THE
WIRELESS ENGINEER

VOL. XIV. AUGUST, 1937 No. 167

Editorial

Standardisation in Science

AT a special meeting of the Verein Deutscher Elektrotechniker held on 18th March the Siemens-Stephan memorial medal was presented to Dr. Julius Wallot, for many years one of the leading members of the German Committee for Units and Definitions and its Chairman since 1930. After the presentation Dr. Wallot delivered an address on "Science and Standardisation," but explained at the outset that he only intended to deal with the internal standardisation of science and not with its commercial applications. Some might think that standardisation had no place in science since, if one asks a question of Nature, one must accept Nature's answer. This is true of the work of those engaged in the direct attack on the fundamental secrets of nature, the front-line troops as Dr. Wallot calls them.

Standardisation begins where agreement is necessary and ceases when things can be proved, and it is surprising how much there is in science that necessitates those engaged in it coming to some agreement. Many of our difficulties, when teaching the elements of the subject, for example, are due to the fact that we do not distinguish clearly enough between things which can be proved and things which we have agreed to assume. This distinction is very important when dealing with the foundations of science, since every proof is built upon certain agreed assumptions. Such agreement is standardisation.

When the German Committee was called into being by Karl Strecker thirty years ago the first question considered was that of symbols, and although superior persons might smile at a committee discussing whether a certain magnitude should be designated by X or U, the importance of agreement on such matters should not be under-estimated. Closely related to the question of symbols is that of terms and the names given to units, the latter a subject in which national pride plays a part in international deliberations. Dr. Wallot pointed out that it took 25 years to get the International Electrotechnical Commission to agree to apply the name "Siemens" to the unit of conductance instead of an undignified distortion of the name of another German scientist, Ohm. One of the original objections to the name "Siemens" for the unit of conductance has certainly vanished, viz., the possibility of confusion with the Siemens unit of resistance which was in use before the ohm was standardised. Dr. Wallot dealt in some detail with the definitions of the magnetic magnitudes and units because of the criticism which has been directed against them. The Committee had originally considered only the giving of names to the units. Until about 1920 physicists expressed field strength in Gauss, but had no name for the c.g.s. unit of magnetic induction. The first suggestion was to call it a Weber; this was in 1919, but it soon became evident that electrical engineers everywhere measured *B* and not *H* and expressed the result in Gauss. The question could not be brushed aside by saying that *H* and *B* had the same dimensions and were therefore really identical, first, because practically everyone who plotted a magnetisation curve regarded *H* and *B* as cause and effect, and secondly, because it was a hotly debated question whether they really had the same dimensions.

The Gauss and the Oersted

Anyone who had not followed the lengthy discussions which took place on the subject, especially in France, must have been very surprised when at Oslo, in 1930, the I.E.C. agreed to give the name "Gauss" to the unit of magnetic induction *B*, and the name "Oersted" to that of magnetising force *H*. The latter step was entirely new both to physicists and electrical engineers and it has been criticised, but although he was not a party to the Oslo decision, Dr Wallot thinks that it was a wise one. Shortly before the Oslo Conference the German Committee after lengthy discussions, in which both physicists and engineers took part, had published a provisional scheme in which *H* and *B* were defined as two different conceptions having different dimensions and measured in different ways. Dr. Wallot maintains that the conception of magnetising force, as defined by the Committee, does not provide by itself a sufficient basis on which to build, but that the conception of magnetic induction, as defined, does provide such a basis. This is in keeping with our definition of magnetic induction as an observable characteristic of the magnetic field and of magnetising force as a purely calculated concept.*

The objection that two conceptions have been defined where one would have sufficed Dr. Wallot holds to be quite unjustified. Anyone is at liberty to use only the conception of magnetic induction and to refer to it as such, but he should not use the conception of magnetic induction and refer to it sometimes as magnetic induction and sometimes as magnetic force, as is often done. The object of a Standardising Committee is not to perpetuate confusing usages, however historical they may be. Dr. Wallot admits that it requires some optimism to believe that physicists will refer consistently to magnetic induction, but this will be greatly helped by the wise decision to retain the name Gauss for the unit of that which can be measured, viz., the magnetic induction.

The advantage to the community of any labour-saving rationalisation depends on the extent to which it is used. The question whether vector products should be indicated this way or that can only affect a relatively small number of people, but when one thinks of the thousands of school children and adults who, year after year, are forced to turn degrees into minutes of angle and minutes into seconds, and vice versa, all because the Babylonians used a sexagesimal division, one realises the enormous waste of time and energy which might be better employed. It is difficult to modify many such irrational schemes because of their honourable antiquity or of the capital involved, but, fortunately, these considerations are of little weight in the field of standardisation which we are considering. Dr. Wallot's sexagesimal example may appear horrible to a German, but it is rationality itself compared with our British system of weights and measures.

Dr. Wallot's address was published in full in the *E.T.Z.* of the 17th June, and in the following number Professor Rogowski, for many years the Editor of the *Archiv für Elektrotechnik*, in a biographical note on Prof. Fritz Emde, expresses his appreciation of the services rendered by Emde in conjunction with Giorgi, Wallot, and Mie in furthering and establishing so convincingly the practice of basing the electric and magnetic units upon four fundamental magnitudes.

We have discussed this address because it indicates clearly the views held by the leading electrotechnical experts in Germany on a subject to which we have occasionally devoted this editorial column.

G. W. O. H.

* See *The Wireless Engineer*, Jan. 1937, Editorial.

Free Oscillations of a Resonant Circuit Loaded by a Diode Rectifier*

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

1. Introduction

THE general behaviour of diode rectifiers is well known and needs only brief consideration here. The circuit to be considered is typified by Fig. 1, which shows a rectifier supplied with a sinusoidal input voltage. Here "rectifier" refers to the combination of valve and load circuit. If the slope resistance of the valve is small compared with the load resistance R, there appears across the load a voltage V in the sense shown which has a value very nearly equal to the peak value of the applied voltage, it being assumed that the time constant of the load circuit is great compared with the periodic time of the applied voltage.

The steady voltage V across the load is maintained by short pulses of current which pass through the valve during the epoch of positive peak value of the input voltage. The operation of the rectifier is thus essentially discontinuous and exact calculation of its reaction on a network to which it is connected is therefore extremely laborious. In radio receivers, the rectifier is commonly connected to a resonant circuit across which the supply voltage is developed. A rigorous examination of this combination would take account of the response of the circuit to the higher harmonics of the pulses of current drawn by the rectifier. It is usual, however, to assume that these higher harmonics find a low impedance path through the capacitance arm of the circuit, and they are accordingly neglected. The fundamental component of the rectifier current is sensibly in phase with the applied voltage since the pulses of current are of very short duration and occur nearly symmetrically about the peak value of the input. Accordingly, the rectifier is supposed to exert a negligible effect on the resonant frequency of the circuit and to exhibit a sensibly pure resistance to the applied voltage. The value of the resistance has been determined by considerations of power balance in the rectifier and found to be slightly greater than one-half the load resistance R[1].

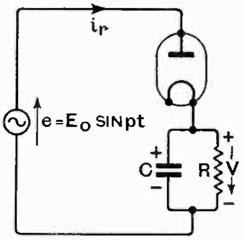


Fig. 1.—*Typical rectifier circuit.*

The prediction of the behaviour of a resonant circuit loaded by a rectifier has accordingly proceeded on the assumption that the rectifier could be replaced by an equivalent pure resistance of about one-half the load resistance. This value of equivalent resistance was deduced, however, under steady conditions; that is, with a supply voltage of constant amplitude when the steady state had been reached. It is the purpose of the present paper to show that only when these steady conditions hold is the above solution valid, and to determine the equations governing free oscillation of a resonant circuit loaded by a rectifier, as the first step in the prediction of the behaviour of the combination.

