES [using the Rapid and Accurate Dynatron Method (Latmiral-Vecchiacchi) : Details of Procedure : Accuracy of Results : Frequencies up to 7.5 Mc/s].—A. Bressi. (*Alta Frequenza*, Aug./Sept. 1938, Vol. 7, No. 8/9, pp. 551–569.) Outstandingly good curves are shown by the 0.5 w "Carbostat" resistances for 1 and 2 megohms (Fig. 12a) : these are superficially-metallised glass threads protected by porcelain tubes.

4501. MEASUREMENT OF CURRENT AT HIGH [and Ultra-High] FREQUENCIES [Calibration of Thermo-Ammeters, at Frequencies up to 100 Mc/s, by Tungsten Lamp and Photocell Method : Accuracy estimated to be within 1%].—K. Tani & N. Taharakuti. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, pp. 41–46.)

For Malsch's optical "Schlieren" method *see* 640 of February, and for Hoyer's tungsten-lamp method *see* 248 of January. *Cf.* also Wallace & Moore, 2710 of 1937, and Miller, 1907 of 1937. For Turner & Michel's electrodynamic ammeter *see* 1106 of March.

4502. THE PREPARATION BY THE EVAPORATION METHOD OF THERMOCOUPLES FOR THE MEASUREMENT OF RADIATED ENERGY.—M. S. Zeltser. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 8, 1938, pp. 920–923.)

A method has been developed for depositing thin layers of metals on mica by evaporating the metals in a vacuum. In this way thermocouples were prepared for astronomical observations using antimony-bismuth, tellurium-bismuth, and "Hutchinson's alloys" (*American Journal of Science*, Vol. 48, 1894, p. 226).

4503. THERMOJUNCTIONS [Analysis of Action of Thermoammeter : Overloading and Sensitivity : "Reversal Effect" and Its Causes : Dependence of Indication on Frequency : etc.].—J. W. L. Köhler. (*Philips Tech. Review*, June 1938, Vol. 3, No. 6, pp. 165–173.)

4504. BEHAVIOUR OF VARIABLE AIR CONDENSERS AT RADIO FREQUENCIES, AND METHODS OF MEASUREMENT.—G. Holzner. (*Alta Frequenza*, Aug./Sept. 1938, Vol. 7, No. 8/9, pp. 582–633.)

Author's summary :—"In the first part those general facts and considerations are collected which may be useful either for the study of the properties of variable air condensers, from low frequencies to not too high radio-frequencies (up to 10 Mc/s), or for the most suitable selection and application of methods of measuring the elements and parameters which determine the behaviour of these condensers. The origins, characteristics, and effects of these elements, and their mode of action at the different frequencies, are all discussed.

"In the second part the proposed methods are reviewed by which the fundamental parameters may be measured at radio-frequencies ; beginning with some practical remarks on the use of the resonance methods most generally employed at high frequencies." The methods finally selected as practical are :—Dye's parallel-substitution method, but with the determination of the equivalent inductance in parallel by means of the substitution method, in place of by measuring the series resistance by the method of added resistance ; Boella's series substitution method (1535 of 1936) with determination, by the substitution method, of the equivalent resistance in series or in parallel according to the frequency and losses under examination ; the method of Field & Sinclair (1897 of 1936), and those of Brown, Wiebusch, & Colby (*Phys. Review*, 1927, p. 887) and of Moullin

(1932 Abstracts, p. 593). These are compared on pp. 632–633. Field & Sinclair's method has undoubtedly the advantage of the greatest simplicity, and is moreover, so far as the writer is aware, the only one suitable for measuring the residual inductance of a condenser.

4505. AN IMPEDANCE BRIDGE FOR MEASUREMENTS AT A FREQUENCY OF 200 MEGACYCLES.—W. R. Hill. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 794 : short summary only.)

4506. MEASURING EQUIPMENT FOR DIELECTRIC LOSS ANGLES AT HIGH FREQUENCIES [up to 30 Mc/s : Hartshorn's Capacitance-Variation Method with Minor Improvements].—T. Nishi, S. Okazaki, & B. Itijô. (*Electrot. Journ.*, Tokyo, Sept. 1938, Vol. 2, No. 9, pp. 219–220.) For Hartshorn & Ward's paper *see* 351 of 1937.

4507. ELECTRICAL BRIDGE FOR THE INVESTIGATION OF INSULATING MATERIALS [Fully Screened Schering Bridge].—American Soc. for Testing Materials. (*Zeitschr. V.D.I.*, 13th Aug. 1938, Vol. 82, No. 33, p. 958.) Taken from the book referred to in 2077 of May.

4508. AN INDUCTANCE AND CAPACITANCE BRIDGE [for 30 to 10 000 c/s].—S. J. Zammataro. (*Bell Lab. Record*, June 1938, Vol. 16, No. 10, pp. 341–346.)

4509. THE "PHILOSCOPE" UNIVERSAL BRIDGE [Type GM 4140, with Philips Cathode-Ray Indicator Tube Type EM1 : with Various Applications].—(*Bull. Assoc. suisse des Élec.*, No. 17, Vol. 29, 1938, pp. 463–466 : in German.)

4510. BRIDGE SCHEMES WITH NON-LINEAR RESISTANCES [including the Ferro-Resonance Bridge : Analytical Treatment].—B. S. Sotskov. (*Automatics & Telemechanics* [in Russian], No. 2, 1938, pp. 23–34.)

4511. THE MUTUAL SHUNT METHOD OF MEASURING SELF-INDUCTANCE AT RADIO FREQUENCIES.—A. Campbell. (*Proc. Phys. Soc.*, 1st Sept. 1938, Vol. 50, Part 5, No. 281, pp. 655–658 : Discussion pp. 658–660.)

The value of the self-inductance is read directly on a mutual inductometer, whose "secondary circuit, with an a.c. ammeter in series, is put in parallel with the coil to be tested, the combination being connected, through the primary coil, to an a.c. source of radio frequency giving constant current. The mutual inductance is now varied until the ammeter reads a minimum current, and then the self-inductance is equal to the mutual inductance. This result does not involve resistance or frequency. Methods for eliminating the errors due to self and mutual capacitances in the inductometer are indicated."

4512. MEASURING [the Phase Shift and Current & Voltage Ratios of] FOUR-POLE NETWORKS [terminated in Any Impedance : Practical Method].—J. L. Clarke. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 30 & 31.)

4513. THE MEASUREMENT OF PHASE DISTORTION IN WIDE-BAND TRANSMISSION CABLES.—Ring. (*See* 4465.)

4514. A 10 MEGACYCLE ATTENUATOR [for Measurements on Coaxial Cables : Attenuation up to 70 db with Error less than 1 db (Special Devices to reduce Key-Switch Errors) : etc.].—K. Kobayasi & T. Usikubo. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts p. 3.)

4515. DETERMINATION OF THE FREQUENCY OF AN OSCILLATOR WITH A CONDENSER [within 1 in 3000, over Wide Range : conversely, for Rapid Measurement of Capacity].—H. Mukherjee. (*Indian Journ. of Phys.*, May 1938, Vol. 12, Part 3, pp. 195–202.)

Based on the fact that one of the two null-point conditions for a dynamometer or wattmeter used as a galvanometer is that the phase difference in the two coil systems should be 90°.

4516. STABILISED - FEEDBACK OSCILLATORS. — Stevenson. (*See* 4308.)

4517. FREQUENCY CHARACTERISTICS OF PIEZO-ELECTRIC OSCILLATORS [the Two Main Modes of Connection, Pierce and Miller : Former properly classed as Colpitts Oscillator, Latter as Hartley : Analysis].—J. E. Anderson. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 22–24.)

4518. TRANSIENT FREQUENCY VARIATION OF CRYSTAL OSCILLATOR [due to Temperature-Differences between Electrodes, even for Zero - Frequency - Temperature - Coefficient Plates : Effect of Roughening the Electrode Surface].—I. Koga & M. Shoyama. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts p. 6 : *Electrot. Journ.*, Tokyo, Sept. 1938, Vol. 2, No. 9, pp. 199–201.)

4519. THE CREVASSE PHENOMENON IN QUARTZ AND ITS APPLICATION TO PHYSICAL MEASUREMENTS.—Hubbard. (*See* 4683.)

4520. DEMONSTRATION OF DAMPING EFFECT OF ATMOSPHERIC PRESSURE, ETC., ON VIBRATING QUARTZ CRYSTAL [in Vacuum, 80 000 Vibrations before Amplitude is Halved—Ten Times as Many as in Air].—O. E. Buckley. (*Bell Lab. Record*, June 1938, Vol. 16, No. 10, p. 357.)

4521. THE BEILBY LAYER ON THIN GROUND QUARTZ CRYSTALS [Ground Crystal covered by Crystalline Beilby Layer of Atoms aligned by External Fields of Crystal Itself].—Hirsh. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 238 : abstract only.)

4522. FIFTY YEARS AGO : THE FIRST MEASUREMENTS MADE ON PIEZOELECTRIC QUARTZ.—J. & P. Curie. (*Rev. Gén. de l'Élec.*, 27th Aug. 1938, Vol. 44, No. 8, p. 225.) Summary of a paper published in 1888.

