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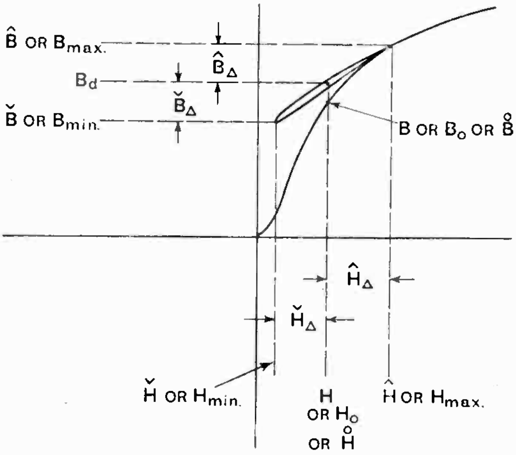
Editorial

Symbols in Electromagnetism with Special Reference to Incremental Magnetisation

NO one can go very far in any branch of electrical science without realising the great importance of having a well-thought-out system of symbols, and various bodies have from time to time drawn up lists of recommended symbols. The want of agreement on the matter introduces an unnecessary difficulty in reading articles of a mathematical nature, and every reader has experienced the annoyance of having to turn continually back to find the meaning of unfamiliar symbols, or—what is much worse—of familiar symbols playing unfamiliar rôles. The attempt to maintain some kind of a standard in the matter is not the least of an editor's worries. The difficulty increases daily with the extension of knowledge, while the number of letters in the alphabet remains unchanged.

We recently saw a proposed list of symbols in which E was made to do duty for (1) potential difference, (2) electromotive force, and (3) electric force or field strength. Now, it is just in the case of closely related magnitudes like these that careful discrimination is most essential, and confusion most likely to occur through the use of non-discriminating symbols. It is true that alternatives were suggested in case of any danger of confusion, viz., U for potential difference and K or $\mathcal{E}$ for electric force, but it is striking that the same symbol should be suggested as the first choice for three entirely different concepts, as if teachers had not trouble enough in imparting clear ideas on the subject to their students. As an example, consider a metre of wire of 0.01 ohm resistance bent into a circle and the ends welded together, and let a magnet pole be plunged into the ring, causing a current of 1 ampere to circulate as the result of the induced electromotive force. What is the value of E (or should it be e)? If by E you mean potential difference, there is none, since all the points of the wire are at the same potential; if by E you mean electromotive force, its value is 0.01 volt, since it suffices to drive a current of 1 ampere through 0.01 ohm; if by E you mean electric force, then it is 10^{-4} volt per cm. This example also shows the necessity of distinguishing between electric force and potential gradient, which are sometimes confused. All points of the ring being at the same potential the gradient is zero.

There is no doubt that neither E nor V are really suitable symbols for potential difference, the former because of its general adoption for electromotive force, the latter because, being the recognised abbreviation for volts, it would lead to such statements as $V = 20$ V. U is commonly employed on the Continent as the symbol for potential difference and seems free from any serious objection.



Symbols suggested by Dr. Sims.

At the recent meeting of the British Association at Nottingham, Dr. Sims, who has devoted much attention to the question of incremental magnetisation, put forward a suggested set of symbols for the various quantities involved. These were purely tentative and were intended to form the material for a discussion on the subject. The suggested symbols are shown in the Figure, and it will be noticed that alternatives are given in several cases. The magnetic symbols have never been brought into line with the electric symbols. It is now generally recognised that small letters should be used for instantaneous values and that a maximum value is only a special instantaneous value. If one agrees to this and decides to represent the maximum value by means of a circumflex as being simpler to write than the suffix *max.*—whether the printer prefers it is another matter—we have as the formula for a sinusoidal current $i = \hat{\imath} \sin \omega t$, but in the analogous case of a sinusoidal magnetic induction we doubt if anyone has had the courage to write $b = \hat{b} \sin \omega t$, or $h = \hat{h} \sin \omega t$, perhaps because these symbols are commonly employed for breadth and height. Is there any other objection? If the circumflex is to be used for the additive amplitude, the suggestion to use the inverted circumflex for the subtractive amplitude seems a very happy one.

There is some doubt whether the term "incremental" is the best one to employ; an alternative suggestion is to refer to the polarised permeability μ_p to distinguish it from the unpolarised or symmetrical permeability. We think that it might be preferable to speak of the symmetrical permeability and designate it, if necessary, by μ_s rather than of the unpolarised permeability designated by the already overworked μ_0. The suffix Δ suggested to indicate the amplitudes of the superposed magnetisation seems quite satisfactory. The values of B and H before the alternating voltage was applied might be referred to as the static values B_s and H_s, corresponding to the symmetrical permeability μ_s. On applying the alternating voltage the mean value of B increases from B_s to B_d, the amount of the displacement depending on the amplitude of the cycle.

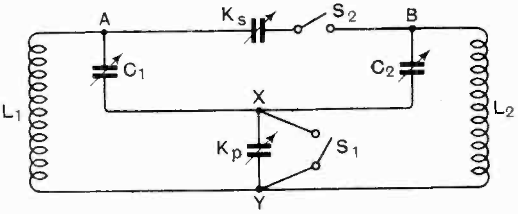
It is to be hoped that a set of symbols and a common nomenclature may be evolved which will commend themselves to all those interested in this subject. We feel sure that Dr. Sims will welcome suggestions and comments.

G. W. O. H.

An Interesting Complex Coupling

ON page 608 we publish a letter received from Mr. E. G. Beard in which he refers to a novel method of coupling two tuned circuits.

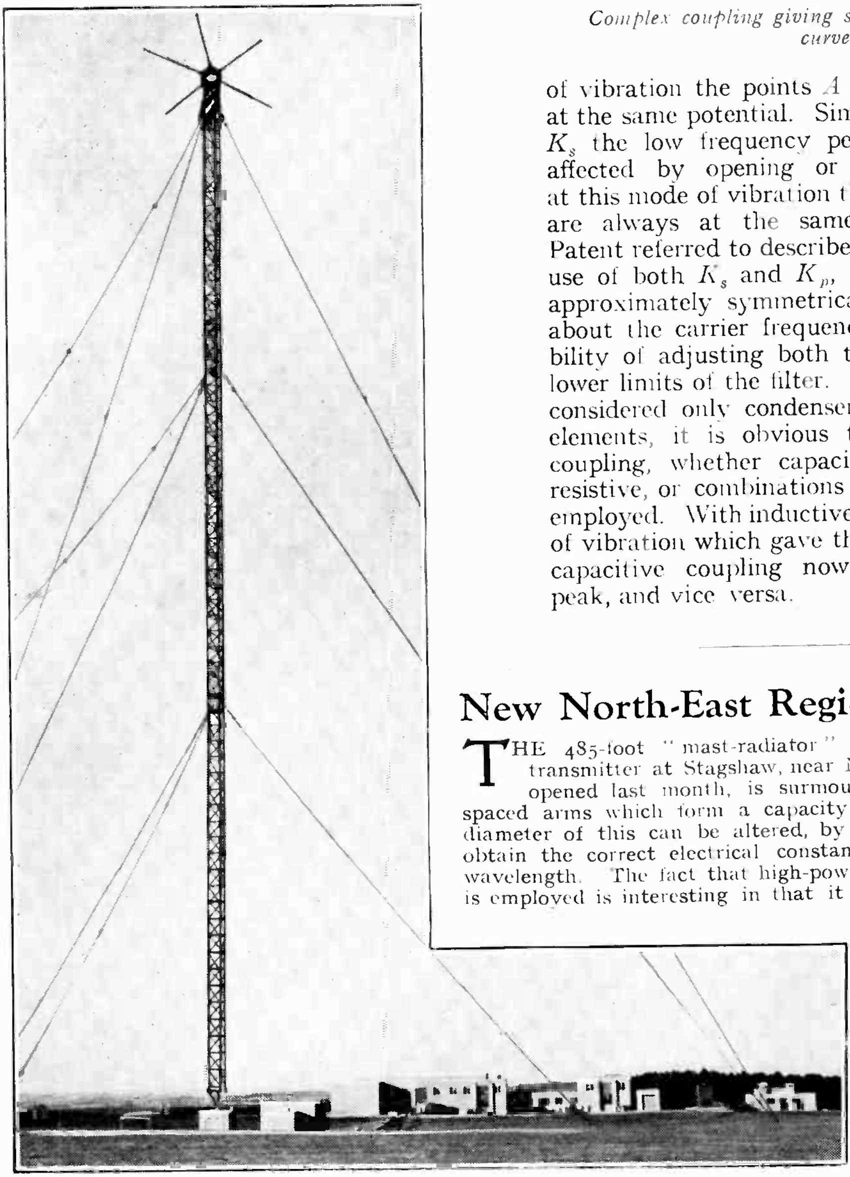
The method, which is described in Australian Patent No. 20677 of 1934, is shown in the Figure. If S_1 is closed and S_2 open, the two circuits L_1 C_1 and L_2 C_2 are independent except for stray coupling, and can be tuned to give a single-peaked resonance curve at the carrier frequency. If S_1 is now opened the circuits are coupled through the condenser K_p and a double-humped resonance curve will be obtained, but not symmetrical about the carrier frequency since one of the humps occurs at the carrier frequency and the other at a higher frequency due to the coupling condenser being in series with C_1 and C_2 at this mode of vibration. If S_1 is closed, thus short-circuiting K_p, and S_2 closed, thus bringing in the coupling condenser K_s, another humped resonance curve is obtained with one hump again at the carrier frequency, but the other now at a lower frequency. It is interesting to note that when using K_p the high frequency peak would not be affected by opening or closing S_2, since at this mode of vibration the points A and B are always at the same potential. Similarly, when using K_s the low frequency peak would not be affected by opening or closing S_1 since at this mode of vibration the points X and Y are always at the same potential. The Patent referred to describes the simultaneous use of both K_s and K_p, thus obtaining an approximately symmetrical resonance curve about the carrier frequency, and the possibility of adjusting both the upper and the lower limits of the filter. Although we have considered only condensers as the coupling elements, it is obvious that any form of coupling, whether capacitive, inductive or resistive, or combinations of these, could be employed. With inductive coupling the mode of vibration which gave the upper peak with capacitive coupling now gives the lower peak, and vice versa. G. W. O. H.



Complex coupling giving symmetrical resonance curve.

New North-East Regional Station

THE 485-foot "mast-radiator" of the new B.B.C. transmitter at Stagshaw, near Newcastle, which was opened last month, is surmounted by six equally spaced arms which form a capacity ring. The effective diameter of this can be altered, by means of hinging, to obtain the correct electrical constants for the operation wavelength. The fact that high-power Class B modulation is employed is interesting in that it is a reversion to the system used for earlier transmitters. To maintain the accuracy of the carrier-frequency (1,122 kc/s) a separate constant frequency drive unit is employed. This is enclosed in an oven the temperature of which is thermostatically maintained.



The Necessary Conditions for Instability (or Self-Oscillation) of Electrical Circuits*

An Alternative Proof of Nyquist's Theorem on Regenerative Systems

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(Lecturer in Communications, City and Guilds (Eng.) College, South Kensington)

SUMMARY.—The possibility of self-oscillation of a circuit is shown to depend on the signs of the real parts of the roots of the characteristic differential equation of the circuit.

The existence of one or more roots with positive real parts, which is the necessary condition for instability, is shown to be reflected in the behaviour of the complex vector ratio of the steady state alternating voltages at two points in the system over the whole range of frequencies from zero to infinity.

Introduction

ALTHOUGH the conditions for self-oscillation of certain simple forms of valve oscillator have been well understood for many years, certain recent developments in regenerative systems, in particular the negative feedback amplifier,† have focused attention on the general problem of the stability or otherwise of a complex system containing a potential source of energy, such as a valve amplifier.

In 1932 Nyquist published a paper‡ in which he derived the necessary condition for the self-oscillation of any system in which there exists a path whereby a disturbance originating in any part of the circuit may travel around the circuit and eventually return to its starting point. Briefly, Nyquist's method depends on the expression of any transient disturbance, $f(t)$, as a Fourier Integral.

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \epsilon^{j\omega t}\, d\omega \int_{-\infty}^{\infty} f(t)\epsilon^{-j\omega t}\, dt$$

By consideration of the change in magnitude and phase suffered by each infinitesimal Fourier component of the disturbance after having travelled around the closed path through the system, such change in magnitude and in phase being denoted by the complex multiplier $AJ(\omega)$, the total disturbance at the starting point after the original disturbance has traversed the circuit "N" times is given by

$$f_n(t) = f(t) + AJ(\omega) \,.\, f(t) + [AJ(\omega)]^2 \,.\, f(t) + \ldots\ldots + [AJ(\omega)]^N \,.\, f(t)$$

where the expression $[AJ(\omega)]^K . f(t)$ is understood to mean that every component having pulsatance (ω) of the Fourier Integral expression for $f(t)$ has been changed in magnitude by a factor equal to the Kth power of the modulus of the appropriate value of $AJ(\omega)$ and in phase by K times the argument (or angle) of $AJ(\omega)$.

By summation of the above series to an infinite number of terms, the resultant disturbance at the starting point is obtained. If the expression $Lim_{n\to\infty} f_n(t)$ approaches infinity as t approaches infinity, even though $f(t)$ approaches zero, i.e., after the original disturbance has died out, then the system is self-maintaining or oscillatory. If not, the system is stable.

Nyquist shows that the above series is divergent if the vector locus of $AJ(\omega)$, plotted for all values of (ω) from minus infinity to plus infinity, encloses the point (1, 0). It converges to a finite value or zero, according as to whether $Lim_{t\to\infty} f(t)$ approaches a finite value or zero, if the locus of $AJ(\omega)$ does not enclose the point (1, 0).

This criterion of stability, involving as it does merely a knowledge of the steady state complex amplification ratio around the closed path, is both simple in conception

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* MS. accepted by the Editor, April, 1937.

† See Ref. 1.

‡ See Ref. 2.

and suitable for application to practical circuits, either by calculation or direct measurement.

The mathematical processes involved in the summation of the series and in relating the result to the locus of $AJ(\omega)$ are, however, of such a nature that their physical interpretation is not at once obvious, and it is felt that the importance of the final result justifies an alternative derivation which makes use only of the elementary ideas of complex quantities which form the groundwork of ordinary A.C. theory.

Before proceeding with this alternative derivation, it may be mentioned that the general theory of the stability of a linear dynamical system (which includes electrical circuits) was worked out by Routh in 1883* who produced a number of criteria for stability, one of which is in a very similar form to that given by Nyquist, but is derived from an earlier theorem of Cauchy.

Also in a paper (Peterson, Kreer and Ware)† describing an experimental investigation of Nyquist's Criterion a partial proof is derived in a manner somewhat similar to that which follows.

Derivation of Criterion for Self-Oscillation

(1) *Restrictions as to linearity.*

In any system in which the conditions for the inception of self-oscillation are under investigation it is legitimate to assume that all impedances, including valve impedances, are linear, since until the amplitude of oscillation has reached a finite and generally relatively large value, the effects of curvature in the characteristics, e.g., of anode current versus grid voltage, or of magnetisation curves of iron cored inductances, are negligible.

In certain cases, as, for example, circuits containing one or more valves initially biased beyond their cut-off point, sustained oscillation may be possible if it is first started by some external source of sufficient magnitude, but will not build up spontaneously from a differentially small initial disturbance. The following reasoning cannot be applied directly to such cases.

(2) *Normal Modes of Vibration.*

When any dynamical system, either electrical or mechanical, is disturbed from its initial condition of rest by an externally applied impulse and then left to itself, it may or may not revert eventually to its original quiescent state, according as to whether this initial state was inherently stable or unstable. In an electrical circuit the necessary disturbance is always present in the form of the random e.m.f. of thermal agitation of the electrons in the conductors, so that an inherently unstable circuit will, immediately upon completion, proceed to build up currents in its various meshes until a stable, though not necessarily stationary, condition is reached.

The behaviour of the circuit subsequent to the removal of the disturbing force is determined by the set of equations which characterise its various meshes, expressing the fact that the total e.m.f.'s around each complete mesh must add up to zero, and that the total current flowing to any point is zero. If the system contains reactances, these equations will involve the differential coefficients of the voltages and currents respectively.

In circuits in which all impedances are linear, these differential equations will all have constant coefficients and will furthermore be linear, i.e., involve only the first powers of the differential coefficients.

As a simple example, consider the circuit shown in Fig. 1, for which the equation of dynamic equilibrium is

$$\int_{-\infty}^{t} \frac{i\,dt}{c} + L\frac{di}{dt} + Ri = 0 \quad .. \quad .. \quad (1)$$

where "i" is the current at time t.

The solution for an equation of this type is found by making the substitution $i = K\epsilon^{pt}$ where K and p are constants, and is of course well known to be

$$i = K_1\epsilon^{p_1t} + K_2\epsilon^{p_2t} \quad .. \quad .. \quad (2)$$

$$\text{where } p_1 = -\frac{R}{2L} + \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$$

$$p_2 = -\frac{R}{2L} - \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$$

and K_1, and K_2 are integration constants determined by the conditions pertaining at the time of the disturbance.

P_1 and P_2, however, are independent of the

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* See Ref. 3.

† See Ref. 4.

form of the initial disturbance and are called the "normal modes" of the system of Fig. 1. They may be real or complex, according as to whether the system is oscillatory or aperiodic. In this case, where the circuit contains only positive elements, the real part of the p's must be negative so that the current dies away exponentially to zero. If the resistance R were to be replaced by a source of power having a "negative resistance" R, for example, a series excited generator, the current would increase towards infinity, and the real part of the p's would be positive.

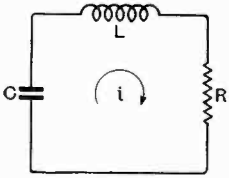

Fig. 1.

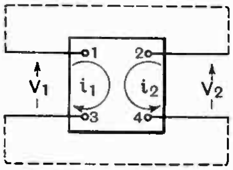

Fig. 2.

Thus whether the resultant current approaches zero or infinity after a sufficient lapse of time is determined by the sign of the real parts of the normal modes of vibration. A negative real part corresponds to a stable initial condition, and a positive real part to an unstable initial condition.

Extension to General Case

In the above case, a single mesh only was considered. In the general case of a linear system containing n closed meshes, there are n differential equations of dynamic equilibrium, each of the form (3) which is that for the Kth mesh.

$$L_{KK}\frac{di_K}{dt} + R_{KK}\,i_K + \int_{-\infty}^{t}\frac{i_K}{C_{KK}}\,dt$$
$$-\sum_{h=1}^{h=n} L_{Kh}\frac{di_h}{dt} + R_{Kh}i_h + \int_{-\infty}^{t}\frac{i_h}{C_{Kh}}\,dt = e_K \quad .. \quad (3)$$

where i_K and i_h are the instantaneous currents circulating in the Kth and hth meshes respectively, e_K is the total externally applied e.m.f. acting in the Kth mesh, L_{KK}, R_{KK}, C_{KK} are the total inductance, resistance and equivalent capacitance (i.e., the reciprocal of the sum of the reciprocals of all the capacitances) which are included in the Kth mesh. L_{Kh}, R_{Kh}, and C_{Kh} are the corresponding quantities which are common to the Kth and hth meshes, and the summations indicated are for all values of h between 1 and n except $h = K$.

In determining the normal modes of vibration, the network is considered free, from all externally applied e.m.f.'s, so that all the e_K's are zero. In this case, by a further differentiation with respect to t, equation (4) is obtained.

$$L_{KK}\frac{d^2i_K}{dt^2} + R_{KK}\frac{di_K}{dt} + \frac{i_K}{C_{KK}}$$
$$-\sum_{h=1}^{h=n} L_{Kh}\frac{d^2i_h}{dt^2} + R_{Kh}\frac{di_h}{dt} + \frac{i_h}{C_{Kh}} = 0 \quad .. \quad (4)$$

Putting

$i_K = I_K\epsilon^{p_Kt} + I'_K\epsilon^{p'_Kt} + I''_K\epsilon^{p''_Kt} + \ldots$ etc.

where the I_K's and p_K's are constants, each of the equations represented by (4) becomes

$$I_K\,\epsilon^{p_Kt}\left[L_{KK}\,p_K^{\,2} + R_{KK}\,p_K + \frac{1}{C_{KK}}\right]$$
$$-\sum_{h=1}^{h=n} I_h\,\epsilon^{p_ht}\left[L_{Kh}p_h^{\,2} + R_{Kh}p_h + \frac{1}{C_{Kh}}\right]$$
$$+\,I'_K\,\epsilon^{p'_Kt}\left[L_{KK}(p'_K)^2 + R_{KK}p'_K + \frac{1}{C_{KK}}\right]$$
$$-\sum_{h'=1}^{h'=n} I'_h\,\epsilon^{p'_ht}\left[L_{Kh}(p_h)^2 + R_{Kh}p'_h + \frac{1}{C_{Kh}}\right]$$
$$+\;\ldots\ldots\ldots = 0 \quad .. \quad .. \quad .. \quad (5)$$

As there are n equations represented by (5), all of which must hold for all values of t, this is only possible if

$$p_1 = p_2 = \ \ldots = p_K = p$$
$$p'_1 = p'_2 = \ \ldots = p'_K = p'$$

etc., and the coefficients of ϵ^{pt}, $\epsilon^{p't}$ are each equal to zero.

$$\text{i.e.}\quad \left\{\begin{array}{l} I_K\left[L_{KK}p^2 + R_{KK}p + \dfrac{1}{C_{KK}}\right] \\ \quad -\displaystyle\sum_{h=1}^{h=n} I_h\left[L_{Kh}p^2 + R_{Kh}p + \dfrac{1}{C_{Kh}}\right] = 0 \\ I'_K\left[L_{KK}(p')^2 + R_{KK}p' + \dfrac{1}{C_{KK}}\right] \\ \quad -\displaystyle\sum_{h=1}^{h=n} I'_h\left[L_{Kh}(p')^2 + R_{Kh}p' + \dfrac{1}{C_{Kh}}\right] = 0 \end{array}\right.$$
$$\text{etc.} \quad .. \quad .. \quad (6)$$

Writing $L_{KK}p^2 + R_{KK}p + \frac{1}{C_{KK}} = S_{KK}$

and $L_{Kh}p^2 + R_{Kh}p + \frac{1}{C_{Kh}} = S_{Kh}$

the n equations represented by (6) may be written after dividing each by p.

$$\left.\begin{array}{l} S_{11}I_1 - S_{12}I_2 - S_{13}I_3 \ldots - S_{1n}\, I_n = 0 \\ -S_{21}I_1 + S_{22}I_2 - S_{23}I_3 \ldots - S_{2n}\, I_n = 0 \\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot \\ -S_{n1}I_1 - S_{n2}I_2 - S_{n3}I_3 \ldots + S_{nn}\, I_n = 0 \end{array}\right\} (7)$$

From these n equations $n - 1$ unknown I's may be eliminated leaving a single equation, which is the same for all the I's, namely,

$$\Delta I = 0 \quad .. \quad .. \quad .. \quad (8)$$

where Δ represents the determinant

$$\begin{vmatrix} +S_{11} & -S_{12} & \ldots & -S_{1n} \\ -S_{21} & +S_{22} & \ldots & -S_{2n} \\ -S_{31} & -S_{32} & \ldots & -S_{3n} \\ -S_{n1} & -S_{n2} & \ldots & +S_{nn} \end{vmatrix}$$

The values of p which make this determinant vanish are therefore the normal modes of vibration of the system.

Normal Modes of a Back-Coupled Amplifying System

In any four terminal network as shown in Fig. 2, containing $(n - 2)$ internal closed meshes but no sources of e.m.f., there are n equations of the form (3), the first 2 being equal to v_1 and v_2 respectively, and the remainder all equal to zero. If v_1 and v_2 are themselves exponential functions of t,

$$v_1 = V_1 \epsilon^{pt}$$
$$v_2 = V_2 \epsilon^{pt'}$$

these n equations are

$$\left.\begin{array}{l} S_{11}I_1 - S_{12}I_2 - S_{13}I_3 \ldots - S_{1n}I_n = V_1 \\ -S_{21}I_1 + S_{22}I_2 - S_{23}I_3 \ldots - S_{2n}I_n = V_2 \\ -S_{31}I_1 - S_{32}I_2 + S_{33}I_3 \ldots - S_{3n}I_n = 0 \\ \cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot\quad\cdot \\ -S_{n1}I_1 - S_{n2}I_2 \ldots\ldots + S_{nn}I_n = 0 \end{array}\right\} (9)$$

From these n algebraic equations, $n - 2$ of the I's may be eliminated, leaving

$$\left.\begin{array}{l} AI_1 + BI_2 = V_1 \\ CI_1 + DI_2 = V_2 \end{array}\right\} \quad .. \quad .. \quad (10)$$

where A, B, C and D are formed from products and quotients of the S's and are therefore polynomials in "p."

When the input terminals 1.3 are connected in parallel with the output terminal 2.4 as indicated by the dotted lines in Fig. 2,

$$V_1 = V_2 = V \text{ and } I_1 = -I_2 = I$$

With the convention that the arrows in Fig. 2 are directed up the potential gradient, the equations (10) be—

$$AI - BI = V$$
$$CI - DI = V$$

which together give $[A + D - B - C]I = 0$. The normal modes of the back-coupled system are therefore the values of p which make

$$[A + D - B - C] = 0 \quad .. \quad .. \quad (11)$$

At this point a restriction is introduced which is substantially valid in most cases to which the theorem is applicable. It is that the network is capable of transmission in one direction only, say from 1.3 to 2.4, so that a voltage applied across 2.4 produces no current through 1.3 when the latter path is short-circuited externally. The necessity for this restriction and its implications will be discussed later.

This restriction amounts to the statement that either $B = 0$ or $C = 0$ according as to whether the network is capable of transmitting in the 1 to 2 or 2 to 1 direction. For example, if transmission is only possible in the 1 to 2 direction, and a voltage V_2 is maintained across the 2.4 terminals by an external source whilst the 1.3 terminals are short-circuited, both V_1 and I_1 must be zero. Substituting $V_1 = 0$ into (15) and subsequently eliminating I_2 leads to the relation

$I_1 = V_2 \times \frac{B}{BC - AD}$ so that B must be zero.

The general network equations (15) then reduce to

$$\left.\begin{array}{l} AI_1 = V_1 \\ CI_1 = DI_2 = V_2 \end{array}\right\} \quad .. \quad .. \quad (12)$$

and the normal modes are given by

$$A + D - C = 0 \quad .. \quad .. \quad .. \quad (13)$$

The specific problem under consideration is to determine whether any of the values of p which satisfy (13) have a positive real part. This may be done by direct solution if all the constants of the network are known, but the object of the theorem is to determine whether the system is stable or not without a complete specification of the interior connections of the network. A knowledge of the voltage transfer ratio is all that is required.

Definition of Voltage Transfer Ratio

The ratio of the voltages V_1 and V_2 across the input and output terminals of the network is dependent on its external as well as internal connections. The voltage transfer ratio, $f(p)$, will be defined as the ratio of the voltage V_2 across the output terminals to the voltage V_1 across the input terminals when the network is iteratively terminated, that is when it is one of an infinite number of identical networks connected in tandem, as shown in Fig. 3.

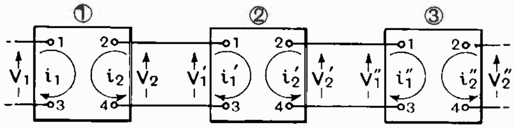

Fig. 3.

This ratio will in general be a complex quantity, dependent on the value of p at which it is measured. In practical measurements p would be the purely imaginary quantity $j\omega$, but for purposes of theory it may have any value, real, or complex.

Since the same pair of equations (12) hold for each of the networks of Fig. 3 and I_2 for one network is the same as $-I_1$ for the subsequent network, whilst V_2 for one network is V_1 for the next, there exists, in addition to equations (12) the relation

$$AI_2 = -V_2$$

Eliminating I_1 and I_2 from (17) by means of this relation gives

$$\frac{V_2}{V_1} = \frac{C}{A + D} = f(p) \quad \ldots \quad \ldots \quad (14)$$

Hence, the condition that $A + D - C = 0$ (13) is the same as the condition that $f(p) = 1$, or $1 - f(p) = 0$. This last form is the most convenient for analytical purposes, and will be used throughout the subsequent discussion.

If the system shown in Fig. 3 is stable, that is when the 1.3 terminals of network (1) are short-circuited and no external e.m.f.'s are applied, no currents flow in the system, then the determinant of the circuit formed by the 2.4 terminals of network 1 and the 1.3 terminals of network (2) must have no modes with positive real parts. But considering the closed circuit formed by the 2.4 terminals of network 1 and the 1.3 terminals of network 2, this determinant is $A + D$, which must therefore have no roots with positive real parts if the system of Fig. 3 is stable. Since A, C and D are all rational polynomials in p, $f(p)$ may be expressed in the form

$$f(p) = \frac{B_m p^m + B_{m-1} p^{m-1} + \ldots + B_0}{A_n p^n + A_{n-1} p^{n-1} + \ldots + A_0} \quad \ldots \quad (15)$$

where the A_K's and B_K's are constants.

In any four terminal network, the transmission efficiency must fall to zero at infinitely high rates of change of applied voltage, owing to the effect of distributed capacity, so that the expression (20) must vanish when p is made infinite. Therefore, with any physical system, the denominator must contain terms of a higher order in p than any in the numerator. On forming the expression $1 - f(p)$ therefore, equation (21) is obtained after dividing numerator and denominator by the factor A_n

$$1 - f(p) = \frac{p^n + \beta_{n-1} p^{n-1} + \beta_{n-2} p^{n-2} + \ldots \beta_0}{p^n + \alpha_{n-1} p^{n-1} + \alpha_{n-2} p^{n-2} + \ldots \alpha_0} \quad \ldots \quad \ldots \quad (16)$$

where the α's are formed by dividing the A's of (20) by A_n, whilst the β's are new coefficients formed by subtracting the coefficients of like powers of p in the numerator from the denominator of (20) and dividing the result by A_n. The expressions for the numerator and denominator may be factored in terms of their roots

$$1 - f(p) = \frac{(p - p_\alpha)(p - p_\beta)(p - p_\gamma) \ldots}{(p - p_1)(p - p_2)(p - p_3) \ldots} \quad \ldots \quad (17)$$

Where p_α, p_β, p_γ, etc., are the roots of the equation

$$p^n + \beta_{n-1} p^{n-1} + \beta_{n-2} p^{n-2} \ldots + \beta_0 = 0$$

whilst p_1, p_2, p_3, etc., are the corresponding quantities for the denominator.

The normal modes of the back-coupled circuit are thus p_α, p_β, p_γ, etc., whilst p_1, p_2, p_3 are those of the determinant $(A + D)$ which is that of the system of Fig. 3. Equation (22), like the preceding ones, is an equation of complex quantities: "p" is a variable which can take on any value in the plane of complex numbers, whilst $p_\alpha, p_\beta, p_\gamma, p_1, p_2 p_3$, etc., are fixed points in this plane. p, p_β, p_γ, etc., may be anywhere in the plane, but p_1, p_2, p_3, etc., must all lie to the left or negative side of the axis of imaginaries, as indicated in Fig. 4.