2. Steady State Conditions

Referring to the circuit of Fig. 1, it has been shown by Marique[3] that when the input voltage is of constant amplitude E_0, and when the time constant of the load circuit is great compared with the periodic time of the input voltage, then

$$V = kE_0 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where k is independent of E_0 to the first order and approximates very closely to unity provided the load resistance is much greater than the valve slope resistance.

The very short pulses of current which flow through the valve to maintain the

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

output voltage V can be represented as a Fourier series :—

$$i_r = A_0 + A_1 \sin pt + A_2 \sin 2pt + B_1 \cos pt + B_2 \cos 2pt \ldots \quad (2)$$

It can readily be shown by ordinary methods of harmonic analysis that as the duration of current flow tends to zero,

$A_1, -B_2, -A_3, +B_4, +A_5 \ldots$ etc. $\rightarrow 2A_0$

and

$B_1, A_2, B_3, A_4, B_5 \ldots$ etc. $\rightarrow 0$.

Hence, neglecting harmonic terms other than the fundamental for reasons outlined in the introduction, and assuming that the steady term A_0 finds a low resistance path in the circuit external to the rectifier* and can also be omitted, the component of rectifier current of importance in the external circuit can be written approximately as

$$i_r = A_1 \sin pt = 2A_0 \sin pt \quad \ldots \quad (3)$$

The equivalent input resistance, r_e say, already quoted, can readily be deduced for

$$A_0 = V/R$$

and
$$r_e = \frac{e}{i_r} = \frac{E_0 \sin pt}{2A_0 \sin pt} = R\frac{E_0}{2V}$$
$$= R/2k \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

from (1).

This result has already been deduced by Terman and Morgan,[1] and is well known. It is deduced here only to illustrate its dependence on the assumption of a constant input amplitude. That it is invalid when the amplitude is varying becomes evident in the next section.

3. Rectifier Current with Varying Input Amplitude

If, in Fig. 1, the generator is replaced by one which delivers an output of varying amplitude E ($= f(t)$) of the form

$$e = E \sin pt,$$

the output voltage V exhibits sympathetic variations. If the change in E is small during the time of a complete oscillation $2\pi/p$, and if certain other conditions to be discussed later are satisfied, it is known that equation (1), with the substitution of E for E_0, remains sensibly true. The method of rectifier operation remains unaltered and equation (2) is valid, but now the coefficients $A_0, A_1, A_2 \ldots B_1, B_2 \ldots$ etc., exhibit a slow variation with time.

* For instance, through the inductance of a resonant circuit, see Fig. 2.

Equation (3) also remains true, but now

$$A_0 = V/R + C\frac{dV}{dt}$$

since V has a variation with time. Be it noted that V is the output voltage of the rectifier supposed freed from R.F. components of frequency equal to or greater than $p/2\pi$. From the modified form of equation (1), $\frac{dV}{dt} = k\frac{dE}{dt}$.

And, from (1) and (3)

$$i_r = 2k\left(\frac{E}{R} + C\frac{dE}{dt}\right) \sin pt \quad \ldots \quad (5)$$

It appears from this equation that if $\frac{1}{E}\frac{dE}{dt}$ were negative and numerically greater than $\frac{1}{CR}$, the phase of i_r would change by 180°. Actually this is impossible on account of unidirectional current flow in the valve, and a limitation of the analysis is that,

$$-\frac{1}{E}\frac{dE}{dt} \ngtr \frac{1}{RC} \quad \ldots \quad \ldots \quad \ldots \quad (5a)$$

Expressed in words, the fractional rate of fall of amplitude in the voltage applied to the rectifier must not exceed the inverse of the time constant of the rectifier load circuit. The same limitation has been discussed elsewhere ([2]) in relation to modulated signals, and it has been shown that unless this condition is satisfied, equation (1) is invalid, and the rectifier output voltage V is then unrelated to the input amplitude E. Physically this is due to the inability of the rectified voltage V to fall quickly enough to permit valve conduction at each positive peak ; V then remains always greater than E throughout the period in which equation (5a) is not satisfied.

The analysis proceeds therefore on the assumption that (5a) is satisfied.

4. Free Oscillations of a Resonant Circuit Loaded by a Diode Rectifier

Fig. 2 represents a resonant circuit connected to a diode rectifier. The circuit losses are represented by the shunt resistance R_1.

We have

$$i_L + i_R + i_C + i_r = 0.$$

If e is the instantaneous circuit voltage as shown, differentiation followed by evaluation of the currents yields,

$$\frac{e}{L_1} + \frac{1}{R_1}\frac{de}{dt} + C_1\frac{d^2e}{dt^2} + \frac{di_r}{dt} = 0.$$

Substitution for i_r from equation (5) involves the introduction of terms such as $E \sin pt$.

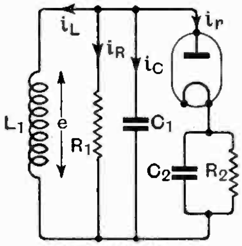


Fig. 2.—*Resonant circuit loaded by a diode rectifier. The circuit losses are represented as a shunt resistance R_1. Branch currents as indicated.*

Fortunately the equation can be solved by assuming a solution

$$e = E \sin pt$$

where E is again a function of time.

For then

$$\frac{E \sin pt}{L_1} + \frac{1}{R_1}\left(pE \cos pt + \frac{dE}{dt}\sin pt\right)$$
$$+ C_1\left(- p^2E \sin pt + 2p\frac{dE}{dt}\cos pt\right.$$
$$\left. + \frac{d^2E}{dt^2}\sin pt\right) + 2k\left(\frac{E}{R_2} + C_2\frac{dE}{dt}\right)p \cos pt$$
$$+ 2k\left(\frac{1}{R_2}\frac{dE}{dt} + C_2\frac{d^2E}{dt^2}\right)\sin pt = 0$$

Whence :—

$$\left\{\frac{E}{L_1} + \left(\frac{1}{R_1} + \frac{2k}{R_2}\right)\frac{dE}{dt} - C_1p^2E\right.$$
$$\left. + (C_1 + 2kC_2)\frac{d^2E}{dt^2}\right\}\sin pt = 0$$

and

$$\left\{E\left(\frac{1}{R_1} + \frac{2k}{R_2}\right) + 2(C_1 + kC_2)\frac{dE}{dt}\right\}p \cos pt = 0$$

Or, writing

$$T = 2\left[\frac{C_1 + kC_2}{\frac{1}{R_1} + \frac{2k}{R_2}}\right] \quad \ldots \quad \ldots \quad (6)$$

and substituting for $\frac{dE}{dt}$ and $\frac{d^2E}{dt^2}$ in the first equation by differentiation of the second, we have,

$$\{E/L_1 - C_1p^2E - C_1E/T^2\} = 0 \quad \ldots \quad (7a)$$

and

$$1 + \frac{T}{E}\frac{dE}{dt} = 0 \quad \ldots \quad \ldots \quad (7b)$$

Or, letting $E = E'$ when $t = 0$,

$$p = \sqrt{\frac{1}{LC} - \frac{1}{T^2}} \quad \ldots \quad \ldots \quad (8a)$$

$$\text{and} \quad E = E'\epsilon^{-t/T} \quad \ldots \quad \ldots \quad \ldots \quad (8b)$$

the equation of the oscillation being then

$$e = E'\epsilon^{-t/T}\sin\sqrt{\frac{1}{LC} - \frac{1}{T^2}}\,t \quad \ldots \quad (9)$$

This equation shows that when a combination of resonant circuit and rectifier is allowed to oscillate freely, an exponentially damped oscillation ensues governed by equations similar to those relevant to a simple resonant circuit. The natural frequency of the oscillations differs but little from the resonant frequency of the circuit since in general practice T may be about $100\sqrt{LC}$. The time constant of the decay is dependent on the constants of the rectifier load circuit, and is not necessarily less than that of the circuit alone, for equation (6) can be rewritten

$$T = 2R_1C_1\left[\frac{1 + kC_2/C_1}{1 + 2kR_1/R_2}\right]$$
$$= aT_1$$

where $T_1 = 2R_1C_1$ is the circuit time constant, and

$$a = \frac{T}{T_1} = \left[\frac{1 + kC_2/C_1}{1 + 2kR_1/R_2}\right] \quad \ldots \quad (10)$$

It may be noted here that if the rectifier were replaced by an equivalent resistance $\frac{R_2}{2k}$, an exponentially damped oscillation would be deduced, but the relevant value of a would not be that given by equation (10); it would be independent of C_2, and would necessarily be less than unity. Accordingly, the experiments described later were designed to illustrate the dependence of a on C_2.