4523. CONTRIBUTION TO THE STUDY OF THE ELECTRICAL CONDUCTIVITY AND DIELECTRIC CONSTANT OF QUARTZ AND CERTAIN OTHER CRYSTALS.—N. G. Rahimi. (*Journ. de Phys. et le Radium*, July 1938, Series 7, Vol. 9, No. 7, pp. 291–296.)

Prolonged (10 hours') heating to about 700°, followed by cooling at about the same rate, diminishes the cold resistance to about one hundredth: the effect is increased by the application of a potential difference during the heating. This thermal and electrical treatment seems to produce a well-defined state free from the dielectric anomalies of the untreated crystal and with a dielectric constant smaller than that of the latter. It is shown that there is a relation between the electrical conductivity and the dielectric constant of the same specimen, anomalies in the one property being accompanied by anomalies in the other: these anomalies must be due to one and the same cause, which is evidently removed by the combined thermal and electrical treatment.

4524. DIFFUSE SCATTERING OF X-RAYS FROM PIEZOELECTRICALLY OSCILLATING QUARTZ [Different Types and Modes of Vibration have No Effect on Intensity of Diffuse Scattering].—G. E. M. Jauncey & W. A. Bruce. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 163–165.) For previous work on one mode of oscillation *see* 285 of 1936: *cf.* also 300 of 1937.

4525. THE EFFECT OF THE CONDENSER LEADS ON MEASUREMENTS WITH A LECHER SYSTEM [New Formula for Capacity of Condenser connected between Lecher-Wire Bridges; Effect of Eddy Currents induced in Condenser Leads].—H. Slätis. (*Ann. der Physik*, Aug. 1938, Series 5, Vol. 32, No. 8, pp. 734–742.)

4526. DISPERSION AND ABSORPTION [of Ultra-Short Waves] IN POLAR SUBSTANCES, *and* FRICTIONAL DISPERSION OF THE DIELECTRIC CONSTANTS OF ORGANIC LIQUIDS.—Debye & Ramm: Plötze. (*See* 4210.)

4527. CALCULATION OF MUTUAL INDUCTANCE OF COILS WHICH ARE NOT COAXIAL.—F. W. Grover. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 10 and 22.)

4528. MAGNETIC FIELD AND INDUCTANCE OF A SYSTEM OF RECTANGULAR PARALLEL BARS.—Ed. Roth. (*Rev. Gén. de l'Élec.*, 3rd Sept. 1938, Vol. 44, No. 9, pp. 275–283.)

4529. THE ACCURACY OF MEASUREMENT OF THE COMMERCIAL CATHODE-RAY OSCILLOGRAPH.—H. Pieplow. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 480: summary of VDE lecture.)

4530. THEORY OF THE DIODE VOLTMETER.—C. B. Aiken. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 859–876.)

"It is the purpose of this paper to develop more fully the circuit analysis [originally due to Colebrook] and to describe the behaviour and peculiarities of the typical diode voltmeter. The theory is also applicable to the detector of the ordinary radio-receiving set in so far as its response to the carrier wave goes . . ."

4531. A PEAK VOLTMETER [Quick Indication and Very Slow Return] USEFUL IN SOUND RECORDING.—H. Loughnane. (*Electronics*, Aug. 1938, Vol. 11, No. 8, p. 42.)

4532. A NEW PHOTOELECTRIC D.C. AMPLIFIER OF HIGH SENSITIVITY [for the Precise Measurement of Very Small D.C. Voltages].—L. Merz. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 484: summary of VDE lecture.) *See* 3322 of August.

4533. LABORATORY AND MEASURING EQUIPMENTS [New Instruments].—(*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 17–19 and 24, 31.)

4534. EQUIVALENT RESISTANCE CHART [applicable also to Determination of Q Values, etc.].—A. E. Teachman. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 31 and 32.)

4535. SOME ECONOMICAL CONSIDERATIONS OF INSTRUMENT MANUFACTURE.—H. Tinsley. (*Journ. Scient. Instr.*, Sept. 1938, Vol. 15, No. 9, pp. 285–289.)

4536. DETERMINATION OF THE UNIT OF RESISTANCE OF THE C.G.S. ELECTROMAGNETIC SYSTEM.—Jouaust, Picard, & Hérou. (*Bull. de la Soc. franç. des Élec.*, July 1938, Vol. 8, No. 91, pp. 587–680.)

SUBSIDIARY APPARATUS AND MATERIALS

4537. COLD-CATHODE, HIGH-CATHODE-POTENTIAL OSCILLOGRAPH.—Trüb, Taüber Company. (*Journ. Scient. Instr.*, Sept. 1938, Vol. 15, No. 9, pp. 306–308.)

4538. A HIGH-FREQUENCY [Cathode-Ray] OSCILLOGRAPH [with Time-Base Voltage from Valve Oscillator giving Amplitudes so large that Only Linear Portion of Curve need be used: Fly-Back darkened or deflected off Screen by 90° Out-of-Phase Voltage (of Same Frequency) rectified by Diode].—Keller (& Geffcken). (*Funktech. Monatshefte*, Aug. 1938, No. 8, pp. 252–253.)

4539. THE ACCURACY OF MEASUREMENT OF THE COMMERCIAL CATHODE-RAY OSCILLOGRAPH.—Pieplow. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 480: summary of VDE lecture.)

4540. AN APPARATUS FOR THE MEASUREMENT OF SCANNING SPEEDS OF CATHODE-RAY TUBES [Maximum Scanning Speed for Photographic Recording found by making Spot describe Logarithmic Spiral with Constant Angular Velocity].—Blok. (*Philips Tech. Review*, July 1938, Vol. 3, No. 7, pp. 216–219.)

4541. AN ANALYTIC STUDY OF ELECTROSTATIC ELECTRON-LENSES [Necessary and Sufficient Conditions for Formation of Image: Ray Dispersion: Gas Concentration: Long and Short Lenses].—Sugata. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, Abstracts pp. 2–3.)

4542. Focal Length and Image Quality of the Electron Lens with Circular Stop and Centre Grid.—Knoll & Weichardt. (*Zeitschr. f. Physik*, No. 3/4, Vol. 110, 1938, pp. 233–236.)

The form of this lens is shown in Fig. 1; the focal length is given by eqn. 3. Curves derived from this expression are compared with measured values in Fig. 2, for various dimensions of the lens. A much smaller lens voltage is needed to attain the same focal length than for the corresponding lens with three stops and no grid. The image of a T-stop (Fig. 3) gives an idea of the accuracy of the lens. Fig. 4 gives curves of the ratio of focal length to stop radius.

4543. Experiments with Magnetic Electron-Optical Systems [with Particular Attention to Their Aberrations: Description of a Special Magnetic Lens and of an Electron-Microscope (Magnification 150–200 Diameters)]. — Malatesta. (*Alta Frequenza*, July 1938, Vol. 7, No. 7, pp. 447–458.) For the writer's article on the electron telescope *see* 2517 of June.

4544. The Super-Microscope.—von Borries & Ruska. (*Chemiker-Zeitung*, 6th Aug. 1938, Vol. 62, No. 63, pp. 561–566.) For other papers on this and other electron-microscopes *see* 4076/4080 & 4199, all of October.

4545. The Method of Rheographic and Rheometric Analogies [including Its Application to Electrical Problems: the Use of the Electrolytic Trough].—Pérès & Malavard: Rougé. (*Bull. de la Soc. franç. des Élec.*, Aug. 1938, Vol. 8, No. 92, pp. 715–744 and 744–747.)

4546. A New Precision Method for the Determination of e/m for Electrons [using Focusing Properties of Crossed Electric and Magnetic Fields: Focusing Criteria eliminate Influence of Electron Energy on Measured Value of e/m].—Shaw. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, pp. 193–209.) For previous work on the focusing properties mentioned *see* 1934 Abstracts, p. 223: *cf.* also 1512 of 1937.

4547. Method of Measuring Luminescent Screen Potential.—Nelson. (*Journ. of Applied Physics*, Sept. 1938, Vol. 9, No. 9, pp. 592–599.)

Fig. 1 shows a diagram of an experimental arrangement for measuring the potentials of areas on the interior surface of a glass vacuum tube. An area on the exterior surface directly opposite the interior area in question is coated with graphite and connected to the grid lead of an electrometer valve. Hot air is directed against the graphite spot. The potential of the interior area can be measured if the electrical resistance through the glass wall is small compared with the input impedance of the electrometer valve. This method is checked, using a tube of the design shown in Fig. 2. Various experimental curves of secondary emission and screen potential are given and their general features discussed. Among other results, the screen potential is found to vary with the beam-current density and life of the tube. "In general, the results also lead to the implication that the accumulation of negative charges on the glass base of the phosphor layer and on depressed surfaces in the layer affects the manner in which the screen potential varies with that of the second anode."

4548. On the Screen Materials for Television Cathode-Ray Tubes.—Reusse. (*See* 4475.)

4549. Charge Potentials of Fluorescent Screens irradiated by Electrons.—Bey. (*Physik. Zeitschr.*, 15th Aug. 1938, Vol. 39, No. 16, pp. 605–611.)