The real and imaginary components of (say) p_α are the projections of a line joining the origin to the point p_α upon the real and imaginary axes respectively. The components of $(p - p_\alpha)$ are similarly corresponding projections of a line joining p to p_α. This line is specified entirely by its length and direction, its position being immaterial. It is therefore a vector quantity. Thus $1 - f(p)$ is also a vector quantity, the quotient of the product of the vectors of the denominator divided into those of the numerator. If p is given the value $j\omega$, then $f(p)$ becomes $f(j\omega)$, i.e., the steady state vector ratio between V_2 and V_1 at a frequency $\frac{\omega}{2\pi}$ and corresponds to the quantity $AJ(\omega)$ in Nyquist's notation. On referring to Fig. 4, it is seen that if p is varied along the axis of imaginaries from $p = +j\infty$ to $p = -j\infty$ the vector $(p - p_\alpha)$ will turn through 180° in a counterclockwise direction if p_α lies on the positive side of the axis of imaginaries, and through 180° in a clockwise direction if p_α is on the negative side of this axis. The vectors in the denominator must therefore all rotate in a clockwise direction as p goes from $+j\infty$ to $-j\infty$ along the imaginary axis. But since the reciprocal of a vector $R \underline{|\theta}$ is $\frac{1}{R} \overline{|\theta}$ the reciprocals of the denominator rotate through 180° in the counterclockwise direction. As the denominator and numerator are of the same degree in p there are an equal number of factors in each so that $(p - p_\alpha)$ may be associated with $(p - p_1)$, and $(p - p_\beta)$ with $(p - p_2)$, etc.

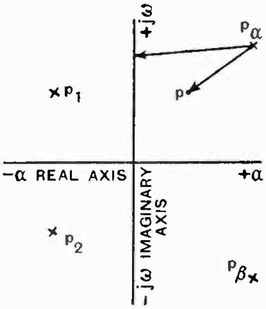

Fig. 4.—*Complex plane of $p = \alpha + j\omega$.*

Thus every root p_α, p_β, etc., to the right of the axis of imaginaries will, with its associated root in the denominator, contribute a rotation of 360° to the vector in the counterclockwise direction, whilst every root p_α, p_β to the left of the axis will contribute nothing, owing to its clockwise rotation being cancelled by the counterclockwise rotation of the reciprocal of its associated vector in the denominator. Thus, if there are m roots, p_α, p_β, etc., with positive real parts, the vector $1 - f(j\omega)$ will rotate through m revolutions in a counterclockwise direction as ω is varied from ∞ to $-\infty$.

In Fig. 5 the vector $1 - f(j\omega)$ is plotted as the line OP in the x, y plane, where $1 - f(j\omega) = x + jy$. If the length of the line $O - A$ is unity, then the line $P - A$ represents $f(j\omega)$. The two paths, $A - P - C - A$ and $A - P' - C' - A'$ represent two possible loci for OP as ω is varied from $+\infty$ to $-\infty$, the total rotation of OP being O and 360° respectively in the two cases. In the first case, the locus of the extremity of the vector of OP encloses the origin, in the second it does not. Alternatively, the locus of $f(j\omega)$ may be plotted as in Fig. 6. If this locus encloses the point (1, 0) once only, the vector $1 - f(j\omega)$ rotates through 360°, and the system has one mode with a positive real part and is unstable. Similarly, if the locus encircles the point (1, 0) twice, the system is unstable, having two modes with positive real parts, and so on. Since the real part of the vector representing the loop voltage transfer ratio is a function of even powers of "ω," whilst the imaginary part is a function of odd powers of "ω," it is only necessary to calculate or measure the ratio for values of ω between zero and + infinity, the remaining half from zero to − infinity being a mirror image about the real axis of the first part.

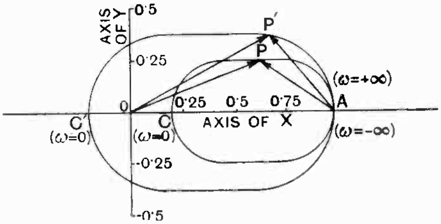

Fig. 5.—*Loci in complex plane of $1 - F(p) = X + jY$ for $p = j\omega$.*

As the complex roots of the numerator and denominator must occur in conjugate pairs (since the coefficients of the p's are real quantities) it will generally happen that the vector locus of $f(j\omega)$ will enclose the point (1, 0) if it does so at all, twice, the only exception to this case being where the network contains a single pure negative resistance such as an arc or dynatron, in which case there may be a single aperiodic positive root.

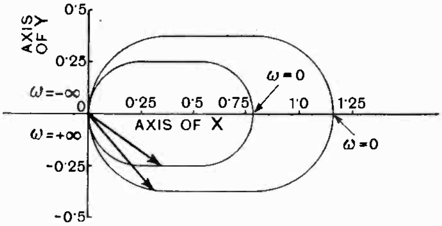

Fig. 6.—*Loci in complex plane of* $F(p) = X + jY$ *for* $p = j\omega$.

Discussion of Restrictions and Implications

In the course of the above proof, it was necessary to impose the restriction that the network should be capable of transmission in one direction only. Although Nyquist does not explicitly make this restriction in his analysis, it is nevertheless implied therein in that the effects of transmission in the reverse direction are not considered. If the restriction is not made, the general equations (10) must be used for determining the loop voltage transfer ratio when iteratively connected.

Under these conditions, assuming a voltage V_1 to be applied to the 1.3 terminals (see Fig. 3), the general expression for $f(p)$ resulting from equation (15) and the fact that

$$f(p) = \frac{V_2}{V_1} = -\frac{I_2}{I_1} \text{ is}$$

$$f(p) = \frac{A + D \pm \sqrt{(A+D)^2 - 4BC}}{2B} \quad \ldots (18)$$

This leads to two values of $f(p)$ which satisfy the condition (11)

namely, $f(p) = 1$ and $f(p) = \frac{C}{B}$

These two values correspond to the two vector ratios of V_2 to V_1 in the two cases (1) where the e.m.f. is applied at the 1.3 terminals, and the resultant voltage measured across the 2.4 terminals when iteratively terminated and (2) when the e.m.f. is applied across the 2.4 terminals, and the resultant voltage measured between the 1.3 terminal iteratively terminated.

But unless $B = 0$ or $C = 0$ the expression (18) for $f(p)$ is no longer a rational algebraic expression in p and so that $1 - f(p)$ cannot be put into the factored form of (17).

If either B or C is zero the loop voltage transfer ratio in one or other direction is zero, and then only can the subsequent factorising process be justified.

It is unfortunate that this restriction is necessary, as it somewhat reduces the generality of the theorem, but, on the other hand, it will be seen that without such a restriction the loop voltage transfer ratio would cease to have a practical as distinct from a theoretical meaning, as it would be impossible to terminate the network with its iterative impedances without an infinite number of identical networks!

Where the transmission is unidirectional the input and output impedances A and D are definitely realisable with a finite number of elements, and are indentical with the iterative impedances.

The one case where this restriction does necessitate special care in the application of the theorem is that of an amplifier in which the anode grid capacitances of the valves have an appreciable admittance (e.g., as in triodes).

Here, for purposes of calculation, at any rate, the input terminals may be looked upon as actually across the grid and filament of one of the valves, the anode-grid capacitance being included in the external feedback path.

Steady State Amplitude of Oscillation

It is not intended here to discuss the general theory of the final amplitude of oscillation taking into account non-linearity in the impedances, as this has been extensively treated elsewhere.*

It is obvious that when the steady state of oscillation has been reached the vector ratio of V_2 to V_1 must equal unity, for so long as the locus encloses instead of passing through the point (1, 0) there exist roots with positive real parts which implies oscillations still growing in amplitude.

As the amplitude of oscillation grows, the series resistances (i.e., differential anode

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* See Ref. 5.

resistances) and the shunt conductances (i.e., grid to cathode conductance) both tend to increase, thereby altering the coefficients of the network equations. Whatever the initial effect of these changes may be (and they may, in the case of an oscillator exhibiting "backlash," cause the exponential growth of the oscillations to increase temporarily) their ultimate effect must be to cause the roots p_α, p_β, etc., to move in a direction toward the left of the complex plane. If there is only one pair of roots with positive real parts, as in an oscillator containing a single tuned circuit, the steady state will be reached when these roots just arrive at the axis of imaginaries.

If, however, there are several pairs of such roots, then on completing the circuit all the corresponding modes will commence to build up at rates determined by their real parts. As the total amplitude grows, all the roots move over to the left, each pair crossing the imaginary axis, after which that particular mode gradually dies out, owing to its real part becoming negative, until eventually the last pair of roots arrive at the imaginary axis. At this point, this last mode will be stable, and eventually all the others die out.

Thus it is seen why an oscillator which is capable of oscillating at either of two different frequencies will in fact only oscillate stably at one of them at a time, namely, the one with the real part which is the last to become zero at large amplitudes of oscillation. It is, however, just conceivable though extremely unlikely that more than one pair of roots might arrive at the imaginary axis simultaneously.

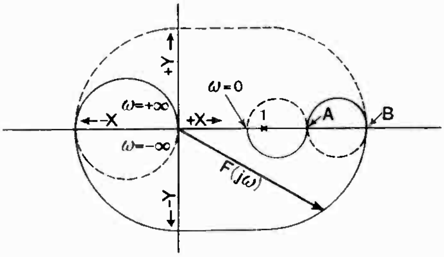

Fig. 7.

Case where the System is Stable although the Voltage Ratio is Greater than Unity

A case of particular interest from the theoretical point of view is that in which the $f(j\omega)$ curve is of the form shown in Fig. 7, the point (1, 0) lying outside the completed loop. There are thus 2 pairs of (positive and negative) values of (ω) corresponding to the points A and B at which the total amplification around the loop of an impressed steady state alternating voltage $V \sin \omega t$ is greater than unity, and the total phase shift around the loop is zero. Yet the system is stable according to the theorem.

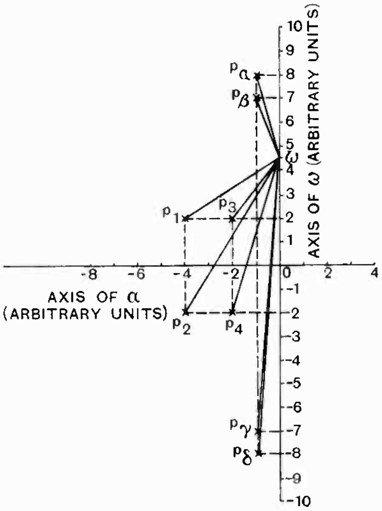

Fig. 8.

This case has been investigated experimentally by Peterson, Kreer and Ware* who set up an amplifier having a steady state amplification ratio of the same form as Fig. 7, and found that it was stable when back coupled, but that if the gain was reduced (without change of the phase shift characteristic) so as to produce a uniform radial contraction of the loop, then directly the point (1, 0) fell inside the loop the system built up oscillations, thus confirming the theorem.

The explanation of the apparent anomaly that the total amplification around the closed loop at some steady state frequency can exceed unity and the phase shift be zero and yet the system still remains stable, lies in the fact that the frequencies for zero phase shift have no significance at all, unless they also correspond to a ratio of unity in the absolute magnitudes of the input and output voltages, for unless this ratio

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* See Ref. 4.

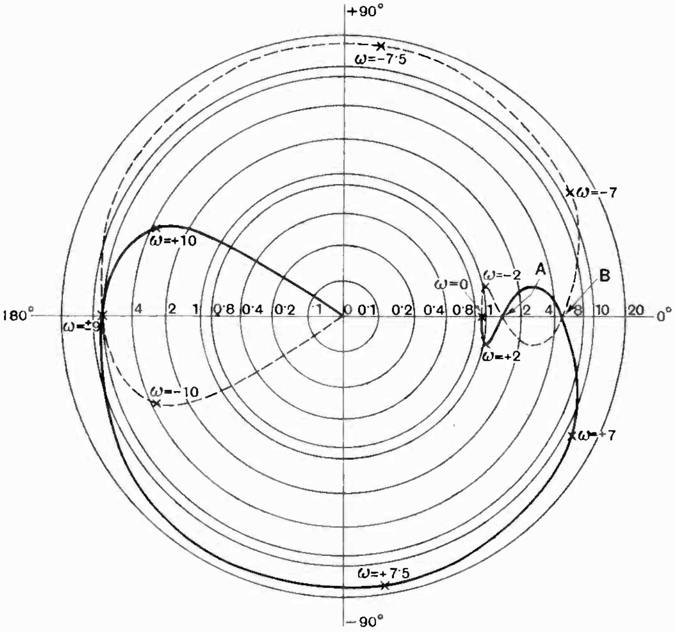

Fig. 9.—*Polar plot of* $F(j\omega)$ *on logarithmic amplitude scale for distribution of roots as in Fig. 8.*

is unity, some external e.m.f. is required to maintain a steady state alternating voltage at any point in the circuit. For example, consider an amplifier whose input admittance is zero and in which the ratio of output voltages to input voltage at some particular frequency is a pure number N (i.e., there is no phase shift at this frequency). Then if the output terminals are connected to the input terminals in series with a generator of e.m.f. "e" having this particular frequency and the voltage appearing across the input terminals is e', that across the output is Ne' so that e' must be made up of the sum of e and Ne' or $e = e'(1 - N)$ so that if N is greater than unity, the voltage across the input terminals is in antiphase to but is nevertheless finite. To illustrate how this re-entrant form of curve may be obtained, a particular case has been computed graphically, the result being shown in Figs. 8 and 9. An expression for

$$1 - f(p) = \frac{(p - p_\alpha)(p - p_\beta)(p - p_\gamma)(p - p_\delta)}{(p - p_1)(p - p_2)(p - p_3)(p - p_4)}$$

has been assumed, the distribution of the p_α's and p_1's in the complex p plane being as shown in Fig. 8, all having negative real parts. Then for any value of $p = j\omega$ the vector products of the lines $p_1 - \omega$, $p_2 - \omega$, $p_3 - \omega$, $p_4 - \omega$, and $p_\alpha\omega$, $p_\beta\omega$, $p_\gamma\omega$, $p_\delta\omega$ are found graphically and their quotient is the vector $1 - f(j\omega)$ for the particular value of ω taken. On subtracting this (graphically) from unit vector, the vector $f(j\omega)$ is obtained, and the result for a number of values of ω is shown in Fig. 9. Owing to the wide variation in magnitude of $f(j\omega)$ for this particular distribution of roots the radial distances in Fig. 9 are plotted logarithmically to conserve space. It is seen that there are two values of ω indicated by the points "A" and "B" in Fig. 9 at which the total amplification around the loop is greater than unity and the phase shift zero.

As the distribution of roots shown in Fig. 8 was selected arbitrarily, it is doubtful whether a network having the particular iterative voltage transfer ratio shown in Fig. 9 could be realised physically with positive element values, but, on the other hand, it is known that circuits can be made having a transfer ratio diagram of similar form, e.g., that used by Peterson, Kreer and Ware.*

It is hoped that the foregoing will explain their apparent anomalous behaviour.

In conclusion, the author would like to express his thanks to Professor C. L. Fortescue, O.B.E., M.A., M.I.E.E., for his very helpful criticisms.

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* See Ref. 4.

Regeneration in Linear Amplifiers*

By G. S. Brayshaw

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SUMMARY.—The conventional method of deriving the gain of a regenerative amplifier is shown to lead to incorrect results in certain cases and a new analysis is given which is free from these defects. A rule for determining stability conditions is stated and the modifications in gain, phase shift, input and output impedances are tabulated for the four basic feed-back circuits. It is shown how regeneration can be made to improve the characteristics of an amplifier and to obtain special circuit characteristics.

BROADLY speaking there are four different effects which are produced by regeneration or feed-back in an amplifying system ; these are :

(*a*) change of gain

(*b*) creation of an unstable condition leading to the production of oscillations

(*c*) change of effective circuit impedances

(*d*) change of phase angle.

In the first part of the present paper a general equation will be derived for the gain of a regenerative amplifier and the stability conditions will be formulated. In the second part of the paper various types of regenerative circuits will be considered and general formulae will be derived for calculating their effective circuit characteristics in terms of the corresponding characteristics without regeneration.

PART I

Stability Conditions

The general conditions for the stability of an amplifying system have been derived by Nyquist[1]; since his proof involves advanced mathematical methods, however, it was thought desirable to give a much simpler treatment of regeneration theory and this has been attempted in the present paper.

Throughout the following discussion only linear systems will be dealt with and hence, in interpreting the results obtained, certain limitations must be borne in mind. For example, it is well known that in the operation of a simple detector valve circuit employing reaction a backlash effect may be noticed. This takes the form of a variation between the minimum degree of anode-to-grid coupling necessary to start oscillations and that required to maintain oscillations when once these have commenced. Since, however, this effect only occurs on account of the non-linearity of the system its existence will not be disclosed by the present analysis.

Instantaneous Series Method

Regeneration is generally explained by the following simple series method and since this implies an infinitely short building up time for the steady state value of the feed-back voltage it will hereafter be referred to as the instantaneous series method.

Consider an amplifier in which there is some degree of coupling or feed-back between its input circuit and any subsequent part of the chain when the amplification ratio is G. If a voltage v is applied at the input it will first be amplified to a value Gv, then a fraction of this voltage $\frac{Gv}{m}$ will be fed back to the input circuit. This additional input voltage will also be amplified and $\frac{1}{m}$ of this voltage $\frac{G^2v}{m^2}$ will be fed back into the input circuit. This action will continue until the number of voltage increments becomes infinite. We can therefore express the effective input voltage to a regenerative amplifier as the sum of an infinite series whose common ratio is $\frac{G}{m}$. Thus, if v_e is the effective input voltage we can write

$$v_e = v + \frac{G}{m}v + \frac{G^2}{m^2}v + \frac{G^3}{m^3}.v + - + \frac{G^n}{m^n}.v.$$

where $n \to \infty$.

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* MS. accepted by the Editor, May, 1937.

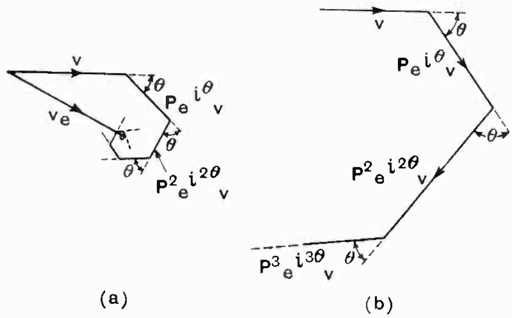
Since the production of a feed-back voltage will, in general, involve a phase change we can regard the feed-back factor $\frac{G}{m}$ as a complex quantity and write it in the form $\bar{P}$ or $P_e^{j\theta}$ where P is the modulus and θ is the phase angle of the factor by which v is multiplied on each successive round-trip through the amplifier. Hence we can write the series for v_e in the form

$$v_e = v(1 + Pe^{j\theta} + P^2e^{j2\theta} + P^3e^{j3\theta} + \ldots + P^ne^{jn\theta}) \quad \ldots \quad \ldots \quad (1)$$
$$n \rightarrow \infty$$

This series will be convergent if $|P| < 1$ and, subject to this condition, it will have a finite sum which is given by

$$v_e = \frac{v}{1 - \bar{P}} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

A clear physical picture of the regenerative effect can be obtained by drawing a series of vectors to represent the increments of voltage produced by successive round trips. This is done in Fig. 1 where the geometrical addition of the vectors V, $Pe^{j\theta}v$, $P^2e^{j2\theta}v$, etc. is shown for two cases. In Fig. 1 (a), the absolute value of $\bar{P}$, is less than one and the resultant is therefore a vector of finite length: in Fig. 1 (b) the absolute value of $\bar{P}$ is greater than one and the resultant is therefore a vector of infinite length.



(a) (b)

Fig. 1.

If we apply the instantaneous series method to the case of an actual amplifier in which regeneration exists, it appears that, although the method gives correct results over a certain range of $\bar{P}$, it breaks down when values of $\bar{P}$ outside this range are considered.

When $\bar{P}$ is positive and ≤ 1 equation (2) is valid, and in the particular case where $\bar{P} = 1$, this equation yields infinity which is the condition that the system will oscillate: this case will be considered in more detail later. When $\bar{P}$ is positive and > 1 only the series (1) is applicable and under these conditions it will have an infinite sum. Thus from a mathematical point of view it would appear that oscillation would always occur when $\bar{P}$ was positive and > 1. This result does not agree with experimental evidence, however, since it has been found that in certain cases oscillation does not take place under these conditions[2].

Similarly when $\bar{P}$ is negative and ≤ 1 equation (2) is valid, but when $\bar{P}$ is negative and > 1 we are faced with another anomaly as in this case also only the series is applicable and this gives a value $\pm\infty$, although it is an experimental fact that an amplifier will be completely stable under these conditions.

Incremental Series Method

In order to overcome this apparent lack of agreement between the mathematical and physical aspects of regeneration we must take account of transient conditions. The feed-back voltage will not attain its final value instantaneously, it will actually build up in such a way that the effective input voltage v_e will not reach a value corresponding to a mathematical discontinuity, except in the special case where oscillation occurs. A steady state value of feed-back voltage must therefore be reached in a finite time and this, in general, will correspond with the normal building up time for the circuit transients. We can, however, avoid the consideration of circuit transients by imagining that the final value of feed-back voltage is reached by a gradual increase of the feed-back coupling at a rate which is very much slower than the building up time of the circuit transients. In this way we are effectively dealing with steady state conditions throughout. This method must obviously give the same final result (in a linear system) as is obtained by suddenly switching on an amplifier in which the degree of coupling remains fixed at its final value.

With the above conditions in mind we

must regard the instantaneous feed-back factor $\overline{p}$ as some arbitrary function of time, say $p = \phi(t)$. This function is then subject to the conditions

$$\phi(t) = 0 \quad \text{when } t = 0$$

$$\phi(t) = \overline{P} \quad \text{when } t = T$$

Where T represents the time required for the feed-back voltage to grow from zero to its final value.

Divide the time T into q equal increments Δt and let the corresponding increments of $\phi(t)$ be $\Delta_1 p, \Delta_2 p, \ldots$ etc.

If Δt is made differentially small the Δp's will also be differentially small and we have

$$\Delta p = \frac{d}{dt}[\phi(t)] \,.\, \Delta t$$

So that $\phi(t) = \phi(0) + \Sigma^r_{r=0}\, \Delta_r p$

Since $\phi(0) = 0$

$$\overline{p} = \phi(t) = \Sigma^r_{r=0}\, \Delta_r \,.\, p.$$

Hence we can replace p by the sum of a series of differentially small increments $\Delta_1 \overline{p}$, $\Delta_2 \overline{p}$, etc.

Since $\overline{p}$ is a vector quantity $\Sigma^r_{r=0}\, \Delta_r p$ represents the vector sum of the Δp's.

If we now consider a circuit in which the feed-back factor is $\overline{\Delta_1 p}$ we can obtain the effective input voltage v_1 from the series (1) since $\Delta_1 p$ is assumed constant in the interval considered, thus

$$v_1 = v[1 + \Delta_1 p + (\overline{\Delta_1 p})^2 + (\overline{\Delta_1 p})^3 \ldots + (\overline{\Delta_1 p})^n] \quad n \to \infty$$

or $v_1 = \dfrac{v}{1 - \Delta_1 p}$, since $\overline{\Delta_1 p} << 1$.

Increasing the feed-back by an amount $\Delta_2 p$ gives

$$v_2 = \frac{v}{1 + \Delta_1 p}[1 + \Delta_2 p + (\Delta_2 p)^2 + (\Delta_2 p)^3 + \ldots + (\Delta_2 p)^n] \quad n \to \infty$$

or $v_2 = \dfrac{v}{1 - \Delta_1 p} \cdot \dfrac{1}{1 - \Delta_2 p}$

After adding the q increments we shall have

$$v_q = v_e = v \,.\, \frac{1}{1 - \overline{\Delta_1 p}} \,.\, \frac{1}{1 - \overline{\Delta_2 p}} \cdots \frac{1}{1 - \overline{\Delta_q p}}$$

or $v_e = \dfrac{v}{1 - [\overline{\Delta_1 p} + \overline{\Delta_2 p} + - + \overline{\Delta_q p} + x]}$

In the above expression x will be composed of products of $\overline{\Delta p}$ and as these are of higher degree than the first they can be neglected in comparison with the remainder of the denominator.

$$\text{Thus} \quad v_e = \frac{v}{1 - \Sigma^q_{r=0}\, \Delta_r p} = \frac{v}{1 - \overline{P}} \quad \ldots \quad (3)$$

$$\text{or} \quad |v_e| = \frac{v}{\sqrt{1 - 2P\cos\theta + P^2}} \quad \ldots \quad (4)$$

It will be noticed that this result is the same as that originally obtained in equation (2), but we have removed the restriction on the value of P; in particular $\overline{P}$ may now exceed unity.

From equation (3)

$v_e = \dfrac{v}{1 - P_e^{j\theta}}$ and it is apparent that if $P = 1$, $\theta = 0$ or $2n\pi$ (n an integer) then v_e will become infinite.

Expressed physically these results mean that if there is any frequency at which $\left.\begin{matrix}\theta = 0 \\ 2n\pi\end{matrix}\right\}$ then the system will oscillate if P become unity. Should the calculated value of P exceed unity for a given system, the value of θ when $P = 1$ must be obtained before it is possible to predict whether or no the system is stable.

We can now state a simple rule for determining the stability condition of a given system.

Derive an expression for the feed-back voltage due to unit applied voltage at the input of the amplifier assuming that the feed-back coupling is disconnected from the input circuit and properly terminated. This will in general be complex and may therefore be expressed as $P\epsilon^{j\theta}$. The condition for stability now is

$$1 - P\epsilon^{j\theta} \neq 0$$

for any frequency from 0 to ∞.

There is a special case which is not covered by the above simplified analysis. Namely, a condition in which an unstable state exists over a certain range of values of the gain of an amplifier, but does not exist with values of gain above or below that range. This case was deduced theoretically by Nyquist[1] and demonstrated experimentally by Peterson, Kreen and Ware[2]. In order to cover this special condition we must make use of Nyquist's stability rule, which is more general than the one given above. His rule states :

"Plot plus and minus the imaginary part of $Pe^{j\theta}$ against the real part for all frequencies from 0 to ∞. If the point $1 + j0$ lies completely outside this curve the system is stable, if not it is unstable."

PART II

Analysis by Circuit Theory

Having obtained an equation for the effective input voltage of a regenerative amplifier by a general analysis, we are now in a position to deal correctly with this same equation derived by elementary circuit theory. From a practical point of view this second method is obviously preferable on account of its simplicity, nevertheless without the preceding analysis it could not be safely used to predict stability conditions.

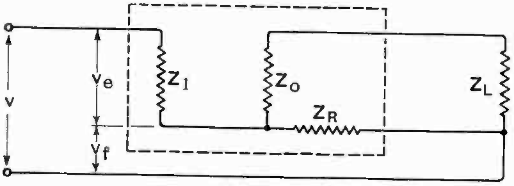


Fig. 2.—v = *applied voltage ;* v_e = *effective input voltage ;* v_f = *feed-back voltage.*

Using the notation in Fig. 2 let $v_f = Ke^{j\beta}v_e$ where K and β are respectively the magnitude and phase angle (relative to v_e) of the feed-back factor $\left(\frac{v_f}{v_e}\right)$.

The circuital equation of voltages, for the input circuit, can now be written

$$v + v_f = v_e \text{ or } v + Ke^{j\beta}v_e = v_e \quad .. \quad (5)$$

giving $v_e = \dfrac{v}{1 - Ke^{j\beta}}$.

By comparison with the previous result equation (3), it is apparent that

$$Pe^{j\theta} = Ke^{j\beta}$$

Hence we may regard $Pe^{j\theta}$ as the total voltage fed back, for unit applied voltage on the grid of the first valve. Thus reverting to the original notation we can write as before

$$v_e = \frac{v}{1 - P} \text{ and } |v_e| = \frac{v}{\sqrt{1 - 2P\cos\theta + P^2}}$$

From the latter equation it is apparent that for a certain range of values of P and θ, v_e will be greater than v and hence there will be an effective amplification due to the feed-back : this is usually referred to as regeneration or positive feed-back.

When θ lies between $\frac{1}{2}\pi$ and $\frac{3}{2}\pi$, $e^{j\beta}$ is negative and hence

$$v_e = \frac{v}{1 + P}$$

and $|v_e| = \dfrac{v}{\sqrt{1 + 2P\cos\theta + P^2}}$.

From this equation it is apparent that for all values of P v_e will be smaller than v, hence there will be an effective attenuation due to the feed-back : this is usually referred to as degeneration or negative feed-back.

It will be noticed that these equations are identical with those obtained by the incremental series method. They must also be interpreted in the same way, namely, v_f must reach its final value in a finite time and not appear instantaneously.

The condition for oscillation, of course, is the same as before and may be written $Pe^{j\theta} = 1$. Inserting this in equation (5) we have

$$v + v_e = v_e.$$

This equation can only be satisfied when the applied voltage is zero and this will be recognised as the condition commonly stated for self oscillation to persist in an amplifying system. Furthermore, the conditional equation $1 - Pe^{j\theta} = 0$ can be split up into two further equations representing the real and imaginary parts of the original expression and if we are able to solve these two equations we can obtain the frequency of oscillation and the degree of coupling required for its commencement.

An important fact is that there is no limitation as to the characteristics of the external circuit impedance, i.e., it is not essential for this impedance to contain a tuned circuit. Provided the instability condition is reached continuous or relaxation oscillations will occur.

In practical systems the amplification at the oscillation point will not of course increase indefinitely as the rise in effective input voltage will cause the system to operate on the non-linear part of its characteristic thus altering the circuit parameters and reducing the feed-back so that a stable state of oscillation is set up. This applies also to the hypothetical case of an amplifier containing no reactances: here the gain would rise to a high finite value determined by the voltage capacity of the system.

We can proceed from the stability conditions of amplifiers to a consideration of the variations in their gain, input and output impedances and phase shifts under regenerative conditions.

These modified parameters have been calculated for series, parallel and combined feed-back systems employing positive and negative regeneration and are given below. The derivation of these results follows from elementary circuit theory and proofs of the formulae have therefore not been included.

In addition to the general results useful approximations, which are sufficiently accurate for most practical purposes, are also given.

Definition of Symbols

An additional subscript R indicates the modified value of a given parameter due to regeneration.

The subscripts S and P indicate the value of a quantity due to series or parallel regeneration: they are only used when combined feed-back circuits are being considered.

A single dash suffix indicates the effective value of an impedance, taking into consideration any other connected impedances, when looking into the amplifier from the input terminals.

A double dash suffix indicates the effective value of an impedance, when looking into the amplifier from the output terminals.

Z_I Input impedance. ${}_TZ_I$ Total input impedance.

Z_0 Output impedance. ${}_TZ_0$ Total output impedance.

Z_R Common impedance between input and output circuits which causes the regeneration to take place.

Z_S Impedance of source of input voltage.

Z_L Impedance of load across which the output voltage is being developed.

$\overline{P}$ or $Pe^{j\theta}$ Complex value of the voltage fed back into the input circuit per unit applied voltage on the grid of the first valve being considered.

λ Total phase change (including the input circuit) which occurs in the amplifier without feed-back. If Z_L, Z_R, Z_S and Z_I are pure resistances $\lambda = \theta$.

λ_0 Value of λ when $Z_S = 0$.

G Numerical value of the gain of the amplifier as given by the ratio of the output voltage to the input voltage when no feed-back occurs, but the circuit conditions are not otherwise changed.

$\overline{G} = Ge^{j\lambda}$.

A Numerical ratio of the output voltage to the input voltage when the output load is assumed infinite and no feed-back occurs.

ψ Phase change which occurs in the amplifier when the output load is assumed infinite and no feed-back occurs.

$\overline{A} = Ae^{j\psi}$.