It may be noted also that, according to equation (10), a may exceed unity. Actually such cannot be the case, for from (5a) we must have

$$-\frac{1}{E}\frac{dE}{dt} \ngtr \frac{1}{R_2C_2}$$

or, substituting for $\frac{1}{E}\cdot\frac{dE}{dt}$ from (7b), the maximum possible value of R_2C_2 is

$$R_2C_2 = T.$$

It follows from equation (10) that $\alpha = 1$ when

$$T = T_1 = R_2C_2 \quad \ldots \quad \ldots \quad (11)$$

Hence the maximum value of α is unity, since α increases with R_2 and C_2.

If the circuit constants are such that $\alpha > 1$ in equation (10), the rate of fall of V (see Fig. 1) is less than the rate of fall of input amplitude E, with the result that V rapidly becomes greater than E during the decay of oscillations; valve conduction ceases entirely and equation (1) is invalid. The circuit then oscillates independently of the rectifier and the observed time constant is T_1 giving $\alpha = 1$.

Experimental Investigation.

A cathode ray oscillograph furnished with a linear time base was used to delineate the circuit oscillations. The circuit used is shown in Fig. 3.

At the end of each time sweep the circuit received an impulse due to the "flash back" of the time base through the small condenser C_3. The time base was synchronised from the circuit oscillations in order to obtain a steady figure.

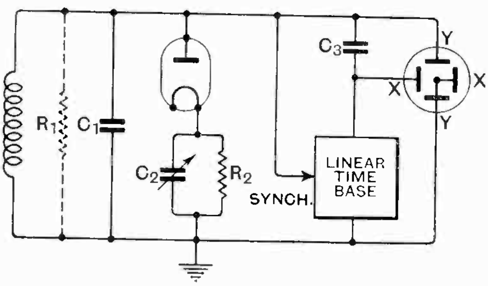
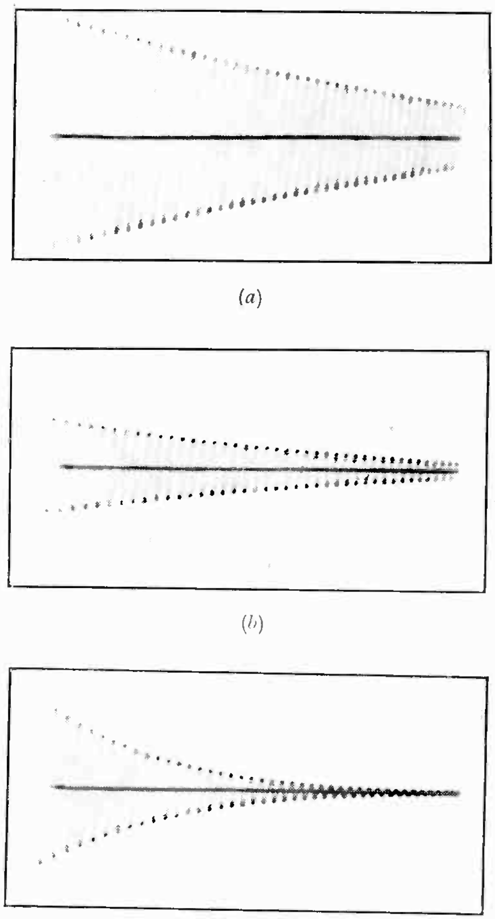


Fig. 3.—*Circuit used to obtain oscillograms of free oscillations. The circuit loss resistance is shown dotted.*

Experiments were first made to determine the form of the oscillation. Typical oscillograms are shown in Fig. 4. Measurement of the amplitude ratio between successive peaks along the length of the oscillograms showed that the envelope was exponential as pre-



(a)

(b)

(c)

Fig. 4.—*Oscillograms of free oscillations of a resonant circuit loaded by diode rectifier. The circuit constants were* $C_1 = 1105\ \mu\mu$F., $R_2 = 50{,}000$ *ohms, resonant frequency* = 99 *kc/s.*

(a) *Circuit alone, valve cathode cold.*

(b) C_2 *large, but less than* C_2'.

(c) C_2 *small.*

dicted. The enclosed oscillation, when extended by time base adjustment, appeared to be sinusoidal. No attempt was made to determine the frequency of the oscillation since equation (8a) shows it to be indistinguishable from the resonant frequency. The resonant frequency was, however, found to be sensibly unaffected by rectifier operation.

Oscillogram (*a*) of Fig. 4 relates to the circuit alone; it was obtained with the valve cathode cold. Oscillograms (*b*) and (*c*) were obtained with the rectifier operating: for (*b*), C_2 was large and for (*c*) C_2 was small. It can be seen at once that reduction of C_2 leads to a decreased time constant as indicated by equation (6). It has been mentioned that if the rectifier were assumed equivalent to a simple resistance equal to approximately half the load resistance, the calculated time constant would be independent of C_2. Evidently such assumption is invalid.

Quantitative verification of the analysis was obtained as follows.

First C_1, R_2 and the resonant frequency of the circuit were determined. R_1 was

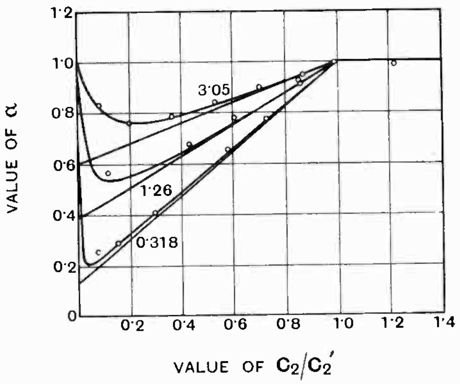


Fig. 5.—*Dependence of α on C_2/C_2'. Circuit conditions as under. C_1 = 1105 μμF., resonant frequency 99 kc/s. The figures on the curves give the relevant values of R_2/R_1. The curves are calculated values (see text). The plotted points are experimental results.*

then evaluated by measuring the decay time constant of the circuit alone, T_1. This measurement was facilitated by the assumption that the natural frequency approximated very closely to the resonant frequency as indicated by equation (8a). A suitable value of R_2 was then chosen. The value of C_2, say C_2', which made $\alpha = 1$, was then determined from equation (11), and C_2, which was a calibrated variable condenser, was set to a value slightly less than C_2'. The time constant, T, of the resulting oscillogram was measured and the value of $\alpha \left(= \frac{T}{T_1}\right)$ determined. α was also predicted from equation (10). The two values of α, predicted and experimental, relating to the oscillograms of Fig. 4 and three others, are shown in Table I, and are in good agreement.

TABLE I.

ILLUSTRATION OF DECREASE OF α WITH DECREASE OF C_2.

C_2 (μμF.).	Calculated α.	Observed α.
6060	0.88	0.91
4 (*b*) 5060	0.76	0.77
4060	0.64	0.65
2060	0.39	0.41
4 (*c*) 1060	0.27	0.29

The circuit constants were:

C_1 = 1105 μμF., R_2 = 50,000 ohms, $\frac{p}{2\pi}$ = 99 kc/s.

Oscillogram 4 (*a*), taken with the valve cathode cold, yields the value 157,000 ohms for R_1, giving C_2' = 7000 μμF.