The experimental arrangement used is shown in Fig. 1. An electrometer string was suspended inside the tube about 1 cm away from the screen; its deflection gave a measure for the voltage difference between screen and anode. Experimental curves for various quantities are given; among other results, it is found that the insulated fluorescent screen behaves like an insulated metallic screen in becoming positive and then assuming the anode voltage as the latter increases. From a given point, however, it follows the anode voltage, though much more slowly. A greater yield of light intensity (§ 4) is found with a metallic screen connected to the anode (curves of light intensity Figs. 4–7). The spot increases in size above the equilibrium potential, due to the radial component of the opposing field (§ 5; Figs. 9, 11). The transverse current across the screen is investigated in § 7 (circuit Fig. 12).

4550. Study of Fluorescence in a Layer of Thickness comparable with the Wavelength: II—The Polarisation of the Fluorescence.—Barysanskaja. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 6/7, Vol. 19, 1938, pp. 465–468: in French.) For Part I *see* 1159 of March.

4551. Is Fundamental Polarisation dependent on Temperature? [Experimental Investigation of Interest in Research on Properties of Fluorescent Molecules].—Jabłoński. (*Acta Physica Polonica*, Fasc. 1, Vol. 7, 1938, pp. 15–23: in German.)

4552. Meet "Exciton" and "Phonon," New Words in Physics [of Phosphorescence: Two Kinds of Energy excited by Light striking Solid Body].—Teller. (*Sci. News Letter*, 27th Aug. 1938, Vol. 34, No. 9, p. 136.)

4553. Considerations on the Synchronisation of Oscillators [particularly the Saw-Tooth Relaxation Oscillator for Time Bases].—Fubini-Ghiron. (*See* 4306.)

4554. The Spontaneous Electron Emission occurring at the Electrodes as an After-Effect of Gas Discharges, and the Field Electron Emission from Thin Insulating Films, *also* Variation of Field Electron Emission from Points with Effective Field Strength, *and* A Search for Temperature Changes accompanying Field Emission at High Temperatures.—Paetow: Haefer: Fleming & Henderson. (*See* 4377/4379.)

4555. RESISTIVITY OF THIN FILMS: CAESIUM.—Mukhopadhyaya. (*See* 4485.)

4556. REMARKABLE CONNECTIONS BETWEEN THE ANOMALOUS CURRENTS, THE LOSS FACTOR, THE APPARENT CAPACITY, AND THE BACK-VOLTAGE IN INSULATING MATERIAL [with the "Internal Conductivity" as the Connecting Link].—Böning. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 19, 1938, pp. 241–247.)

Author's summary:—(1) In an ideal structure, consisting of two condensers connected in series, each with a parallel resistance, it is shown that the following quantities are linked together by a common parameter, the "internal conductivity" [G_i, eqn. 5]: post-charge current $I_{nt} = PG_i e^{-t/T}$ [this is a decaying current superposed (on the Hopkinson superposition principle) at the beginning of the charging process, on the charging current for the geometrical capacity: when C_1R_1 and C_2R_2 are equal, it is zero]; back-current I_{rt} [this is the "anomalous discharge current," and thus has the same course as the post-charge current above, but is of opposite sense]; apparent capacity $C' = G_iT + C$; loss factor $\tan\delta = (G_i + G)/\omega C$; back-voltage curve, tangent at origin $\tan\alpha = PG_i/C$.

"(2) It is concluded from the above that the anomalies which a single simple condenser with a real dielectric displays can also be represented by a single simple parameter. For this parameter the tangent at origin of the back-voltage curve, $\tan\beta$, is chosen [in the actual case of a single condenser, the curve can no longer be treated as a simple function, as in the ideal dual-condenser case of (1): the measured curve (simply taken with a string electrometer and a quick-action switch) can however be treated as made up of two or more components with different time constants and maxima, and tangent angles α_1, α_2 . . . ; then $\tan\beta = \tan\alpha_1 + \tan\alpha_2 + \ldots$] and it is shown that the dielectric loss factor is proportional to this value: $\tan\delta = k \tan\beta$. Here the back-voltage curve is treated as corresponding to a structure of ideal condensers and resistances. The loss-factor component depending on the break-down conductivity can also be derived from the back-voltage curve."

4557. THE ELECTRICAL CONDUCTIVITY AND DIELECTRIC CONSTANT OF QUARTZ AND CERTAIN OTHER CRYSTALS.—Rahimi. (*See* 4523.)

4558. SILICATE GLASS IN [High- and] ULTRA-HIGH-FREQUENCY FIELDS.—Kharkov & Vodopyanov. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 8, 1938, pp. 910–914.)

4559. A 25 YEARS RETROSPECT: FROM RETROACTION TO THE "THERMAL OHM" [Development of Heat-Conducting Insulating Materials: Their Importance, and the Necessary New Technique for Design Calculations].—Meissner. (*AEG-Mitteilungen*, Aug. 1938, No. 8, pp. 444–445.)

4560. GLASS INSULATING TAPE.—(*Indust. & Eng. Chemistry* (News Ed.), 10th June 1938, Vol. 16, No. 11, p. 339.) *See* also 3377 of August, and for an article on "fibre glass" *see* 2988 of July.

4561. PHENOL-FORMALDEHYDE MOULDING MATERIALS FOR ELECTROTECHNICAL PURPOSES.—Halls. (*Plastics*, May 1938, Vol. 2, pp. 166–167.)

4562. THE HARDENING SYNTHETIC RESINS IN THE SERVICE OF ELECTRICAL ENGINEERING, *and* THE USE OF NON-HARDENING SYNTHETIC MATERIALS FOR ELECTRO-INSULATION [including "Luvican," "Oppanol," "Igelite" ("Astralon"), & "Stabol"].—Pinten: Beck. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, pp. 482–483: p. 483: summaries of VDE lectures.)

4563. THE TYPE CLASSIFICATION OF INSULATING MOULDING MATERIALS.—Burmeister. (*Elektrot. u. Masch:bau*, 14th Aug. 1938, Vol. 56, No. 33, pp. 420–423.)

4564. INSULATING MATERIALS IN THE MANUFACTURE OF CABLES, *and* DIELECTRIC PROPERTIES OF COLOURED CELLULOSE-TRIACETATE FILMS.—Pfestorf & Hetzel. (*Elektrizitätswirtsch.*, 5th May 1938, Vol. 37, pp. 334–336: *Kunststoffe*, June 1938, Vol. 28, pp. 144–145.)

4565. IMPROVEMENTS IN RELAY-COIL INSULATION [particularly to prevent Copper Wire Corrosion: the Use of Cellulose Acetate].—Garvin. (*Bell Lab. Record*, Aug. 1938, Vol. 16, No. 12, pp. 407–410.)

4566. THE DIELECTRIC PROPERTIES OF CELLULOSE ACETATE [Report (Ref. L/T49) of the British E.R.A.].—Hartshorn & Rushton. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 315–332.)

4567. "BUNA" IN ELECTRICAL ENGINEERING.—Roelig. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 483: summary of VDE lecture.) For its use in cables *see* also 2073 of May.

4568. DIELECTRIC STRENGTH OF LACS OF KNOWN ORIGIN [including Hard Lac Resins, for which Enhanced Electrical Properties have been claimed: Effect of Baking at 90° C (Greatly Increased Strength) and Possible Reasons: etc.].—Venkatasubban & others. (*Current Science*, Bangalore, Aug. 1938, Vol. 7, No. 2, pp. 49–51.)

4569. "ISOLIERLACKE" [Insulating Varnishes: Book Review].—Raskop. (*Elektrot. u. Masch:bau*, 21st Aug. 1938, Vol. 56, No. 34, p. 444.)

4570. "ELEKTRISCHE ISOLIERSTOFFE: IHR VERHALTEN AUF GRUND DER IONENADSOPTION AN INNEREN GRENZFLÄCHEN".—Böning. (At Patent Office Library, London: Cat. No. 78786: 140 pp.)

4571. THE ARTIFICIAL RUBBERS: MANUFACTURE, PROPERTIES, AND APPLICATIONS.—Génin. (*Bull. de la Soc. franç. des Élec.*, June 1938, Vol. 8, No. 90, pp. 527–540.)

4572. The Testing, without Injury, of H.T. Ceramic Insulators by Loss-Angle Measurements and Subjection to Undamped High-Frequency Voltages.—Obenaus. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 481 : summary of VDE lecture.)

4573. Measuring Equipment for Dielectric Loss Angles at High Frequencies, *and* Electrical Bridge for the Investigation of Insulating Materials.—Nishi & others : American Soc. for Testing Materials. (*See* 4506 & 4507.)

4574. Behaviour of Variable Air Condensers at Radio Frequencies [up to 10 Mc/s], and Methods of Measurement.—Holzner. (*See* 4504.)

4575. Vacuum Tank Condenser [6 . . 50 μμF Units, 2″ Diameter, 6½″ Long, R.F. Peak Volts 32 000, R.F. Current Rating 20–50 Amperes].—Eitel McCullough Company. (*Communications*, Aug. 1938, Vol. 18, No. 8, p. 23.)

4576. Electrolytic Condensers [Conclusions from Systematic Measurements on Commercial Dry & Wet Types for Broadcast Receivers : Nominal Capacities usually reasonably Accurate, Discrepancies on Large Side more frequent than on Small Side (15 μF stamped 2 μF) : Some Makers exaggeratedly Optimistic regarding Maximum Voltages : Power Factor as the True Factor of Merit : Influence of Frequency on Capacity and Power Factor].—L. Chrétien. (*L'Onde Élec.*, Aug./Sept. 1938, Vol. 17, No. 200/201, pp. 384–398.)