$\overline{A}_0$ Value of $\overline{A}$ when $Z_S = 0$.

In expressions of the type $(1 \mp \overline{P})$ the upper sign indicates positive feed-back and the lower sign negative feed-back.

Series Feed-Back—1

(Coupling impedance in series with the load, Fig. 3.)

$$Z'_R = \frac{Z_R(Z_0 + Z_L)}{Z_R + Z_0 + Z_L} \qquad \left\{ Z''_R = \frac{Z_R(Z_S + Z_I)}{Z_R + Z_S + Z_I} \right.$$

$$\overline{P} = \frac{Z''_R \cdot \overline{A}_0}{Z''_R + Z_L + Z_0} \qquad \left\{ \overline{G} = \frac{Z_L \cdot \overline{A}}{Z_0 + Z_L + Z''_R} \right.$$

$${}_TZ_{IR} = Z_I(1 \mp \overline{P}) + Z'_R \quad \ldots \quad \ldots \quad (6)$$

$${}_TZ_{IR} \doteqdot Z_I(1 \mp \overline{P}) \quad \ldots \quad \ldots \quad \ldots \quad (6a)$$

$${}_TZ_{OR} = Z_0 + Z''_R(1 \mp \overline{A}) \quad \ldots \quad \ldots \quad (7)$$

$$G_R = \frac{\overline{G}}{1 \mp \dfrac{\overline{P} \cdot Z_I}{Z_I + Z_S + Z''_R}} \quad \ldots \quad \ldots \quad (8)$$

$$G_R = \frac{G}{1 \mp \overline{P}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8a)$$

When the feed-back is negative and

$$Z''_R A >> Z_R'' + Z_L + Z_0, \quad G_R = \frac{Z_L}{Z''_R}$$

and the amplifier gain is therefore independent of G.

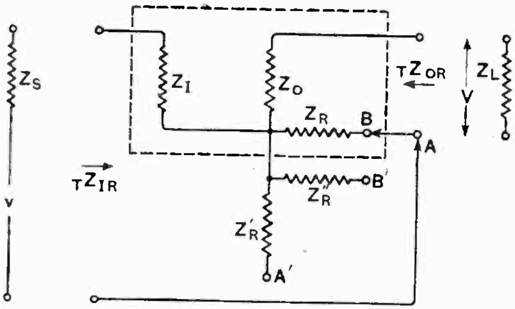


Fig. 3.—*Coupling impedance in series with the load.* $G = \frac{V}{v}$ *when A is connected to A' and B is connected to B'.* $G_R = \frac{V}{v}$ *with circuit arrangement shown in figure.*

Phase Shift.

In order to simplify the form of the results assume $Z'_R << Z_I + Z_s$ and let $\frac{Z_s}{Z_I} = Qe^{j\alpha}$

Then $\lambda = \lambda_3 - \tan^{-1} \frac{Q \sin \alpha}{1 + Q \cos \alpha}$

$$\lambda_R = \lambda_0 - \tan^{-1} \frac{Q \sin \alpha \mp P \sin \theta}{1 + Q \cos \alpha \mp P \cos \theta} \quad \ldots \quad (9)$$

If $P \sin \theta >> Q \sin \alpha$ and $P \cos \theta >> (1 + Q \cos \alpha)$

Then $\lambda_R = \lambda_0 - \theta$ .. .. .. (9a)

Hence if $\lambda_0 = \theta$ the effective phase shift of the amplifier becomes zero.

Series Feed-Back—IA

(Coupling impedance in parallel with the load, Fig. 4.)

$$Z'_{R2} = \frac{Z_{R2}\left(Z_{R1} + \frac{Z_0 . Z_L}{Z_0 + Z_L}\right)}{Z_{R2} + Z_{R1} + \frac{Z_0 . Z_L}{Z_0 + Z_L}}$$

$$Z''_{R2} = \frac{Z_{R2}(Z_S + Z_I)}{Z_{R2} + Z_S + Z_I} \quad Z''_L = \frac{Z_L(Z_{R1} + Z_{R2})}{Z_L + Z_{R1} + Z_{R2}}$$

$$\overline{P} = \frac{Z''_{R2} . Z''_L . \overline{A}_0}{(Z''_{R2} + Z_{R1})(Z''_L + Z_0)}$$

$$\overline{G} = \frac{Z''_L}{Z''_L + Z_0} . \overline{A}$$

$$_TZ_{IR} = Z'_{R2} + Z_I(1 \mp \overline{P}) \quad \ldots \quad \ldots \quad (10)$$

$$_TZ_{IR} \doteqdot Z_I(1 \mp \overline{P}) \quad \ldots \quad \ldots \quad \ldots \quad (10a)$$

$$_TZ_{0R} = \frac{Z_0}{1 + \frac{Z_0 \mp Z''_{R2} . A}{Z''_{R2} + Z_{R1}}} \quad \ldots \quad \ldots \quad (11)$$

$$G_R = \frac{G}{1 \mp \frac{P . Z_I}{Z_I + Z_S + Z'_{R2}}} \quad \ldots \quad \ldots \quad (12)$$

$$G_R \doteqdot \frac{G}{1 \mp P} \quad \ldots \quad \ldots \quad \ldots \quad (12a)$$

Phase Shift.

Assume $Z'_{R2} << Z_I + Z_S$ and let $\frac{Z_S}{Z_I} = Qe^{j\alpha}$

$$\lambda = \lambda_0 - \tan^{-1} \frac{Q \sin \alpha}{1 + Q \cos \alpha}$$

$$\lambda_R = \lambda_0 - \tan^{-1} \frac{Q \sin \alpha \mp P \sin \theta}{1 + Q \cos \alpha \mp P \cos \theta} \quad \ldots \quad (13)$$

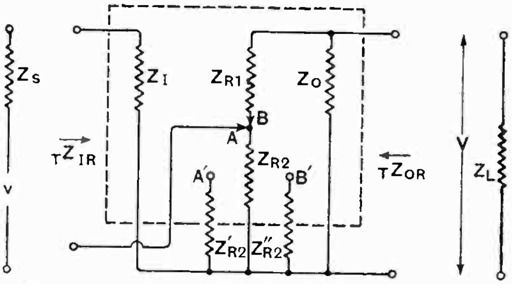


Fig. 4.—*Coupling impedance in parallel with the load.* $G = \frac{V}{v}$ *when A is connected to A' and B is connected to B'.* $G_R = \frac{V}{v}$ *with the circuit arrangement shown in figure.*

Parallel Feed-Back—II

(Coupling impedance in parallel with the load, Fig. 5.)

$$Z'_I = \frac{Z_I\left(Z_R + \frac{Z_0 Z_L}{Z_0 + Z_L}\right)}{Z_I + Z_R + \frac{Z_0 Z_L}{Z_0 + Z_L}}$$

$$Z''_I = \frac{Z_I . Z_S}{Z_I + Z_S} \quad Z''_L = \frac{Z_L(Z_R + Z''_I)}{Z_L + Z_R + Z''_I}$$

$$\overline{P} = \frac{Z''_I . Z''_L . \overline{A}_0}{(Z''_I + Z_R)(Z''_L + Z_0)} \quad \overline{G} = \frac{Z''_L . \overline{A}}{Z''_L + Z_0}$$

$$_TZ_{IR} = \frac{Z'_I}{1 \mp \overline{P}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

$$ {}_{T}Z_{0R} = \frac{Z_0}{1 + \dfrac{Z_0 \mp Z''_I \bar{A}_0}{Z''_I + Z_R}} \qquad \ldots \qquad \ldots \qquad (15) $$

If $Z_S \to \infty$, $Z_0 << Z''_I A_0$, $1 << \dfrac{Z''_I A_0}{Z''_I + Z_R}$,

then

$$ Z_{0R} \doteqdot \frac{Z_0(Z_I + Z_R)}{\bar{A}_0 Z_I} \qquad \ldots \qquad \ldots \qquad (15a) $$

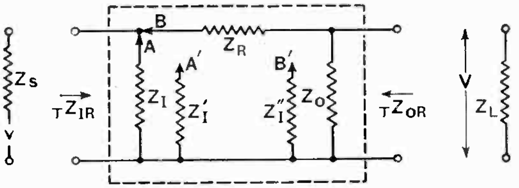


Fig. 5.—*Coupling impedance in parallel with the load.* $\bar{G} = \dfrac{V}{v}$ *when A′ is connected to the input terminal in place of A and B is connected to B′.* $\bar{G}_R = \dfrac{V}{v}$ *with the circuit arrangement shown in figure.*

If Z_I is a pure reactance, Z_R a pure resistance or vice versa and $Z_I << Z_R$, then $Z_{0R} = \dfrac{Z_0 . Z_R}{A_0 Z_I}$ and this represents a reactance whose value is inversely proportional to the amplification of the circuit.

$$ G_R = \frac{G}{1 \mp \dfrac{\bar{P} Z_S}{Z_S + Z_I}} \qquad \ldots \qquad \ldots \qquad (16) $$

Phase Shift.

Let $\dfrac{Z_S}{Z_I} = Qe^{j\alpha}$

Then $\lambda = \lambda_0 - \tan^{-1} \dfrac{Q \sin \alpha}{1 + Q \cos \alpha}$

$$ \lambda_R = \lambda_0 - \tan^{-1} \left\{ \frac{Q\,[\sin \alpha \mp P \sin (\alpha + \theta)]}{1 + Q[\cos \alpha \mp P \cos (\alpha + \theta)]} \right\} $$

If $P \sin (\alpha + \theta) >> \sin \alpha$ and

$QP \cos(\alpha + \theta) >> 1 + Q \cos \alpha$

$\lambda_R = \lambda_0 - (\alpha + \theta)$, hence if $\lambda_0 = \alpha + \theta$, $\lambda_R = 0$.

Parallel Feed-Back—IIA

(Coupling impedance in series with the load, Fig. 6.)

$$ Z'_I = \frac{Z_I Z_R (Z_0 + Z_L)}{Z_I(Z_R + Z_0 + Z_L) + Z_R(Z_0 + Z_L)} $$

$$ Z''_R = \frac{Z_R . Z_I . Z_S}{Z_R Z_I + Z_R Z_S + Z_I Z_S} $$

$$ \bar{P} = \frac{Z''_R \bar{A}_0}{Z''_R + Z_L + Z_0} \qquad \bar{G} = \frac{Z_L \bar{A}}{Z_L + Z_0 + Z''_R} $$

$$ {}_{T}Z_{IR} = \frac{Z'_I}{1 \mp \bar{P}} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (18) $$

$$ {}_{T}Z_{0R} = Z_0 + Z''_R(1 \mp \bar{A}_0) \qquad \ldots \qquad \ldots \qquad (19) $$

$$ G_R = \frac{G}{1 \mp \dfrac{Z_S \bar{P}}{Z_S + Z_I}} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (20) $$

Phase Shift.

Let $\dfrac{Z_S}{Z_I} = Qe^{j\alpha}$

$\lambda = \lambda_0 - \tan^{-1} \dfrac{Q \sin \alpha}{1 + Q \cos \alpha}$

$$ \lambda_R = \lambda_0 - \tan^{-1} \left\{ \frac{Q\,[\sin \alpha \mp P \sin (\alpha + \theta)]}{1 + Q[\cos \alpha \mp P \cos (\alpha + \theta)]} \right\} $$

Series and Parallel Feed-Backs Combined—III

Fig. 7.—

In this case the general formulae for the amplifier characteristics involve very complex algebraic expressions, so the following approximations will be made in the analysis in order to express the essential results in as concise a form as possible.

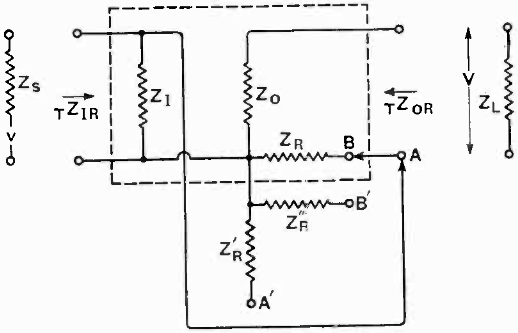


Fig. 6.—*Coupling impedance in series with the load.* $\bar{G} = \dfrac{V}{v}$ *when A is connected to A′ and B is connected to B′.* $\bar{G}_R = \dfrac{V}{v}$ *with the circuit arrangement shown in figure.*

Assume $Z_I, Z_{RP} >> Z_{RS}, Z_0, Z_L$

$Z_S >> Z_{RS}$

Then

$$ Z'_{RS} = \frac{Z_{RS}(Z_L + Z_0)}{Z_{RS} + Z_L + Z_0} $$

$$ Z''_{RS} = Z_{RS} \qquad\qquad Z''_L = Z_L $$

$$Z'_I = \frac{Z_I \, . \, Z_{RP}}{Z_I + Z_{RP}} \qquad Z''_I = \frac{Z_I \, . \, Z_S}{Z_I + Z_S}$$

$$\bar{P}_S = \frac{Z_{RS}\bar{A}_0}{Z_{RS} + Z_L + Z_0}$$

$$\bar{P}_P = \frac{Z''_I(Z_L + Z_{RS})}{(Z''_I + Z_{RP})(Z_L + Z_{RS} + Z_0)}$$

It will be noticed that notwithstanding the above restrictions on the values of the circuit parameters, $\bar{P}_S$ and $\bar{P}_P$ can assume any values and are independent.

$$_TZ_{IR} = Z'_{RS} + \frac{Z'_I(1 \mp \bar{P}_S)}{1 \mp \bar{P}_P} \quad \ldots \quad \ldots \quad (22)$$

If $\bar{P}_S = \bar{P}_P$ then $_TZ_{IR} = Z'_{RS} + Z'_I$ from which it is seen that the input impedance is independent of the gain of the amplifier. Actually under this condition the input and output e.m.f.'s appear across the diagonals of a balanced bridge.

$$_TZ_{0R} = \frac{Z_0}{1 + \dfrac{Z_0 \mp Z''_I\bar{A}}{Z''_I + Z_{RP}}} + Z''_{RS}\left(1 \mp \frac{Z''_I\bar{A}_0}{Z_I'' + Z_S}\right) \quad \ldots \quad \ldots \quad (23)$$

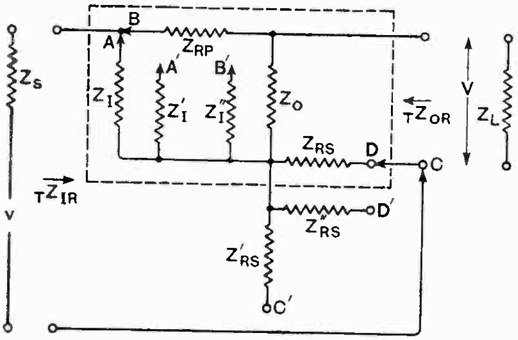


Fig. 7.—$\bar{G} = \dfrac{V}{v}$ *when A′ is connected to the input terminal in place of A, B is connected to B′, C to C′, and D to D′.* $\bar{G}_R = \dfrac{V}{v}$ *with the circuit arrangement shown in figure.*

If $\bar{P}_S = \bar{P}_P$ the output impedance is not independent of $\bar{A}$ as the load impedance appears in one arm of the bridge and not across a diagonal.

$$G_R = \frac{G(Z'_I + Z'_{RS} + Z_S)}{Z'_I(1 \mp P_S) + (Z'_{RS} + Z_S)(1 \mp P_P)} \quad \ldots \quad (24)$$

If $\bar{P}_S = \bar{P}_P = \bar{P}$

$$G_R = \frac{G}{1 \mp \bar{P}} \quad \ldots \quad \ldots \quad \ldots \quad (24a)$$

Hence under the balanced input condition the gain of the amplifier still depends on the amount of feed-back.

Phase Shift.

Let $\dfrac{Z_S}{Z_I} = Q\epsilon^{j\alpha}$ then $\lambda = \lambda_0 - \tan^{-1}\dfrac{Q \sin \alpha}{1 + Q \cos \alpha}$

$$\lambda_R = \lambda_0 - \tan^{-1} \left\{\frac{\mp P_S \sin \theta_S + Q\,[\sin \alpha \mp P_P \sin(\theta_P + \alpha)]}{1 \mp P_S \cos \theta_S + Q[\cos \alpha \mp P_P \cos(\theta_P + \alpha)]}\right\} \quad \ldots \quad \ldots \quad (25)$$

Conclusions

Considering the above results in detail it appears that the general effects of regeneration in an amplifying system may be stated as follows.

In the series system I positive regeneration causes a reduction of input and output impedance, an increase in gain and an increase in overall phase shift, equations (6) to (9). On the other hand, negative regeneration causes an increase of input and output impedance, a reduction of gain and a reduction in the overall phase shift, equations (6) to (9). Furthermore, by using a large amount of degeneration the overall gain becomes independent of the gain of the amplifier, equation (8b) and the overall phase shift approaches zero (9a).

In the parallel system II the variations of gain and phase shift are similar to the series system I, but the changes of input and output impedance are exactly opposite, equations (14) to 17).

By combining parts of two systems it is possible to select certain desirable features from each. For example, using series regeneration with a parallel coupling circuit, system Ia, a degenerative amplifier can be made which has a high input impedance (10) but a low output impedance (11). Also, by combining the two complete systems I and II we get system V which can be made to have a constant input impedance regardless of the amplifier gain. This scheme constitutes a new method of neutralising the well-known Miller effect.

In addition to obtaining improved amplifier characteristics, it is possible to employ feed-back circuits for special purposes. As an example equation (15a) shows that the effective value of the output impedance of an amplifier may be made inversely proportional to the (theoretical) amplification of the system. Further, by a suitable choice of circuit parameters we can convert this impedance into a reactance whose magnitude is inversely proportional to the amplification. By applying this to a single valve circuit we get an expression of the form $\frac{Z_R}{gZ_1}$ where g is the mutual conductance of the valve and this is the basis of the control valve used in certain automatic tuning correction systems.

Finally, the author would like to thank Messrs. G. B. Baker and H. D. Ellis for suggesting the problem which led him to the compilation of this paper.

References

1. H. Nyquist, *Bell S. Tech. Journ.*, Vol. XI, No. 1, p. 126.

2. E. Peterson, J. G. Kreer, L. A. Ware, *Bell S. Tech. Journ.*, Vol. XIII, No. 4, p. 680.

Book Review

Radio Engineering (2nd Edition).

By F. E. Terman, Sc.D., 813 pp. 475 Figs. McGraw-Hill Publishing Co., Ltd., Aldwych House, London, W.C.2. Price 30s.

In examining revisions of books in the field of radio one often gets the impression that the authors are reluctant to discard any of the original material, or to take the trouble of incorporating the new in a manner that does not leave the seams and joints painfully obvious. The work under review is a happy exception. In spite of considerable deletions the net expansion of the book is no fewer than 145 pages (incidentally, without increase in price). But that is not all. The greater part of the chapters retained have been rewritten, and over half of the illustrations are new. Such subjects as negative feedback, electronic transit-time effects in valves and the latest A.F.C. methods, are now included. Examining it more carefully one is not conscious of any bondage to the past, of any awkward transition from old to new material. The clarity of style that distinguished the first edition has been fully retained. It is easy to find what one wants, thanks among other things to the adequate index and the author's mathematical restraint. In various ways, all more helpful to the reader than the display with which some authors delight to adorn their pages, he restricts equations to those of real importance, which accordingly can be picked out without confusion. The treatment steers between the academic on the one hand and mere description of obsolescent equipment on the other. While the theory is sound, it is brought into forms calculated to help the engineer who has no time to spare for licking information into usable shape. For example, while some writers are content to give formulae from which resonance curves of tuned circuits and frequency characteristics of amplifiers can be worked out, Prof. Terman presents these in the form of universal curves that can very rapidly be adapted to the special case.

In spite of the size of the volume, it would be hard to find a superfluous paragraph. The chapter on measurements has been cut out, because the subject is more adequately treated in the author's companion volume. There are no lengthy introductory chapters on elementary electricity and magnetism; the author assumes a general knowledge of these and proceeds straight away to develop it into essential radio concepts. He has added a chapter on television, but wisely kept it brief; detailed descriptions of present American technique would soon be out of date. Obsolete systems—spark, arc, etc.—have merely been mentioned, with references to information for the benefit of any interested. References are also freely given for externally supplementing much of the author's material. The subject of amplifiers is especially thoroughly expounded, and one notes that wide-range amplifiers (for video frequencies) are included.

If one had to criticise, it would be on the ground that a few subjects are dismissed rather too hurriedly; for example, the various effects produced by interfering carrier waves, so promisingly defined in Sec. 91; the subject of interference generally; and the frequency-modulation system of Armstrong. "Beam power tubes" are briefly described, but one would have expected that the work of J. H. O. Harries on "critical distance" would have been mentioned. The symbols used generally are beyond reproach, but it should be noted that the abbreviations are not those recommended by the International Electro-technical Commission (such as mA., μF., Mc., etc.).

To students seeking a textbook and engineers a work of reference, Prof. Terman's revised edition can be recommended most heartily.

M. G. S.

The Industry

AGENCIES for several well-known American makes of apparatus of the kind used in research and production work have been taken up by Leland Instruments, Ltd., 46, Bedford Row, London, W.C.1. Special mention should be made of the Clough-Brengle oscillators and oscillograph, the Ferris Standard Signal Generator and of the Boonton "Q" Meter.

With reference to the All-Wave Avo Oscillator described in last month's issue, it should have been stated that the R.F. output is controlled by means of a step attenuator as well as by a slide wire. With this combination three variable outputs are provided, viz.: zero to 500 micro-volts, zero to 5 milli-volts and zero to 50 millivolts. This is, of course, in addition to the fixed output of one volt.

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

Frequency Changers in All-Wave Receivers

To the Editor, The Wireless Engineer

SIR,—Referring to the interesting comments in the September, 1937, issue of *The Wireless Engineer*, by Mr. E. W. Herold, on my article covering the above subject, which appeared in the April, 1937, issue of this journal, the following points might be of some relevancy. Since the article was accepted by the Editor of *The Wireless Engineer* (in June, 1936), investigations and developments have led to further insights and constructions in this laboratory than were mentioned in my article. Mr. Herold justly points out that neutralization of electron coupling in octode type frequency changers by a condenser firstly is difficult to carry out for a whole short-wave band or even for several such bands, owing to varying oscillator volts throughout these bands, and secondly is imperfect because of a transit time effect, which results in the need of a resistance in series with the neutralizing condenser. As to the first point, the answer is that neutralization is fortunately only needed in the highest frequency range of each band. As pointed out in my article, induced oscillator volts on the input circuit are highest at the H.F. end of each band and drop very fast if the input circuit tuning is removed from this end. It was found in receiver measurements that sufficient neutralization could be obtained by the use of a condenser. As to the second point, the transit time effect of electron coupling, owing to which a resistance should be connected in series with the neutralizing condenser, was observed in this laboratory some time ago and is described in an article "Transit Time Effects in Multigrid Valves," in course of publication. This neutralization needs also only to be exact at the short-wave end of any short-wave band. Some measured results with the octode EK2 (Philips) will illustrate this. For comparison, Mr. Herold's values are also reproduced.

The first three rows of this table show that the use of a neutralization condenser only must be regarded as satisfactory in the 10–30 m. band, as induced oscillator volts on the input circuit are only considerable at 10 m. The neutralization capacitance is only 1 $\mu\mu$F., which means that much less electron coupling exists with the EK2 than with the 6A8, having 2 $\mu\mu$F. In this respect the EK2 must be regarded as an advance in octode type frequency changer design. Development work has been done on a new valve in this laboratory, in which electron coupling is again materially reduced as compared with the EK2. Input resistance of the EK2 using a capacity of 0.8 $\mu\mu$F. only for neutralization was 67,000 ohms at 13 m., which is much better than with most of the hexode frequency changers on the market. The fourth, fifth and sixth rows of the table show that the series resistance is by no means very variable in one wave band. Hence one fixed resistance might do the job reasonably well. Attention is drawn to the properties of the EH2 (hexode frequency changer with suppressor grid), in which the disadvantages of existing hexode constructions are much reduced.

Eindhoven, Holland. M. STRUTT.

Neutralization between Grid 1 and Grid 4. Capacitance in $\mu\mu$F.	Oscillator volts, Grid 1.	Induced Oscillator volts, Grid 4.	Wave-length. m.	Valve.
1.0	9	2.0	10.4	EK2
0.9	9	0.5	17.0	,,
0.8	9	0.1	31.0	,,
1.0 and series resistance of 2,100 ohms	9	Zero	10.4	,,
0.9 ,, ,, 2,200 ,,	9	,,	17.0	,,
0.8 ,, ,, 2,400 ,,	9	,,	31.0	,,
2.0	6	3.3	15.0	6A8
2.0 and series resistance of 455 ohms	6	Zero	15.0	,,

Abbreviations

To the Editor, The Wireless Engineer.

SIR,—Use of the popular abbreviations "D.C." and "A.C.," more especially the former, is increasingly absurd. The most chaste authorities, not excepting *The Journal of The Institution of Electrical Engineers* nor even your own esteemed journal, are not guiltless of "D.C. current." I have striven to avoid this particular solecism in my own work, but am only too well aware that the apparently inescapable "D.C. voltage" is, if anything, an even more appalling crime. "D.V." is liable to be misunderstood (as is "D. current"). "Direct voltage" or "Direct potential" written in full may be consistent, but are impracticable in some contexts owing to conflict between specialised and general connotations of the word "direct." There is a limit to infelicity of expression even among radio engineers, and "indirect direct potential" is, let us hope, beyond that limit.

It is the word "direct" that is wrong. And current, as one presumably must interpret the "C," is usually wrong too. The alternatives are:—Either scruples can be swallowed, and things left to take their course—i.e., the ultimate establishment of yet another curiosity of symbolism—" D.C." meaning " zero frequency "—or substitition of the correct term, abbreviated by the normal process of retaining only the first letters of each word.

A term is wanted which, when abbreviated, does not tie one down to current, but is available for potential, E.M.F., M.M.F., sound and light intensity, and other quantities so closely associated in rapidly developing fields of practice. So why not that suggested above—" Z.F." ? The use of " A.F." and " R.F.," subdivided where necessary into " I.F.," " V.F." and " U.H.F.," is now becoming general, and is free from reasonable objection so long as writers resist the temptation to put " I.F. frequency." " Z.F." is in line with this useful trend in radio terminology, and is more accurate than "direct," " steady," " unvarying," or any other of the numerous words among which one fumbles to avoid the detestable " D.C. voltage."

" D.C." may be thought to have its roots too firmly established to be ejected. But such established symbols as " C " for current and " ω " for ohms have been replaced in recent time, and if an example were set in influential publications technical terminology would soon be rid of its most ridiculous anomaly. M. G. Scroggie.

Bromley, Kent.

Damping due to a Perfect Diode Rectifier

To the Editor, The Wireless Engineer.

Sir,—Although several writers have discussed the damping of a tuned circuit by a diode rectifier, a certain amount of confusion still occurs: in particular, the distinction between the series and parallel rectifier circuits is not generally appreciated.

During the course of some other work a highly illuminating result was obtained through the formulation of a somewhat unusual Fourier Series, which will now be described.

Under normal operating conditions, particularly when the capacitance across the load R is fairly large, the diode is conductive only for a very small fraction of each cycle of the applied signal. For simplicity, we will assume that the conductive periods are infinitely short, so that the current passed by the diode during these epochs is of infinite amplitude, the charge passed per cycle being finite, *i.e.*, the current flowing through the diode is purely impulsive, having the form of the derivative of a series of Heaviside unit functions.

Let $e = -E\cos\theta$ be the applied signal. We assume that the current through the diode can be represented by the Fourier series

$$f(\theta) = a_0 + \sum_{1}^{\infty} (a_n \cos n\theta + b_n \sin n\theta)$$

and that $f(\theta)$ vanishes everywhere except at $\theta = \pi$, 3π, 5π, . . . $(2m - 1)\pi$, when it is infinite but such that

$$\int_0^{2\pi} f(\theta)\,d\theta = A.$$

Evaluating coefficients

$$a_0 = \frac{A}{2\pi}, \quad b_n = 0$$

$$a_n = \underset{\epsilon\to 0}{Lt}\,\frac{1}{\pi}\int_{\pi-\epsilon}^{\pi+\epsilon} \frac{A}{2\epsilon}\,.\cos n\theta\,d\theta$$

$$= \frac{A}{\pi}(-1)^n. \qquad |a_n| = \frac{A}{\pi}.$$

Now A_0 is the current through the load which would be measured by a D.C. meter, and therefore, since the diode is operating as a peak rectifier,

$$|a_0| = E/R.$$

But $|a_n| = 2\,|a_0|$. $\therefore |a_n| = 2E/R$,

and hence the damping due to a series diode rectifier is equivalent to a resistance $R/2$.

However, in the case of the parallel rectifier the damping due to the load itself must be taken into account, making the input impedance equal to $R/3$.

London, N.5. L. Jofeh.

(Research Department,
A. C. Cossor, Ltd.)

Distortion in Negative Feedback Amplifiers

To the Editor, The Wireless Engineer.

Sir,—In your May issue you published a letter[1] from me in which I deduced the overall characteristic of a negative feedback amplifier from given characteristics of the amplifying path and the feedback path. It was assumed that both characteristics were independent of frequency, at all relevant frequencies, and that the characteristic of the amplifying path was non-linear.

In a letter[2] in your July issue Mr. J. v. Frommer contested my conclusions and said that he was about to publish an article on the subject. Through his courtesy I now have a copy of the article[3], but I remain quite unconvinced either that my letter contained any error, or that Mr. Frommer's conclusions are correct.

To avoid troubling the readers of the *Wireless Engineer* with controversy, I am getting in touch with Mr. Fommer directly, and hope to be able to publish presently a statement with which Mr. Frommer finds himself in agreement.

I thank Mr. Frommer for pointing out the misprint in my previous letter.

Wembley, Middlesex. Robt. W. Sloane.

(Research Laboratories of
the General Electric Co., Ltd.)

Resistance-Tuned Oscillators.

To the Editor, The Wireless Engineer.

Sir,—Will you allow me to make some observations on the article bearing the same title published in your issue of September?

What I wish to put well in evidence is the fact that the change of the frequency of a circuit containing

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[1] *The Wireless Engineer*, Vol. XIV., p. 259.

[2] *The Wireless Engineer*, Vol. XIV., p. 369.

[3] *Tungsram Technische Mitteilungen* " B," August, 1937, p. 23.

inductance, capacitance and resistance brought about by the single change of the resistance is only applicable to the generation of oscillations and not to their reception.

It is well known that the natural pulsation of a circuit containing L, C and R is

$$p = 2\pi n = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

Free electrical oscillations are possible in this circuit if $\frac{R^2}{4L^2} < \frac{1}{LC}$ independently of the sign R, be it positive or negative.

If R is the resultant of a positive Rp and of a negative Rn, the circuit will oscillate as long as $\frac{(Rp - Rn)^2}{4L^2} < \frac{1}{LC}$.

If the value of Rp is too large to allow the circuit to oscillate of its own, it is possible to make it oscillate within an interval of values of Rn comprised between $/ Rn / = 2\sqrt{\frac{L}{C}} - Rp$ and $/ Rn / = Rp + 2\sqrt{\frac{L}{C}}$. The extreme frequencies will be $\frac{1}{2\pi\sqrt{LC}}$ and 0.

For the reception the conditions are quite different. It is known that the intensity of the current in a circuit (L, C, R) acted upon by an e.m.f. E of pulsation p is given by

$$J = \frac{E}{\sqrt{\left(pL - \frac{1}{pC}\right)^2 + R^2}}$$

and the maximum of this current is obtained when $pL - \frac{1}{pC} = 0$ or $p = \frac{1}{\sqrt{LC}}$ independently of the value of R, be it positive, negative or zero.