Further experimental confirmation is summarised in Figs. 5 and 6, which refer to circuits resonating at 99 kc/s and 31 kc/s respectively. The ordinates are values of α and the abscissae are values of C_2/C_2'. Curves relating to several values of R_2/R_1 are given. The straight lines give the value of α calculated from equation (10), assuming $k = 1$; the plotted points are experimental results. Agreement is good except when

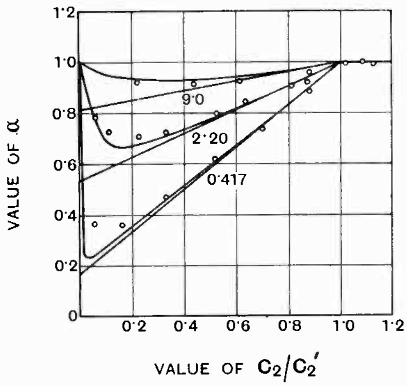


Fig. 6.—*Dependence of α on C_2/C_2'. Circuit conditions as under. C_1 = 1183 μμF., resonant frequency 31 kc/s. The figures on the curves give the relevant values of R_2/R_1. The curves are calculated values (see text). The plotted points are experimental results.*

C_2/C_2' is small or R_2/R_1 is large. Both these conditions correspond with small values of C_2, and the discrepancy is ascribed to the effect of interelectrode capacitance in the valve. An analysis, taking account of this capacitance, Cd say, has been made but need hardly be given here. This analysis showed that equation (10) remained valid provided P^2k was written for k, where

$$P = \frac{C_2}{C_2 + Cd}.$$

Further, C_2 becomes $(C_2 + Cd)$ [2], and C_1 becomes $C_1 + PCd$. With these modifications the expectation is given by the curves of Figs. 5 and 6, which follow the experimental points very closely. Such discrepancy as remains at low values of C_2 is ascribed to a decreasing value of k, as a result of the time constant of the rectifier load circuit becoming comparable with the periodic time of the oscillations.[3] Several points are plotted for values of $C_2/C_2' > 1$. These give $\alpha = 1$ as expected.

Conclusion.

It is concluded that a diode rectifier can be assumed equivalent to a resistance of about half the load resistance only when the amplitude of the input signal is constant. With varying input amplitude such assumption is invalid, for the time constant of the combination of circuit and rectifier is found to be dependent also on the value of the load capacitance. However, the combination executes free oscillations of the type normally associated with resonant circuits. The natural frequency of these oscillations approximates very closely to the resonant frequency of the circuit alone. The time constant governing the decay of amplitude is given by equation (6) and may be equal to or less than that of the circuit alone. The decay time constant cannot exceed that of the circuit for then the rectifier and circuit operate independently.

These results are believed to be of considerable importance in radio technology, for the modulation frequency response and selectivity of a resonant circuit loaded by a diode rectifier are dependent on the time constant of the combination, which has hitherto been considered essentially less than that of the circuit alone. Further, earlier papers have discussed conditions for faithful rectification of modulated signals in terms of the modulation frequency and depth of modulation. The latter is not usually known except at the input ; its value at the rectifier depends on the response curve of the apparatus, which in turn depends on the time constant of the rectifier stage. These, and other problems, are being investigated.

The research described in this paper was carried out in the John Hopkinson Laboratories at Manchester University, and the author is indebted to Professor R. Beattie for facilities placed at his disposal, and to Mr. W. Makinson, M.Sc., for assistance with the experimental work.

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THE LATE MARCHESE MARCONI

It is with the deepest regret that we have to record the death in Rome on July 20th of the Marchese Marconi. The story of Marconi's life work and his services to mankind are so well known as to require no restatement here. Wireless communication, which he initiated in practical form and sponsored through the early and difficult stages of its development, remains a permanent monument to his genius.

Inverse Feed-Back*

Its Application to Receivers and Amplifiers

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PART of the output voltage of an amplifier may be fed back to the input with the result that the performance of the amplifier will be altered. Formerly the usual object of feed-back was to increase the amplification, but more recently applications of feed-back have been made, whereby the amplification was decreased to obtain other advantages. This form of feed-back, which may be termed inverse feed-back, was investigated in 1928 by K. Posthumus of this laboratory [1] and by Black and has lately become better known by papers of several authors, notably a paper by Black [2].

The object of the present paper is to discuss several properties of inverse feed-back amplifiers and more specifically the application of inverse feed-back to amplifiers and receivers feeding a loud speaker.

General Properties of Inverse Feed-Back

When feed-back is applied to an amplifier, as illustrated in Fig. 1, we must distinguish between the signal voltage E_s and the input voltage E_i to the amplifier proper, the difference being equal to the feed-back voltage E_b. When the voltages are considered to be positive when working in the denoted directions, then

$$E_i + E_b = E_s \quad \ldots \quad (1)$$

If the input impedance of the amplifier, i.e. the impedance between the terminals 1 and 2, is large with respect to the output impedance of the feed-back circuit, i.e. the impedance between the terminals 3 and 4, E_b will not be influenced by E_s directly, but only through the amplifier and the feed-back circuit, and E_0 will also only be influenced by E_s through the amplifier and not inversely via the feed-back circuit. If we denote the amplification of the amplifier by α and the part of E_0 which is fed

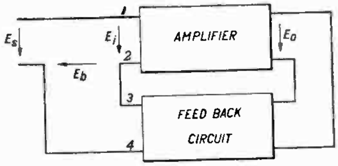

Fig. 1.—*General feed-back circuit.*

back by β (α and β in general being complex quantities depending on the frequency), we can write

$$E_0 = \alpha E_i$$
$$E_b = \beta E_0, \text{ and so}$$
$$E_b = \alpha\beta E_i.$$

Putting this into (1) we obtain

$$E_i = \frac{1}{1 + \alpha\beta} E_s, \text{ hence}$$

$$E_0 = \frac{\alpha}{1 + \alpha\beta} E_s \quad \ldots \quad (2)$$

If $\alpha\beta$ is real, negative and of absolute value smaller than one, the amplification is increased by the feed-back. If $\alpha\beta = -1$ the amplification becomes infinite, i.e. the system becomes unstable. If $\alpha\beta$ is real and positive, the amplification is decreased. In general, apart from stability considerations, which one of us hopes to discuss on another occasion, the modulus $|1 + \alpha\beta|$ determines the change in amplification. When this modulus is large with respect to one, $1 + \alpha\beta$ is approximately equal to $\alpha\beta$ and (2) reduces to

$$E_0 = \frac{1}{\beta} E_s \quad \ldots \quad (3)$$

We see that α is no longer contained in (3). Now α, being the amplification of the amplifier without feed-back, will generally

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

[1] *Cf.* British Patent 323 823.

[2] H. S. Black, Stabilized feed-back amplifiers. *Bell System Techn. Journal*, 13, 1, 1934; also *Electrical Engineering*, 53, 114, 1934.
G. H. Bast and F. H. Stieltjes, A new feed-back repeater. *Post Office Electr. Eng. Journal*, 28, 225, 1935.

be a function of the frequency which it is not always easy to give the required shape and, moreover, α depends on the properties of the valves, in particular on the slope, which may vary due to several circumstances: not all valves of the same type have exactly the same slope and this slope varies to a certain extent during the life of the valve and depends also on the tension of the mains, which is not always constant. When a large amount of feed-back is used, the amplification depends on β only, which is determined by the feed-back circuit. This circuit generally will not contain valves and can easily be constructed in such a way to give β the desired frequency dependence. If constant amplification is required, the feed-back circuit may consist of two resistances in series mounted in parallel to the output. (Fig. 2).