4577. Systematic Measurements of High Resistances.—Bressi. (*See* 4500.)

4578. On the Behaviour of Resistors at High Frequencies, *and* The Effect of the Distributed Capacity on the Behaviour of Resistors at High Frequencies.—Pontecorvo : Hartshorn. (*See* 4276 & 4277.)

4579. Electrolytic Resistors for D.C. Applications in measuring [and controlling] Temperatures.—Craig. (*See* 4264.)

4580. Iron Powder Cores : Their Use in Modern Receiving Sets, *and* Distribution of Magnetic Flux in an Iron Powder Core.—Friedlaender : G. W. O. H. (*See* 4320 & 4321.)

4581. The Mechanical and Magnetic After-Effect of Carbonyl Iron [show Same Temperature Variation].—Richter. (*Ann. der Physik*, Aug. 1938, Series 5, Vol. 32, No. 8, pp. 683–700.)

4582. Magneto-Electrolytic Method of producing Strong Anisotropies [in Cobalt Plates, lasting after Many Hours' Baking : Relation to the Remarkable Coercive Properties of Certain Ferromagnetic Powders].—Perrier & Mermod. (*Helvetica Phys. Acta*, Fasc. 4, Vol. 11, 1938, pp. 362–364 : in French.) For the work on magnetite powders *see*, for example, Gottschalk, 2786 of 1935, and Sappa, 1622 of April.

4583. The Cause of the Low-Temperature Anomaly in Magnetite [may be the Rupture of a Linkage between Two Atoms of Divalent Iron in Elementary Unit of Crystal, which are really Trivalent and connected by Supplementary Valency].—R. Forrer. (*Comptes Rendus*, 25th July 1938, Vol. 207, No. 4, pp. 281–283.)

4584. Ferromagnetic Colloid for studying Magnetic Structures.—Elmore. (*Phys. Review*, 15th Aug. 1938, Series 2, Vol. 54, No. 4, pp. 309–310.)

4585. Magnetic Properties of Thin Evaporated Iron Films [Measurements of Volume Susceptibility : Change in Magnetic Properties at Thickness of about 100 Atoms].—Dixit. (*Physik. Zeitschr.*, 1st Aug. 1938, Vol. 39, No. 15, pp. 580–582.)

4586. Instruments for the Measurement of Incremental Permeability [British Association Paper].—Gall. (*Engineering*, 16th Sept. 1938, Vol. 146, pp. 348–350.)

4587. The Magnetic Anisotropy of Ferromagnetic Crystals in Weak Fields : II—Theory of the Reversible Susceptibility, III—The Reversible Susceptibility of Iron Crystals in Various Crystallographic Directions.—Kondorsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 19, 1938, pp. 397–400 & 401–404 : in English.) *See* also 2565 of June and 3775 of September.

4588. The Bend in the Magnetisation Curve of the Single Iron Crystal in a Weak Magnetic Field [Magnetic Region of Reversible Susceptibility at Beginning of Curve : Theoretical Explanation of Experimental Results].—Honda & Nishina. (*Zeitschr. f. Physik*, No. 11/12, Vol. 109, 1938, pp. 758–761.)

4589. Change in Photoelectric Threshold Frequency of Iron due to Magnetic Field.—Loughridge & Olsen. (*See* 4491.)

4590. An Anomalous Change [Decrease] in the Electric Resistance of Iron-Silicon Alloys with a Longitudinal Magnetic Field at Various Temperatures.—Shirakawa. (*Nature*, 27th Aug. 1938, Vol. 142, p. 395.)

4591. Magneto-Resistance Change of Ferromagnetics in an Alternating Magnetic Field.—Sharan. (*Indian Journ. of Phys.*, May 1938, Vol. 12, Part 3, pp. 203–210.)

4592. Time Effects in Magnetisation [Magnetic Viscosity ("Nachwirkung") and Reversible Decrease of Permeability with Time (Reversible Ageing) both as Results of Elastic Viscosity Effects (due to Magnetostrictive Strains) in the Barrier Layers of the Weiss Domains : leading to Elementary Mathematical Theory].—Snoek. (*Physica*, Aug. 1938, Vol. 5, No. 8, pp. 663–688 : in English.)

4593. THE PARAMAGNETISM OF THE FERROMAGNETIC ELEMENTS [Accurate Measurement of Magnetic Susceptibilities at Temperatures up to 1500° C: Existing Theory inadequate to explain Results].—Sucksmith & Pearce. (*Proc. Roy. Soc.*, 5th Aug. 1938, Vol. 167, No. 929, pp. 189–204.)

4594. MAGNETIC PROPERTIES OF ANHYDROUS NICKELOUS CHLORIDE AND THE LAWS OF VARIATION OF PARAMAGNETISM [with New Experimental Data on the Multiplicity of Moments which the Nickel Ion may assume].—Laurent. (*Journ. de Phys. et le Radium*, Aug. 1938, Series 7, Vol. 9, No. 8, pp. 331–336.)

4595. EFFECT OF COLD WORKING AND HEAT TREATMENT ON THE ELECTRIC AND MAGNETIC PROPERTIES OF PURE NICKEL: II—DRILLED AND STRETCHED NICKEL WIRE [Magnetic and Elastic Phenomena].—Bittel. (*Ann. der Physik*, Aug. 1938, Series 5, Vol. 32, No. 7, pp. 608–624.)

4596. FERROMAGNETISM AND ELECTRICAL PROPERTIES: VIII—THE THERMOMAGNETIC LONGITUDINAL AND TRANSVERSE EFFECT FOR NICKEL.—Wagner. (*Ann. der Physik*, Aug. 1938, Series 5, Vol. 32, No. 8, pp. 665–682.)

4597. THE TRANSITION POINT λ OF THE MAGNETIC SUSCEPTIBILITY OF MANGANESE PROTOXIDE MnO.—Bizette, Squire, & Tsaï. (*Comptes Rendus*, 29th Aug. 1938, Vol. 207, No. 9, pp. 449–450.)

4598. MAGNETIC SHIELDING OF TRANSFORMERS AT AUDIO FREQUENCIES.—Gustafson. (*See* 4414.)

4599. A COMPARATIVE ANALYSIS OF DYNAMIC AND STATIC ELECTRO-MAGNETIC CHARACTERISTICS.—Kovalenkov. (*See* 4286.)

4600. THE SATURATION CHOKE COIL AS A POWER AMPLIFIER.—Herzenberg. (*See* 4285.)

4601. IMPROVING REGULATOR PERFORMANCE [Conventional Triode Voltage-Regulating Circuit extended in Range by Shunt across Plate Circuit of Regulator Valve: Use of Series of Neon Lamps to provide Grid Bias].—Bousquet. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 26–27.)

4602. A VACUUM TUBE HIGH-VOLTAGE STABILISING CIRCUIT FOR D.C. SOURCES.—Schultz. (*Phys. Review*, 15th Aug. 1938, Series 2, Vol. 54, No. 4, p. 314: abstract only.)

4603. VOLTAGE REGULATION OF D.C. GENERATORS BY MEANS OF TRIODES.—Voorhoeve & de Jong. (*Philips Tech. Review*, April 1938, Vol. 3, No. 4, pp. 97–103.)

4604. STABILISING POWER SUPPLIES [and the Use of the Barretter and of Specially Designed Transformers].—Bell. (*Wireless World*, 11th & 18th Aug. 1938, Vol. 43, pp. 119–120 & 143–144.)

4605. THE MOVING-COIL VOLTAGE REGULATOR [Survey of Existing Voltage-Regulating Devices, leading to Writer's M.C. Regulator].—Norris. (*Journ. I.E.E.*, July 1938, Vol. 83, No. 499, pp. 1–19: Discussion pp. 19–35.)

4606. THE TIME LAG EFFECT IN AUTOMATIC REGULATING PROCESSES.—Vicker. (*Automatics & Telemechanics* [in Russian], No. 6, 1937, pp. 59–76.)

4607. THE AUTOMATIC CHARGING OF ACCUMULATOR BATTERIES BY THE "SHOCK-CHARGE" SYSTEM [Stossladegeräten: High Charging Rate cut down suddenly to Very Low Maintenance Rate on Attainment of Limiting Voltage.]—Miehlich & Müller. (*E.T.Z.*, 14th July 1938, Vol. 59, No. 28, pp. 747–750.)

4608. THE PERMATRON—A NEW TYPE OF RECTIFIER WITH MAGNETIC CONTROL [Types RM-208 & 209].—Raytheon Corporation. (*QST*, Sept. 1938, Vol. 22, No. 9, pp. 42 and 86, 88.)

4609. THE A-TYPE SENDYTRON USING A NEW METHOD OF STARTING AN ARC [requiring only a Momentary Power of Several Watts for Igniting: Advantages over Ignitron].—Watanabe & others. (*Electrot. Journ.*, Tokyo, Aug. 1938, Vol. 2, No. 8, pp. 180–185.)

4610. PAPER FOR THE CHEMICAL RECORDING OF ELECTRIC CURRENTS AND FOR STYCTOGRAPHY, *and* ACTIVE COHERERS FOR STYCTOGRAPHY.—Iofa. (*See* 4246.)