A circuit, consequently, cannot be tuned by varying the resistance, which has only influence on the sharpness of the tuning and not on the tuning itself.

It appears, consequently, that the title "Resistance-Tuned Oscillators" requires explanation.

Paris. E. BELLINI.

Novel Method of Coupling

To the Editor, The Wireless Engineer.

SIR,—I have been very much interested by your recent Editorials on Couplings and their effect on resonant frequencies of coupled circuits.*

Up to date I have not noticed any attention drawn to the fact that the upper and lower limits of the bandpass of coupled circuits can be conveniently and independently adjusted by the use of a combination of series and parallel coupling impedances.

Enclosed is a Patent Specification describing a method used very successfully by the writer which may be of interest to you.†

In the July number of *The Wireless Engineer* is an article on the Double Super-Heterodyne and the pessimistic conclusions have caused me to bring still another patent (Australian No. 19369 of 1934) to your notice dealing with the Double Super-Heterodyne in commercial form.

Incidentally I would like to ask the author of this Paper if he has investigated the possibilties of using an intermediate frequency equal to the sum of the beat frequencies instead of the difference in order to minimise phantom signals.

E. G. BEARD
(Managing Director,
Ace Amplifiers, Ltd.)

Cremorne, N.S.W.

Triode Input Capacitance

To the Editor, The Wireless Engineer.

SIR,—I notice a misprint, which may cause stumbling, on page 298 of your issue of June 1937 (in "Audio-frequency Transformers" by E. T. Wrathall). The formula for the effective grid-filament capacitance should be

$$C^1_{gf} = C_{gf} + C_{ga}\left(1 + \frac{\mu R}{R + R_a}\right).$$

One of the incidental advantages of the fixed-potential grid (or grids) between anode and control grid in screen-grid (or pentode) valves is the reduction of the third, and much the largest, term in the above expression for triodes. It was in this term that the mistake occurred.

L. B. TURNER.

Engineering Laboratory,
Cambridge.

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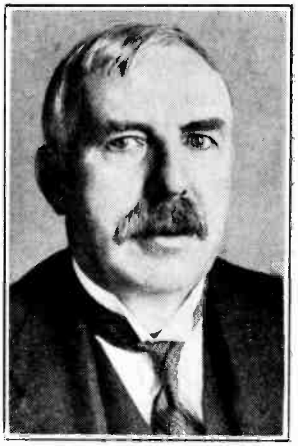
* June and July, 1937.

† See Editorial in this number.

The Late Lord Rutherford, O.M., F.R.S.



BY the death of Lord Rutherford, which occurred at Cambridge on October 19th, science has lost a physicist of world renown. Born in New Zealand in 1871, most of his life has been devoted to research, his most outstanding contribution to knowledge being in connection with his investigations into radioactivity and the nature of the atom.

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

3980. GROUP VELOCITY CURVES FOR RADIO-WAVE PROPAGATION IN THE IONOSPHERE [Boundary Curves show that Points where Group Velocity becomes Zero are More Numerous than Points where Refractive Index becomes Zero: that there is therefore One More Possible Condition of Reflection: Reflections corresponding to New Condition observed Experimentally].—R. R. Bajpai & K. B. Mathur. (*Indian Journ. of Phys.*, July 1937, Vol. 11, Part 3, pp. 165–175.)

3981. ON A METHOD OF MEASURING THE VELOCITY OF PROPAGATION OF ELECTROMAGNETIC WAVES.—L. I. Mandelstam & N. D. Papalexi. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 559–578.)

The method proposed is based on observation of interference between the direct and "reflected" waves and consists essentially of the following:—A wave of frequency ω_1 is radiated from a point I and a voltage corresponding to this wave is applied to one pair of plates of a cathode-ray oscillograph. The wave is received at a point II and re-radiated after it has been displaced in phase and its frequency transformed into ω_2, such that $\omega_1/\omega_2 = m/n$, where m and n are integers. It is then received again at point I and a voltage corresponding to it applied to the second pair of oscillograph plates. A Lissajous' figure is thus obtained, on the screen of the oscillograph, whose form is dependent on the phase angle between the direct and "reflected" waves. If ω_1 is then continuously varied (within certain limits) the form of the Lissajous' figure will also vary, and if the ratio ω_1/ω_2 is maintained constant, it is possible from the variation of the Lissajous' figure to obtain R, the optical distance between points I and II. Knowing D (geodesic distance between the two points) the velocity of propagation of the waves v can be calculated, and conversely, knowing v and R, the distance D can be found.

The theory of the method is discussed and a brief account is given of experiments which were conducted in Russia in 1934/1936. Measurements were made between isolated mountain peaks and over fresh and sea water. The wavelengths used were of the order of 300 m, and distances from 10 to 40 km were covered. The experiments confirmed the practicability of the method proposed and showed that v does not differ much from c and closely approaches it when the waves are propagated over water. *See* also 3982 & 3983.

3982. AN EXPERIMENTAL INVESTIGATION OF THE VELOCITY OF PROPAGATION OF ELECTROMAGNETIC WAVES, HAVING FREQUENCIES USED IN RADIO, IN THE NEIGHBOURHOOD OF THE EARTH'S SURFACE.—E. Ya. Shchegolev. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 579–613.)

A detailed account of the experimental investigation referred to in the preceding abstract. The preliminary laboratory investigation started in 1932 is briefly described, and this is followed by a detailed report with numerous tables and curves on experiments carried out in 1934/1936 in the North Caucasus, on the Black and Kara Seas, and on Lake Ilmen. Particular attention is paid in this report to an analysis of the conditions under which the experiments took place, and various factors are discussed affecting the accuracy of the measurements, such as the reflection of the waves from the upper ionised layer and from the surface of the earth.

3983. ON THE MEASUREMENTS AND CALCULATIONS IN DETERMINING THE VELOCITY OF PROPAGATION OF ELECTROMAGNETIC WAVES BY THE INTERFERENCE METHOD.—K. E. Viller. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 614–626.)

In this paper the actual measurements and observations to be made in connection with the method proposed by Mandelstam & Papalexi (3981, above) are discussed, and the procedure for calculating the results is explained. The necessary corrections are indicated and the accuracy of the method estimated.

3984. Gas- and Electron-Thermal Processes in thr F Region of the Ionosphere, *and* The Hals-Störmer Echo as a Phenomenon of the Ionosphere.—J. Fuchs. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 242.) Summary of paper read before the International Congress for Short Waves in Physics, Biology, & Medicine.

3985. The Ionisation of the Lower Part of the Ionosphere [Theoretical Results explaining Difference in Ionospheric Records in Mean and Tropical Latitudes as Effect of Latitude Variation of Solar Ionisation].—Irène Mihul & C. Mihul. (*Comptes Rendus*, 9th Aug. 1937, Vol. 205, No. 6, pp. 363–365.)

3986. On the Ultra-Violet-Light Theory of Magnetic Storms [Study of Effects of Three Solar Flares observed in 1936 does not support This Theory].—A. G. McNish. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 155–160.)

"A detailed study of the magnetic effects" associated with these solar flares "indicates that they do not produce magnetic storms but result in a very special type of magnetic effect." "When a flare of ultra-violet light increases the conductivity of the lower regions of the atmosphere, increased diurnal-variation currents flow. The current systems necessary to produce magnetic storms are of an entirely different type." Diagrams are given of the "overhead currents necessary to produce the field changes associated with solar-flare disturbances and those necessary to produce the normal diurnal variation departures obtaining at the time." These support the view that the normal diurnal currents are increased by the improved conductivity of the upper atmosphere due to a sudden increase in the ionising radiation from the sun, which also causes absorption of radio waves. The mechanism which gives rise to the sudden commencement of a magnetic storm must be quite different from that which operates when a sudden flare of ultra-violet light from the sun impinges on the earth's atmosphere."

3987. The Emission of Electrified Particles by the Sun, and the Theory of Polar Auroras [Emitted Particles have Very Low Energy compared with the 6×10^4 eV for Aurora Production or 10^{10} eV required by Dauvillier's Theory: Suggested Theory that Earth is Positively Charged (Charge maintained by Cosmic Rays) and thus gives the Electrons a Sufficiently High Velocity].—D. Barbier. (*Journ. de Phys. et le Radium*, July 1937, Vol. 8, No. 7, pp. 303–308.)

3988. The Agents of Ionisation of the Upper Atmosphere [Data on Collisional Frequencies and Solar Eclipse Observations (June 1936) show that F_2 Ionisation can Not be explained by Ultra-Violet Radiation only: Superposed Effect of Secondary Electrons due to Dauvillier's 2×10^{10} eV Electrons from Sun].—I. Ranzi. (*Nuovo Cimento*, April 1937, Vol. 14, No. 4, pp. 145–170.) An appendix gives a description of the experimental apparatus and methods employed for measuring the apparent height and the coefficient of reflection.

3989. Observations of the Ionosphere during the Total Eclipse of the Sun of June 19th, 1936, in the Town of Tomsk [Separation of Superposed Effects of Intense Magnetic Storm: Ultra-Violet Radiation largely responsible for Ionisation of F_2 and Absorbing D Layers, but Good Evidence of Marked Corpuscular (Electron, Ion, Neutral) Action on F_2 and probably on D].—Kessenich, Baerwald, Bulatov, & Denisov. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 466–484: in English.) For a preliminary note *see* 3672 of 1936: *cf.* also Tetelbaum, 3237 of September.

3990. Frequency Characteristics of Abnormal Attenuation of Short Waves during the "Dellinger Effect" [of 27th Jan. 1937: Fukuoka Measurements on Several American Stations: Increase of Attenuation varies approximately Inversely with Square of Frequency, and decreases with Time roughly Logarithmically: is due Not Only to Increased Electronic Density but also to Increase of Collisional Frequency in Ionised Region newly formed a Little Lower than Normal Position].—M. Nakagami, K. Miya, & K. Simizu. (*Electrotech. Journ.*, Tokyo, Sept. 1937, Vol. 1, No. 4, pp. 143–144.)

3991. Sudden Disturbances of the Ionosphere [Compressed Summary of World-Wide Data on 118 Cases of "Dellinger Effect": Discussion and Explanation: Bibliography].—J. H. Dellinger. (*Journ. of Res. of Nat. Bur. of Stds.*, Aug. 1937, Vol. 19, No. 2, pp. 111–141.)

3992. The Exploitation of Radioelectric Communication on Short Waves [based on Reception Data (obtained at Villecresnes) of Buenos-Ayres/Paris, New-York/Paris, and Tokio/Paris Routes: Daily, Yearly, and 11-Yearly Cycles: Fade-Outs: etc.].—J. Maire. (*Bull. Soc. franç. des Élec.*, July 1937, Vol. 7, No. 79, pp. 703–724.)

3993. Skip Distances on Ultra-High Frequencies [Inversely Proportional to Frequencies at Night? 10-Metre Day Skip Distance often 500 Miles or Less, 5-Metre 900 Miles].—R. T. Sampson. (*QST*, Sept. 1937, Vol. 21, No. 9, p. 68.)

3994. Is Selective Fading present on Ultra-Short Television Wavelengths?—Scholz. (*See* 4197.)

3995. Television Signals across the Atlantic [Alexandra Palace Signals received at RCA Laboratory, 21st Jan.–4th April].—H. O. Peterson & D. R. Goddard. (*Television*, Sept. 1937, Vol. 10, No. 115, pp. 527–528.)

3996. Day Propagation at Medium Frequencies [550–1500 kc/s: Pennsylvania Measurements on Sixty Stations within 1000 km: Agreement with van der Pol's Ground-Wave Approximation to Sommerfeld Theory: Stronger Sky-Wave Signals when Atmospheric Pressure was High at Receiving End (especially True for Signals from South West): etc.].—R. M. Bell & P. S. Le Van. (*Comm. & Broadcast Eng.*, Aug. 1937, Vol. 4, No. 8, pp. 5–6 and 7.)

3997. A More Accurate Form of the Improved Sommerfeld Propagation Formula for Wireless Waves extending Its Validity Range to Smaller Distances from the Origin.—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 7, Vol. 29, 1937, pp. 569–584.)

For previous work *see* 1354 of April. Here the power series there assumed are further developed and the case of arbitrary ground constants is considered. The results of the calculations are represented in the form of curves.

3998. Decision between the Two Sommerfeld Formulae [published in 1909 and 1926 respectively] for the Propagation of Wireless Waves [the Second is Correct: Demonstration of the Error in the First].—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 7, Vol. 29, 1937, pp. 585–596.)

3999. The Ground-Level Field Strength and Its Dependence on the Vertical Characteristic of the Transmitting Aerial.—Grosskopf. (*See* 4090.)

4000. The Service Area of a Long-Wave Telegraphic Transmitter [Aerial Efficiency, Propagation, Atmospherics: Calculation of Optimum Wavelength (about 4000 m for Radius up to 5000 Miles, Day and Night): etc.].—A. L. Green. (*AWA Tech. Review*, July 1937, Vol. 3, No. 1, pp. 7–29.)

"It has been assumed that the parameters α and d_0 in Watson's formula are independent of wavelength, thus making possible a great simplification in the calculations. The hypothesis has been subjected to a severe test by attempting to extend the range of validity of Watson's formula to cover the known facts of sky-ray propagation at medium broadcasting frequencies." It was also assumed (with considerable support from experimental data) that the intensity of interference from atmospherics is directly proportional to the wavelength to which the receiver is tuned.

4001. On the Design Calculations of Apparatus for the Registration of Rapid Phenomena.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 7, 1937, pp. 1065–1082.)

A method is proposed for calculating the constants of an apparatus, such as an oscillograph or seismograph, used for registering rapidly varying signals. In this method the constants of the apparatus are determined in accordance with the maximum permissible distortion and the type of function representing the signal to be registered. This is achieved by deriving and solving the so-called "equation of distortion" for the system and signal under consideration. The discussion is illustrated by calculations relating to a system consisting of an electrodynamic microphone and oscillograph.

4002. The Eclipses of the Moon and the Distribution of Atmospheric Ozone, *and* The Infinite Universe and the Light of the Night Sky.—B. Fessenkoff. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 25th April 1937, Vol. 15, No. 3, pp. 119–121: pp. 123–125: in French.)

4003. The Preparation of Auroral Afterglow Tubes [Spectrograms showing Clean-Up of Impurities].—J. Kaplan. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 254: abstract only.)

4004. The Production of Ions in the Auroral Glow [Theory based on Hypothesis of Enhancement of Certain Level of Initial Electronic State of Goldstein-Kaplan Bands at Expense of Metastable Molecules in Certain State].—J. Kaplan. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 257: abstract only.)

4005. The Position of New Zealand Aurorae.—M. Geddes. (*New Zealand Journ. of Sci. & Tech.*, June 1937, Vol. 19, No. 1, pp. 55–62.)

4006. The Calculation of the Mean Ionisation Energy of Gases [with Analytical Expressions for Velocity Distribution of Secondary Electrons and for Differential Ionisation for Atoms with Several Electrons: Numerical Results for H, N_2, Ne].—E. Bagge. (*Ann. der Physik*, Series 5, No. 1, Vol. 30, 1937, pp. 72–90.)

4007. The Recombination of Ions in Pure Oxygen as a Function of Pressure and Temperature [Value of Recombination Coefficient under Various Conditions], *and* Preliminary Report on Recombination of Ions in Air at High Pressures [Experimental Curves analysed by Different Laws].—M. E. Gardner: G. T. Merideth & J. W. Broxon. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 252–253: p. 252: abstracts only.)

4008. Collector Theory for Ions with Maxwellian and Drift Velocities.—A. H. Heatley. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 235–238.)

4009. "Raster"-Type Reflection Gratings [Calculations of Fraunhofer Diffraction Figures for Gratings with Forked Rectangular Cross-Section: Application to Infra-Red Spectroscopy: Formulae giving Optimum Grating Dimensions for Given Spectral Region].—K. H. Hellwege. (*Zeitschr. f. Physik*, No. 9/10, Vol. 106, 1937, pp. 588–596.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

4010. Snow Static Effects on Aircraft [from a Report on United Air Lines' Investigation: including Practical Developments therefrom].—H. M. Hucke. (*Comm. & Broadcast Eng.*, July 1937, Vol. 4, No. 7, pp. 7–10 and 28, 29.) *See* also 3603 of October.

4011. Mathematical Theory of Front Shifting in the Atmosphere.—I. Kibel. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 5th March 1937, Vol. 14, No. 7, pp. 429–431: in English.)

4012. The Relation between the Intensity of Interference from Atmospherics and the Wavelength to which the Receiver is Tuned.—Green. (*See* 4000.)

4013. Model Tests on Lightning Strokes.—Matthias. (*E.T.Z.*, 9th Sept. 1937, Vol. 58, No. 36, pp. 973–976.) Conclusion of the work dealt with in 3606 of October.

4014. The Problem of Ball Lightning [Theory].—T. Neugebauer. (*Zeitschr. f. Physik*, No. 7/8, Vol. 106, 1937, pp. 474–484.)

The theory here given, based on quantum-mechanical exchange forces, shows that a gaseous sphere consisting of free electrons and positive ions can hold together provided that the electron density is of the same order of magnitude as the number of molecules per unit volume of atmospheric air. This condition could arise at the end of a linear lightning-discharge channel. Various observed properties of ball lightning are explained by the theory; calculations of recombination and energy are given.

4015. The Liability of Overhead Line Systems to Direct Lightning Strokes [Graphical Determination of Liability, for Various Numbers and Positions of Earth Wires, etc.: Method applicable to Design of Complete Protection of Buildings].—A. Schwaiger. (*Elektrot. u. Masch:bau*, 1st Aug. 1937, Vol. 55, No. 31, pp. 369–375.) Patents have been applied for in connection with this method and its resulting systems of protection.

4016. A Multiple Camera for Lightning Studies.—E. J. Workman & R. E. Holzer. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 256: abstract only.)

4017. Cosmic Radiation [Cantor Lectures].—P. M. S. Blackett. (*Journ. Roy. Soc. Arts*, 13th, 20th, & 27th Aug. 1937, Vol. 85, pp. 893–903, 905–918, and 921–931.)

4018. The Specific Ionisation in Air for Cosmic Rays and Gamma Rays, *and* Cosmic Rays and the Earth's Magnetic Field: II.—J. Clay: E. M. Bruins. (*Physica*, Aug. 1937, Vol. 4, No. 8, pp. 645–647: pp. 659–666: both in English.)

In Bruins's paper the conclusion is reached that "the earth-magnetic effects cannot be explained by assuming a single dipole. . . . Evidence is given that local magnetic disturbances have an effect on the cosmic ray intensity, in the South Pacific as well as in the South Atlantic."

4019. The Atmospheric Potential Gradient at Ottawa, Canada.—D. C. Rose. (*Canadian Journ. of Res.*, Aug. 1937, Vol. 15, No. 8, Sec. A, pp. 119–148.)

PROPERTIES OF CIRCUITS

4020. Discontinuous Phenomena in Radio Communication.—B. van der Pol. (*Journ. I.E.E.*, Sept. 1937, Vol. 81, No. 489, pp. 381–398.)

Shot effect: "circuit noise," or Brownian motion: the "impulsive function," its definition and usefulness in physical applications: application to the calculation of thermal fluctuations and to general circuit theory: behaviour of a low-pass filter under an impulsive voltage, and the transition to a smooth line: the "discrete wave equation" and the "discrete potential equation": Appendix—finding the other part of an impedance when either the real or the imaginary part is known.

4021 Laplacian Transform Circuit Analysis [Method for General Solution of Linear Lumped Circuits with Constant Coefficients by Operational Process: Matrix Generalisation to Most General *n*-Mesh Circuit: Case of Two Coupled Circuits].—L. A. Pipes. (*Phil. Mag.*, Sept. 1937, Series 7, Vol. 24, No. 161, pp. 502–511.)

4022. Amplification of Very Wide Frequency Ranges [Frequency-Independent Resistance Amplifiers].—H. Pieplow. (*E.N.T.*, July, 1937, Vol. 14, No. 7, pp. 225–232.)

The fundamental principles of resistance amplification are described in § 2 for frequencies of period large compared to the transit time of the electrons in the amplifying valve. Fig. 2 shows the circuit for resistance coupling with two-stage amplification, Fig. 3 its vector diagram. Eqn. 3 gives the necessary and sufficient condition to be satisfied by the high-frequency limit of resistance amplification. The limits are discussed theoretically in § 3 with reference to the deleterious capacity C (Fig. 4b); Fig. 5 gives the vector diagram of the amplification for various anode impedances, Figs. 6, 7 the real and imaginary parts of the amplification, its absolute value and phase angle error. Fig. 8 shows the limit frequencies and amplification of various types of valve.

Distortion is discussed in § 4; Fig. 9 gives the circuit for removal of distortion by introducing an inductance, Fig. 10 the amplification factor as a function of frequency ratio for various inductances. A suitable inductance is found to increase the frequency range by a factor of four. As examples of the action of the amplifier, its effect on "trip" voltages (Fig. 11) and on the Heaviside unit impulse (Fig. 12) is discussed theoretically. Fig. 13 illustrates the softening of the sharp corner in the unit impulse. Fig. 14 gives a general vector diagram of the "reduced" amplification factor with dimensionless parameters, Figs. 15a, b the numerical "trip" amplitudes of the harmonics of the "trip" voltages for a variable ratio of the return stroke, Fig. 16 the frequency spectra of the "trip" voltage, which need only be multiplied by the frequency curve of the amplifier to deduce the effect of the latter on the "trip" voltage.

4023. Amplification at High Frequencies [over about 1 Mc/s: the Effect of the Equivalent Damping Resistances (representing Grid Damping due to Finite Transit Time) in a Cascade of Valves in a H.F. Amplifier: Greatest Amplification may be given by Valve with Least Steep Slope: Method of Decreasing the Damping Action].—H. Rothe. (*Telefunken-Röhre*, Aug. 1937, No. 10, pp. 143–146.) Following on his previous paper (2574 of July).

4024. On the Problem of the Linear Characteristic [in connection with Valve Design].—Kleen. (*See* 4110.)

4025. On the Measurement of Total Square Deviation.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 7, 1937, pp. 1083–1095.)

The use of the method of least squares for estimating the linear distortion of a signal has been discussed in a previous paper (2909 of August). In the present paper a method is proposed for the experimental measurement of the integral $\int_0^T [\delta(t)]^2 dt$, where δ is the error of the record. A device capable of doing this would be required to (1) subtract two voltages from one another; (2) square the result; and (3) integrate this. Each of these requirements is discussed separately, and as a result of this a circuit is developed (Fig. 16), comprising essentially two valves working in opposition (operation 1), a symmetrical square-law detector consisting of a number of copper-oxide rectifiers (operation 2), and a ballistic galvanometer (operation 3). A special telegraphic key for producing the signal has also been developed. Experiments show that the circuit described gives sufficiently accurate results.

4026. Non-Linear Distortion Phenomena of Magnetic Origin [in Amplifiers].—J. W. L. Köhler. (*Philips Tech. Review*, July 1937, Vol. 2, No. 7, pp. 193–200.)

General considerations on non-linear distortion: distortion due to non-loaded and loaded iron-core coils: eddy current losses and their effects: distortion due to transformers: distortion at high induction values.

4027. On the Resonance in a Non-Linear System with Two Degrees of Freedom.—V. V. Migulin. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 627–641.)

As early as 1934 Mandelstam & Papalexi showed that if an e.m.f. of frequency ω_0 is applied to a non-linear oscillating system with two degrees of freedom, and ω_0 is equal or nearly equal to one of the two resonant ("combining") frequencies ω_1 and ω_2 of the system, the latter will start to oscillate and the relationship between these frequencies is expressed by the equation $m\omega_0 = p\omega_1 + q\omega_2$, where m, p and q are integers. In the present paper this phenomenon, called by the author "combined resonance," is investigated on the example of a Thomson oscillating circuit (Figs. 1 and 2). The theory of the operation of the circuit is discussed, and an account is given of experiments which fully confirmed the theoretical considerations. Methods are also indicated for approximate calculations relating to the operation of the system. It is pointed out that apart from its purely scientific interest the phenomenon described is of considerable practical importance as a means for frequency multiplication, and in fact it has already been so used in a number of practical investigations.

4028. The Parametric Excitation of "Combining" Oscillations.—V. A. Lazarev. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 642–645.)

Mandelstam & Papalexi have shown that if one of the parameters of an oscillating system is varied with a frequency n, such that $n_1 \pm n_2 = n$ where n_1 and n_2 are the "combining" frequencies, the system will start to oscillate. In the present paper a preliminary communication is made on experiments with an oscillating circuit having two degrees of freedom, in which a rotating condenser C with a variable capacity was connected in parallel with a tuning condenser C_1 (Figs. 1 and 2). The results so obtained are in agreement with the theory and indicate the practical value of the circuit for frequency multiplication purposes.

4029. Counter-Phase Retroaction [Negative Feedback].—F. Marietti. (*Alta Frequenza*, Sept. 1937, Vol. 6, No. 9, pp. 568–617.)

Diminution of non-linear distortion; of background noise and cross-talk; of variations of the amplification. Improvement of the frequency characteristic; of the reproduction of transients. Effect of defects in the feedback circuit; correction of the frequency characteristic by means of correctors in the feedback circuit. Amplifiers with multiple feedback (whole amplifier, with a feedback circuit of its own, is divided into two parts in series, one or both having an additional feedback circuit). In-phase feedback; feedback with any value of θ. Conditions for the stability of feedback amplifiers. List of practical applications.

Constant-current negative feedback and constant-voltage negative feedback: their particular uses. Experimental results: application to various parts of the transmitting and receiving apparatus of the Turin broadcasting station: results confirm the theoretical work.

4030. Detection by Diodes and Triodes at High Frequencies [Revised Theoretical Treatment (and Experimental Confirmation) of Detection of Unmodulated Carriers varied from 0 to 24 Mc/s: Anode-Bend and "Ultra-Top-Bend" Detection (and a Hysteresis Effect with Oxide-Coated Cathodes): "Anomalous (Driven) Instability": New Light on Frequency Doubling in Radio Transmitters: etc.].—W. E. Benham. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, pp. 472–477.) *See* also 2108 of June.

4031. Resistance-Tuned Oscillators.—Gordon & Makinson. (*See* 4056.)

4032. A New Type of Negative Resistance.—Kleen & Rothe. (*See* 4111.)

4033. Selectivity and Fidelity.—Sturm. (*See* 4066.)

4034. The Resultant "Q" of Tuned Circuits [Approximate Equations and Table for determining Reduction due to Terminal Strip, Socket, Switch, etc.].—A. W. Barber. (*Rad. Engineering*, July 1937, Vol. 17, No. 7, pp. 5–6.)

4035. "Versuche zur elektrischen Resonanz mit hochfrequenten und niederfrequenten Wechselströmen [50 c/s to 30 Mc/s: Book Review].—F. Moeller. (*Electrician*, 17th Sept. 1937, Vol. 119, p. 311.)

4036. The Two-Wire Circuit as a Quadripole Network [Treatment by Modern Algebraic Methods: using Brillouin's Work on "Filters and the Theory of Matrices"].—Th. Boveri: Brillouin. (*Bull. de l'Assoc. suisse des Élec.*, No. 19, Vol. 28, 1937, pp. 441–446: in German.)

See 931 of 1936. The writer sets himself to find an intermediate way between an extended discussion of general principles and a detailed treatment of an example. "There is every reason to suppose that such methods will be introduced more and more into the mathematical treatment of technical problems."

4037. Some T and Pi Pad Tables [for Resistive Attenuating Networks: compiled, from McElroy's Paper, for Commercial Broadcast Practice].—R. S. Naslund: McElroy. (*Comm. & Broadcast Eng.*, Aug. 1937, Vol. 4, No. 8, pp. 12–15.) *See* 2412 of 1935.

4038. Condenser Discharge Chart [Nomogram]. —(*Electronics*, Sept. 1937, Vol. 10, No. 9, p. 20.)

TRANSMISSION

4039. Remarks on the Paper: "The Dynamics of Transversely and Longitudinally Controlled Electron Beams."—F. W. Gundlach: Hollmann & Thoma. (*Hochf: tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 65–67.)

For the paper in question *see* 2914 of August. Gundlach here questions results there given which seem to contradict physical facts; he finds that boundary conditions were introduced which do not agree with the true physical conditions and that there are errors in the calculations. As regards the ultradynamic conditions, he doubts whether the conditions are sufficiently exactly described by taking the integral only over the electron paths between the plates. He finds that the meaning of the inversion theory, which is intended to include both longitudinal and transverse control, is not clear.

4040. Methods for the Generation of Ultra-Short [and Micro-] Waves.—H. E. Hollmann. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 242–246 and 246–247.)

Long summary of the survey read before the International Congress for Short Waves in Physics, Biology, and Medicine. It includes the Hollmann "sphere-circuit" oscillators (in one of which three midget valves are *inside* the sphere): a discussion of the effects of electron inertia (with definition of the "ultradynamic transit-time angle"): retarding-field methods (including the Farnsworth "Dynode"): magnetrons: "inversion" oscillations with diodes, particularly a special push-pull diode with high-emission cathode: ultradynamic inversion acts not only on convection currents but also on the induction currents, so that for generation of oscillation the electrons need not *reach* an anode—hence the "Auskoppel" (out-coupled) generator, where an electron ray is shot through a hollow electrode (at a lower, braking potential) and removed on exit by a collector electrode: and a step further—the cathode ray as oscillation generator.

4041. The Calculation of the Behaviour of Multi-Grid Valves at High [and Ultra-High] Frequencies [Extension of Müller's Treatment to Cases where Initial Velocity and Field Strength are Not Zero: Importance of D.C. Processes: etc.].—I. Runge. (*Telefunken-Röhre*, Aug. 1937, No. 10, pp. 128–142.)

For plane electrodes, at frequencies for which the transit times are comparable with the oscillation period. Eqns. 23, 24 give the total current and the convection current for an electrode which takes up the whole electron stream. But in practice it is more often required to know the current taken up by a negatively biased grid, which allows the whole convection stream to pass through. A first approximation is given by the difference between the total current and the convection current, but this calculation neglects the influence of the electrons in the space beyond the grid: this neglect is only justifiable if the potential in the space is so high that the path time becomes negligible. For cases where the path time in the second space is of the same order as that in the first space, eqn. 21 allows this influence to be taken into account. For Müller's paper *see* 1933 Abstracts, pp. 443–444.

4042. The Production of Electron Oscillations with "Grid" Diodes [Equivalence to Retarding-Field Triode, the Glass Container being the Third Electrode].—E. Djakov. (*Hochf:tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 41–50.)

Diodes are classified (§ II) into (1) closed diodes, (2) open diodes in which the electrons can pass through the second electrode. These are sub-divided into (2a) true open diodes, in which the potential rises steadily between cathode and grid (Fig. 1), and (2b) pseudo-diodes, in which the potential first rises and then falls (Fig. 2). The present investigation is confined to class (2a) and in particular to diodes without a magnetic field. It is assumed that electrons which arrive at the glass container give it a negative charge, so that it plays the part of a third electrode and the field distribution is analogous to that in a retarding-field triode. The diodes used are shown in Figs. 3–8; Fig. 9 shows a diode with a built-in cathode-ray tube. The experimental system consists of a diode oscillator (Fig. 10) and a Lecher-wire system

(Fig. 11). The results (§ IV) show that all the properties of the diode are analogous to those of the retarding-field triode. The effect of the distance of the glass container on the wavelength is investigated (§ IV 2); an external electrode has no effect on the retarding field. The "glass-wall potential" of the container is determined by comparison with a triode, by the deviation of an electron beam (Figs. 9, 18), and by an electrometer method; it is found to be slightly negative and dependent on the intensity of the oscillations.