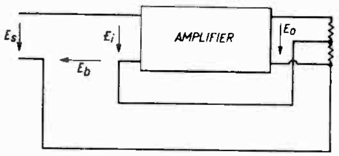

Fig. 2.—*Feed-back circuit to obtain constant amplification.*

Equation (3) suggests another advantage of inverse feed-back. An amplifier is generally not linear, due to the curvature of the valve characteristics, and so harmonics and combination frequencies may be generated within it. The feed-back circuit can be constructed of linear elements, so that it may be expected that when the amplification depends on β only no harmonics and combination frequencies will be present in E_0.

We can easily calculate the reduction of harmonics, when distortion is small; in that case, generally, only the second harmonic is of importance. Let us suppose E_s to be sinusoidal. If a certain amount of second harmonic P is present in the output voltage E_0, E_b will contain an amount βP of second harmonic and as the signal voltage consists of the fundamental frequency only, by virtue of (1) E_i will contain an amount of $-\beta P$ of second harmonic. The second harmonic in E_0 consists of two parts. One part is due to the second harmonic in E_i and will be equal to $-\alpha\beta P$, the other part Q is generated in the amplifier due to the non-linear elements in it. In the case of small second harmonic distortion Q depends on the component of fundamental frequency in E_i only and is not influenced by the presence of $-\beta P$ in E_i. Thus Q is the amount of second harmonic in the absence of feed-back. As we originally supposed the amount of second harmonic with feed-back in E_0 to be P, we come to the following equation:

$$P = -\alpha\beta P + Q, \text{ hence}$$

$$P = \frac{Q}{1 + \alpha\beta} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (4)$$

The foregoing reasoning shows that in (4) α and β are to be taken at the frequency of the harmonic, not of the fundamental. The amplitude of the second harmonic is thus reduced by $|1 + \alpha\beta|$, which is equal to the decrease in amplification by feed-back of a signal of the frequency of this harmonic.

In this region of small second harmonic distortion the output energy from the amplifier varies proportionally to E_s^2, the percentage distortion proportionally to E_s and thus the output energy varies as the square of the percentage distortion. If, by the application of inverse feed-back, the amplification is reduced a times, the percentage distortion will also be reduced a times. If the same amount of distortion as without feed-back is allowed, the output energy can be raised a^2 times. If e.g. a distortion of only 1 per cent. is allowed and the amplification is reduced 3 times by feed-back, the output energy may be raised 9 times.

When distortions become larger and higher harmonics occur, relations are not so simple, as has been shown by Feldtkeller.[3] In this case the harmonics present in E_i may combine in the non-linear elements of the amplifier with the fundamental and amongst themselves to give rise to additional harmonics which add to the amplified harmonics of E_i and the harmonics generated by the fundamental alone. For example, when second and third harmonics are present in E_i, part of the third harmonic in E_0 will be generated directly by the fundamental and part will result from a combination of the

[3] R. Feldtkeller, Die 3. Teilschwingung in Verstärkern mit Gegenkopplung, *Telegr. und Fernsprechtechn.* 25, 217, 1936.

fundamental and the second harmonic. Feldtkeller has shown that the result is, that with a small amount of inverse feed-back in certain cases the higher harmonics in the output can increase, but that when feed-back is raised sufficiently, these harmonics will decrease again. If second harmonic distortion is absent, as in the case of push-pull, and distortion is small, only the third harmonic is of importance. By inverse feed-back the reduction of the third harmonic will now be equal to the decrease in amplification of a signal of the frequency of this harmonic.

Application to Receivers and Amplifiers Feeding a Loud Speaker

Above we considered E_b to be a certain part β of the output voltage. If the amplifier is loaded with a loud speaker, we may consider the voltage on the loud speaker as the output voltage. If β is independent of frequency, the application of inverse feed-back will make the amplification from the input to the voltage on the loud speaker nearly independent of frequency. Instead of a certain part of the output voltage, E_b may be made equal to a certain factor γ times the output current. All considerations of the first part of this article may be applied to this case. In particular, if the current through the loud speaker is considered as the output current and if γ is independent of frequency, the application of inverse feed-back will make the amplification from the input to the current through the loud speaker nearly independent of frequency. We may denote the first method of inverse feed-back as *voltage feed-back*, the second method as *current feed-back* (these terms can also be used if β and γ depend on frequency). In the case of voltage feed-back the output voltage becomes nearly independent of the load, or, in other words: voltage feed-back lowers the internal resistance of the amplifier. In the case of current feed-back the output current becomes nearly independent of the load, or, in other words, current feed-back raises the internal resistance of the amplifier. What should we aim at?

If we make the current through the coil of a moving-coil loud speaker independent of frequency, the sound output will have a large maximum at the principal resonance frequency of the loud speaker, determined by the mass and compliance of the moving part, which usually lies between 50 and 100 c/s. This resonance will be much more pronounced than when feeding a loud speaker in a normal way through a pentode output valve. The high internal resistance of a pentode will make the current through the primary of the output transformer independent of frequency, but due to the limited value of the transformer inductance the current through the loud speaker coil will not be independent of frequency. Especially at the resonance frequency of the loud speaker, where the speaker impedance is large, the current through the loud speaker coil can show a minimum and so the resonance in the sound output will be much less pronounced than with a constant current through the loud speaker coil.

If we make the voltage on the loud speaker independent of frequency, the resonance in the sound output will be still further reduced. On the other hand, many loud speakers give the best high note reproduction if the current through the coil is independent of frequency. As the impedance of most loud speakers increases when the frequency increases, this condition may differ considerably from a constant voltage on the loud speaker. We thus come to the conclusion that at the lower frequencies we should like to apply voltage feed-back and that at the higher frequencies we should like to apply current feed-back. We can overcome this difficulty by applying voltage feed-back which depends in an appropriate way on the frequency. If, without feed-back, and disregarding the frequencies near the principal loud speaker resonance, the amplification from the input to the current through the loud speaker is independent of frequency, the amplification α to the voltage on the loudspeaker will be proportional to the loud speaker impedance. If β is constant, $|1 + \alpha\beta|$ will increase when the frequency increases and therefore the higher frequencies will be more attenuated than the lower frequencies. If, however, we make β inversely proportional to the loud speaker impedance at the higher frequencies, $|1 + \alpha\beta|$ will become constant and the amplification to the loud speaker current will become constant at the higher frequencies, whilst at the lower frequencies the amplification to the loud speaker voltage will become constant.

We can realize this form of feed-back, e.g. by the circuit of Fig. 3. This circuit represents an ordinary resistance-coupled audio-frequency amplifier containing a triode amplifier and a pentode output-valve. To obtain feed-back an impedance is put in parallel to the secondary of the output transformer and part of this impedance is connected in the cathode-lead of the amplifying valve. L_1, R_1 and R_2 together can be given such values, that the combination has about the same frequency dependence as the loud speaker impedance at the higher frequencies. The value of this parallel impedance can be made large enough with respect to the loud speaker impedance that only a negligible part of the output energy is absorbed by it, whereas the impedance in the cathode-lead of the amplifying valve can remain small. Suppose e.g. that the first valve is a Mullard 354V which amplifies 20 times. If a Mullard PenA4 is used in the output stage, the amplification at a medium frequency, e.g. 800 c/s, is 60 times (slope of 9 mA/V and plate circuit impedance of 7,000 Ω). When a loud speaker with a low resistance coil is used, e.g. 8 Ω at medium frequencies, the step down ratio of the output transformer for matching purposes must be equal to $\sqrt{\frac{7000}{8}} = 30$. The total amplification α is in this case equal to $20 \times 60 \times 1/30 = 40$ times. If we want to decrease the amplification 6 times by the use of inverse feed-back, $1 + \alpha\beta$ must be equal to 6. Hence $\alpha\beta = 5$ and $\beta = \frac{1}{8}$. Now if we make the impedance parallel to the loud speaker coil 200 Ω at medium frequencies, practically no energy is absorbed by it. The resistance in the cathode lead of the first valve must then have a value of 25 Ω, which is so small that it will give no trouble. By these means a large reduction in harmonic distortion will be obtained and by adjusting the values of L_1, R_1 and R_2 the desired frequency response can be obtained.