4611. TELEDYNAMIC CONTROL BY SELECTIVE IONISATION.—Seeley, Deal & Kimball. (*See* 4313.)

STATIONS, DESIGN AND OPERATION

4612. TESTS ON THE USE OF MICRO-WAVES FOR AIR TRANSPORT COMMUNICATION: FREEDOM FROM STATIC INTERFERENCE.—Western Electric Company. (*Science*, 26th Aug. 1938, Vol. 88, Supp. p. 10: paragraph only.)

4613. PRESENTATION OF VARIOUS SETS FOR RADIO-TELEPHONY ON METRIC WAVES [3.5–8.0 m approx: for Communication between Aircraft and Ground Stations].—Lehmann. (*L'Onde Élec.*, Aug./Sept. 1938, Vol. 17, No. 200/201, p. 423: summary only.)

4614. TECHNICAL PROBLEMS IN MULTI-CHANNEL RADIO-TELEPHONY [on Short or Ultra-Short Waves: Confined to Amplitude Modulation as giving Best Speech Quality: Choice of Modulation Level: Economic Comparisons: etc.].—Yonezawa. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 294–295: summary only.)

4615. WIDE-BAND AMPLIFIER FOR HIGH-FREQUENCY WIRE BROADCASTING.—Buchmann & Barthel. (*TFT*, June 1938, Vol. 27, No. 6, pp. 213–220.)

Dealing with "an important component problem [in wire broadcasting], the calculation and construction of wide-band amplifiers: in particular, the seriousness of non-linearity, in actual service, is closely examined. The course of the investigation leads to a division of the amplifier into control and output amplifiers, where one control amplifier can supply up to ten output amplifiers—in practice, five. The amplifiers are so carefully linearised by negative feedback that their full output can be used without the appearance of disturbances due to non-linearity."

4616. REDIFFUSION IN GREAT BRITAIN [Description of System now operating in Nottingham].—Adorjan. (*Communications*, Aug. 1938, Vol. 18, No. 8, pp. 5–7 and 31.) For previous papers *see* 4240 of 1936.

4617. AUDITORY PERSPECTIVE ON A SINGLE CARRIER [Application of Woodyard's Work on Simultaneous Amplitude and Frequency Modulation].—Sandstedt. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, p. 927: summary only.) For Woodyard's paper *see* 1613 of 1936.

4618. COMPRESSION AND EXPANSION IN SOUND TRANSMISSION [General Problems: the Two Main Groups of Circuits—using Change in Valve Voltage Relations and Change in Resistance of Filaments].—V. C. Henriquez. (*Philips Tech. Review*, July 1938, Vol. 3, No. 7, pp. 204–210.)

4619. NOTES ON FIELD INTENSITY MEASUREMENTS IN THE BROADCAST BAND AND THEIR INTERPRETATIONS [Effects of Aerial Efficiency, Soil Conductivity, and Transmitter Power on Coverage].—Jansky. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 803: summary only.)

4620. MAKING BROADCAST SYNCHRONISATION EASY [for Common-Wave Working: the Western Electric 280A Synchronising Panel].—Bayles. (*Bell Lab. Record*, June 1938, Vol. 16, No. 10, pp. 347–349.)

4621. STATION CBL [Choice of Site: Aerial System: Transmitter].—Smith: Doherty. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, pp. 810–811: summaries only.)

4622. RESEARCHES IN RADIOTELEPHONY [for the Improvement of Short-Wave Long-Distance Services: Directive Aerial Systems (the "Musa" Receiving System for Vertical-Plane Directivity, and Preliminary Results with Musa for Horizontal-Plane Directivity): Tests on Similar Control of Directivity at Transmitting End: "Compandors" and "Vogads": Single-Sideband Transmission: Multi-Channel Problems].—Bown. (*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 395–402.) For work leading to the horizontal-directivity "musa" *see* Feldman, 2181 of June.

4623. A 50 KW SHORT-WAVE BROADCASTER.—Tanaka. (*Rep. of Rad. Res. in Japan*, June 1938, Vol. 8, No. 1, pp. 31–39.)

4624. INTERNATIONAL-BROADCAST-LICENCE ENGINEERING [Problem of Collecting and Arranging the Material for Licence Application].—Pack. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 795: short summary only.)

4625. COMMERCIAL COMMUNICATION WITH SHORT RADIO WAVES . . . [Present Frequencies Too Low].—Ohno. (*See* 4217.)

4626. LANDSEND RADIO: BRITAIN'S SOUTH-WESTERN WIRELESS OUTPOST.—Ainslie. (*Wireless World*, 22nd Sept. 1938, Vol. 43, pp. 267–268.)

4627. A NEW COASTAL MARINE RADIO-TELEPHONE SET.—Woodworth. (*Bell Lab. Record*, June 1938, Vol. 16, No. 10, pp. 358–360.)

4628. MARINE RADIO-TELEPHONY.—Anderson. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 807: short summary only.)

4629. A NEW USE FOR RADIO IN THE FIELD OF FIRE PREVENTION AND CRIMINAL APPREHENSION [Device actuated by Fire or Burglary Detector and broadcasting (on Police Channel) Recorded Speech giving Nature and Location of Emergency].—Foss. (*Proc. Inst. Rad. Eng.*, Aug. 1938, Vol. 26, No. 8, pp. 926–927: summary only.)

4630. RADIO COMMUNICATION AND EQUIPMENT DEVELOPMENT IN THE FIELD OF NATIONAL FOREST PROTECTION.—Lawson. (*Proc. Inst. Rad. Eng.*, July 1938, Vol. 26, No. 7, p. 794: short summary only.) *See* also 4155 of October.

GENERAL PHYSICAL ARTICLES

4631. FUNDAMENTAL PHYSICAL CONCEPTS [derived from Flux-Cutting Equations, Ionic Constitution of Matter, & Physical Treatment of Electric Wave Propagation, aid Reconciliation between Classical and Modern Theories].—Drysdale. (*Nature*, 13th Aug. 1938, Vol. 142, pp. 288–289.)

4632. MAGNETIC FLUX IN MOTION: A GRADUAL CHANGE IN THE SURROUNDING ETHER? *and* CONTROVERSIES IN ELECTROMAGNETISM.—Ledward: Cullwick. (*Electrician*, 9th Sept. 1938, Vol. 121, p. 285: p. 286.)

4633. ELECTROTECHNICAL CONSIDERATIONS ON POYNTING'S THEOREM.—Bunet. (*Rev. Gén. de l'Élec.*, 27th Aug. 1938, Vol. 44, No. 8, pp. 243–254.)

4634. THE MEASUREMENT OF THE VELOCITY OF LIGHT OVER A SINGLE JOURNEY [Discussion of Possibility: Outline of Possible Method, using Standing Waves on Transmission Line to Synchronise a Pair of Shutters].—Clark. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 361–376.)

4635. A NEW PRECISION METHOD FOR THE DETERMINATION OF e/m FOR ELECTRONS.—Shaw. (*See* 4546.)

4636. The First and Second Townsend Ionisation Coefficients for Pure H_2.—Hale. (*Phys. Review*, 1st Aug. 1938, Series 2, Vol. 54, No. 3, p. 241: abstract only.)

MISCELLANEOUS

4637. Operational Solution of the [Inhomogeneous] Wave Equation, *and* Integration of General Differntial Equation of Wave Motion for One, Two, and Three Dimensions.—Pipes: Lowan. (*See* 4241 & 4242.)

4638. An Integral Representation for the Product of Two Hermite Polynomials.—Bailey: Howell. (*Journ. Lond. Math. Soc.*, July 1938, Vol. 13, Part 3, No. 51, pp. 202–203.) Generalisation of work referred to in 2141 of May.

4639. A Note on the Polynomials of Hermite and Laguerre.—Watson. (*Journ. Lond. Math. Soc.*, July 1938, Vol. 13, Part 3, No. 51, pp. 204–209.)

4640. Operational Forms and Contour Integrals for Bessel Functions with Argument $a\sqrt{(t^2-b^2)}$.—McLachlan. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 394–408.)

4641. Generalised Fractional Integration and Differentiation.—Fabian. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 408–410.)

4642. The Complete Solution of the Differential Equation for the Confluent Hypergeometric Function.—Archibald. (*Phil. Mag.*, Sept. 1938, Series 7, Vol. 26, No. 175, pp. 415–419.)

4643. "Rechnerisches Verfahren zur harmonischen Analyse und Synthese" [with Sum-and-Product Tables: Book Review].—Hussmann. (*Elektrot. u. Masch:bau*, 28th Aug. 1938, Vol. 56, No. 35, p. 460.)

4644. Method of Study of Statistical Series of Exponential Type: Application to Radioactivity.—Ferber. (*Journ. de Phys. et le Radium*, Aug. 1938, Series 7, Vol. 9, No. 8, pp. 337–344.)

4645. On the Notion of "Angle" [Special Nature of Its Dimension: Employment as Coordinate: Measurement: Blondel's Notation: Formula of Magnetomotive Force: etc.].—Brylinśki. (*Rev. Gén. de l'Élec.*, 17th Sept. 1938, Vol. 44, No. 11, pp. 345–349.)

4646. Regulations for Controlling the Earthing of Electrical Installations to Metal Water-Pipes and Water-Mains.—(*Journ. I.E.E.*, Sept. 1938, Vol. 83, No. 501, pp. 434–435.)

4647. The Increase of Light from a Mercury Discharge due to a Magnetic Field, and Its Possible Use for the Modulation of Light.—Fabrikant. (*See* 4493.)