4043. Retarding-Field Generators with Cavity Resonators ["Resotanks"] for Decimetre Waves.—W. Dällenbach. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 247.)

The hollow chamber acts as the frequency-determining resonator, a retarding-field electron-ray generator being mounted inside it. Variation of a second cavity, coupled to the first, is used for tuning, on an acoustic analogy. A 14 cm wave is used for tests on the dependence of output energy and frequency on loading and emission. The generator can also be used as a receiver.

4044. Triode Oscillator with Open Tank Circuit [Experiments with Micro-Wave Oscillator (i) having Its $\lambda/2$ Aerial enclosed by Coaxial Metal Cylinder, and (ii) Itself, with Its Dipole Aerial, enclosed in Ellipsoidal Container].—K. Morita. (*Electrotech. Journ.*, Tokyo, Sept. 1937, Vol. 1, No. 4, p. 142.)

(i) If the cylinder radius is an even multiple of $\lambda/4$ the radiation resistance approaches zero and the radiation falling on the inside surface of the cylinder is reflected back on to the aerial in correct phase, producing powerful oscillations. When the radius is an odd multiple of $\lambda/4$ the radiation resistance becomes infinitely large. (ii) If the dipole is placed at one focus of the ellipsoid, oscillatory energy can be collected at the other focus. "The idea of collecting the energy in this manner is not new; however, the idea of controlling the oscillating condition by enveloping the oscillator with an ellipsoid and of finding the best condition between wavelength generated and the ellipsoid dimensions is considered quite independent."

4045. On Bell's Discussion on Our Article "The Stabilisation of Oscillators by Systems with Distributed Constants."—B. Wwedensky: Bell. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 503–504: in English.)

Bell's criticism (939 of March) is based on his mistaken assumption that the *S* in the Russian formula (which is in fact Barkhausen's formula for the condition of self-excitation) represents the anode slope conductance, whereas actually it represents the grid slope conductance.

4046. A Magnetron free from Back-Heating [a Four-Segment Magnetron with Filament Displaced axially so as to be Outside the Cylinder, where Electrons cannot Land on It].—Haelbig. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 247.) Short summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine.

4047. The Electron-Beam Magnetron.—Okabe. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 247.) Summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine. *See* also 2966 of August.

4048. Amplitude Modulation of a Magnetron, free from Unwanted Frequency Modulation, by the "Chopping-Up" Method.—K. Posthumus. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 246.)

Summary of a paper read before the International Congress for Short Waves in Physics, Biology, and Medicine. With anode modulation of a 20 cm wave, even if the magnetron is coupled to a very weakly damped circuit, frequency changes of the order of a megacycle occur. Such frequency modulation can be eliminated by interrupting the magnetron at a supersonic frequency, so that in an unmodulated condition it sends out alternate and equally long pulses and spaces: the anode voltage is kept constant, and modulation takes the form of varying the proportion of active to passive periods (Fig. 3c).

4049. Portable Five-Metre Transmitter [with Concentric-Line Stabilisation: Constructional Article].—H. B. Dent. (*Wireless World*, 24th Sept. 1937, Vol. 41, pp. 302–304.)

4050. A Beam Valve [Crystal] Oscillator.—(*Television*, Sept. 1937, Vol. 10, No. 115, pp. 558, 560.) Using the new Mazda AC4/PEN, which "is very similar to the 646, but seems to be more docile in operation. . . . It is intended for use as a high audio output pentode amplifier, but its characteristics are such that it is ideal for use in crystal oscillator circuits."

4051. The Temperature Compensation of Master Oscillators, Signal Generators, etc. [particularly where Crystal Control is inapplicable because of Continuous Wave-Change: Experimental Investigation on Elimination of Frequency Variation].—N. Schöller. (*Elektrot. u. Masch:bau*, 12th Sept. 1937, Vol. 55, No. 37, pp. 445–448.)

Prolonged tests on circuits selected for their independence of voltage fluctuations (Abstracts, 1932, p. 164, Dow: 1934, pp. 495–496, Schweimer & Pungs) showed that frequency fluctuations occurred which originated in temperature changes (Fig. 1) acting on condensers, coils, valves, sockets, connecting leads, and housing. Systematic investigations showed that self-supporting formerless coils and coils wound on Pertinax both gave irregular, non-reproducible frequency variations. Heavy enamelling of the winding on Pertinax gave a reproducible relation between temperature-changes and frequency, an increase of temperature producing a decrease of frequency. To obtain the greatest possible independence of frequency, coils on ceramic formers, with their windings "burnt on," had to be used [the word "aufgebrannt" evidently refers to one of the several recently developed processes by which the conductor is consolidated with its ceramic former, such as the use of vitreous enamel and subsequent firing, or the sintering of a metallic layer on to the former and the subsequent attachment of the conductor to this layer].

Mica and paper condensers were ruled out at once because of the irregularity of the temperature/frequency curves given by them. Rotating plate condensers gave a frequency drop with rise of temperature. "Condensers with a dielectric of ceramic material were remarkable for the proportionality, not found with any other material, of their capacity variations with temperature, and for the quite exceptional reproducibility of their temperature curves. These properties make it possible to remove, or at any rate to diminish greatly, the variations with temperature of coils and other components in an oscillatory circuit. According to the magnitude and sense of the necessary compensating changes, condensers of Calan, Tempa, or Condensa were employed."

Sockets and valves: sockets of Calit were used in the experimental model, tests having showed them to be completely independent of temperature. A valve with its cathode cold caused no frequency variation even for large changes of temperature. "Application of the cathode-heating voltage produced long-lasting frequency variations, corresponding to an apparent increase in the valve capacity": with the heated valve a slight dependence on changes in the external temperature could also be noticed.

The writer then deals with the calculation of the values of the ceramic-dielectric condenser necessary for compensating a circuit against frequency variation with changes of temperature; first in the case of a parallel connection of the compensating condenser and secondly in the case of a series connection. Fig. 5 shows the frequency characteristic, over a 3½ hours' test, of an oscillator, of nominal frequency 2368 kc/s, stabilised in this way: it shows the delayed entry of the action of the compensating condenser. This delay can be eliminated by situating the condenser in such a position that the temperature changes act on it at the correct time and to the correct extent. Without this refinement it was found possible to limit the peak frequency variation (over a temperature range of 7° C) to 130 c/s or 0.055‰, corresponding to a mean variation of only 50 c/s or 0.021‰.

4052. Modes of Fracture in Piezoelectric Crystals: Characteristics of X and Low Coefficient Cuts [and Methods of avoiding Fracture].—E. W. Sanders. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 17–18 and 84.)

4053. An Isothermal Chamber constant to One-Thousandth of a Degree Centigrade [for Quartz Oscillators, etc.].—Turner. (*See* 4349.)

4054. The Oscillation Characteristic Curves of the Dynatron.—H. H. Meinke. (*Hochf: tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 50–54.)

Precursor of a paper on the behaviour of the dynatron oscillator in the ultra-short-wave field. The characteristic field of the "anode" dynatron (distinguished from the "grid" dynatron in that its secondary electrons produce a falling *anode*-current characteristic) is shown in Fig. 1; it corresponds to the circuit of Fig. 2 (equivalent circuit Fig. 3). This is investigated theoretically in § I; the construction of the oscillation characteristic (Fig. 4) is described. Fig. 6 shows characteristics for various anode voltages, Fig. 5 curves of anode voltage, current amplitudes, and alternating power. The choice of anode and grid voltages and working rules for nickel anodes are discussed in § II. It is found that full advantage is taken of the characteristic slope if the grid voltage is chosen at least twice, but not more than three times, as large as that of the anode. The variation of slope with increasing emission current is described in § III, with a discussion of dynatron characteristic theory. § IV deals with the variation of the oscillation characteristics as the emission current increases (Fig. 11), § V with the characteristics for barium anodes (Fig. 12), whose preparation is described. The oscillation characteristics for barium anodes (§ VI) are shown in Fig. 15.

4055. A New Type of Negative Resistance.—Kleen & Rothe. (*See* 4111.)

4056. Resistance-Tuned Oscillators [Analysis of Cabot's Circuit and Three Transformations: Frequency Ranges: Effect of Stray Capacities: Practical Results: Application to New Method of Frequency Modulation].—W. G. Gordon & R. E. B. Makinson: Cabot. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, pp. 467–471.)

"In one of the oscillators tested it was possible to vary the frequency from 470 to 2750 c/s by merely varying the tuning resistance from zero to 10 000 ohms. To cover the same range with an oscillator of the conventional type would necessitate the switching of large capacities, while a beat-frequency oscillator is considerably more expensive to construct." The frequency-modulation application has been used by one of the authors in the frequency-response-curve apparatus dealt with in 2144 of June.

4057. Carrier Regulation ["Trägersteuerung": Floating Carrier System] at the Leipzig High-Power Broadcasting Station.—H. Brückmann & R. Seidelbach. (*T.F.T.*, April 1937, Vol. 26, No. 4, pp. 82–85.)

Known also in Germany as "Hapug-Modulation," from the development work of Harbich, Pungs, & Gerth (79 of January). *See* also Ditcham, 1934 Abstracts, pp 150–151.

4058. An Electronic Volume Compressor Easily Constructed Unit which can be applied to almost Any Speech Amplifier [based on Use of Variable-Mu Valve—the 647 Pentagrid Mixer].—R. E. Bullock & H. N. Jacobs. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 37–38.)

Allowing the average level to be increased (for music) about 10 db, "which should at least double the percentage modulation . . . practically as effective as increasing the carrier power four times," and preventing over-modulation from sudden bursts of sound.

4059. An A.V.C.-Controlled Pre-Amplifier: Output-Limiting Unit with High Gain and Flat Frequency Response.—J. Hanson. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 42–43 and 96.)

4060. The Low-Power Transmitters [100- and 250-Watt American Broadcasting Transmitters].—J. P. Taylor. (*Comm. & Broadcast Eng.*, June & July 1937, Vol. 4, Nos. 6 & 7, pp. 14–17 & 36, 37 and pp. 19–21 & 23.)

4061. A Compact Airplane-Type 'Phone Transmitter with Vibrator Power Supply [weighing 14 lbs. complete with "Vibrapack" and Accumulator and giving 10 Watts 100% Modulated Output].—R. M. Ellis. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 46–47.)

RECEPTION

4062. The Linear Reflex Detector [Defects of Diode Detector: Development and Advantages of Linear Reflex Detector with Cathode Resistor by-passed only for R.F.: Deep Modulation Capability, High Input Impedance, Appreciable Gain, etc.]—C. P. Healy & H. A. Ross. (*AWA Tech. Review*, July 1937, Vol. 3, No. 1, pp. 1–6.)

4063. Detection by Diodes and Triodes at High Frequencies.—Benham. (*See* 4030.)

4064. Multi-Stage Inverse Feedback: Applying Degeneration to Complete Amplifier Systems [with Provision of Correction for High-Note Attenuation: Theory: Practical Circuits].—(*Radio Review of Australia*, July 1937, Vol. 5, No. 7, pp. 170–174.) From "Low-Frequency Inverse Feedback" in a Philips publication.

4065. Frequency Changers in All-Wave Receivers.—Herold: Strutt. (*See* 4106.)

4066. Selectivity and Fidelity [Fundamental Relations: Formulae and Curves: Circuits with Loose Coupling: with Tight Coupling ("Coupling Filters"): Band Filters with Variable Band Width: Tunable Band Filters].—T. Sturm. (*Funktech. Monatshefte*, Aug. 1937, No. 8, pp. 245–254.)

4067. A New Quartz-Crystal Filter of Wide-Range Selectivity [Band Width variable between 300 c/s and 7 kc/s: using a 1560 kc/s Crystal, in Special Holder, giving Shunt Capacity of only 6 $\mu\mu$F].—D. H. Bacon. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 24–25 and 86, 88.)

4068. "High-Frequency Coils with Iron Ribbon Cores and Adjustable D.C. Magnetic Bias" [Disclaimer].—Maus: AEG. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 285.) The AEG state that this paper (3650 of October) was published without their consent and that the author only is responsible for the statements contained therein.

4069. Inductance or Capacity Tuning?—W. E. Bonham. (*Rad. Engineering*, July 1937, Vol. 17, No. 7, pp. 17–18 & 31. to be contd.)

4070. Remote Tuning Control [New Electrical System using Coaxial Cables].—J. F. Ramsay. (*Wireless World*, 3rd Sept. 1937, Vol. 41, pp. 231–232.)

4071. Push-Button Station Selection [Motor-Tuned and Tuned-Circuit-Substitution Systems].—B. V. K. French. (*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 16–19.)

4072. Developments in 1938 Receivers [particularly Automatic Tuning (with the Necessary Frequency Stabilisation)].—(*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 13–15 and 42.)

4073. Flexible Tone Control [Constructional Article].—M. G. Scroggie. (*Wireless World*, 10th Sept. 1937, Vol. 41, pp. 263–266.)

4074. Built-In Noise Suppressors [used in Modern American Broadcast Receivers].—W. N. Weeden. (*Wireless World*, 17th Sept. 1937, Vol. 41, pp. 281–282.)

4075. The Measurement of Noise Level in Receivers [and the Definition and Uses of the "Noise Factor"].—A. G. Tynan. (*Rad. Engineering*, July 1937, Vol. 17, No. 7, p. 21.)

The "noise factor" ("very useful in design work as it enables one to avoid the confusing effect of gain as affecting noise output") is the product of noise/signal ratio and receiver sensitivity: more specifically, it is sensitivity (in microvolts) × E_n/E_s ×100, where E_n is the voltage of noise output without modulation and E_s the voltage of signal output with 30% modulation.

4076. Elimination of Near-By Interference by Use of Small Aerials with Screened Downleads (with Transformers) and Counterpoise.—Bergtold. (*See* 4087.)

4077. Twelve-Phase Rectifiers in Service [Discussion of Radio and Telephone Interference].—E. Schulze. (*E.T.Z.*, 9th Sept. 1937, Vol. 58, No. 36, pp. 997–998.)

4078. Interference Testing Set [approved by G.P.O.].—(*Wireless World*, 17th Sept. 1937, Vol. 41, pp. 294–295.)

4079. New Aircraft Radio Receivers [Models AVR 10 & 10A: Small and Easily Installed, for Weather Reports and Traffic Control Instructions].—S. J. Gustof: RCA. (*Comm. & Broadcast Eng.*, Aug. 1937, Vol. 4, No. 8, pp. 8 and 19.)

4080. Double-Frequency-Change Superheterodyne Reception of Micro-Waves [17 cm Waves in Aermel Channel Link: I.Fs 10 Mc/s and 500 kc/s].—A. H. Reeves & E. H. Ullrich. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 248.) Short summary of paper read before International Congress for Short Waves in Physics, Biology, and Medicine.

4081. Higher Technical Performance: a Cross-Section through the New Receiver Programme.—E. Schwandt. (*Funktech. Monatshefte*, Aug. 1937, No. 8, pp. 256–261.)

Steady progress towards better receivers and lower prices: cheapening of valves increases 4-valve sets and doubles number of sets with more than 5 valves, at expense of 3-valve type: large number of auxiliary valves in the better receivers: increased proportion of superhets: improvements to m.c. loudspeakers (change in method of centering; diaphragms almost transparent at edge to give extremely flexible mounting; lengthened speech-coil to avoid non-linear distortion at large amplitudes): increased care in acoustical design of cabinets: negative feedback to improve deep notes and decrease non-linear distortion: improved fidelity by addition of "speech/music" switch: popularity of compensated ("physiologically correct") volume control and variable-selectivity control: variable-selectivity control and tone control coupled together: dual loudspeakers and contrast expansion: automatic tuning correction: "touch" tuning: etc.

4082. "Consumers' Research" looks at Radio [Analysis of a Report of an American Consumers' Organisation to Its Members, criticising Broadcast Receiver Design and Selling Methods].—(*Rad. Engineering*, July 1937, Vol. 17, No. 7, pp. 12–13 and 16.)

4083. Olympia Show Review [Analysis of New Designs].—(*Wireless World*, 3rd Sept. 1937, Vol. 41, pp. 226–229, 233–235, 239–240, 241–243, 248–249, and 254.)

4084. The 14th Great German Radio Exhibition, Berlin, 1937.—Flanze. (*T.F.T.*, Aug. 1937, Vol. 26, No. 8, pp. 183–188.)

4085. What the Berlin Radio Exhibition of 1937 brings to the Home Constructor in the Way of Novelties [Circuits, Tuning Devices, Contrast Expansion, Components].—W. W. Diefenbach. (*Radio, B., F. für Alle*, Sept. 1937, No. 187, pp. 129–140.)

4086. Circuit Diagrams of a Number of Broadcast Receivers.—(*Radio, B., F. für Alle*, Sept. 1937, No. 187, Supp. pp. 129–160.)

AERIALS AND AERIAL SYSTEMS

4087. The Significance of the Aerial Capacity for Screened [-Downlead] Installations for Broadcast Reception.—F. Bergtold. (*E.T.Z.*, 16th Sept. 1937, Vol. 58, No. 37, pp. 1007–1010.)

"Since too little importance has been paid to the aerial capacity in broadcast receiving installations, the significance of this capacity is here elucidated, and the minimum value which it should have, in the present state of technique, is found: in this connection the useful capacity must be distinguished from the unwanted capacity. Estimates indicate that the aerial capacities of screened-downlead installations not furnished with transformers are generally made too small, whereas if transformers are provided quite small capacities are sufficient . . . Screened installations should always be furnished with transformers, and if these are suitable quite high signal voltages can be obtained with small aerials. The comparatively small influence of the unwanted capacity makes it possible to fix the small aerial very firmly to the appropriate support. With small aerials the aerial/earth capacity can be reduced almost to zero by arranging a comparatively large counterpoise (a metal roof will serve instead); by this means interference from near-by sources is almost completely suppressed" [*see* also 3676 of October and 2944 of August].

4088. Investigations on Vertical Aerials with Horizontal Top Capacities.—F. Vilbig & K. Vogt. (*Hochf:tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 58–65.)

Impedances of aerials with end loads are measured and compared with those of unloaded aerials, in order to obtain numerical data of the magnitude of the end loads and their effect on the whole aerial system. The results obtained on model aerials are given. The aerials are electrically equal to or less than a quarter-wavelength aerial. The measurement of the effective impedance by the method of adding impedances (Fig. 1) and the interpolation method (Fig. 2) is described; the circuit used for the measurements is shown in Fig. 3, with the aerial arrangement of Figs. 4a, b. The frequency variation of the effective and blind impedances of loaded and unloaded aerials is given in Figs. 5–8. Measurements, on the unloaded vertical aerial (§ iv), of electrical length and impedance and losses *via* the stays and earth are described. For the loaded vertical aerial (§ v) the apparent height and impedance and the radiation resistance were measured (Figs. 14–17). The end loads were found to act as pure capacities.

4089. On the Calculation of the Electromagnetic Field near a Straight Aerial.—P. Ryazin. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 7, 1937, pp. 646–667.)

A theoretical investigation of the field in the immediate vicinity of the aerial, starting from the surface of the aerial itself. Using the method of "delayed potentials" proposed by Abraham, the writer obtains equations for the electromagnetic field (both in the near and distant zones) due to a straight aerial carrying a sinusoidal current. The results so obtained are applied to the case of a half-wave aerial, and particular attention is paid to the phase relationships in the field around it. The distribution of the radiating energy along the aerial is also discussed, and the results of this investigation are compared with the findings of other authors.

4090. The Ground-Level Field Strength and its Dependence on the Vertical Characteristic of the Transmitting Aerial [Frequent Neglect of Limitation of Usual Formula to Dipole with Semi-Circular Characteristic: Derivation of Correction Factor for Other Cases].—J. Grosskopf. (*T.F.T.*, Aug. 1937, Vol. 26, No. 8, pp. 181–183.) The correction factor for an $n\lambda$-aerial is $6.33\,.\,(1 - \cos 2\pi n)/\sqrt{R_{\mathrm{rad}}}$: for a $\lambda/2$-aerial this gives a 29% increase over the Hertz dipole of the formula.

4091. " The Effect at a Distance of the Order of a Wavelength of a Vertical Dipole Emitter on a Plane Earth " : Extension to Smaller Distances from Origin.—Niessen. (*See* 3997.)

4092. Directional Array Field Strengths [Calculation of Performance and Comparison with That of Single Vertical Radiator of Same Height].—A. R. Rumble. (*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 16–17 and 72.) Extension of Laport's work (2603 of 1936).

4093. Investigations on the Earth Systems of Wireless Transmitting Stations.—F. Vilbig. (*E.T.Z.*, 2nd Sept. 1937, Vol. 58, No. 35, p. 960 : summary only.)

Plate earths should lie as much as possible on the earth's surface [the wording here, " möglichst auf der Erdoberfläche," is not quite clear] and for an unloaded aerial should have a radius of 0.16λ, for a top-loaded aerial a radius of 0.13λ : a cylindrical earth, for the same earth resistance, may have a much smaller radius (0.04λ). Radial-wire earths have a lower resistance the greater the number of wires, so that the least resistance is given by an infinite number of wires, *i.e.* by a solid plate. A full report will appear in the 9th volume of the *VDE-Fachberichte*.

VALVES AND THERMIONICS

4094. Characteristic Constants of H.F. Pentodes : Measurements at Frequencies between 1.5 and 300 Mc/s [Technique and Results (including Acorn Pentodes) : Bibliography].—M. J. O. Strutt. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, pp. 478–488.) Covering much the same ground as the German paper dealt with in 2573 of July.

4095. A Power Amplifier Tube for Ultra-High Frequencies [Double-Pentode Valve of Very Special Design : Anode Dissipation 15 Watts each : for Frequencies up to 300 Mc/s].—A. L. Samuel. (*Bell Lab. Record*, July 1937, Vol. 15, No. 11, pp. 344–349.) *See* also 1798 of May.

4096. The RCA 887 & 888 [New Water-Cooled Triodes for Ultra-High Frequencies].—(*Comm. & Broadcast Eng.*, June 1937, Vol. 4, No. 6, pp. 18–19.) Tentative characteristics, maximum ratings, and typical operating conditions of the valves dealt with in 3322 of September.

4097. The Westinghouse WL-461 Triode [for 400 Watts Output at 50 Mc/s : Tantalum Anode, Short Heavy Rods supporting All Electrodes].—Westinghouse Company. (*Comm. & Broadcast Eng.*, Aug. 1937, p. 19 : *QST*, Sept. 1937, p. 45 : *Journ. of Applied Phys.*, Aug. 1937, p. 550.)

4098. The Production of Electron Oscillations with " Grid " Diodes [" Open " Diodes, in which Electrons can pass through Second Electrode].—Djakov. (*See* 4042.)

4099. A Magnetron free from Back-Heating.—Haelbig. (*See* 4046.)

4100. The Electron-Beam Magnetron.—Okabe. (*See* 4047.)

4101. The Calculation of the Behaviour of Multi-Grid Valves at High [and Ultra-High] Frequencies.—Runge. (*See* 4041.)

4102. Amplification at High Frequencies [Effect of Finite Transit Time].—Rothe. (*See* 4023.)

4103. The Mazda AC4/PEN Beam Valve.—(*See* 4050.)

4104. Plate Efficiency of Class B Amplifiers [Analysis and Graphs].—P. Adorjan. (*Rad. Engineering*, July 1937, Vol. 17, No. 7, pp. 14–16.)

4105. Valve Capacities : Their Influence on Circuit Technique and Their Measurement : Part II [Definition of the " Capacity Triangle " : Direct and Indirect Methods of Measurement of " Partial " and " Working " Capacities].—K. Steimel & C. Zickermann. (*Telefunken-Röhre*, Aug. 1937, No. 10, pp. 115–127.)

Including the description of a bridge for very small capacities (10^{-4}–2×10^{-1} picofarad) and a special calibrating condenser for use with it. For Part I *see* 2581 of July.

4106. Frequency Changers in All-Wave Receivers [Inner-Grid Injection of Oscillator Voltage *versus* Outer-Grid : Disagreement with Strutt's Conclusions : Major Defects of Outer-Grid Injection overcome by Electron Beam Principle].—E. W. Herold : Strutt. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, pp. 488–489.) Prompted by Strutt's paper (2589 of July).

4107. Pentagrid Converter Oscillator Considerations [Facts and Principles useful in Design of Circuit : based on Study of Service Troubles].—Ken-Rad Company. (*Radio Review of Australia*, July 1937, Vol. 5, No. 7, pp. 184–186.)

4108. Resistance-Coupled Pentodes [Very Satisfactory in Intermediate Stages for Wide-Range Amplification at Audio and Television Frequencies : Discussion of Correct Operating Conditions].—(*Wireless World*, 24th Sept. 1937, Vol. 41, pp. 308–310.)

4109. Trilinear Co-ordinates [and Their Application to Valve Classification Charts, etc.].—H. Aiken. (*Journ. of Applied Physics* [formerly *Physics*], July 1937, Vol. 8, No. 7, pp. 470–472.)

4110. On the Problem of the Linear Characteristic [and Possible Ways of obtaining Improved Linearity not by Negative-Feedback Methods but by Valve Design].—W. Kleen. (*Telefunken-Röhre*, Aug. 1937, No. 10, pp. 147–156.)

(i) Linear open-circuit characteristics ($R_a \gg R_i$) : the need for a constant amplification factor. (ii) Linear working characteristic : " internal distortion-compensation " by appropriate combined action between $\partial S/\partial V_g$ and $\partial \mu/\partial V_g$ is impossible for an ordinary triode but possible when " current division " control is used, *e.g.* in a hexode with its screen grid " set free " [the word used is " fortlassen " : floating ?] or directly connected to its anode (537 of Feb.), for here the two factors are of opposite sign, as desired. They are also opposite, but in a reversed sense, in the Wien " plate valve." Thus both these types of valve give the theoretical possibility of a linear characteristic with zero " klirr " factor over a definite range of grid a.c. But such " internal compensation " is only possible for very definite conditions of supply voltages and external resistance. (iii) Linear short-circuit characteristic ($R_a \leqslant R_i$) : of particular interest. The normal space-charge characteristic is always non-linear, so that a current-dividing effect *must* be used if a linear short-circuit characteristic is desired (this entails one or more auxiliary electrodes positive with respect to the cathode, so that a multi-grid valve is essential). There are three possible ways : (a) linearisation by Schottky's " double control " (used by him for obtaining increased slope, without realising its linearising powers) as given by a hexode with the input signal applied simultaneously to both the control grids : (b) linearisation by electron-optical action on the current division : and (c) linearisation by " Stau-effekte " (" damming " effect) : this space-charge phenomenon was described in the paper dealt with in 2575 of July, and has been applied in the hexode AH 100 developed for special purposes. Its effect is to change the small-space-charge curve 1 (Fig. 5) into the large-space-charge curve 2 ; by suitable design an intermediate, linear curve 3 can be obtained. The practical importance of a linear short-circuit characteristic is discussed.

4111. A NEW TYPE OF NEGATIVE RESISTANCE [Special Valve with Auxiliary Secondary-Emission Electrode : No Magnetic Field required].—W. Kleen & H. Rothe. (*Telefunken-Röhre*, Aug. 1937, No. 10, pp. 157–160.)

In the final, specially designed valve, the auxiliary electrode giving secondary emission is a cylinder of rectangular section : inside this is a perforated anode, of slightly smaller similar rectangular section. The central cathode is surrounded by two grids, whose action is to regulate the magnitude of the cathode current and to keep small the direct influence of the anode on the cathode current. The anode is maintained at a higher potential than the outer, auxiliary electrode, so that the secondary electrons from the latter fly to it. If the anode voltage is increased, the distribution of electron flow is altered, more primary electrons reach the anode, and fewer reach the auxiliary electrode beyond it ; since the secondary emission factor is greater than unity, this results in a decrease in total anode current and a falling anode characteristic. The auxiliary electrode also has a negative resistance (ordinary dynatron characteristic) and the two negative resistances may be used simultaneously for the excitation of oscillations.

4112. THE CALCULATION OF THE GRID TEMPERATURES OF ELECTRONIC VALVES.—S. Wagener. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 270–280.)

Author's summary :—The general method for the " Calculation of the Transmission of Heat by Radiation " given elsewhere [1821 of May] is applied to calculate the grid temperature of receiving and transmitting valves with any number of cylindrical electrodes. A way is given by which the fulfilment of the two fundamental conditions [temperature distribution and temperature gradient conditions, given in the previous paper] can be assured : the inner and outer sides of the electrodes must be considered separately, and the actual grids must be replaced by " idealised " grids having flat coils and struts instead of round. The incident-radiation figures of the fundamental-equation system thus obtained are calculated individually. Finally, the method is extended to the case where an appreciable amount of energy is taken from the grids by thermal conduction : the thermal conduction equation then holding for the grid is given. The calculated grid temperatures are compared with those found experimentally : the discrepancy amounts at the most to 4% for the valve types examined, which resembled mass-produced types.

4113. RADIO TUBE NOISE [due to Variable Electrical Leakage Deposits, Conducting Carbonaceous Threads between Elements, Variable or Sliding Contact between Metal Parts, Poor Welding, etc : Elimination of Noisy Valves at Factory Inspection).—H. G. Hamilton. (*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 26–29.)

4114. DISCONTINUOUS PHENOMENA IN RADIO COMMUNICATION [including Shot Noise and Thermal Fluctuation].—van der Pol. (*See* 4020.)

4115. ON THE INITIAL CURRENT FLOWING THROUGH AN ELECTRONIC VALVE AT THE SUDDEN APPLICATION OF AN IMPULSE POTENTIAL : II [including the Presence of a Constant Magnetic Field].—G. Grünberg. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 485–492 : in German.) Extension of the work dealt with in 2196 of 1936.

4116. EXPERIMENTAL RESEARCHES ON THE THERMO-ELECTRONIC CURRENTS OF DIODES AND POLYODES [heated with A.C : Formulae (with Experimental Confirmation) for Emission Fluctuations].—T. Franzini. (*Nuovo Cimento*, Feb. 1937, Vol. 14, No. 2, pp. 53–63.)

For previous work *see* 3067 of 1935. A special diode was employed, with a cylindrical anode split into 5 short lengths. With the filament earthed at its centre point the emission consisted of a continuous current of the order of 10^{-3} A and an alternating component $i \sin 2\omega t$ of the order of 10^{-6} A. With the earth connection made to one end of the filament the continuous current was of the order of 10^{-3} A and there were two alternating components, $i \sin \omega t$, of the order of 1^{-4} A, and $i' \sin 2\omega t$, of the order of 10^{-5} A. Measurements were also made on a commercial triode with cylindrical coaxial electrodes : as was to be expected in such a comparatively complex case, there was no strict concordance between measured values and those calculable from the geometrical and physical characteristics, although there were certain qualitative agreements.

4117. The Volta Potential between Barium and Magnesium: an Experimental Test of the Relation betweeen Work Functions and Volta Potential [Check of Sommerfeld-Eckart Relation].—P. A. Anderson. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 253: abstract only.)

4118. "Gases and Metals: an Introduction to the Study of Gas-Metal Equilibria" [Book Review].—C. J. Smithells. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 287.)

4119. Electron-Microscopical Observations of Field-Emission Cathodes.—E. W. Müller. (*Zeitschr. f. Physik*, No. 9/10, Vol. 106, 1937, pp. 541–550.)