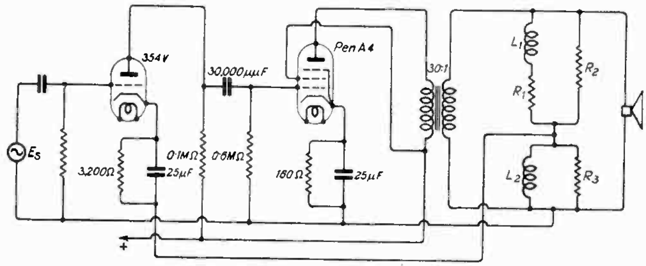

Fig. 3.—*Two valve amplifier containing feed-back from the loud speaker coil to the cathode of the first valve.*

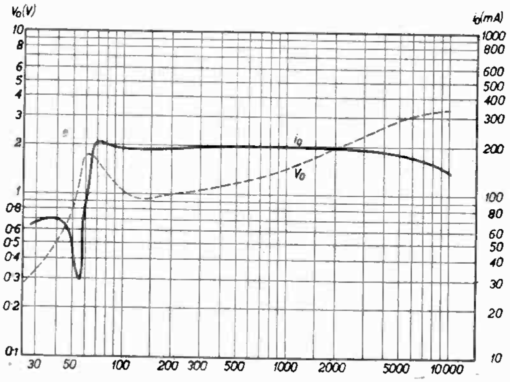

Fig. 4.—*Frequency characteristics without feed-back. Full line = current through loud speaker coil, dotted line = tension on loud speaker coil.*

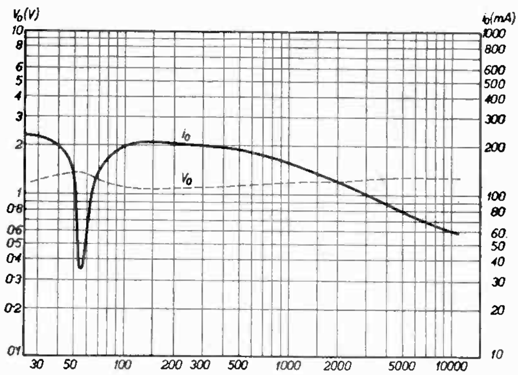

Fig. 5.—*Frequency characteristics with constant feed-back. Full line = loud speaker current, dotted line = tension.*

In many cases the low frequency response from the loud speaker is too weak, due to insufficient baffle area of the receiver cabinet. This can be compensated by increasing the low frequency response of the amplifier, which is easily done by reducing the amount of feed-back at these frequencies. For this purpose a small inductance may be put in parallel to the cathode resistance R_3 (L_2 in Fig. 3). This illustrates the flexibility of the feed-back circuit to obtain the desired frequency characteristic. Circuits of this kind are incorporated in several Philips and Mullard receivers of this season.

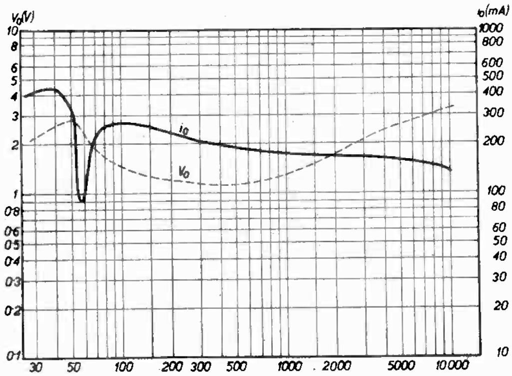

Fig. 6.—*Frequency characteristic with corrected feed-back as in Fig. 3. Full line = loud speaker current, dotted line = tension.*

Some measurements have been taken with the amplifier of Fig. 3 to illustrate the results. Figs. 4, 5 and 6 show frequency-characteristics of both the current and the tension of the loud speaker for three different cases. Fig. 4 belongs to the amplifier without feed-back. At the higher frequencies the current through the loud speaker is constant, at the frequency of the principal speaker resonance the current shows a minimum, which, as explained above, is due to the influence of the output transformer inductance and which is equivalent to a damping of this resonance. Fig. 5 belongs to the case where a constant part of the loud speaker voltage is fed back (β constant, $R_2 = 200\ \Omega$, $R_3 = 32\ \Omega$, no inductances). At the higher frequencies the current through the loud speaker decreases, at the speaker resonance frequency the tension on the speaker remains practically constant and so this resonance is more fully damped than without feed-back. Fig. 6 belongs to the case of corrected feed-back of Fig. 3 ($R_1 = 200\ \Omega$, $L_1 = 28\ mH$, $R_2 = 500\ \Omega$, $R_3 = 32\ \Omega$, $L_3 = 38\ mH$). At the higher frequencies the current through the loud speaker is again practically constant, whereas the low-frequency response is raised to counteract the effect of a limited baffle area.

Fig. 7 shows some distortion measurements. A signal of 400 c/s is fed to the input and the percentage second and third harmonics in the current through the loud speaker is measured both for the case without feed-back and for the case corresponding to Figs. 3 and 6. The percentage harmonics is reduced about 6 times, which equals the reduction in amplification.

Summary

Some properties of inverse feed-back are discussed. A two-valve amplifier, feeding a loud speaker, is described which contains feed-back from the voltage on the loud speaker coil to the cathode of the first valve with such frequency dependence that a desired frequency characteristic results. Some measurements of frequency characteristics and distortion illustrate the advantages of inverse feed-back.

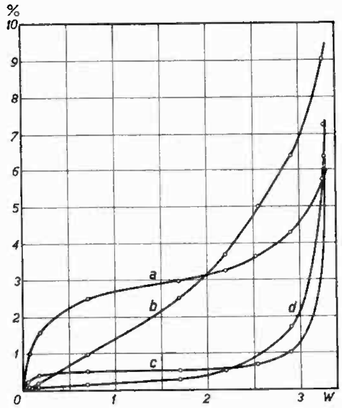

Fig. 7.—*Distortion of loud speaker current of amplifier without feed-back and with corrected feed-back against output Watts.*

a = *percentage of second harmonic without feed-back.*

b = *percentage of third harmonic without feed-back.*

c = *percentage of second harmonic with feed-back.*

d = *percentage of third harmonic with feed-back.*

Audio-Frequency Transformers

By E. T. Wrathall, A.C.G.I., A.M.I.E.E.

(Concluded from page 369 of the last issue)

Design of Input Transformer.

There are two distinct methods of design, the use of which depends on circuit conditions. Reference to Fig. 6 will show that if an input transformer is connected directly into the grid circuit of a valve, a peak occurs in the response curve where the circuit capacitance resonates with the leakage reactance of the transformer. If the grid circuit is shunted by a suitable resistance the characteristic becomes much more level. A flat characteristic is not always desired, but when it is, the problem resolves into finding a value of shunting resistance which will make negligible the change in terminating impedance at the higher frequencies caused by the circuit capacitance. The value of the resistance must be determined at the highest frequency for which the characteristic is required to be level; the higher the frequency the smaller must be the resistance, and of course the smaller will be the gain. Once the value of resistance has been determined, the design can be carried out along the lines given for the 1 800 ohms to 600 ohms transformer which has just been discussed, as the terminating impedances are resistive.

A case in which a level characteristic will not be desired is that of a transformer connecting a gramophone pick-up to a valve, for almost without exception pick-ups accentuate low frequencies. Another interesting case is one in which a limited characteristic is required, such as will be found in the input transformer of an A.F. amplifier working in a line in which there is a carrier frequency circuit just above the commercial speech limit of 2 750 p.p.s. In this instance the circuit capacitance may be utilised to produce a resonant point above which the response falls off rapidly, thereby assisting the carrier circuit discriminating filters to keep the inter-channel interference to a minimum. In both of the non-linear examples quoted, the required characteristic can be obtained by suitably arranging the circuit constants. It is felt, however, that it would be better to consider a more general case, which will be that of an input transformer coupling a 600 ohms line to a V.T.40 valve, as shown in Fig. 20. It will be seen that it will be possible to obtain a characteristic level to within ±1 db. from 100 p.p.s. to 5 000 p.p.s., using the same type of transformer as that used for the previous design example. It will not be necessary to load the secondary winding with a resistance, therefore the maximum possible voltage increase will be obtained.