4648. The Employment of Luminous Flux in Measurement [Principle and Applications of the Photoelectric Comparator, particularly the Differential Type].—Quevron. (*Rev. Gén. de l'Élec.*, 3rd Sept. 1938, Vol. 44, No. 9, pp. 265–268.) *See* also 3063 of July and 3963 of 1937.

4649. A New Photoelectric D.C. Amplifier of High Sensitivity [Mirror-Galvanometer/Photocell Combination].—Merz. (*See* 4532.)

4650. A Low-Velocity Oceanographic Current Recorder [Friction reduced by Photocell Device].—Dahl & Dahl. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, pp. 243–245.)

4651. "Photoelements and Their Application" [Book Review].—Lange. (*Journ. Am. Chem. Soc.*, June 1938, Vol. 60, No. 6, pp. 1518–1519.) Translation of the German book dealt with in 1656 of 1937.

4652. Selenium Rectifier Photocells and Their Application to Automatic Control [Electrical and Engineering Requirements: Types made in USSR: Various Application Methods].—Shchekin. (*Automatics & Telemechanics* [in Russian], No. 1, 1938, pp. 9–25.)

4653. 100 Practical Uses for the Photoelectric Cell: the Photocell in Industry.—Cossor, Ltd. (*Television*, July 1938, Vol. 11, No. 125, pp. 411–412.)

4654. Oscillating Relays: Apparatus for Measuring the Frequency [using Galvanometer, Photocell, and Counter].—Durepaire. (*Electrician*, 3rd June 1938, Vol. 120, p. 721.)

4655. Galvanometer with Logarithmic Response [using Photoelectric Cell with Suitably Cut Illuminating Slit to produce Smaller Opposing Current through Galvanometer Coil].—LeGrand. (*Comptes Rendus*, 4th July 1938, Vol. 207, No. 1, pp. 50–51.)

4656. The Photoelectric Contact-Making Galvanometer [particularly Useful for Bridge Work in Production Testing, etc.]—Carson. (*Gen. Elec. Review*, July 1938, Vol. 41, No. 7, p. 314.)

4657. Type BSZ. 237 Micro-Relay [Extremely Sensitive Combination for Use with Selenium Photocells, etc.].—(*Elec. Communication*, April 1938, Vol. 16, No. 4, pp. 374–375.)

4658. "Photozelle, Glimmlampe, Braunsche Röhre" [Photocells, Glow-Discharge Lamps, and Cathode-Ray Tubes, and Their Practical Use, especially for Demonstration and Instruction: Book Review].—Möller. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 19, 1938, p. 183.)

4659. Radio Warning at Railroad Crossing.—Smith & Clausing. (*Scient. American*, June 1938, Vol. 158, No. 6, p. 349.)

4660. Graininess Meter [Microphotometer and Photoelectric Integrator for examining Grain Structure of Motion-Picture Film.]—Goetz & Gould. (*Electronics*, June 1938, Vol. 11, No. 6, p. 69: photograph and caption only.)

4661. WATER-LEVEL INDICATOR [making Permanent Record and indicating Level by Telephone when Called Up].—(*Electronics*, June 1938, Vol. 11, No. 6, p. 52: picture and caption only.)

4662. RECENT IMPROVEMENTS IN CEMENT TESTING [including the Wagner "Turbidimeter"—Photoelectric Device for determining Fineness of Grinding].—Eitel. (*Zeitschr. V.D.I.*, 9th July 1938, Vol. 82, No. 28, pp. 821–823.)

4663. ON THE QUESTION OF THE TRUE COURSE OF THE SPECTRAL BRIGHTNESS SENSITIVITY OF THE EYE [in connection with Photometry].—Dresler. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 19, 1938, pp. 206–212.)

4664. THE OBJECTIVE MEASUREMENT OF COLOUR [by Photocell Instruments: the Requirement of Uniformity and Reproducibility of the Cells employed, and the Merits of the Potassium-on-Silver Type: etc.].—Perry. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, pp. 270–277.)

4665. A PHOTOELECTRIC COLORIMETER [Balanced Circuit, with Balance obtained by Variable Resistance in One Photocell Circuit].—Hare & Phipps. (*Science*, 12th Aug. 1938, Vol. 88, pp. 153–154.)

4666. THE SNAP PYROMETER [Photocell Instrument registering the Temperature of the Hot Object "snapshotted"].—Cambridge Instrument Company. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, pp. 277–278.)

4667. PHOTOELECTRIC CHEQUE-SIGNER.—Watson. (*Electronics*, July 1938, Vol. 11, No. 7, p. 44: photograph and caption only.)

4668. PHOTOELECTRIC WEFT-STRAIGHTENER CONTROL [in Weaving].—LaPierre & Mansfield. (*Elec. Engineering*, Sept. 1938, Vol. 57, No. 9, pp. 513–519.)

4669. PHOTOELECTRIC APPARATUS FOR PROCESS SUPERVISION.—Noack. (*Elektrot. u. Masch:bau*, 11th Sept. 1938, Vol. 56, No. 37, p. 478: summary of VDE lecture.)

4670. PHOTOELECTRIC COPYING-CONTROL FOR MILLING MACHINES, etc. [working direct from Drawing instead of from Model].—Haller. (*Elektrot. u. Masch:bau*, 4th Sept. 1938, Vol. 56, No. 36, p. 467: summary only.)

4671. AUTOMATIC TYPE-SETTING MACHINE ["Semagraph"] EMPLOYS PHOTOELECTRIC TRANSLATION DEVICE.—Green. (*Electronics*, Aug. 1938, Vol. 11, No. 8, p. 33.)

4672. A PHOTOELECTRIC STATIC PRECISION EXTENSOMETER [measuring Changes of 0.1 Micron].—Askania Company. (*Elektrot. u. Masch:bau*, 4th Sept. 1938, Vol. 56, No. 36, p. 469: summary only.)

4673. CAMERA AUTOMATICALLY SETS DIAPHRAGM [as Shutter is released, Photocell-driven Galvanometer adjusts Aperture to give Correct Exposure].—Kodak Company. (*Scient. American*, Sept. 1938, Vol. 159, No. 3, pp. 157–158.)

4674. ACCIDENTS DUE TO ELECTRICITY, OCCURRING IN SWITZERLAND IN THE YEARS 1936 AND 1937.—Sibler. (*Bull. Assoc. suisse des Élec.*, No. 18, Vol. 29, 1938, pp. 485–490: in French.)

4675. RELATION OF THE ELECTROMAGNETIC SPECTRUM TO MEDICINE.—May. (*Journ. Inst. Eng. Australia*, June 1938, Vol. 10, No. 6, pp. 227–231.)

4676. ELECTRON TRANSFER DURING MUSCULAR CONTRACTION [recorded by Photoelectric Method based on Changes in Absorption Spectrum of Muscle].—Urban & Peugnet. (*Sci. & Culture*, Calcutta, July 1938, Vol. 4, No. 1, p. 57: from a *Proc. Roy. Soc.* [Series B] paper.)

4677. SUPERSONIC CENTRIFUGE [with Biological Applications].—Girard & Marinesco. (*See* 3669 of September.)

4678. A SPEED INDICATOR AND CONTROL FOR THE ULTRA-CENTRIFUGE [Photocell Device].—Kahler. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, p. 257.)

4679. TEMPERATURE DISTRIBUTION IN STRATIFIED BIOLOGICAL TISSUES AFTER TREATMENT IN AN ELECTROMAGNETIC RADIATION FIELD (1) WITH AIR AS THE EXTERNAL MEDIUM [Wavelength 25 cm]: (2) WITH AN EXTERNAL MEDIUM OF HIGH DIELECTRIC CONSTANT [Wavelength 100 cm].—Esau, Pätzold, Ahrens, Osswald. (*Naturwiss.*, 22nd July 1938, Vol. 26, No. 29, pp. 477–478: 478–479.)

4680. SHORT-WAVE [3.5 m] EFFECTS ON LIVING TISSUE [Growth Hindered, Death the Final Result].—Hasché. (*Naturwiss.*, 29th July 1938, Vol. 26, No. 30, p. 493.)

4681. "TICKER TAPE" RECORDS EYE MOVEMENTS [with Eyelids Closed (for Analysis of Brain Lesions): Minute Electrical Energy of Moving Eye utilised].—Halstead. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 34 and 36.)

4682. AN ELECTRONIC CARDIOTACHOMETER.—Horton. (*Electronics*, Aug. 1938, Vol. 11, No. 8, pp. 14–17 and 55.)

4683. THE CREVASSE PHENOMENON IN PIEZOELECTRIC QUARTZ AND ITS APPLICATION IN PHYSICAL MEASUREMENTS [Further Applications of Author's Ultramicrometer Method].—Hubbard. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, pp. 87–88: summary only.) *See* 4283 of 1936.

4684. A SIMPLE ARRANGEMENT FOR THE MEASUREMENT OF THE SPECIFIC RESISTANCE OF LIQUIDS [Waste Water, Rinsing Water in Laundries, etc.].—Claassen. (*Philips Tech. Review*, June 1938, Vol. 3, No. 6, pp. 183–186.) Using the "Philoscope" bridge (*see* 4509, above).

4685. RADIO PIPE-LINE TRACER [weighing 7 lb].—(*Scient. American*, Sept. 1938, Vol. 159, No. 3, p. 139.) *Cf.* 4194 of October.