The electron microscope used is shown in Fig. 1; it employs as cathode a fine etched single-crystal metal point with a completely smooth surface. Electrons emitted from this strike a luminescent screen and give a very high lateral magnification. Electron images of emission from tungsten, molybdenum, etc., are given; the dependence of field emission and work function on crystal structure and direction is illustrated. The absorption of thorium or oxygen films is also observable. Current densities up to 10^8 amp/cm^2 were attained.

4120. Porous Ceramic Materials for High-Frequency Technique [particularly "Ergan": Very Low Loss Angle: Dielectric Constant much Smaller than That of Non-Porous Materials].—Albers-Schönberg. (*E.T.Z.*, 2nd Sept. 1937, Vol. 58, No. 35, p. 960: summary only.) A full report will appear in the 9th volume of the *VDE-Fachberichte*.

4121. High-Frequency Supply for Degassing.—E. G. Shower. (*Bell Lab. Record*, Aug. 1937, Vol. 15, No. 12, pp. 391–397.)

DIRECTIONAL WIRELESS

4122. Direction-Finding by Pulses.—H. Plendl. (*Hochf:tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 37–41.)

A general account is first given of night errors in direction-finding and of the principles of pulse direction-finding, where the ground-wave pulse is separated from the ionospheric echoes by spreading them out on a time-base. Photographs of apparatus used for pulse direction-finding are shown (Figs. 4–8), but the apparatus is not described; some practical results are given (§ III). The advantages of pulse direction-finding over the Adcock method (§ IV) are stated to be that results obtained at night are as trustworthy as those found in the daytime, while a much smaller aerial height suffices. Its drawbacks are that a pulse emitter is required, which emits a broad frequency band. For previous work *see* 2601 of July.

4123. The Extended-Feeder Marconi-Adcock Direction Finder [Feeder Lengths up to 1 Kilometre: Operating and Site Advantages: Loss of Sensitivity (at 300 kc/s) 14 db for 700-Metre Feeder].—S. B. Smith. (*Marconi Review*, May/Aug. 1937, No. 66, pp. 23–30.) So that an aeroplane which, for a normal centre-site installation, gave an overload d.f. range of 400 km would give the same class of result at 270 km on an installation with an extended feeder of 700 m. Over-all accuracy ± 2° or better.

4124. False Bearings from Radiobeacons and Their Causes [Use of Three-Legged Protractor to eliminate Effect of Magnetic Compass Error: Coastal Reflection (Land Effect): Night Effect (including Its Reduction by Use of Vertical Tower Radiators): D.F. Environment (including Importance of Disconnecting Other Aerials): Personnel Errors: Calibration Errors].—L. M. Harding. (*Lighthouse Conference, Berlin* 1937: *Papers submitted by U.S. Lighthouse Service*: Topic C-2, pp. 1–8.)

4125. Progress in the Development of Ship's Direction Finders [including a Visual (Central Zero) Type working on Rapidly Alternated Quasi-Minimum obtained by Alternately Unbalancing the Loop: "Crossed Pointer" Type with Crossed Loops and Two R.F. Amplifiers (reducing Night Effect —"Reason Obscure"): etc.].—L. M. Harding. (*Lighthouse Conference, Berlin* 1937: *Papers submitted by U.S. Lighthouse Service*: Topic C-5, pp. 1–5.)

4126. Application of Long, Short, and Ultra-Short (Decimetre) Waves for Omni, Directional, and Rotating Radiobeacons [with Reasons for Rejection, for Marine Purposes in U.S.A., of Radio-Range and Rotating Beacons].—L. M. Harding & S. F. Clark. (*Lighthouse Conference, Berlin* 1937: *Papers submitted by U.S. Lighthouse Service*: Topic C-6, pp. 1–6.)

4127. Experiences on the Usefulness of the Existing Organisations of Radiobeacons [as Leading Guides: for Position Finding: for Distance Finding (with Sound-in-Air Signals): for Locating Fishing Grounds: Factors affecting Usefulness of Systems].—C. A. Park. (*Lighthouse Conference, Berlin* 1937: *Papers submitted by U.S. Lighthouse Service*: Topic C-4, pp. 1–22.) Supplements include official notes for masters of vessels, a report on co-ordination between U.S.A. and Canada, etc.

4128. Accomplishment of Measurements of the Field Strength of Radiobeacons: Method, Results and Their Exchange [for Adjusting the Aerial Current to give Required Service Area: Validity of Measurements in Vicinity of Beacon: Simple Comparison-Method Portable Equipment for Field Service].—L. M. Harding. (*Lighthouse Conference, Berlin* 1937: *Papers submitted by U.S. Lighthouse Service*: Topic C-1, pp. 1–6.)

4129. Measures for the Stabilisation of the Frequency of the Waves and the Modulation of Radiobeacons.—L. M. Harding & S. F. Clark. (*Lighthouse Conference, Berlin* 1937 : *Papers submitted by U.S. Lighthouse Service :* Topic C-3, pp. 1–3.)

4130. Distant Control of Navigation Aids by Radio [using " Tuned-Reed Motor-Generator of Inductor Alternator Type " (No Contacts or Wearing Parts : Superior to Electrical Filter Circuits) : Supervision of Starting-Up Operation provided Automatically by U.S.W. Radiotelephone].—L. M. Harding, G. B. Skinner, & F. C. Hingsburg. (*Lighthouse Conference, Berlin* 1937 : *Papers submitted by U.S. Lighthouse Service :* Topic C-7, pp. 1–7.)

4131. Aerial Navigation by the Valoris Radio Beacon [Beacons in Groups of 3, transmitting (in turn, for One-Third Second) on Same Wavelength, modulated to 3 Different Audio-Frequencies : Non-Directional Reception gives Field Intensity (recorded Optically) of Each].—Valoris. (*Les Ailes*, 1st July 1937, No. 837, p. 8.)

4132. The Importance of Ultra-Short Waves for the Security of Life and Material in Aviation.—R. M. Wundt. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 248–249.) Summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine.

4133. Marconi Aerodrome Approach Beacon Equipment, Type WBD.4 [Main (Equi-Signal) Beacon and Two Marker Beacons].—(*Marconi Review*, May/Aug. 1937, No. 66, pp. 15–22.)

4134. Position Finding and Course Plotting on board an Aeroplane by means of Radio [and the Philips Direction-Finder-Homing-Device V.P.K. 35].—(*Philips Tech. Review*, June 1937, Vol. 2, No. 6, pp. 184–190.)

4135. Robot detects and radios Cloud's Altitude to Pilot [Automatic Device for Mountain Tops and High Ground, using Two Pivoting Search Lights and Photocell Relay].—J. P. Buckley. (*Sci. News Letter*, 4th Sept. 1937, Vol. 32, p. 156.)

ACOUSTICS AND AUDIO-FREQUENCIES

4136. A Contribution to the Problem of Large Sound Projection Equipments [for Big Open-Air Gatherings : Present Neglect of Concentrated System in favour of Distributed Mushroom Loudspeakers : Latter necessary for Community Singing, Drilling, etc., and satisfactory for Speeches : Unsatisfactory for Good Music : Successful Nürnberg Stadium Installation with 5 Exponential-Horn Loudspeakers in Bell Tower].—H. Emde, H. E. Henrich, & O. Vierling. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 252–255.)

Giving a wide frequency band and a large range of contrast (in both of which attributes the distributed mushroom system is unsatisfactory). The necessary height of tower depends on the area to be covered and on the configuration of the ground. For an area of 30 000 m² a power of 800 watts was found necessary. The five loudspeaker horns were sloped at different angles to the horizontal to suit the stadium requirements : the one directed straight ahead at the " tribune " (Fig. 2) was found to give a marked directional effect for the high frequencies, and an " opposing " horn was therefore introduced into it to give the necessary dispersion. With the others, the tower structure itself had a sufficiently dispersive effect.

4137. A Method of Acoustical Design of Rooms equipped with Loudspeakers [to give Constancy of Acoustic Ratio over Seating Area].—V. Furdujev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 5th June 1937, Vol. 15, No. 6/7, pp. 313–314 : in English.)

4138. Auditorium Acoustics : Part I.—D. B. Foster. (*Wireless World*, 17th Sept. 1937, Vol. 41, pp. 278–280.)

4139. The Electrical Regulation of Acoustic Reverberation [as used in the Poste-Parisien Studios].—M. Adam. (*Rev. Gén. de l'Élec.*, 4th Sept. 1937, Vol. 42, No. 10, pp. 305–312.) Covering the same ground as 2225 of June.

4140. Experimental Investigations of Reverberation Optimum for Different Frequencies [Studio with Rectilinear Optimum (Békésy) Very Inferior to Studio with Curvilinear Optimum (MacNair-Lifshitz)].—S. Lifshitz. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 5th June 1937, Vol. 15, No. 6/7, pp. 315–318 : in English.)

4141. The Improvement of Acoustics in Churches.—R. Forberger. (*E.T.Z.*, 26th Aug. 1937, Vol. 58, No. 34, pp. 926–928.)

4142. On Transients in Acoustic Systems.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 7, 1937, pp. 938–950).

The properties of groups of sound radiators are examined from the standpoint of transients, and formulae are derived determining transient functions for some of the simpler groups. Examples are given to illustrate the use of these functions.

4143. On the Work of the Research Institute of the Musical Industry [Laboratories of Keyboard & Plucked Instruments : of Reed Instruments : of Wind Instruments : of Materials : Electro-Acoustical Laboratory].—K. Struve. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 507–509 : in English : *Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 7, 1937, pp. 1126–1128.)

In the first-named laboratory, a grand piano of small dimensions, 125 cm long, has been constructed : it preserves the acoustical properties of large grand pianos. The optimum position for a hammer to strike its string has been determined. Travelling waves are present in the sounding board, not only standing waves : " this refutes certain propositions put forward by Grützmacher."

4144. A New Optical Method of Sound Reproduction.—T. Korn. (*E.N.T.*, July 1937, Vol. 14, No. 7, pp. 248–251.)

A critical discussion of known optical methods of sound reproduction is followed by a description of a method which is stated to combine the technical advantages of the opaque rotating-drum method with high quality tone reproduction and simplicity of working. The principle of the method is shown in Fig. 2. A sound diapositive is laid on a highly-polished metal drum. Light is focused on this and reflected obliquely on to a photocell connected to the usual electrical apparatus. The conditions to be fulfilled by the diapositive are compared with those of the ordinary sound-film positive (Fig. 2). Fig 3 shows the blackening factor (eqn. 1) as a function of the angle of incidence of the light ray on the drum. It is found that the equivalent blackening of the reflection positive here described is about 2.5 times as large as that of a developed strip of sound film. The sound intensity of the new method is only decreased by absorption of light by the mirror surface and the celluloid. The Goldberg condition for non-linear distortion takes the form given in eqn. 3. Linear distortions are chiefly caused by the increased width of the optical slit. Fig. 4 shows calculated frequency curves giving the amplitude of the alternating light current for the transparent and the reflection methods (eqn. 5). A theoretical disadvantage is the higher noise level but this proves to be of little practical importance. The technical application of the method to various types of sound reproduction is mentioned.

4145. The Electrical Recording and Reproduction of Sounds [Survey of New Recording Methods for Special Purposes, including the "Livre Sonore" (Talking Book) System; the Resistographone, with Graphite Point on Paper Tape; the "Célénophone," with Positive Copy on Paper read by Reflection; the "Fotoleptophone"; Philips-Miller Process; "Incomplete Cut" Method (Diamond Point on Film): "Chlorine" Process: etc.].—R. Hardy. (*Rev. Gén. de l'Élec.*, 31st July 1937, Vol. 42, No. 5, pp. 141–156.)

4146. Recording Bird Voices by Short-Wave Radio.—Brand. (*Science*, 20th Aug. 1937, Vol. 86, Supp. pp. 8–9.)

4147. Performance of a Direct Lateral Recording System [for Various Types of Gramophone Discs].—F. W. Stellwagen. (*Comm. & Broadcast Eng.*, July 1937, Vol. 4, No. 7, pp. 12–14 and 27.)

4148. The Measurement of Small Variations in Gramophone Record Speed by the Interference-Note Method.—K. Steffenhagen. (*Funktech. Monatshefte*, Aug. 1937, No. 8, pp. 255–256.)

4149. Papers on Rochelle Salt.—Mikhailow: Busch: Bantle & Busch. (*See* 4243 & 4244.)

4150. Stroboscope [Portable "Stroboglow" Unit] aids Dynamic Loudspeaker Design.—W. O. Rogers. (*Electronics*, Aug. 1937, Vol. 10, No. 8, p. 30.)

4151. A Device for Measuring Mechanical and Acoustical Impedance [Siemens "Vibrometer," with Moving-Coil Combination ("Driving" and "Velocity" Coils) on Very Flexible Spider].—(*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, p. 324: summary only.)

4152. Acoustical Detection of Purely Mechanical Vibrations in Quartz Plates [Certain Thickness Vibrations may produce Acoustical Effect without Electrical Effect: Their Frequency measured by Wavelength produced in Gas of Known Supersonic Velocity].—W. H. Pielemeier. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 244: abstract only.)

4153. Investigation of the Bending Vibrations of Rhombic Plates with Free Edges.—B. Pavlík. (*Akustische Zeitschr.*, July 1937, Vol. 2, No. 4, pp. 161–169.)

4154. Internal Friction in Solids: I—Theory of Internal Friction in Reeds [Thermodynamical Calculations].—C. Zener. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 230–235.)

4155. The End-Correction of an Unflanged Pipe [Theoretical Justification of Accepted Value].—A. E. Bate. (*Phil. Mag.*, Sept. 1937, Series 7, Vol. 24, No. 161, pp. 453–458.) The value is 0.58 × radius of pipe.

4156. Investigation of the Vibrating Systems of Carbon Microphones by the Measurement of Their Complex Transmission Equivalent.—C. Trage. (*T.F.T.*, May 1937, Vol. 26, No. 5, pp. 98–105.)

4157. Aerodynamic Microphone [of Pressure-Operated Type: Frequency Range 100 to 6000 c/s].—(*Journ. of Applied Physics* [formerly *Physics*], July 1937, Vol. 8, No. 7, p. 488: note on microphone introduced by RCA Commercial Sound Section.)

4158. A High-Quality Headset [Moving-Coil Telephone] for Monitoring.—F. S. Wolpert. (*Bell Lab. Record*, July 1937, Vol. 15, No. 11, pp. 353–356.)

4159. Headset Earcaps for Smoothing-Out Frequency Response [Caps with Built-In Resonance Chambers, forming Acoustic Filter, to fit All Makes of Head Telephones].—Jarnak. (*QST*, Sept. 1937, Vol. 21, No. 9, p. 23.)

4160. Public Address Amplifiers [Design Considerations], *and* 30-Watt Public Address Amplifier [with Push-Pull Pentode Output, Negative Feedback, and Special Mixing & Tone-Control Unit].—W. T. Cocking. (*Wireless World*, 3rd Sept. 1937, Vol. 41, pp. 236–237: 10th & 17th Sept. 1937, pp. 256–259 and 284–287.)

4161. Resistance-Coupled Pentode Amplifiers [give Very High Stage-Gain and Very Low Distortion: Frequency Response extends Above and Below that of Triodes: Mathematical Investigation].—(*Rad. Review of Australia*, June 1937, Vol. 5, No. 6, pp. 157–163.)

4162. Multi-Stage Inverse Feedback: Applying Degeneration to Complete Amplifier Systems.—(*See* 4064.)

4163. Class B Audio Driver Considerations: Determining Power Requirements and Transformer Characteristics for Low Distortion.—D. Fortune. (*QST*, Sept. 1937, Vol. 21, No. 9, pp. 26–27 and 88, 90.)

4164. Non-Linear Distortion Phenomena of Magnetic Origin.—Köhler. (*See* 4026.)

4165. On Delay in Transmission through Telephone Apparatus and Network [Wave Filters, Repeating Coils, Audio-Amplifiers, etc: Measurements of Phase Shift: Conclusions].—P. B. Ghosh. (*Indian Journ. of Phys.*, July 1937, Vol. 11, Part 3, pp. 193–201.)

4166. The Use of Amplifiers (Repeaters) in Telephony.—W. Six & H. Mulders. (*Philips Tech. Review*, July 1937, Vol. 2, No. 7, pp. 209–215.)

4167. Mixer Circuits: Part II.—A. Preisman. (*Comm. & Broadcast Eng.*, Aug. 1937, Vol. 4, No. 8, pp. 9–11 and 21.) For Part I *see* 3358 of September.

4168. High-Frequency Eddy Currents in Screened Leads in the Form of Circular Cylinders with Drilled Holes containing Pairs of Leads [*e.g.* for Wide-Band Cables].—Buchholz. (*See* 4191.)

4169. Carrier for Coaxial Groups: Group Terminal for the Coaxial System: Repeaters for the Coaxial System.—Peterson: Jensen: Black. (*Bell Lab. Record*, July & Aug. 1937, Vol. 15, Nos. 11 & 12, pp. 357–360: 361–365: 385–390.) All connected with the "million cycle" New-York/Philadelphia coaxial system.

4170. Study of the Balancing Circuits of Overhead or Buried Telephone Lines [Homogeneous Telephone Circuit as a Simple Four-Element Network: Easy Method of Calculation].—M. Manjineanu. (*Rev. Gén. de l'Élec.*, 18th Sept. 1937, Vol. 42, No. 12, pp. 359–366.)

4171. An A.F. and R.F. Wiring Device [" Panel Wiring Box " for Improved Wiring of Mixer, Relay, Switching Panels, etc: Eliminating Shielded Wire and Low-Pass Filter Effects: Capacity to Earth reduced to One Sixth].—M. Bjorndal. (*Comm. & Broadcast Eng.*, June 1937, Vol. 4, No. 6, pp. 24 and 35.)

4172. The Measurement of Sound Absorbing Materials in Reverberation Chambers [Discrepant Results obtained in Different Laboratories: Systematic Investigation of Causes: Suggestions].—E. Meyer. (*Akustische Zeitschr.*, July 1937, Vol. 2, No. 4, pp. 179–192.)

4173. Portable High-Speed Level Recorder [for Reverberation-Time and Absorption Measurements, etc: with Potentiometer Slider (carrying Recording Stylus) driven through Magnetic Clutch by Constantly Rotating Disc].—A. W. Niemann. (*Comm. & Broadcast Eng.*, July 1937, Vol. 4, No. 7, pp. 15–16.)

4174. On the Design Calculations of Apparatus for the Registration of Rapid Phenomena [*e.g.* Microphone/Oscillograph Combination].—Kharkevich. (*See* 4001.)

4175. A Proposed Test Code for Apparatus Noise Measurement.—(*Elec. Engineering*, Sept. 1937, Vol. 56, No. 9, pp. 1079–1082.)

4176. Resistance-Tuned Oscillators.—Gordon & Makinson. (*See* 4056.)

4177. The Differential Equations of the Sound Field [Application of Maxwellian Field-Theory Methods to Acoustic Field].—O. Heymann. (*Akustische Zeitschr.*, July 1937, Vol. 2, No. 4, pp. 193–202.)

4178. On Sound " Intensity " and " Loudness " [Difference between Intensity ("Lautstärke", measured in Phons relative to 1000 c/s Note) and Loudness (" Lautheit " or " Empfindungsmass "): the Latter a Function (independent of Frequency) of the Former].—M. Kwiek. (*Akustische Zeitschr.*, July 1937, Vol. 2, No. 4, pp. 170–178.)

4179. Terms and Definitions in Acoustics [Tentative Proposals of German Acoustic Committee].—(*Akustische Zeitschr.*, July 1937, Vol. 2, No. 4, pp. 214–215.)

4180. Intensity Formulae for the Diffraction of Light by Weak Supersonic Waves [derived by Generalisation of Mathieu Functions for Arbitrary Direction of Incident Primary Ray: Intensities of First and Second Order Spectra]: *and* Intuitive Consideration of the Diffraction of Light by Weak Supersonic Waves [Figures showing Paths of Light Rays, Wave Fronts, etc., given by Theoretical Formulae].—E. David: Korff. (*Physik. Zeitschr.*, 1st Aug. 1937, Vol. 38, No. 15, pp. 587–591: pp. 592–596.) For experimental work here theoretically confirmed *see* 197 of January (Korff).

4181. The Intensity and Polarisation of the Light Diffracted by Supersonic Waves in Solids [calculated from Photoelastic Effect due to Strains created by Electric Waves: Observations confirm Principle of Equipartition of Energy between All Forced Vibrations of Same Frequency].—H. Mueller. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 223–229.)

4182. The Production of Truly Plane Supersonic Waves in Liquids, and the Demonstration of Fresnel Diffraction Phenomena at These Waves [using a Quartz Disc, after Straubel, on High Harmonic (up to 25th, *i.e.* 11 000 kc/s)].—R. Bär. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 10, 1937, pp. 311–322: in German.)

4183. Supersonic Dispersion in Air [exhibited by Anomalous Humidity Regions].—W. H. Pielemeier. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 244: abstract only.)

4184. Dispersion of [Supersonic] Sound Velocity in Liquids [Previous Results are Indecisive: Precision Measurements at 3.5 and 14.5 Mc/s show No Dispersion for Toluene and m-Xylene: Definite Increase at Higher Frequency for Benzene, etc: Decrease for Amyl Acetate].—S. Parthasarathy. (*Current Science*, Bangalore, Aug. 1937, Vol. 6, No. 2, pp. 55–56.)

4185. The Effect of Containing Tubes on Ultrasonic Velocities in Benzene [Velocity Maxima and Minima agree with Field's Theory of Radial Resonance Phenomenon].—W. H. Hulswit & B. J. Spence. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 256: abstract only.) For Field's work *see* 1931 Abstracts, p. 505, and *Canadian Journ. of Res.*, 1931, Vol. 5, p. 131.

4186. Measurements on the Velocity and Absorption of Sound in Various Gases between + 100° C and − 100° C: Influence of Pressure on the Absorption [Deviations from Classical Theory].—van Itterbeek & Mariens. (*Physica*, Aug. 1937, Vol. 4, No. 8, pp. 609–616: in English.)

4187. Distance Efficiency (Range) of Fog Signals and Its Control [Most Effective Pure Tones are below 500 c/s: etc.]—I. L. Gill & H. W. Rhodes. (*Lighthouse Conference, Berlin 1937: Papers submitted by U.S. Lighthouse Service*: Topic B-4, pp. 1–13.)

PHOTOTELEGRAPHY AND TELEVISION

4188. Noise in Photophone Receivers and the High-Frequency Method of Its Suppression [Noises arise chiefly in Photocell: decreased by Application of H.F. Current: Success of Yagi's System of Modulating a H.F. Current by Voice and using It to Modulate the Light thrown on Photocell].—M. Yamada: Yagi. (*Electrotech. Journ.*, Tokyo, Sept. 1937, Vol. 1, No. 4, pp. 131–133.)

4189. A New Time-Modulation System for Picture Telegraphy on Short Waves [Advantages of Time Modulation over Amplitude Modulation: Defects of the Ranger (RCA) System: the New System: Improved Picture Quality given by Chess-Board Raster in place of Line Raster: Application to New System].—E. Hudec. (*T.F.T.*, July 1937, Vol. 26, No. 7, pp. 147–157.)

4190. On the Behaviour of a Cathode-Ray Tube at Ultra-High Frequencies: the Frequency-Dependence of Sensitivity, and the Distortions occurring in the Reproduction of Anharmonic Processes [Effect of Edge-Fields of Deflecting Plates].—H. Hintenberger. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 256–259.)

Author's summary:—"Starting from the calculation of the paths of charged particles in a.c. electric fields, taking into account the action of the stray fields at the edges of the deflecting condensers, the variation of the sensitivity of the cathode-ray tube with the frequency of the applied voltage is investigated. It is found that in the expression given by H. E. Hollmann [1932 Abstracts, pp. 652–653] for the frequencies giving minimum sensitivity, namely $\nu/\sqrt{V} = \kappa/a_p \,.\, n$ ($n = 1, 2, 3 \ldots$, V = accelerating voltage, a_p = plate length [and $\kappa = \sqrt{e/m \,.\, 1/150}$]), the a_p should be replaced by $a_p + 1.23 \,.\, k$ (where $2k$ = distance between plates) on account of the action of the edge fields, and that there is a second frequency condition, $\nu/\sqrt{V} = \kappa/a_1 \,.\, n$, for which the sensitivity becomes zero [$a_1 = 2.15 \,.\, k$: *see* eqn. 5.1 and Fig. 1; *also* eqns. 6 & 7]. The distortions occurring with anharmonic processes are considered, and the Fourier coefficients for the motions of the cathode ray on the fluorescent screen are given for any arbitrary voltage wave form [these distortions are due to two causes: the strengths of different harmonics are reproduced with different intensity owing to the variation of sensitivity with frequency, and (as seen from eqn. 14) phase displacements occur between the various harmonics. For frequencies satisfying eqn. 15 the first cause becomes negligible, but the phase displacements are still clearly noticeable. The cathode ray really follows an anharmonic process in an undistorted manner only when, for all harmonics occurring with appreciable intensity in the $2U = f(t)$ wave, $n\pi(a_1 + a_2 + a_1)/\kappa \,.\, \nu/\sqrt{V}$ is negligible compared with unity].

"It may also be pointed out that the undeflected emergence of charged particles from an alternating field, here treated as an unwanted phenomenon, can be applied to the velocity measurement and velocity filtering of canal rays [Thomson's "positive rays"] and cathode rays, and formula 7 can then (with the transformation $\kappa\sqrt{V} = \dot{x}$) give the filtered velocities." The equations in the present paper are taken from the writer's *Zeitschr. f. Phys.* paper (3120 of August). Libby's modification of the Hollmann formula (272 of January) is referred to on pp. 257 & 258.

4191. High-Frequency Eddy Currents in Screened Leads in the Form of Circular Cylinders with Drilled Holes containing Pairs of Leads [*e.g.* for Wide-Band Cables: Calculations including the Effect of Uniform Drilling of the Internal Conductors: Magnitude of Screen Coupling and Magnetic Coupling between Two Pairs of Leads not exactly Perpendicular to One Another].—H. Buchholz. (*Arch. f. Elektrot.*, 10th Aug. 1937, Vol. 31, No. 8, pp. 507–523.)

4192. Video Amplifier Design [Frequency Response: Phase Response (Max. Permissible Variation in Phase Delay estimated at 0.1 μsec. over 10 : 1 Frequency Band): Transient Response: High- and Low-Frequency Response: Suitable Valves: etc.].—R. L. Freeman & J. D. Schantz. (*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 22–25 and 60, 62.) From the Farnsworth laboratories.

4193. Amplification of Very Wide Frequency Ranges [Frequency-Independent Resistance Amplifiers].—Pieplow. (*See* 4022.)

4194. Resistance-Coupled Pentodes for Television Frequencies. (*See* 4108.)

4195. Mechanical Scanner for Television/Telephone Service [Televisaphone Service between Berlin and Other German Cities].—(*Wireless World*, 10th Sept. 1937, Vol. 41, p. 259.)

4196. Jerkless Film Scanning [German "Mechau" System with Continuously Moving Film and Rotating and Oscillating Mirrors: for use with Iconoscope for Television].—(*Wireless World*, 10th Sept. 1937, Vol. 41, p. 262.)

4197. Two Problems connected with the Wireless Reception of High-Definition Television Images [Is Selective Fading (unamenable to Automatic Fading Compensation) present on Ultra-Short Wavelengths? and The Effect of the Electrical Surroundings of the Receiving Aerial on the Reception of the Frequency Band].—W. Scholz. (*Funktech. Monatshefte*, Aug. 1937, No. 8, Supp. pp. 61–63.)

To clear up these two points the German Post Office has made two investigations, one a comparison of the fadings recorded, simultaneously, on the 6.77 m and 7.06 m waves of the Witzleben transmitter at distances ranging from 50 to 100 km; and the second a comparison of the field strengths given by these two waves at various positions in streets and buildings and on roofs. Since the two carrier waves differ in frequency by 1800 kc/s, they are taken as representing almost the two extremes of the modulation band of the new German 441-line transmissions. The results are: (i) fading is non-selective over that width of band; this is particularly important for the Brocken/Harz and Feldberg/Taunus services, where the distant-reception zones subject to fading cover large areas: (ii) the action of neighbouring objects capable of absorption and re-radiation leads to the anticipated result that the field strength is most nearly the same for the two waves (*i.e.* is most independent of frequency) on top of a flat roof, well away from the wiring, etc., in the interior of the building; the worst positions for the undistorted reception of the wide frequency band are landings, halls, and courtyards.

4198. The Importance of [Ultra-] Short Waves for Television.—F. Schröter. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 247–248.) Summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine.

4199. Television Signals across the Atlantic [Alexandra Palace Signals received at RCA Laboratory, 21st Jan.–4th April].—H. O. Peterson & D. R. Goddard. (*Television*, Sept. 1937, Vol. 10, No. 115, pp. 527–528.)

4200. Television in Europe: Report on Visit.—M. P. Wilder. (*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 13–15.)

4201. Television Development.—T. H. Kinman. (*BTH Activities*, July/Aug. 1937, Vol. 13, No. 4, pp. 121–125.)

4202. Television Receivers and Apparatus at Olympia.—(*Television*, Sept. 1937, Vol. 10, No. 115, pp. 532, 535–538, 546, 575.)

4203. Television at the 1937 Berlin Radio Exhibition.—H. Richter. (*Radio, B., F. für Alle*, Sept. 1937, No. 187, pp. 140–144.)

4204. Television at the 14th Great German Radio Exhibition, 1937 [giving Dates, from 1928, of Important Developments in German Television].—(*Funktech. Monatshefte*, Aug. 1937, No. 8, Supp. p. 63.) Introduction to detailed reports to follow in later issues.

4205. German Television Progress: Impressions at the Berlin Exhibition.—J. Sieger. (*Television*, Sept. 1937, Vol. 10, No. 115, pp. 541–542 and 544.)

4206. Television Studio Considerations: Part IV.—W. C. Eddy. (*Comm. & Broadcast Eng.*, July 1937, Vol. 4, No. 7, pp. 17–18 and 23.) For previous parts *see* 3045 of August.

4207. Television and the Kinema [Competitors or Allies?].—R. H. Cricks. (*Television*, Sept. 1937, Vol. 10, No. 115, pp. 539–540.)

4208. Television Terms.—F. J. Somers. (*Electronics*, Aug. 1937, Vol. 10, No. 8, p. 34.) Supplementary to 3047 of August.

4209. Water-Cooled Mercury Lamps [Super-High-Pressure Types SP and SSP: Luminous Efficiencies 60 and 62 Lumens/Watt].—E. G. Dorgelo. (*Philips Tech. Review*, June 1937, Vol. 2, No. 6, pp. 165–171.)

4210. A New Light Valve [Adhesion of Mica Crystals to Reflecting Side of Total-Reflection Prism "released" by Cathode Ray as It passes].—C. Sheils. (*Popular Wireless*, 18th Sept. 1937, p. 37.) Described as "the latest attempt to produce large-scale pictures" with a cathode-ray tube. So long as the crystals adhere to the glass they disperse the ray of light and prevent it from being reflected on to the viewing screen.

4211. Papers on the Diffraction of Light by Supersonic Waves.—David: Mueller: Bär. (*See* 4180/4182.)

4212. The Nature of the Barrier Layer in Selenium Barrier-Layer Cells.—P. Görlich. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 373–378.)