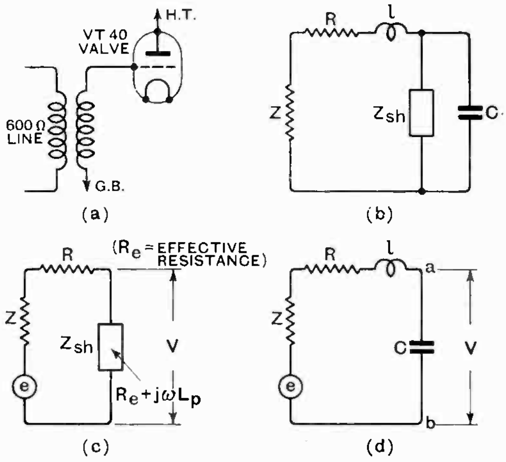

Fig. 20.—*Equivalent circuits used in connection with design of input transformer.*

The method of design about to be described can easily be applied to the design of a non-linear transformer when desired.

Necessary data in addition to that on page 366 of the last issue are given below.

Valve effective grid-filament capacitance $= 85\ \mu\mu F.$

Secondary winding self-capacitance $= 60\ \mu\mu F.$

Total capacitance on high side $= 145\ \mu\mu F.$

In Fig. 20 (b)

C = Total capacitance
l = Leakage inductance
Z = Line resistance
Considered on the high or low side as required.

The transformer will be designed to have the maximum possible voltage ratio consistent with the specified frequency response. The valve will be assumed to be working in the class A condition, for which there will be no grid current.

Fig. 20 (b) is the equivalent circuit of Fig. 20 (a); it is similar to Fig. 15 (b) except that Z'_2 is replaced by C. At low frequencies the effect of C is negligible and the conditions can be represented by Fig. 20 (c): at high frequencies Z_{sh} becomes negligible and the circuit is equivalent to that shown in Fig. 20 (d). The total voltage acting in the circuit is shown by "e" and the voltage available on the grid by "V." The ratio $\frac{V}{e}$ must be as high as possible and remain sensibly constant over the range of frequencies to be covered.

At 100 *p.p.s.*

The voltage ratio for a 2 db. loss is 1.26 and it is required to find a value of Z_{sh} which will give this figure; this is most easily done by means of a vector diagram in which the vectors may be considered either as reactances or voltages, as the case is that of a series circuit. At this stage it is necessary to assume a value for R, the combined resistance of the windings referred to the primary side; a value of 70 ohms will be taken. The impedance vector diagram corresponding to Fig. 20 (c) is shown in Fig. 29. The diagram is constructed in the following manner: the axis XX is drawn and from A as origin, AB is laid off proportional to $Z + R$, that is 670 ohms. The vector Z_{sh} must pass through B, and ϕ is 77° since the Q of the winding is 4.5; so the line BC is laid off at this angle. By trial, a point D is found which makes $\frac{AD}{BD} = 1.26$. AD is the total impedance of the circuit, namely 1 480 ohms; BD gives the value of Z_{sh}, namely 1 170 ohms; and the perpendicular through D meeting XX in E, gives the value of X_{sh}, namely 1 140 ohms. This value of X_{sh} is actually the primary winding reactance X_p, and L_p can be calculated from it; this will be the correct value to make $\frac{e}{V}$ 1.26, as "e" is proportional to AD and "V" is proportional to BD.

$$X_p = \omega L_p = 1\,140 \text{ ohms}$$
$$\omega = 2\pi \times 100$$
$$\therefore L_p = \frac{1\,140}{2\pi \times 100}$$
$$= 1.82\ H.$$

As in the previous design example it is advisable to take a value of L_p 6 per cent. higher than this, namely 1.93 H, hence the number of turns required is:—

$$T_p = \sqrt{\frac{1.93}{1.3}} \times 1\,000$$
$$= 1\,290 \text{ turns.}$$

At 5 000 *p.p.s.*

It is now desirable to calculate a suitable secondary winding which will give a loss at 5 000 p.p.s. not greater than 2 db. Referring to Fig. 20 (d) it will be seen that the ratio $\frac{e}{V}$ is given by

$$\frac{e}{V} = \frac{(Z + R) + j\left(\omega l - \frac{1}{\omega C}\right)}{-j\frac{1}{\omega C}}$$

or
$$\left|\frac{e}{V}\right| = \frac{\sqrt{(Z + R)^2 + \left(\omega l - \frac{1}{\omega C}\right)^2}}{\frac{1}{\omega C}}$$

The calculation of the secondary winding entails finding a value of C which will give the required value of $\left|\frac{e}{V}\right|$; again, a vector diagram provides the easiest solution.

The value of l for a sandwiched winding is 0.85 per cent. of L_p

$$\text{hence } l = \frac{1.93 \times 0.85}{100} = 0.0164\ H$$

$$\omega l = 2\pi \times 5\,000 \times 0.0164 = 515 \text{ ohms.}$$

For an ordinary winding $l = 0.0347\ H$, hence $\omega l = 1\,090$ ohms.

It appears that an ordinary winding will be satisfactory, so in the vector diagram ωl will be taken as 1 090 ohms; the construction is shown in Fig. 21. Two perpendicular axes X and Y are drawn and the point A is made the origin of the diagram; AB is then laid off proportional to $Z + R$ (670 ohms) and at B a perpendicular BB' is erected and BC marked off proportional to ωl (1 090 ohms). Finally by trial, a point D is found making $\frac{AD}{DC}$ equal to 1.26; CD is then proportional to the required value of $\frac{1}{\omega C}$ referred to the primary side.

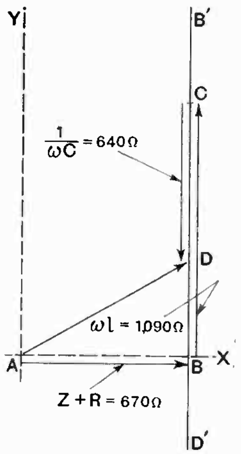

Fig. 21.—*Method of finding value of C (Fig. 20 d) in design of input transformer.*

CD will be found to be 640 ohms.

Since $\frac{1}{\omega C} = 640$ ohms

$$C = \frac{1}{2\pi \times 5\,000 \times 640} = 0.0499\ \mu\text{F}.$$

The effective capacitance on the high side is 145 $\mu\mu$F.

Ratio of required capacitance on low side to that on high side .. $= \frac{0.0499}{0.000145} = 344.$

This ratio will be called the impedance ratio, hence the turns ratio is $\sqrt{344} = 18.52$; hence the number of turns on the high side $= 1\,290 \times 18.52 = 23\,880 = T_s$.

The process of this part of the design has been to find the value of negative reactance (referred to the primary side) which will give the desired ratio of $\frac{e}{V}$, and then to arrange the turns ratio so that the effective capacitance on the high side when referred to the primary is 0.0499 μF as calculated.

Determination of size of wire.

For the secondary the smallest convenient gauge will be used, namely 44 S.W.G. enamelled, of which the area required per turn is 0.0037^2 sq. in. Hence the winding area required is $0.0037^2 \times 23\,880 = 0.326$ sq. in. Area available for the low winding $= 0.43 - 0.326 = 0.104$ sq. in. Primary winding area per turn $= \frac{0.104}{1\,290} = 0.0000806$ sq. in., therefore the outside diameter of wire $= \sqrt{0.0000806} = 0.00898$ in. 36 S.W.G. enamelled wire is 0.0086in. o/d and therefore is quite suitable.