Some Recent Patents

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

487 953.—Transformer coupling for an audio-frequency amplifier in which the first stage is a " driver " and the second a power valve.

The General Electric Co. and K. A. Macfadyen. Application date 12th January, 1937.

AERIALS AND AERIAL SYSTEMS

488 480.—Dipole aerial and feed-line, or counterpoise, with means for preventing the leakage of high-frequency currents over the outer sheath of the feed-line.

Standard Telephones and Cables (assignees of A. B. Bailey). Convention date (U.S.A.) 15th April, 1937.

489 704.—Method of matching the impedance of a high-frequency transmission line to an aerial or other load by inserting an auxiliary " coupling " line between the two.

E. C. Cork and J. L. Pawsey. Application date 30th January, 1937.

490 414.—" Wave " aerial for short-wave working in which a series of capacity-loaded sections set up a phase velocity greater than that of the " free " wave.

E. C. Cork ; M. Bowman-Manifold ; and J. L. Pawsey. Application date 9th February, 1937.

490 449.—Matching a feed-line to an associated aerial, with a resistance-component which is substantially constant over a wide band of frequencies.

E. C. Cork and J. L. Pawsey. Application date 13th November, 1936.

DIRECTIONAL WIRELESS

487 302.—Radio-navigational system of the overlapping-beam type in which precision of steering is increased by the use of directional aerials carried by the craft under guidance.

Telefunken Co. Convention date (Germany) 14th November, 1936.

487 708.—Directive aerial system of the kind comprising two co-planar conductors set at an angle of 60° to each other and excited in phase-opposition.

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.) 28th April, 1936.

488 520.—Directional aerial array made up of two co-planar lines of conductors each carrying in-phase currents, and having means for adjusting the current and phase relations.

Marconi's W.T. Co. (assignees of P. S. Carter). Convention date (U.S.A.) 13th November, 1936.

488 611.—Direction-finding system based upon the use of what is called a " phase " cardioid as distinct from the usual amplitude cardioid.

Marconi's W.T. Co. (assignees of J. Plebanski). Convention date (Poland) 9th September, 1936.

488 823.—Direction-finding set for an aeroplane in which the sum and difference of the pick-up voltage from two dipole aerials, mounted on opposite wings of the machine, is alternately fed to the receiver.

J. I. Heller. Application date 16th November, 1937.

488 827.—Method of keying the two " lobes " of a navigational beam so as to prevent the occurrence of keying " clicks " along the centre-line of the beam.

Telefunken Co. Convention date (Germany) 23rd November, 1936.

489 032.—Directional equipment for " homing " an aeroplane directly on to a distant non-directional transmitter in spite of the presence of a cross-wind.

Sperry Gyroscope Co. Inc. (assignees of M. F. Bates). Convention date (U.S.A.) 13th December, 1935.

490 650.—Preventing interaction between a number of goniometer coils coupled to the same directional aerial.

C. Lorenz Akt. Convention date (Germany) 29th January, 1937.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television.*)

487 417.—Wireless receiver in which a brake is automatically applied when the tuning controls pass through a worth-while station.

N. V. Philips' Lamp Co. Convention date (Germany) 23rd March, 1936.

487 451.—Wireless receiver fitted with dual loud-speakers one of which operates with a rising curve just before the cut-off point in order to combine quality and selectivity.

The General Electric Co. and F. H. Brittain. Application date 8th April, 1937.

487 610.—Electron-multiplier designed to operate either as a detector, or as a high or low-frequency amplifier.

Farnsworth Television Inc. Convention date (U.S.A.) 11th February, 1936.

487 641.—Wireless receiver in which automatic gain control is applied by varying the value of the input coupling from the aerial to the set.

Hazeltine Corporation. Convention date (U.S.A.) 14th October, 1936.

487 700.—All-wave superhet receiver in which the local oscillator is operated as a Colpitts oscillator on the short waveband and as a Hartley oscillator for the longer waves.

G. Hayes. Application date 11th February, 1937.

487 880.—Automatic tuning control system for a wireless receiver in which the action is " sharpened " by means of a filter circuit.

Marconi's W.T. Co. and N. M. Rust. Application date 31st December, 1936.

487 984.—Direction-finder in which a continuously-rotated frame aerial gives a visual indication of the bearings of a distant transmitter, the reading being checked by an audible signal.

Telefunken Co. Convention date (Germany) 15th July, 1936.

488 021.—D.F. receiver in which the signals received on a frame aerial and a vertical aerial are alternately reversed in polarity, when "homing" on a non-directional beacon, by a local oscillator acting on a pair of rectifiers.

N. V. Philips' Lamp Co. Convention date (Holland) 14th May, 1936.

488 111.—Automatic tuning system in which the control valve serves as a variable reactance, but does not reflect resistance into the tuning circuit.

Marconi's W.T. Co. and O. E. Keall. Application date 31st December, 1936.

488 266.—Tuning control operated by finger-holds in a rotary disc and combined with automatic fine tuning.

Marconi's W.T. Co. [addition to 487 687]. *Convention date (U.S.A.) 3rd January*, 1936.

488 269.—Means for stabilising the frequency-changer of a superhet receiver capable of handling frequencies up to 300 megacycles.

Marconi's W.T. Co. (communicated by G. L. Grundmann). Application date 31st December, 1936.

488 566.—Reducing re-radiation from the local oscillator of a superhet receiver.

Radio-Akt. D. S. Loewe [addition to 458 147 *and* 458 149]. *Convention date (Germany) 13th January*, 1936.

488 898.—Suppressing "image" frequencies in a superhet set by means of a rejector circuit loosely coupled to the aerial.

C. Lorenz Akt. Convention date (Germany) 12th August, 1936.

489 048.—Powdered-iron coil "unit," with means for adjusting the effective inductance, particularly for the I.F. stage of a superhet receiver.

E. K. Cole (communicated by Rowe Radio Research Laboratory Co.). Application date 22nd February, 1937.

489 094.—Automatic tuning system in which the required correction depends upon a phase-difference set up by the initial mis-tuning.

Marconi's W.T. Co. Convention date (U.S.A.) 17th October, 1935.

489 256.—Automatic selectivity control in which the broad pass-band for fidelity, and the narrow one for selectivity, are both made substantially flat-topped and rectangular.

The British Thomson-Houston Co. Convention date (U.S.A.) 22nd October, 1936.

489 289.—Balancing or stabilising the operation of a push-pull amplifier by means of negative reaction.

Standard Telephones and Cables and C. E. Strong. Application date 22nd January, 1937.

489 309.—Construction of valve intended to rectify very high frequencies.

Standard Telephones and Cables; W. T. Gibson and W. R. Moscrip. Application date 25th January, 1937.

489 370.—All-wave set in which the "fine-tuning" of short-wave stations is carried out on the medium-wave scale.

Murphy Radio; L. A. Moxon; and J. D. A. Boyd. Application date 22nd December, 1936.

489 486.—Frequency-changer for a superhet receiver in which the incoming signals are applied to an electrode in one stream, and the local oscillations to an electrode in another stream, both electron streams being in series.

L. L. de Kramolin [addition to 409 756]. *Convention date (Germany) 24th October*, 1935.

489 571.—Automatic tuning system for a superhet set, in which the correcting current is derived from a piezo-electric crystal tuned to the fixed intermediate frequency.

J. Robinson. Application date 29th January, 1937.

489 636.—Receiver for frequency-modulated signals in which "noise" and distortion is automatically reduced.

Standard Telephones and Cables (assignees of J. G. Chaffee). Convention date (U.S.A.) 26th March, 1936.

489 669.—High-frequency coil-unit mounted on the chassis of a set so that the trimming-condensers are readily accessible.

Marconi's W.T. Co. Convention date (U.S.A.) 31st January, 1936.

490 138.—Input circuit for an all-wave superhet set arranged to eliminate or attenuate "image" frequencies.

G. W. Johnson (communicated by Philco Radio and Television Corporation). Application dates 9th and 25th January, 1937.

490 346.—Motor-driven tuning device for a wireless set in which a moving element explores a number of contacts and stops at a predetermined one.

Marconi's W.T. Co. (assignees of K. Nowak). Convention date (Austria) 4th January, 1937.

490 485.—Superhet set arranged to receive short-wave signals, and also "distress calls" from the same aerial.

C. Lorenz Akt. Convention date (Germany) 7th October, 1936.

490 672.—Volume expansion or contraction control for a low-frequency amplifier, in which the non-linear feed-back circuit includes an electric incandescent lamp.

Pye Radio and M. V. Callendar. Application date 9th February, 1937.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION.

487 318.—Rotating-mirror scanning device with an auxiliary optical system for increasing the effective scanning angle for a given number of reflecting elements.

Scophony and H. W. Lee. Application date 13th November, 1936.

487 321.—Saw-toothed oscillation-generator of the multi-vibrator type in which successive discharges are controlled by a common impedance coupling the cathodes of the two cross-coupled valves.

E. L. C. White. Application date 12th December, 1936.

487 833.—Method of mounting the mosaic-cell electrode in a cathode-ray transmitter so as to reduce "microphonic" vibration.

H. Miller and J. E. I. Cairns. Application date 22nd December, 1936.

487 940.—Television transmitter in which a mosaic photo-sensitive screen produces charges which are scanned from the opposite side of the screen to that on which the light is projected.