It is found experimentally that the cell sensitivity is greater when the barrier electrode is produced by cathode spraying than by vaporisation in a high vacuum (Fig. 1). From the experiments it seems probable that, at the selenium surface, selenium oxides and adsorbed gas atoms are distributed in a thin film or as islands on the surface. This view is supported by the fact that the maximum yield of the cells formed in nitrogen is obtained at greater thicknesses of the barrier electrode than with cells formed in air.

4213. "BOUNDARY-LAYER" PHOTOCELLS [Selenium].—Tungsram Company. (*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, pp. 318–319.)

4214 "PHOTOCELLS WITH SECONDARY-EMISSION AMPLIFICATION": CORRECTION.—Kluge, Beyer, & Steyskal. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 285.) Correction to two captions in the work dealt with in 3792 of October.

4215. TEMPERATURE EFFECTS IN PHOTOELECTRIC EMISSION [Theory introducing Small Positive Temperature Coefficient of Work Function: Departure from T^2 Law explained].—R. J. Cashman. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 246: abstract only.)

4216. REMARKS ON THE PAPER BY V. MIDDEL: "PHOTOELECTRIC MEASUREMENTS WITH METALLIC ANTIMONY" [Antimony Films studied by Middel were partly in Unmetallic State].—R. Suhrmann & W. Berndt. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 354–357.) *See* 3075 of August.

4217. PHOTOELECTRIC SENSITISATION OF ALUMINIUM [as Cathode of Hydrogen Glow Discharge under Various Conditions of Outgassing and Contact with Air].—L. P. Thein. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 245: abstract only.)

4218. ON THE PHOTO-THERMIONIC EFFECT IN INCANDESCENT METALS [for White Light, with Tungsten Filaments the Effect is purely Thermal: partly Photoelectric with Filaments coated with Alkaline-Earth Oxide].—I. Ranzi & R. Ricamo. (*Nuovo Cimento*, March 1937, Vol. 14, No. 3, pp. 114–118.)

4219. THE PHOTOELECTRIC EFFECT OF H_2 [Computations of Photoelectric Cross-Section].—L. Motz & W. Rarita. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4 pp. 271–273.)

4220. NOTE ON NUCLEAR PHOTOEFFECT AT HIGH ENERGIES [Theory].—Kalcker, Oppenheimer, & Serber. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, pp. 273–278.)

MEASUREMENTS AND STANDARDS

4221. TWO NEW MAINS-DRIVEN STABILISED VALVE VOLTMETERS [with Low Losses, and suitable for Very High Frequencies].—O. Macek. (*Elektrot. u. Masch:bau*, 18th July 1937, Vol. 55, No. 29, pp. 349–353.)

Type I employs an electrometer valve (acting as anode-bend rectifier) as input valve. Previous mains-driven voltmeters which have been stabilised successfully have had comparatively small input resistances, and owing to the use of condensers (either in the input or anode circuit) have been unsuitable for frequencies over about 10^6 c/s as well as for low frequencies such as 50 c/s. These defects are avoided by the high internal resistance of the electrometer valve (actually an AEG-Osram T 113) and the avoidance of all coupling condensers, the second valve being coupled to the rectifier by a coupling resistance R_p (Fig. 1) in the anode circuit of the latter. A third stage can be added (Fig. 2: for high sensitivity or to enable a low-sensitivity milliammeter to be used). A Stabilivolt tube is employed in the mains unit, and since the voltage obtainable from it is limited to 280 volts the second valve is used in the space-charge-grid connection.

Type II employs a diode-rectification stage in front of the electrometer valve. The diode is preferably indirectly heated (Fig. 6). For ultra-high frequencies up to about 10^9 c/s, either a special type is used, with a very small electrode gap to reduce the electron-path-time error, such as von Ardenne's (2708 of July), or else a photocell, illuminated by a lamp fed from the stabilised mains circuit, is employed as rectifier (Fig. 7). This plan has the advantage that the electron source (photo-sensitive layer) is completely insulated from the energy source (lamp). For a previous paper, on diode voltage measurement, see 2706 of July.

4222. THE USE OF A CONSTANTLY ILLUMINATED PHOTOCELL AS A RECTIFIER IN A VALVE VOLTMETER FOR ULTRA-HIGH FREQUENCIES.—Macek. (*See* 4221.)

4223. NEW AUXILIARIES IN SHORT [and Ultra-Short] WAVE MEASURING TECHNIQUE [including a 1–250 Volt Voltmeter, fed by Dry Cells, correct for Frequencies 50 c/s–50 Mc/s: Range extended to 2500 Volts by Potential Divider: Signal Generator: etc.].—L. Rhode [Rohde ?]. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 249.) Summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine.

4224. A NEW AMMETER FOR ULTRA-HIGH FREQUENCIES [Small Thin Glass Plate, One Side coated with Transparent Metallic Film, in H.F. Magnetic Field: Eddy Currents heat Film which heats Glass: Strains observed Polariscopically].—H. Straubel. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 251.) Summary of paper read before International Congress for Short Waves in Physics, Biology, and Medicine.

4225. THE MEASUREMENT OF ENERGY OUTPUT AND DOSE OF SHORT AND ULTRA-SHORT WAVES USED IN MEDICINE ["Phantom," Incandescent-Lamp, Resonance-Curve, and Current/Voltage Methods].—G. Schwarz. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 249–251.) Long summary of paper read before the International Congress for Short Waves in Physics, Biology, and Medicine.

4226. The Variation of Dielectric Losses in Ketones with Molecular Constitution and Size [Measurements of Relaxation Time by Heat produced in H.F. Field: Explanation on Dipole Theory].—W. Holzmüller. (*Physik. Zeitschr.*, 1st Aug. 1937, Vol. 38, No. 15, pp. 574–587.)

4227. Correction to the Paper "Experiments on the Mechanism of Current Conduction in Liquids of Low Dielectric Constant" [Calculation Error invalidates Fig. 20 and Conclusions Therefrom].—K. H. Reiss. (*Ann. der Physik*, Series 5, No. 1, Vol. 30, 1937, p. 34.) *See* 1903 of May.

4228. The Measurement of Phase Angles and Power at High Frequencies by an Electro-Optical Method.—E. Brake. (*E.N.T.*, July 1937, Vol. 14, No. 7, pp. 232–248.)

A Kerr-cell arrangement for the measurement of phase angles is shown in Fig. 2. Two voltages differing in phase act on two cells connected optically in series; the phase difference is measured by the resultant brightness (Figs. 2,3), of which the theory is given. Fig. 4 gives the calibration curve for phase-difference measurement and Fig. 5 the errors as a function of the magnitude of the double refraction for a single cell. Fig. 6 shows the experimental arrangements for objective measurement with a photocell and amplifier and for subjective measurement with a photometer; these methods, their errors, advantages and disadvantages are described in detail. Fig. 11 shows the complete circuit for the objective measurement In § 4 the sources of error are discussed; these are (a) faulty orientation of the cells, and (b) the effect of unequal double refraction of the separate cells.

The circuit for l.f. power measurement is shown in Fig. 17. A suitable phase displacement between the cells Z_1 and Z_2 can be produced by varying R and C and the previously-described methods applied. The dimensions of the cells are discussed in § 6; Fig. 20 shows the arrangement of the electrodes. High-frequency power measurements are discussed in § 7; Fig. 23 shows the circuit and Fig. 24 results obtained using the subjective method at a frequency of 1.5×10^5 c/s. The highest frequency used was 1.3×10^6 c/s. High voltages (several hundred volts) are necessary if the measurements are to be reliable.

4229. A Thermionic Wattmeter [Direct Method using Heptode to modulate Electron Stream by Two Grids simultaneously: Elimination of Error due to Harmonics: Accuracy within 1–2% for Sinusoidal Inputs].—R. J. Wey. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, pp. 490–495: Oct., pp. 552–555.)

4230. A New Construction for Highly Sensitive Linear Thermopiles.—Alexandrov & Courtener. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 7, pp. 974–975.)

4231. A Recording Field-Strength Meter of High Sensitivity [for Field Strengths of One Microvolt/Metre upwards: Wave Range 10–2000 m: with Incorporated Oscillator for Sensitivity Calibration during Measurement].—M. Ziegler. (*Philips Tech. Review*, July 1937, Vol. 2, No. 7, pp. 216–223.) Also useful as a selective voltmeter with adjustable sensitivity and high aperiodic input impedance.

4232. Accomplishment of Measurements of the Field Strength of Radiobeacons.—Harding. (*See* 4128.)

4233. The Ninth "Cycle of Measurement" of the Associazione Elettrotecnica Italiana [Comparison of Constants of Resonant Circuit measured at Several Italian Laboratories by Various Methods].—E. F. Ghiron. (*L'Elettrotec.*, 25th Aug. 1937, Vol. 24, No. 16, pp. 506–508.)

4234. Paper on the Measurement of Valve Capacities.—Steimel & Zickermann. (*See* 4105.)

4235. A.C. Bridges with Automatic Balancing [and Ink Recording: for Capacity and Loss Factor Measurements, etc: as a Frequency Meter: as a Compensating High-Speed D.C. Recording Meter (on "Current-Chopper" Principle) for Photocell, Thermopile or other Small Currents or Voltages].—W. Geyger. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, pp. 259–270.) With 30 literature references.

4236. Schering Capacitance Bridge [for Audio Frequencies: Direct Reading in Capacitance and Power Factor].—(*Journ. of Applied Physics* [formerly *Physics*], July 1937, Vol. 8, No. 7, p. 488: note on bridge designed by General Radio Co.)

4237. A Simple Impedance-Measuring Bridge with Central-Zero Pointer Galvanometer as Null Indicator [giving Sense as well as Magnitude of Out-of-Balance Settings].—E. Mittelmann. (*Elektrot. u. Masch:bau*, 4th July 1937, Vol. 55, No. 27, pp. 321–322.)

4238. A Possible Extension of the Method of Magnetic Differentiation for the Measurement of Impedances [of Widely Different Values, by Use of Voltage Transformer of Known Errors: Application to Comparison between Mica and Air Condensers].—F. Neri. (*L'Elettrotec.*, 25th June 1937, Vol. 24, No. 12, pp. 366–369.) For previous papers on this method *see* 3104 of August.

4239. Bridge for Direct Impedance Measurement.—G. W. Sutton: Serner. (*Wireless Engineer*, Sept. 1937, Vol. 14, No. 168, p. 488.) Prompted by the editorial referred to in 2698 of July.

4240. A Wavemeter of the Highest Precision: Part I [for Wavelengths 200–20 000 m: based on Use of PTR Broadcast Standard Frequency of 0.998 . . . kc/s (accuracy $1 - 2 \times 10^{-8}$) multiplied in Two Stages].—H. H. Heinze. (*T.F.T.*, June 1937, Vol. 26, No. 6, pp. 123–126.)

4241. Note on a Peculiar Case of Fracture of a Quartz Resonator [Moral: Keep All Hard Rigid Bodies away from Possible Reach of Driven Resonator: It may dash Itself to Pieces].—K. S. van Dyke. (*Journ. of Applied Physics* [formerly *Physics*], Aug. 1937, Vol. 8, No. 8, pp. 567–568.)

4242. An Isothermal Chamber constant to One-Thousandth of a Degree Centigrade [for Quartz Oscillators, etc.].—Turner. (*See* 4349.)

4243. The Influence of Temperature on the Dynamic Piezo-Modulus of Rochelle Salt.—Mikhailow [Michailov]. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 461–465: in English.)

Longitudinal vibrations were excited in a crystal orientated at 45° to the *bc* axes, an electric field of 10^5 c/s being applied on the *a* axis: the linear components of the tensor strain are connected, in this case, by only one piezo-modulus d_{14}, which was measured by the method described in a previous paper (3895 of 1936), below 0° and 40° C. "The character of the resulting relationship is analogous to the change in the dielectric constant in dependence on the temperature. The dynamic values of ϵ and d_{14} at 0° are about 60 times less than the static values. A maximum value of d_{14} was found for the upper Curie point at about 24.5° C."

4244. The Electrical Properties associated with Rochelle Salt exhibited by Isomorphous Crystals, *and* Dielectric Investigations of Rochelle Salt [Dielectric Constant is Constant at Wavelengths 49 m–30 cm].—G. Busch: Bantle & Busch. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 10, 1937, pp. 261 and 262–264: both in German.) The sudden drop and negative value below 21 m, found by Zeleny & Valasek (252 of 1935) is explained as due to their experimental technique.

4245. The "Crevasse" in the Curve of a Magnetostrictive Oscillator.—I. Šimon. (*Hochf:tech. u. Elek:akus.*, Aug. 1937, Vol. 50, No. 2, pp. 54–58.)

A resonance effect in the oscillations of a circuit whose coil contains a magnetostrictive plate is an accurate indicator of the oscillations of the plate. This effect is here investigated, using a nickel plate and the circuits shown in Figs. 1, 2: Fig. 3 gives an experimental curve of the oscillating current obtained with the circuit of Fig. 2. The attenuation coefficient of the plate can be obtained from the breadth of this curve (Fig. 4). A sharp dip in a resonance curve taken with the circuit of Fig. 1 (Figs. 5, 6) is obtained when the frequency of the emitter is the same as the natural frequency of the plate. The theoretical explanation is derived in § 11 from the equivalent circuit of Fig. 7.

4246. A Method of Measuring the Elastic Constants of Ferromagnetic Materials [using Two Kinds of Magnetostrictive Longitudinal Oscillations of Thin Rectangular Plates].—I. Šimon. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 379–394.)

4247. Stable Commutator Contacts for Measuring Purposes [Not Depending on Rubbing: Mercury and Platinum in Sealed Glass Tube].—Boutry & Tréherne. (*Comptes Rendus*, 7th June 1937, Vol. 204, pp. 1713–1715.)

4248. Elektromagnetic Quantities and Units [No Need to involve Dielectric Constant or Magnetic Permeability of Vacuum: etc.].—Brylinski. (*Bull. Soc. franc. des Élec.*, Aug. 1937, Vol. 7, No. 80, pp. 817–846.)

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4249. Triple Cathode-Ray Oscillograph.—Kasai & Satoh. (*Arch. f. Elektrot.*, 10th Aug. 1937, Vol. 31, No. 8, pp. 551–554.)

The principle of separation of the electron filament into several parts by dividing plate electrodes (Fig. 1) is used. The electrode scheme is shown in Fig. 2 and the system along which the filaments are conducted in Fig. 3. Oscillograms for a mercury arc (Fig. 4) and for discharge onset in a grid-controlled rectifier (Fig. 5) are shown. The new tube is said to have the advantages of good concentration, small filament current for good recording velocity, and simple working.

4250. New Midget Cathode-Ray Oscillograph [with 1" Screen and Reduced Voltage Requirements].—(*Journ. of Applied Physics* [formerly *Physics*), July 1937, Vol. 8, No. 7, p. 487: note on new model from Clough-Brengle Co.)

4251. The AWA Cathode-Ray Oscillographs [with Chassis suitable for Portable and Rack Mounting, and allowing Use of 5" and 3" Tubes].—Campbell & Roberts. (*AWA Tech. Review*, July 1937, Vol. 3, No. 1, pp. 30–34.)

4252. On the Behaviour of a Cathode-Ray Tube at Ultra-High Frequencies.—Hintenberger. (*See* 4190.)

4253. Remarks on the Paper: "The Dynamics of Transversely and Longitudinally Controlled Electron Beams."—Gundlach: Hollmann & Thoma. (*See* 4039.)

4254. Demonstration of the Image Errors of Electron Lenses by the Electron Filament Method.—Gundert. (*Physik. Zeitschr.*, 15th June 1937, Vol. 38, No. 12, pp. 462–467.)

The experimental arrangement is shown in Fig. 2. An electron filament is successively deviated in different zones of an electron lens; its path and the image errors produced under various circumstances are photographed. The path in an electrostatic lens is shown in Fig. 3, in a magnetic lens for different currents in the coils by Fig. 4. Fig. 5 illustrates the aperture errors of a magnetic lens.

Fig. 6 shows the effect of space charge in an electrostatic lens for different voltages. Fig. 7 shows aperture errors with a symmetrical electrostatic tube lens, Fig. 8 aperture errors for various lens forms. Fig. 9 demonstrates the correction of an aperture error by a scattering field.

4255. ON CATHODE-RAY SELECTOR DESIGN [for Telemechanics: Approximate Method based on Experiment: Formulae].—Kovalenkov & Petrov. (*Automatics & Telemechanics* [in Russian], No. 6, 1936, pp. 3–11.) *See* also 797 of February.

4256. ELECTRON-MICROSCOPICAL OBSERVATIONS OF FIELD-EMISSION CATHODES.—Müller. (*See* 4119.)

4257. ELECTRON OPTICS [Historical Survey].—Gabor. (*BTH Activities*, July/Aug. 1937, Vol. 13, No. 4, pp. 138–148: *BEAMA Journal*, Sept. 1937, Vol. 41, No. 3, pp. 80–87.)

4258. ELECTRON DISTRIBUTION IN THE FOCUS OF X-RAY TUBES [Improvements in Electron-Optical Measurements: Comparison with Pin-Hole Camera Method].—Dosse. (*Arch. f. Elektrot.*, 10th Aug. 1937, Vol. 31, No. 8, pp. 534–544.)

4259. THE "GHOSTS" OBSERVED IN THE MASS SPECTROMETER WITHOUT A MAGNETIC FIELD [explained by Generalisation of Theory of Velocity Filter: Formulae for Position Calculation: Suggestions for Avoidance].—Hintenberger & Mattauch. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 279–290.)

4260. THE TIME-BASE RELAY AND H.F. OSCILLATOR USED WITH THE CATHODE-RAY OSCILLOGRAPH OF THE SKODA WORKS; *also* A HIGH-VOLTAGE CATHODE-RAY OSCILLOGRAPH OF THE SKODA WORKS; *and* THE HOT-CATHODE OSCILLOGRAPH OF THE COSSONAY CABLE WORKS.—Nemec: Bláha: Foretay. (*Rev. Gén. de l'Élec.*, 4th Sept. 1937, Vol. 42, No. 10, pp. 73–74D: p. 74D: p. 74D: summaries only.)

4261. DIRECT-COUPLED PUSH-PULL OSCILLOGRAPH DRIVER STAGE [for Slowly Changing Biological Signals: giving Undistorted Swing of 700 Volts].—Talbot. (*Electronics*, Aug. 1937, Vol. 10, No. 8, p. 40.)

One advantage of the push-pull output is that the total plate-current does not change, so that a single plate supply can be used to feed two amplifiers, one for each set of deflecting plates, without interaction between the circuits.

4262. NOTES ON THE ELECTROGRAPHIC EFFECT [Engraving by Means of High-Voltage Cathode-Rays: Description of Various Attempts at Image Production].—Schickele & Carr: Selényi. (*Journ. of Applied Physics* [formerly *Physics*], Aug. 1937, Vol. 8, No. 8, pp. 558–560.)

4263. CONSTRUCTION AND ACTION OF PHOSPHORESCENT ZINC SULPHIDES AND OTHER LUMINOPHORES [Spectra: Meaning of Blue Band: Mechanism of Luminescence Phenomenon: Connection between Fluorescence and Phosphorescence: Decay Curves: Molecular Construction: Calcium Tungstate].—Riehl. (*Ann. der Physik*, Series 5, No. 7, Vol. 29, 1937, pp. 636–664.)

4264. STUDY OF SOME INHIBITORS OF FLUORESCENCE [*e.g.* Gardinol acting on Rhodamine].—Banderet. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 10, 1937, pp. 259–261: in French.)

4265. HIGH-VACUUM GAUGES [Survey, leading to Philips Vacuum-Meter using Electrons spiralling in Magnetic Field and thus colliding with Enough Gas Molecules even at Very High Vacua].—Penning. (*Philips Tech. Review*, July 1937, Vol. 2, No. 7, pp. 201–208.)

4266. A DEMOUNTABLE VACUUM JOINT WITH CLAMP.—Weintroub. (*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, pp. 315–317.)

4267. A PRACTICAL NEEDLE VALVE FOR VACUUM APPARATUS.—von Meyeren. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 281.)

4268. THE PREPARATION OF A HIGH-VACUUM GREASE: *also* AN AUTOMATIC PUMP OF THE SPRENGEL TYPE: *and* THE USE OF A THERMO-SIPHON FOR THE COOLING OF LANGMUIR PUMPS.—Bruns & others: Bruns: Bruns. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 7, 1937, pp. 964–966: pp. 967–968: p. 970.)

4269. "DIE VAKUUMTECHNIK" [Book Review].—Holland-Merten. (*E.T.Z.*, 9th Sept. 1937, Vol. 58, No. 36, p. 999.)

4270. AN ELECTRO-MECHANICAL VIBRATOR DEVICE AS TIME MARKER AND RECORDING-DRUM DRIVE [giving Current Pulses up to 200 c/s accurate to ± 0.3%: Very Small and Light].—Krumnow. (*Zeitschr. V.D.I.*, 7th Aug. 1937, Vol. 81, No. 32, pp. 943–945.)

4271. NEW LABORATORY APPARATUS FOR THE PRODUCTION OF HIGH TENSIONS, WORKING ON CONTINUOUS CURRENT: II—TWO ARRANGEMENTS WITHOUT MOVING PARTS [Thyratron Voltage Trebler: Rectifier/Triode/Iron-Cored Choke Combination giving Voltages up to 10 kV].—Piekara & Kryczkowski. (*Acta Phys. Polonica*, Fasc. 1, Vol. 6, 1937, pp. 89–93.) *See* also 1553 of April.

4272. HIGH VOLTAGE REGULATION [5000 Volts maintained Constant to about 1/20th Volt].—Pallister & Smith. (*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, pp. 311–313.)

4273. A NEW TYPE OF PRECISION VOLTAGE REGULATOR FOR DIRECT CURRENT [Accuracy and Economy both increased by using Valve as Inertialess Regulating Resistance Only, Actual Control being by Special Control-Galvanometer].—Sauermann. (*E.T.Z.*, 16th Sept. 1937, Vol. 58, No. 37, pp. 1003–1007.) For the special galvanometer *see* 291 of January.

4274. The Marconi-Stabilovolt System: Glow-Gap Voltage Dividers with Ignition Gaps [to ensure Faultless Striking when the Starting Voltage can only Slightly Exceed the Working Voltage: the "Z Stabilovolt"].—Körös & Seidelbach. (*Marconi Review*, May/Aug. 1937, No. 66, pp. 31–35.)

4275. A Simple A.C. Voltage Regulator [for Full A.C.-Mains Operation of Precision Oscillators, Analysers, etc.].—Lampkin. (*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 30–31 and 36, 39, 40.)

4276. An Inductive A.C. Voltage Regulator using Iron-Cored Choke whose Biasing Current is controlled by Valves.—Metal & Rosenzweig. (*Elektrot. u. Masch:bau*, 22nd Aug. 1937, Vol. 55, No. 34, pp. 410–413.)

4277. Electro-Magnetic Voltage Stabilisers [Recent Progress].—Geyger. (*E.T.Z.*, 17th June 1937, Vol. 58, No. 24, p. 666: summary only.)

4278. Thyratron D-C Motor Control.—Garman. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 20–21.)

4279. The Use of Discharge Tubes for the Control of Electrical Machines: Parts II and III.—Sequenz. (*Elektrot. u. Masch:bau*, 6th June & 5th Sept. 1937, Vol. 55, Nos. 23 & 36, pp. 274–280 and 436–441.) For Part I *see* 1531 of April. A long French summary of Part I is given in *Rev. Gén. de l'Élec.*, 14th Aug. 1937, Vol. 42, No. 7, pp. 216–218.

4280. Welding and Voltage Control using Kathetrons [Control Tube with External Grid].—Craig. (*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 26–28.)

4281. Regulation of Grid-Controlled Rectifier [Factors not included in Usual Formulae].—Kilgore & Cox. (*Elec. Engineering*, Sept. 1937, Vol. 56, No. 9, pp. 1134–1140.)

4282. High-Voltage Vacuum Tube Rectifiers: Physical Factors influencing Their Design [General Account of Effect of Field Currents, Electrode Spacing, Electrostatic Mechanical Forces, Envelope Surface Phenomena, etc.].—Gross & Atlee. (*Journ. of Applied Physics* [formerly *Physics*], Aug. 1937, Vol. 8, No. 8, pp. 540–543.)

4283. Mercury Vapour Grid-Controlled Tubes; Their Electric Control by a Phase-Shifting Network: Part II [Theoretical Examination of Behaviour of Transformer connected through a Tube to a Variable A.C. Resistance Load: Tests with Air- and Iron-Core Transformers: Transformer Data: Grid Control].—Strelzoff. (*Journ. Franklin Inst.*, Aug. 1937, Vol. 224, No. 2, pp. 191–215.) For Part I *see* 3857 of October.

4284. The Commutation Period in Grid-Controlled Mercury-Arc Rectifiers [and a Stroboscopic Method of measuring Overlap Angle].—Fairley. (*Journ. Roy. Tech. Coll.*, Glasgow, Jan. 1937, Vol. 4, pp. 147–158.)

4285. Large [Iron-Container] Rectifiers without Vacuum Pumps [and the Possible Development of Small Rectifiers on Same System].—Dällenbach & Gerecke. (*Zeitschr. V.D.I.*, 28th Aug. 1937, Vol. 81, No. 35, p. 1019.)

4286. A 300-kW Grid-Controlled Rectifier [supplying 8000–20 000 Volts to Anodes at Rocky Point, Long Island].—Willems. (*Comm. & Broadcast Eng.*, July 1937, Vol. 4, No. 7, pp. 5–6.)

4287. Glow-Discharge Rectifiers [Principles and Construction: Advantages]. — Beljawsky. (*Tech. Phys. of USSR*, No. 6, Vol. 4, 1937, pp. 493–502: in German.)

Tables of "normal" cathode fall values for some metals in gases and in mercury vapour, and for carbon in mercury vapour: large drop in value caused by slight admixture of calcium or strontium: "abnormal" cathode fall occurs when whole cathode surface is covered by the glow discharge: valve action increased by arranging that the discharge takes place in one direction with "normal" and in the other direction with "abnormal" cathode fall: practical rectifiers based on this fact: stable action ensured by carefully freeing walls and electrodes from foreign gases and by suitable choice of gaseous mixture: destructive effect of frequencies above 180 kc/s, and its cause.

4288. Electronic Semiconductors in Strong Electric Fields, *and* Properties of the Blocking Layer of Solid Rectifiers.—Joffe & Joffe. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 15th July 1937, Vol. 16, No. 2, pp. 77–81: pp. 81–82: both in English.)

4289. On the Breaking Down of Copper-Oxide Rectifiers.—Yu A. Dunaev & P. V. Sharavski. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 7, 1937, pp. 1057–1064.)

An experimental investigation of copper-oxide rectifiers of Russian manufacture, the object of which was to determine the conditions resulting in their breakdown and to evolve the necessary precautionary measures. The following three main causes of breakdown were examined separately: (a) overheating of the elements due to inadequate cooling (thermal breakdown); (b) over-loading of the elements due to a high voltage applied to the rectifier for a short time (electrical breakdown); and (c) electrolytic action (electrolytic breakdown). The results of these experiments are discussed and a number of practical suggestions made.

4290. The Effect of Sodium Ions on the Amalgamating Properties of Thin Silver Films [with New Form of Kunsman Anode as Ion Source: Conditions for Activation and Passivation of Films towards Mercury Vapour].—Kehler. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 296–310.)

4291. FUNDAMENTAL MECHANISMS WHICH DETERMINE THE STARTING POTENTIALS OF THE LOW-PRESSURE CORONA DISCHARGE.—Loeb. (*Journ. of Applied Physics* [formerly *Physics*], July 1937, Vol. 8, No. 7, pp. 495–496.)

4292. THE TRANSITION OF THE CUSTOMARY GLOW DISCHARGE INTO THE "SPRAY" DISCHARGE WITH INCREASING THICKNESS OF OXIDE FILMS PRODUCED ELECTROLYTICALLY ON ALUMINIUM [Experiments].—Güntherschulze & Bär. (*Zeitschr. f. Physik*, No. 9/10, Vol. 106, 1937, pp. 662–668.) *Cf.* Schnitger, 682 of February.

4293. COMPARISON OF THE CATHODE SPUTTERING OF PURE AND OXIDE-COVERED MAGNESIUM SURFACES [Small Sputtering from Surfaces consisting of Magnesium Compounds explained by Sputtering of Magnesium Ions from Them: These are Re-Attracted to Cathode], *and* COMPARISON OF CATHODE SPUTTERING OF COPPER IN LIGHT AND HEAVY HYDROGEN [No Difference].—Güntherschulze & Betz: Güntherschulze. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 365–370: pp. 371–372.)

4294. GASEOUS DIELECTRICS [Summarising Account of Specific Resistance, Dielectric Constant and Losses, Breakdown, Lightning Flashes, Spark Gaps, etc.].—Güntherschulze. (*Arch. f. Elektrot.*, 10th Aug. 1937, Vol. 31, No. 8, pp. 495–507.)

4295. DYNAMIC CHARACTERISTIC CURVES OF GLOW-DISCHARGE TUBES [Cathode-Ray Oscillographic Observations using Valve to limit Current passed by Discharge Tube: Departure of Curves from Form commonly assumed explained on Basis of Ionisation- and Deionisation-Times of Gas].—Reich & Depp. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 245: abstract only.)

4296. CONTRIBUTION TO THE DYNAMICS OF GLOW DISCHARGES: PART II.—Druey. (*Helvet. Phys. Acta*, Fasc. 1, Vol. 10, 1937, pp. 3–31: in German.) Continued from 1134 of March.

4297. INTERMITTENT ARC DISCHARGE UNDER LOW PRESSURE [Three Distinct Types of Arc Discharge developed from Intermittent Glow Discharges in Low-Pressure Gas-Filled Tubes].—Katayama. (*Electrotech. Journ.*, Tokyo, Sept. 1937, Vol. 1, No. 4, pp. 123–128.)

4298. HIGH-PRESSURE ARC PHENOMENA [Study of Electric Gradient and Current Density in Various Gases].—Suits. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 245: abstract only.)

4299. THE CONTROL BY GRIDS OF THE POINT DISCHARGE AND CORONA CURRENTS [in Discharges at Atmospheric Pressure: Experimental Investigation of Modulation, Amplification, and Rectification Effects: etc.].—Greinacher. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 10, 1937, pp. 271–283: in German.)

4300. STRIKING OF POSITIVE COLUMN AND TOWNSEND'S THEORY [Theory including Effect of Diffusion of Charge Carriers to Discharge-Tube Walls].—Mierdel & Steenbeck. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 311–314.)

4301. THE FINE STRUCTURE OF THE LUMINOUS FLASHES PRODUCED BY THE DISCHARGE OF A CONDENSER THROUGH A GAS-FILLED TUBE, *and* STUDY OF THE DISCHARGE OF A CONDENSER THROUGH A GAS-FILLED TUBE.—Laporte & Corda: Laporte. (*Journ. de Phys. et le Radium*, June 1937, Vol. 8, No. 6, pp. 233–234 and Plate: Aug. 1937, No. 8, pp. 332–342.)

4302. THE ANODE FALL IN THE INERT GASES HE, NE AND AR [in Glow and Arc Discharges: Behaviour Explained by Consideration of Faraday Dark Space as a Plasma].—Druyvesteyn. (*Physica*, Aug. 1937, Vol. 4, No. 8, pp. 669–682.)

4303. THE DELAYED GAS DISCHARGE [Experimental Evidence as to Mechanism].—Fischer. (*Naturwiss.*, 21st May 1937, Vol. 25, No. 21, pp. 331–332.)

4304. THE STRIKING POTENTIAL OF THE H.F. DISCHARGE IN HYDROGEN AS CONDITIONED BY FREQUENCY [Existence of "Critical Spark Length": Its Decrease with Increasing Frequency between 5 & 10.5 Mc/s].—Githens. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 688: abstract only.)

4305. BREAKDOWN OF VACUUM SPARK GAPS [Critical Cathode Field not reduced by Considerable Thermionic Emission from Cathode: Positive Ion Emission from Bombarded Anode not a Factor up to 50 kv].—Mason. (*Phys. Review*, 15th July 1937, Series 2, Vol. 52, No. 2, pp. 126–127.)

4306. STUDY ON THE INITIAL ELECTRONS FOR THE IMPULSE SPARK DISCHARGE.—Suzuki, Nakamura, & Mikami. (*Electrotech. Journ.*, Tokyo, Sept. 1937, Vol. 1, No. 4, pp. 134–141.) For previous work *see* 1155 of March.

4307. RESEARCH ON SYNTHETIC MATERIALS [based on Düsseldorf "Nation at Work" Exhibition].—Schmidt. (*Zeitschr. V.D.I.*, 4th Sept. 1937, Vol. 81, No. 36, pp. 1052–1053.) *See* also Schwandt, 3298 of September.

4308. POROUS CERAMIC MATERIALS FOR HIGH-FREQUENCY TECHNIQUE [particularly "Ergan"].—Albers-Schönberg. (*See* 4120.)

4309. INVESTIGATION OF THE STRUCTURE OF PLASTIC MATERIALS [by Microscopic Method employing Stains].—Weigel. (*Zeitschr. V.D.I.*, 7th Aug. 1937, Vol. 81, No. 32, pp. 935–938.)

4310. POLYMERISATION IN THE ELECTRIC FIELD [as displayed by Impregnating and Condenser Oils: Direct Action, *not* due to Gas Particles in Suspension: etc.].—Liechti & Scherrer. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 10, 1937, pp. 267–269: in French.)

4311. Contribution to the Study of the Matrix, Electric Moment [and the Dielectric Polarisation Theories of van Vleck and Niessen].—Courtines. (*Ann. de Physique*, July/Aug. 1937, Vol. 8, pp. 5–145.)

4312. The Deformability of the Molecule in an Electric Field [and the Much Larger Decrease of Dielectric Constant of Dilute Nitrobenzol/Hexane Solutions, caused by an Electric Field, than That corresponding to the Orientation of the Molecules].—Piekara. (*Acta Phys. Polonica*, Fasc. 2, Vol. 6, 1937, pp. 150–157 : in German.)

4313. An Experiment about Electric Absorption [Dielectric Losses in Dipole Substances in H.F. Field Not Appreciably Changed by Superposition of Parallel Constant Electric Field].—Gorter & Brons. (*Physica*, Aug. 1937, Vol. 4, No. 8, pp. 667–668 : in English.) As opposed to the effect in the paramagnetic case (371 of January).

4314. Mains Transformer Design : Method of ascertaining the Optimum Size of Core.—Dent. (*Wireless World*, 18th June 1937, Vol. 40, p. 593.)

4315. Computation Curves for Design of Mains Transformers and Chokes.—Nüsslein. (*Funktech. Monatshefte*, Aug. 1937, No. 8, pp. 233–244.)

4316. Permanent Magnets and Their Manufacture.—Venco. (*L'Elettrotec.*, 25th Aug. 1937, Vol. 24, No. 16, pp. 494–501.)

4317. On the Internal Changes in Nickel-Aluminium Steel used for Permanent Magnets.—G. B. Livshits & M. P. Savtsova. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 7, 1937, pp. 907–916.) An experimental investigation to determine the effect of tempering and annealing on the atomic structure of this type of steel. The conclusions reached are compared with those of other authors.

4318. The Lattice Spacing of Iron/Nickel Alloys [Measurements after Slow Cooling and after Quenching].—Bradley, Jay, & Taylor. (*Phil. Mag.*, April 1937, Series 7, Vol. 23, No. 155, pp. 545–557.)

4319. Change of Saturation Magnetisation by Pressure on All Sides [Ballistic Measurements on Fe, Ni, Various Alloys : Small Pressure Coefficient except for Some Alloys, where Saturation Intensity Decreased markedly as Pressure Increased : Explanation in Terms of Alloy Structure, etc.].—Ebert & Kussmann. (*Physik. Zeitschr.*, 15th June 1937, Vol. 38, No. 12, pp. 437–445.)

4320. Domain Theory of Ferromagnetics under Stress : Part I [General Form of Statistical Theory : Formulae for Magnetisation and Strain Components : Special Case of Nickel Crystals].—Brown. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, pp. 325–334.)

4321. The Behaviour of Bitter's Lines [formed by Colloidal Iron Oxide Deposits on Polished Surfaces of Single Ferromagnetic Crystals] under Elastic Distortions [Lines are Boundaries of Weiss-Heisenberg Regions : Demonstration of Change of Magnetisation Direction under Elastic Distortions : Estimate of Internal Tensions in Crystal].—Soller. (*Zeitschr. f. Physik*, No. 7/8, Vol. 106, 1937, pp. 485–498.)

4322. "Nickel-Handbuch" [Book Review : Nickel/Iron and other Nickel Alloys with Special Physical Properties].—(*Zeitschr. f. tech. Phys.*, No. 9, Vol. 18, 1937, p. 287.)

4323. "Magnetische und elektrische Eigenschaften der legierte Werkstoffe" [Ferromagnetic Alloys : Book Review].—von Auwers. (*Elektrot. u. Masch:bau*, 22nd Aug. 1937, Vol. 55, No. 34, p. 416.)

4324. Coercive Force in Single Crystals [of Silicon-Iron : Measurements in Different Directions].—Sixtus. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, pp. 347–352.)

4325. The Magnetic After-Effect with Carbonyl Iron [Measurements : Theory : Effect of Eddy Currents, Temperature, Field-Strength : Principle of Superposition : Effect of Plastic Deformation : Consequences for Loss-Angle Measurements].—Richter. (*Ann. der Physik*, Series 5, No. 7, Vol. 29, 1937, pp. 605–635.)

4326. Precise Magnetic Torque Measurements on Single Crystals of Iron.—Tarasov & Bitter. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, pp. 353–360.)

4327. The Ferromagnetic Moments of Some Alloys of Cobalt [with Chromium, Aluminium, Tungsten, and Molybdenum].—Farcas. (*Ann. de Physique*, July/Aug. 1937, Vol. 8, pp. 146–152.)

4328. On the Theory of Dependence of the Ferromagnetic Properties of Metals on Temperature, *and* On the Question of the Nature of the Coercive Force.—Akulov : Kondorskij. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 15th June 1937, Vol. 15, No. 8, pp. 445–450 in English : pp. 457–459 : in German.)

4329. The Temperature Dependence of the Magnetisation of a Ferromagnetic Material at Low Temperatures.—Opechowski. (*Physica*, Aug. 1937, Vol. 4, No. 8, pp. 715–722 : in German.)

4330. The Theory of Ferromagnetism : Lowest Energy Levels [Spin Wave Theory suitable for investigating Temperature Variation of Magnetisation : Energy Band Theory tells Which Elements should be Ferromagnetic : Perturbation Theory].—Slater. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, pp. 198–214.)

4331. On the Magnetic Permeability of Chemical Combinations of Ferromagnetic Bodies in a Field of High [Short-Wave] Frequency.—Zimowski. (*Acta Physica Polonica*, Fasc. 1, Vol. 6, 1937, pp. 6–11: in French.)

4332. Contribution to Knowledge of Surface Bonds [Magnetic Effects connected with Adsorption of Various Gases at Carbon Surface].—Juza & Langheim. (*Naturwiss.*, 6th Aug. 1937, Vol. 25, No. 32, pp. 522–523.)

4333. Contribution to the Theoretical Problem of the Foucault Currents [produced by Alternating Fields in Massive Ferromagnetic Material at Rest: Extension of Maxwell-Thomson Theory: Consideration of Variable Permeability and Reaction of Foucault Currents].—Bászel. (*Zeitschr. f. Physik*, No. 5/6, Vol. 106, 1937, pp. 343–353.)

4334. The Dispersion Band and Skin Effect in the Sinusoidal Field and in the Transitional Field.—Arkadiev. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 5th July 1937, Vol. 16, No. 1, pp. 35–40: in French.)

4335. New Method of Determining the Magnetic Properties of Iron [the Siemens & Halske "Ferrometer," with Vibrator Rectifier and De-Phasing Device].—Triau. (*Rev. Gén. de l'Élec.*, 28th Aug. 1937, Vol. 42, No. 9, pp. 264–268.)

4336. Note on the Absolute Determination of Magnetic Field Strength [by Inductometric Method: Strength of Field at Source of Charged Particles in Focusing Magnetic Spectrograph].—Rogers. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, p. 381.)

4337. An Arrangement for Increasing the Sensitivity of a Moving Coil Galvanometer used Ballistically for the Measurement of Magnetic Flux.—Bellasio. (*L'Elettrotec.*, 25th Aug. 1937, Vol. 25, No. 16, pp. 501–506.)

4338. A New Magnetic Flux Meter [using Hall Effect in Bismuth Spirals in Bridge Circuit].—Smith. (*Elec. Engineering*, April 1937, Vol. 56, No. 4, pp. 441–445 and 475, 476.)

4339. Preparation of Tellurium Film whose Resistance changes with Magnetic Flux [also acts as Rectifier and Thermocouple].—Wein. (*Electronics*, Sept. 1937, Vol. 10, No. 9, p. 29.) In a miscellany entitled "Questions and Answers."

4340. Resistance Characteristics of Tellurium and Silver/Tellurium Alloys [for Negative-Temperature-Coefficient Resistances for Compensating Purposes].—Faus. (*Elec. Engineering*, Sept. 1937, Vol. 56, No. 9, pp. 1128–1133.)

4341. Glucinium [Beryllium] and Its Alloys.—Gadeau. (*Rev. Gén. de l'Élec.*, 11th Sept. 1937, Vol. 42, No. 11, pp. 328–334.)

4342. Electrolytic Recording of Weak Electric Currents [Solutions with Sodium Diethyldithiocarbamate or Rubeanic Acid as Indicators give Dark Permanent Records: about 5 Times as Sensitive as Starch Iodide Solution].—Lutkin. (*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, pp. 306–308.)

4343. On Optical Indicators [Glow-Discharge Indicating Tubes].—L. G. Usikov. (*Izyestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 46–52.)

A general discussion on various devices in which use is made of glow-discharge tubes for indication purposes. The operation of a two-electrode neon lamp is discussed in detail, and the main conclusions are given of an experimental investigation which was carried out to determine the various factors affecting the striking voltage and the stability of the discharge. Phase and pole-finding lamps, indicating respectively the phase synchronism of two systems (in wavemeters, etc.) and the direction of the current in a conductor, are also discussed. The paper is concluded by brief descriptions of various indicating devices proposed by Pohl & Straeler (1934 Abstracts, p. 322), Gehrcke, and others.

4344. Instrument Suspensions [Silica Fibres: Conductive Coatings: Suspension: Metal Wires and Filaments: etc.].—Walden. (*Journ. Scient. Instr.*, Aug. 1937, Vol. 14, No. 8, pp. 257–268.)

4345. Miniature Ball Bearings [of Extreme Precision: Over-All Size from 1.5 mm Upwards: for Ultra-Sensitive Meters, etc.]—(*Journ. Scient. Instr.*, Sept. 1937, Vol. 14, No. 9, p. 317.)

4346. Relays in Tube Output Circuits [Methods of Rapid Determination of Circuit Conditions for Optimum Relay Magnetomotive Force].—George. (*Electronics*, Aug. 1937, Vol. 10, No. 8, pp. 19–21 and 58.)

4347. On the Design of a Relay of Small Dimensions and Weight [Operating Time 0.5 Millisecond or Less].—Peretz-Orlovsky. (*Automatics & Telemechanics* [in Russian], No. 6, 1936, pp. 89–92.)

4348. Resistance of Silver Contacts [Oxide is Not a Good Electrical Conductor: Tarnish may be a Sulphide: Need for Investigation].—Windred. (*Electrician*, 3rd Sept. 1937, Vol. 119, p. 266.)

4349. Constant Temperature: a Study of Principles in Electric Thermostat Design; and a Mains-Operated Isothermal Chamber constant to One-Thousandth of a Degree Centigrade.—L. B. Turner. (*Journ. I.E.E.*, Sept. 1937, Vol. 81, No. 489, pp. 399–417: Discussion pp. 418–422.)

4350. The Efficiency of Counters and Counter Circuits [Formulae in Terms of Recovery Times of Counter, Amplifier, and Recording Unit].—Ruark & Brammer. (*Phys. Review*, 15th Aug. 1937, Series 2, Vol. 52, No. 4, pp. 322–324.)

4351. Torch Ion Counter [New Type of Counter employing the "Torch" Effluence produced by Short-Wave Generator].—Prokofiev. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 5th July 1937, Vol. 16, No. 1, pp. 41–43: in English.)

4352. A Universal Counter [using Richter & Geffcken's Relay (Three-Electrode Neon Tube) and Neher & Harper's Arrangement].—Dauvillier. (*Comptes Rendus*, 5th July 1937, Vol. 205, No. 1, pp. 36–37.) *See* 3621 of 1936.

4353. Determination of the Counting Losses in Thyratron Recording Circuits, *and* Discharge Mechanism and Characteristics of Geiger-Müller Counter Tubes.—Lifshutz, Duffendack, & Slawsky. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1027: abstract only.)

4354. Vacuum Tube Circuits for Scaling Down Counting Rates [give Shorter Resolving Time, Greater Stability and Durability than Thyratron Circuits].—Stevenson & Getting. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1027: abstract only.)

4355. An A.F. and R.F. Wiring Devic.—Bjorndal. (*See* 4171.)

4356. Cable with Two-Layer Sheath [to Economise in Lead].—Reuschenbach. (*Zeitschr. V.D.I.*, 4th Sept. 1937, Vol. 81, No. 36, p. 1055.) Developed at the Felten & Guilleaume works.

4357. Protection of Buried Metallic Conductors against Electrolytic Corrosion by means of the "Electronic Filter" [Semiconducting Layer keeping out Chemical Bodies but passing Electrons to carry the Current brought by the Ions: Rubber Tape impregnated with Graphite].—Borel. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 28, 1937, pp. 54–57: in French.)

4358. Accumulator Parts made of New Synthetic Materials [particularly "Decelith" (Polyvinyl Chloride)].—Hauffe. (*E.T.Z.*, 2nd Sept. 1937, Vol. 58, No. 35, p. 963: abstract only.)

It is even suggested that Decelith should, as a carrier, replace lead in the plates themselves, but this proposal is criticised by the abstractor.

4359. A Diverter-Pole Generator for Battery Charging.—de Kay. (*Bell Lab. Record*, Aug. 1937 Vol. 15, No. 12, pp. 382–384.)

4360. Résumé of Some Researches on the Molecular Mechanism of the Production of Energy in Primary Batteries.—Cordebas. (*Rev. Gén. de l'Élec.*, 21st Aug. 1937, Vol 42, No. 8, pp. 231–236.)

STATIONS, DESIGN AND OPERATION

4361. Radio Communication in Lighthouse Work.—Harding. (*Lighthouse Conference, Berlin 1937: Papers submitted by U.S. Lighthouse Service:* Topic C-8, pp. 1–2.) For a number of other papers in this volume *see* under "Directional Wireless."

4362. Ship-to-Shore Communication.—Riddle. (*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 9–12 and 58.)

4363. Soviet Radio at the North Pole [Photographs and Captions].—(*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 22–23.)

4364. Radio Link with Ireland [Nine-Channel Ultra-Short-Wave Belfast/Stranraer Link].—(*Wireless World*, 10th Sept. 1937, Vol. 41, pp. 260–261.) *See* also Ullrich, 3890 of October.

4365. Short-Wave Telephony: Inauguration of Belfast/Stranraer Nine-Channel Ultra-Short-Wave Radio Link.—(*Electrician*, 3rd Sept. 1937, Vol. 119, pp. 257–258.)

4366. An Ultra-Short-Wave Telephone Link between Eindhoven and Tilburg [on 123 and 140 cm Waves, Distance nearly 30 km (Direct Optical Path): Yagi Aerials: TB 1/60 Triode as Generator: "Autodyne-Superhet" Receivers].—von Lindern & de Vries. (*Philips Tech. Review*, June, 1937, Vol. 2, No. 6, pp. 171–176.)

4367. The Radiotelephonic Link Paris/New York.—Rigal. (*Ann. des Postes, T. et T.*, June 1937, Vol. 26, No. 6, pp. 489–532.)

4368. The Service Area of a Long-Wave Telegraphic Transmitter.—Green. (*See* 4000.)

4369. The Electrical Design of a Broadcasting Centre [Discussion of Advantages and Disadvantages of "Centralised," "Decentralised," and "Mixed" Systems, leading to Detailed Description of the "Decentralised" System evolved by the Belgian National Broadcasting Institute].—Hansen. (*L'Onde Élec.*, Aug. 1937, Vol. 16, No. 188, pp. 437–466.)

"In conclusion, the decentralised system is preferable for an important broadcasting centre because it presents marked advantages in technical quality and facility of working, and is hardly more costly in material [the fact that, on the average, rehearsals occupy 4 hours to every hour of transmission, and that recordings also occur, means that in a modern centre most of the studios are in use simultaneously: this deprives the centralised system of most of its advantage in economy of material]. We do not think that the system [the "alpha-lambda" decentralised system here described] has so far been employed by any other broadcasting centre."

4370. Simplifying BC Operators' Job [Simplified Control Panel at KONO: using Rotary Multi-Contact Switches in place of Patch Cords: etc.].—Ing. (*Electronics*, Sept. 1937, Vol. 10, No. 9, pp. 24–25.)

4371. The Fourth Meeting of the CCIR, in Bucharest.—Münch. (*T.F.T.*, Aug. 1937, Vol. 26, No. 8, pp. 188–190.)

GENERAL PHYSICAL ARTICLES

4372. Solution of the General Problem of the Diffraction of Electromagnetic Waves [by Use of Fredholm's Theory], *and* On the Theory of Electromagnetic Oscillations in Plane Inhomogeneous Fields.—Kupradze. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 5th July 1937, Vol. 16, No. 1, pp. 31–34 : 25th July, No. 3, pp. 165–168 : both in German.)

4373. On the Lorentz Equation of Motion in the New Electrodynamics.—Chraplvwyj. (*Acta Phys. Polonica*, Fasc. 1, Vol. 6, 1937, pp. 31–39 : in English.)

4374. Study on a New Method of Integration of Maxwell's Equations, and Its Application to the Calculation of the Electromagnetic Field of the Electron in Motion.—Reulos. (*Ann. de Physique*, May/June 1937, Vol. 7, pp. 700–789.)

4375. On the Properties of Certain Vibratory Doublets [Calculations of Common Frequency of Two Stationary Electrons at Various Distances Apart : Energy of Moving Doublet : Doublet and Photon].—Jones. (*Phil. Mag.*, Sept. 1937, Series 7, Vol. 24, No. 161, pp. 458–466.)

4376. On the Production of Pairs by the Collision of Electrified Particles.—Racah. (*Nuovo Cimento*, March 1937, Vol. 14, No. 3, pp. 93–113.)

4377. Collisions of the Second Kind and Sensitised Fluorescence of Tin and Mercury Atoms [Measurements of Spectral Lines Emitted].—Winans & Williams. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 250 : abstract only.)

4378. On the Values of Fundamental Atomic Constants [All Present Experimental Values of h/e are probably too low].—Birge. (*Phys. Review*, 1st Aug. 1937, Series 2, Vol. 52, No. 3, p. 241.)

4379. The Time Effect in the Normal Wien Effect [in Ionic Clouds and Electrolytes : Theoretical Explanation of Frequency Variation].—Falkenhagen, Fröhlich, & Fleischer. (*Naturwiss.*, 25th June 1937, Vol. 25, No. 26/27, pp. 446–447.)

4380. Reciprocals to Ampère's Law [Variant Form of Faraday's Law of Electromagnetic Induction : Law of Equivalence of Magnetic Circuit with Changing Flux and Electric Shell].—Carwile. (*Phys. Review*, 1st June 1937, Series 2, Vol. 51, No. 11, p. 1016 : abstract only.)

MISCELLANEOUS

4381. A Graphical Method for Integrating the Differential Equations of Electrotechnics [using Direction-Field of First-Order Equations : Illustrative Examples of Iron-Free and Iron-Cored Choke Coil].—Böning. (*Arch. f. Elektrot.*, 10th Aug. 1937, Vol. 31, No. 8, pp. 545–551.)

4382. On Products of Laguerre Polynomials [Deductions by Operational Calculus from Definition of Polynomials by Generating Function].—Howell. (*Phil. Mag.*, Sept. 1937, Series 7, Vol. 24, No. 161, pp. 396–405.)

4383. On Boole's Operators in the Calculus of Finite Differences [Treatment as Ordinary Variables by Means of Integral Transformations : Connection with Transformations due to Bromwich and Carson].—Florin. (*Phil. Mag.*, Sept. 1937, Series 7, Vol. 24, No. 161, pp. 492–502.)

4384. International Terminology in Engineering [Connection with Decimal Classification System, Dictionaries, and the Purification of Languages : Formation of German Committee].—Frank. (*Zeitschr. V.D.I.*, 4th Sept. 1937, Vol. 81, No. 36, pp. 1048–1050.)

4385. Recent Developments in the Photographic Copying of Published Articles.—Dadswell. (*Journ. of Council for Sci. & Indust. Res., Australia*, Aug. 1937, Vol. 10, No. 3, pp. 187–192.)

4386. A Property of a Bad Contact [between a Very Fine Wire and a Less Thin Wire : Resistance diminishes regularly as Current diminishes : Liable to Falsify certain Experimental Results].—Vernotte. (*Journ. de Phys. et le Radium*, June 1937, Vol. 8, No. 6, pp. 70–71S.)

4387. Noise in Photophone Receivers, and the H.F. Method of Its Suppression.—Yamada. (*See* 4188.)

4388. Light-Beam Control of Fog Signals.—Phippeny & Merrill. (*Lighthouse Conference, Berlin 1937 : Papers submitted by U.S. Lighthouse Service :* Topic B-3, pp. 2–9.)

4389. On Cathode-Ray Selector Design [for Telemechanics].—Kovalenkov & Petrov. (*See* 4255.)

4390. Carrier-Current Telephony with Partially Transmitted Carrier and Single Sideband [Amount of Carrier is fixed by Band-Pass Filter and Not by usual "Compensating Carrier Current" Method, and is Larger than usual, with Certain Advantages].—Chakravarti. (*L'Onde Élec.*, Aug. 1937, Vol. 16, No. 188, pp. 467–490.)

4391. Wired - Wireless Intercommunication Systems [for Offices].—(*Wireless World*, 24th Sept. 1937, Vol. 41, pp. 305–306.)

4392. Dose Measurement in Short- and Ultra-Short-Wave Therapy.—Schwarz. (*See* 4225.)

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. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

466 020.—Aerial and input circuit designed to receive either television signals or the normal broadcast programmes.

The General Electric Co. and D. C. Espley. Application date 14th November, 1935.

466 516.—Form and arrangement of a dipole aerial suitable for receiving television signals.

E. C. Cork. Application date 30th November, 1935.

469 245.—Television aerial and transmission line and method of matching their effective impedances over a wide band of frequencies.

E. C. Cork. Application dates 21st November, 1935, and 18th June, 1936.

TRANSMISSION CIRCUITS AND APPARATUS

466 014.—Two-way signalling system in which a common beat frequency is used for heterodyne reception at both terminal stations.

Telefunken Co. Convention date (Germany) 28th January, 1936.

466 032.—Thermionic oscillation-generator in which the frequency is stabilized by an electro-mechanical resonant device, such as a piezo-electric crystal.

Marconi's W.T. Co. and T. D. Parkin. Application date 20th November, 1935.

466 014.—Two-way short-wave set in which the difference between the carrier wave used for transmission and that used for reception serves as the intermediate frequency for superhet reception at both ends of the link.

The Telefunken Co. Convention date (Germany) 28th January, 1936.

466 327.—Multiplex signalling systems in which the original speech frequencies are converted into "defining" signals before transmission so as to ensure privacy.

Electrical Research Products Inc. Convention date (U.S.A.) 30th October, 1935.

466 686.—Coupling of a short-wave valve oscillator to a frequency-stabilizing resonant line comprising a pair of concentric tubes a quarter-wave long.

Marconi's W.T. Co. (assignees of H. Tunick). Convention date (U.S.A.) 15th June, 1935.

467 332.—Means for preventing or cancelling-out the effects of phase-distortion in modulated carrier-wave signalling systems.

Ferranti; M. K. Taylor; and S. Atkinson. Application date 10th September, 1935.

468 548.—Method of propagating ultra-short waves of the "displacement" type along a dielectric guide, and of modifying or reshaping them, say, from one form or orientation to another.

Standard Telephones and Cables (communicated by Western Electric Co. Inc.). Application date 25th September, 1936.

RECEPTION CIRCUITS AND APPARATUS

466 404.—Amplifying circuit with "negative" feed-back for reducing valve-curvature distortion.

N. V. Philips Lamp Co. Convention date (Germany) 23rd December, 1935.

466 415.—Superheterodyne receiver in which part of the output from the frequency-changer is fed back to the local oscillator in order to increase the overall selectivity of the set.

J. Robinson. Application date 22nd November, 1935.

466 526.—Receiver in which the degree of reaction is automatically adjusted in accordance with the setting of the wave-change switch.

E. K. Cole and G. Bradfield. Application date 31st January, 1936.

467 263.—Balancing-out or reducing the effect of transient interference in radio reception.

W. S. Percival. Application date 8th November, 1935.

467 284.—Self-contained short-wave adapter for a superhet receiver.

T. A. Biddington and R. Pearl. Application date 18th January, 1936.

467 771.—Method of facilitating the tuning of a wireless receiver by applying a check or brake to the controls at the critical point.

N. V. Philips Lamp Co. Convention dates (Germany) 20th August, 26th October, and 8th November, 1935.

468 172.—Receiver for converting frequency modulations into amplitude variations in carrier-wave signalling.

Marconi's W.T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.) 17th October, 1935.

468 763.—Method of balancing-out ignition interference in a motor-car radio set.

Galvin Manufacturing Corp. (assignees of R. E. Wood and R. S. Yoder). Convention date (U.S.A.) 10th January, 1935.

VALVES AND THERMIONICS

465 863.—Electrode assembly particularly suitable for a valve handling ultra-short waves.

Standard Telephones and Cables (assignees of Le Materiel Telephonique). Convention date (France) 12th December, 1935.

466 363.—Amplifier valve with one or more auxiliary diode or rectifying electrodes.

E. K. Cole and G. Bradfield. Application date 17th January, 1936.

DIRECTIONAL WIRELESS

465 792.—Wireless set for receiving directional or navigational signals from "marker" and overlapping beam beacons, particularly on board an aeroplane.

R. P. G. Denman. Application date 14th November, 1935.

466 122.—Radio navigation system for guiding and landing aeroplanes in which use is made of two syllables, such as "Croy" and "Don" to indicate the correct course.

D. N. Sharma. Application date 21st November, 1935.

467 547.—Balancing-out capacity reaction between the rotor and stator of a radiogoniometer, and correcting for quadrantal error.

Soc. des Etablissements Henry-Lepaute. Convention date (France) 26th November, 1935.

467 892.—Direction-finding system in which the bearing signals are integrated by high-speed switching means and are definitely distinguished from "jamming" or other undesired signals.

Marconi's W.T. Co. and G. M. Wright. Application date 20th November, 1935.

TELEVISION AND PHOTOTELEGRAPHY

465 887.—Amplifying circuit designed to give a uniform gain over a wide band of signal frequencies, as in television.

Baird Television and G. W. White. Application date 15th November, 1935.

465 892.—Time-base circuit for a television receiver in which the anode of the saw-toothed oscillation valve is directly connected to the deflecting-plates of the cathode-ray tube.

Baird Television and L. R. Merdler. Application date 16th November, 1935.

465 966.—Television scanning system in which an auxiliary scanning spot of constant intensity is utilised to augment the normal electron-emission from a photo-sensitive electrode.

The British Thomson-Houston Co. (communicated by the A.E.G.). Application date 22nd November, 1935.

465 970.—"Phasing" arrangement for use with a rotating-mirror scanning-device for television.

E. Traub.

466 419.—Separating the picture signals from the synchronizing impulses in a television receiver.

Baird Television and L. M. Merdler. Application date 23rd November, 1935.

466 715.—Method of superposing both picture signals and synchronizing impulses upon the carrier wave at the same amplifying stage in a television transmitter.

Baird Television and G. W. White. Application date 2nd December, 1935.

466 826.—Electrostatic deflecting-plates for a cathode-ray television receiver.

E. Ruska and Fernsen Akt. Application date 24th December, 1935.

467 916.—Rectifying and filter circuit for separating the picture signals from the synchronizing-impulses used in television.

Radio-Akt. D. S. Loewe. Convention date (Germany) 2nd January, 1935.

467 918.—Method of reproducing television pictures outside a cathode-ray tube by utilising the effect of the scanning stream upon the total reflecting properties of a glass prism mounted at the end of the tube.

Marconi's W.T. Co. and G. M. Wright. Application date 27th December, 1935.

468 191.—Television system in which the signals are transmitted on a single carrier of constant frequency and are projected as simultaneous lines on the viewing-screen of the receiver.

F. von Okolicsanyi. Convention date (Germany) 12th December, 1935.

468 483.—Cathode-ray television transmitter in which an electrode producing secondary emission is interposed between the "gun" and the photo-electric screen.

Standard Telephones and Cables (assignees of Nippon Electric Co.). Convention date (Japan) 3rd August, 1935.

468 965.—Arrangement for ensuring that the electron stream in a cathode-ray television transmitter reaches all points on the photo-electric screen in a direction perpendicular to its surface.

H. G. Lubszynski. Application date 15th January, 1936.

SUBSIDIARY APPARATUS AND MATERIALS

465 830.—Moving-coil speaker having a large and relatively flaccid diaphragm, and also a light rigid diaphragm working into a flat horn.

E. K. Cole and A. E. Falkus. Application date 21st November, 1935.

466 031.—Photo-electric light valve which operates by variations produced in the "adhesion" attraction between small crystals, such as mica.

Marconi's W.T. Co.; L. M. Myers; and E. F. Goodenough.

467 516.—Loud speaker in which the driving force is applied to the base of the cone in a direction extending along the line of its walls towards the apex.

W. Ditsche. Convention date (Germany) 19th December, 1934.

468 146.—Photo-electric cell fitted with a centre electrode and a spiral anode for producing secondary emission.

The General Electric Co. and C. H. Simms. Application date 4th March, 1936.

MISCELLANEOUS

466 046.—Preventing distortion effects in a cathode-ray tube due to the use of A.C. for heating the filament of the tube.

E. Michaelis (communicated by E. Kinne). Application date 25th January, 1936.

466 426.—Construction of cathode-ray tube whereby the usual "thickening" of the glass at the neck of the tube is avoided.

Baird Television and A. H. Johnson. Application date 27th November, 1935.

468 179.—Cold-cathode high-frequency oscillators utilising secondary emission.

Marconi's W.T. Co. (assignees of W. van B. Roberts). Convention date (U.S.A.) 5th November, 1935.