F. A. Lindeman. Application date 28th December, 1936.

488 221.—Rotating-disc scanner with a double spiral of lenses, the scanning area being uniformly illuminated by a parallel beam of light.

Radio-Akt. D. S. Loewe. Convention date (Germany) 10th January, 1936.

488 268.—System for televising "composite" pictures, or for producing "dissolving" and "trick" effects.

Marconi's W.T. Co. Convention date (U.S.A.) 31st December, 1935.

488 419.—Method of scanning with high definition a continuously moving cinema film by a rotating ring or spiral of lenses.

Radio-Akt. D. S. Loewe. Convention date (Germany) 4th October, 1935.

488 486.—Interlaced scanning by a rotating disc having an odd number of apertures and rotating an odd number of times for each complete scan.

Radio-Akt. D. S. Loewe. Convention date (Germany) 4th October, 1935.

488 644.—Cathode-ray television transmitter, of the Iconoscope type, in which the glass walls of the tube are coated with a non-oxidising metal free from secondary emission.

Radio-Akt. D. S. Loewe. Convention date (Germany) 9th November, 1935.

488 843.—Coupling circuit for a time-base generator designed to prevent lateral displacement of the first "lines" of the picture.

N. V. Philips' Lamp Co. Convention date (Germany) 8th March, 1937.

489 102.—Separating the line and frame synchronising impulses by using an impulse, derived from the flyback movement after each line, to "block" an amplifier in the path of the framing impulses.

Baird Television and P. W. Willans. Application date 19th January, 1937.

489 231.—Scanning system in which means are provided to prevent irregularities due to the effect of adjacent impulses upon each other.

Electric and Musical Industries and C. L. Faudell [addition to 455 375]. Application dates 20th January and 18th March, 1937.

489 270.—Construction and assembly of the photo-electric "mosaic" screens used in television transmitters.

C. Lorenz Akt. Convention date (Germany) 31st March, 1937.

489 275.—Automatic volume control for a television receiver in which a voltage derived from the minimum picture-brightness regulates the gain.

Telefunken Co. Convention date (Germany) 2nd November, 1935.

489 307.—Interlaced scanning system in which certain frames contain a whole number of lines more than others.

Telefunken Co. Convention date (Germany) 24th January, 1936.

489 362.—Television transmitter of the Iconoscope type arranged to ensure a rectilinear scanning of the photo sensitive screen.

Radio-Akt. D. S. Loewe. Convention dates (Germany) 25th October and 29th November, 1935.

489 422.—Television transmitter in which the sensitive mosaic screen is scanned by a moving ray of light instead of by an electron stream.

Radio-Akt. D. S. Loewe. Convention date (Germany) 22nd November, 1935.

489 426.—Television receiver in which the picture signals are fed, after phasing, directly from the detector to the control grid of the cathode-ray tube.

The British Thomson-Houston Co. Convention date (France) 26th November, 1935.

489 625.—Saw-toothed oscillation-generator for generating "balanced" scanning-voltages having opposite polarities with respect to ground.

Hazeltine Corporation (assignees of M. Cawein). Convention date (U.S.A.) 15th February, 1936.

489 666.—Means for producing a slot-shaped synchronising impulse at the framing frequency.

Marconi's W.T. Co. (assignees of A. V. Bedford). Convention date (U.S.A.) 31st January, 1936.

489 715.—Mixing picture signals and synchronising impulses by applying them to a pair of valves working into a common load-impedance.

Baird Television and A. J. Brown. Application date 2nd February, 1937.

490 203.—Means for showing "insets" or producing composite pictures on a television programme.

Marconi's W.T. Co. Convention date (U.S.A.) 31st December, 1935.

490 656.—Broad-band amplifier, particularly suitable for television, wherein the first and second valve stages are given complementary response-characteristics.

Hazeltine Corporation (assignees of M. Cawein). Convention date (U.S.A.) 11th May, 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television.)

488 393.—Carrier-wave transmitter in which only a half-wave of the modulating frequency is applied to the grid of the high-frequency oscillation-generator.

C. Lorenz Akt. Convention date (Germany) 13th June 1936.

488 508.—Oscillation-generator in which a number of valves are arranged with their anode-grid capacities in series with each other and with a common inductance.

Telephone Manufacturing Co. and L. H. Paddle. Application date 4th March, 1937.

489 598.—Electrically-tuned or resonant concentric line which can be used to control the frequency of a wireless transmitter.

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.) 4th January, 1937.

489 608.—Magnetron valve for generating ultra-short waves at a high level of efficiency.

Telefunken Co. Convention date (Germany) 30th November, 1935.

490 258.—Neutralising bridge-circuit designed to equalise the grid load on a short-wave oscillator.

Telefunken Co. Convention date (Germany) 24th April, 1936.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

487 328.—Electron multiplier in which the secondary-emission electrodes are arranged so that their surfaces lie substantially parallel with the primary stream, in order to increase the amplification factor.

Baird Television; T. M. C. Lance; and G. E. G. Graham. Application date 17th December, 1936.

487 768.—Multigrid amplifier in which the grid electrodes are so arranged that the screen-grid current is kept at a low value without increasing the inter-electrode capacity.

C. S. Bull. Application date 18th September, 1936.

487 974.—Method of mounting, aligning, and spacing the various electrodes in a cathode-ray tube.

The General Electric Co.; J. E. B. Jacob; L. C. Jesty; and G. W. Seager. Application date 8th March, 1937.

488 416.—Electron optical arrangement comprising a series of apertured discs for focusing the electron stream in a discharge tube of the cathode-ray type.

V. Zeitline; A. Zeitline; and V. Kliatchko. Convention date (France) 5th May, 1936.

488 661.—Electron multiplier in which an oscillating cloud of electrons passes between a pair of target electrodes, one of which is impervious to electrons, whilst the other is apertured.

Farnsworth Television Inc. Convention date (U.S.A.) 24th February, 1936.

488 688.—Secondary-emitting electrode made of an alloy capable of giving copious emission and able to resist high temperatures.

Soc. Francaise Radio-Electrique. Convention date (France) 23rd October, 1936.

488 747.—Short-wave amplifier, oscillator, or detector valve utilising the principle of lateral or transverse deflection, instead of the more-usual longitudinal grid-control.

Telefunken Co. [addition to 477 668]. Convention date (Germany) 26th May, 1936.

488 870.—Construction and assembly of the electrodes, and container, of an electron discharge system, particularly to prevent over-heating.

C. Lorenz Akt. Convention date (Germany) 16th January, 1936.

488 948.—Construction and arrangement of the "gun" electrodes in a cathode-ray tube with the object of ensuring a more-sensitive grid-control of the electron stream.

Radio-Akt. D. S. Loewe. Convention date (Germany) 20th January, 1936.

489 028.—Arrangement of accelerating and space-charge electrodes in the "gun" of a cathode-ray tube.

Radio-Akt. D. S. Loewe. Convention date (Germany) 16th November, 1935.

489 130.—Preventing variations in the overall sensitivity of an electron multiplier caused by the disturbing effect of leads carrying high biasing voltages to the electrodes of the tube.

The General Electric Co. and C. H. Simms. Application date 25th May, 1937.

489 428.—Electrode arrangement of a cathode-ray tube designed to reflect the electron stream by "mirror" action.

F. H. Nicoll. Application date 24th December, 1936.

489 440.—Resilient mounting for protecting the electrodes of a valve against vibration and rough usage.

Marconi's W.T. Co. and A. J. Young. Application date 26th January, 1937.

SUBSIDIARY APPARATUS AND MATERIALS

487 576.—Loud-speaker unit designed to favour the transmission of sound in one or more desired directions.

H. Jyrch. Convention date (Germany) 25th November, 1936.

487 870.—Means for cyclically varying the frequency of a valve oscillator so as to produce a "wobbling" tone or a saw-toothed wave.

Ferranti; N. H. Searby; and G. M. Tomlin. Application date 28th December, 1936.

487 913.—Valve circuit for converting variations of frequency into variations of current, particularly in the case of a condenser microphone.

Egyesult Izzolampa es Villamossagi Reszvenytarsasag. Convention date (Hungary) 10th June, 1936.

488 076.—Stabilising the frequency of an oscillatory circuit, in spite of temperature variations, by a method of sheathing the circuit components.

C. Lorenz Akt. Convention date (Germany) 27th October, 1936.

488 081.—Construction of choke-coil particularly for use in high-frequency rejector circuits.

V. Poulsen and D. P. L. Grether. Convention date (Denmark) 12th November, 1936.

488 645.—Valve relay for detecting and giving positive warning of a fault in an oscillating circuit.

R. Willoughby. Application date 10th November, 1936.

489 505.—Rectifier and smoothing circuit for A.C. mains, in which a large load capacity is combined with a constant terminal voltage.

Marconi's W.T. Co. Convention date (U.S.A.) 31st January, 1936.

489 534.—Method of sealing the lead-in conductors through the quartz or like walls of an electric discharge tube.

The General Electric Co.; V. J. Francis; N. L. Harris; J. W. Ryde; and K. G. Schnetzler. Application date 28th January, 1937.

489 588.—Tabular filter or resonator units for preventing acoustic resonance effects from a loud-speaker enclosed in a wireless cabinet.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 2nd September, 1936.