Resistance of windings.

High winding (the outer)

$$R_s = 23\,880 \times 6.3 \times \frac{1.011}{12}$$
$$= 12\,700 \text{ ohms}$$

This referred to the low side

$$= \frac{12\,700}{344} = 37 \text{ ohms.}$$

Low winding (the inner)

$$R_p = 1\,290 \times 4.5 \times \frac{0.1766}{12} = 85 \text{ ohms.}$$

Hence $R = (85 + 37)$ ohms $= 122$ ohms.

This is higher than was assumed, but the effect of the extra resistance is not great enough to warrant re-calculation as will be evident from Figs. 21 and 29.

Calculation of minimum loss (referred to low side).

The minimum loss will occur when $\omega l = \frac{1}{\omega C}$; that is, at a frequency given by $\omega_r = \frac{1}{\sqrt{lC}}$.

$$\omega_r = \frac{1}{\sqrt{0.0347 \times 0.0499 \times 10^{-6}}}$$
$$= 24\,000$$

hence $f_r = 3\,830$ p.p.s.

At this frequency the ratio $\frac{e}{V}$ is given by

$$\left|\frac{e}{V}\right| = \left|\frac{Z + R}{\frac{1}{\omega_r C}}\right| = \frac{722}{836} = 0.865.$$

Unfortunately the last calculation shows that the voltage "V" across the grid of the valve is actually greater than the voltage "e" in the line at the resonant frequency; the excess voltage represents a gain of 1.26 db., therefore between 100 p.p.s. and 5 000 p.p.s. the overall change in gain is 3.26 db. or $\pm$ 1.63 db.: this is in excess of the specified limits so the design must be modified accordingly.

The simplest way to overcome this undesirable effect at resonance is to make $Z + R$ equal to $\frac{1}{\omega C}$; that is $Z+R=836$ ohms and $R = 236$ ohms. This figure of 236 ohms will not be taken as final but will be used as a very close estimate of what the value of R should be; and the design re-calculated on this basis: it is necessary to re-calculate completely as the change in $Z + R$ is enough to affect the vector diagrams to an extent which cannot be neglected. The re-calculation takes only a little time and will be done as briefly as possible in the next section.

Re-calculation of previous design based on a more accurate knowledge of the value of $Z+R$.

At 100 p.p.s.

For a 2 db. loss $\left(\text{i.e. } \frac{e}{V}\, 1.26\right)$ the value of L_p is determined from the vector diagram of Fig. 30 in which $Z + R = 836$ ohms.

From the diagram $X_p = \omega L_p = 1\,370$ ohms

$$\therefore \quad L_p = \frac{1\,370}{2\pi \times 100} = 2.18\ H;$$

adding 6 per cent. makes $L_p = 2.31\ H$,

$$\text{hence } T_p = \sqrt{\frac{2.31}{1.3}} \times 1\,000 = 1\,334 \text{ turns.}$$

At 5 000 p.p.s.

Using an ordinary winding,

$$l = \frac{2.31 \times 1.8}{100} = 0.0415\ H$$

$$\therefore \omega l = 1\,302 \text{ ohms.}$$

The value of $\frac{1}{\omega C}$ is determined from Fig. 31 to be 780 ohms.

$$\therefore C = \frac{1}{2\pi \times 5\,000 \times 780} = 0.041\ \mu\text{F}.$$

Ratio of required capacitance on low side to that on high side $= \frac{0.041}{0.000145} = 283$

hence turns ratio $= \sqrt{283} = 16.8$

and $T_s = 16.8 \times 1\,334 = 22\,400$ turns.

Size of wire.

Using 44 S.W.G. for the secondary, winding area required

$$= 0.0037^2 \times 22\,400 = 0.306 \text{ sq. in.}$$

Area available for low winding

$$0.43 - 0.306 = 0.124 \text{ sq. in.}$$

Resistance of high winding

$$= 22\,400 \times 6.3 \times \frac{1.011}{12} = 11\,900 \text{ ohms.}$$

This, referred to the primary

$$= \frac{11\,900}{283} = 42 \text{ ohms,}$$

hence the primary winding resistance must be $236 - 42 = 194$ ohms.

$R_p = T_p \times$ length of mean turn $\times$ resis. per inch.

$\therefore$ Resis. per inch

$$= \frac{194}{1\,334 \times 4.5} = 0.0323 \text{ ohm.}$$

The nearest gauge is 39 S.W.G. which has a resistance of 0.0318 ohm per inch. The overall diameter of 39 S.W.G. enamelled wire is 0.006 in. hence winding area required is $1\,334 \times 0.006^2 = 0.048$ sq. in. so the available space is ample; the actual resistance of the primary is $1\,334 \times 4.5 \times 0.0318 = 191$ ohms.

Calculation of minimum loss.

$$\omega_r = \frac{1}{\sqrt{0.0415 \times 0.041 \times 10^{-6}}} = 24\,230$$

$$\therefore f_r = \frac{24\,230}{2\pi} = 3\,870 \text{ p.p.s.}$$

At this frequency, the ratio $\left|\frac{e}{V}\right|$ is given by

$$\left|\frac{e}{V}\right| = \left|\frac{Z+R}{\frac{1}{\omega_r C}}\right| = \frac{600+42+191}{780} = \frac{833}{780} = 1.07,$$

which represents a loss of 0.56 db.

The re-design therefore gives an overall loss between 100 p.p.s. and 5 000 p.p.s. of 1.44 db. which is well within the specification.

The maximum theoretical voltage gain is 16.8; this can be expressed as a gain of 24.5 db. From this it will be seen that at 100 p.p.s. and at 5 000 p.p.s. the gains are 22.5 db. and at 3 870 p.p.s. the gain is 23.94 db. These figures have been plotted in Fig. 22, curve (a). It is convenient to regard the efficiency of the transformer on a db. basis as the results are more easily visualised than if a curve of voltage step-up were plotted, which is perhaps the more logical thing to do.

Design Summary.

Number of primary turns T_p = 1 334.

Number of secondary turns T_s = 22 400.

Wire for primary, 39 S.W.G. enamelled copper.

Wire for secondary, 44 S.W.G. enamelled copper.

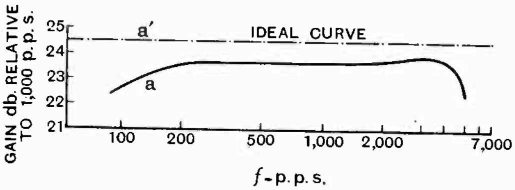

Fig. 22.—*Calculated response curve of input transformer.*

D.C. resistance : primary, R_p = 191 ohms.

D.C. resistance : secondary, R_s = 11 900 ohms.

Total loss at 100 p.p.s. and at 5 000 p.p.s. = 2 db.

Total loss at 3 870 p.p.s. = 0.56 db.

Turns ratio = 16.8.

Primary inductance = 2.31 *H*.

NOTE.—Rather than use 39 S.W.G., which is an odd size of wire for the primary, 38 S.W.G. could be used and the resistance made up with resistance wire.

Special Cases of Design

It is necessary to treat the following sections rather briefly in order not to make the article too long. It is hoped that reference to essential points together with the design methods already given will be adequate to enable the reader to solve problems in which any special features come within the scope of the following notes.

Transformers carrying Direct Current.

In order to eliminate direct current in transformer windings, for example in an output transformer, choke-capacity coupling may be used ; or the circuit may be arranged in push-pull so as to annul the effect of the valve feeds. If neither of these methods can be used, it is useful to have a family of curves such as those shown in Fig. 23 to enable a suitable air gap to be chosen to give the maximum winding inductance. When an air gap is introduced, allowance must be made for the change in leakage factor and Q value of the winding.

The manner in which Q changes is shown in Fig. 24. Both Figs. 23 and 24 apply to the type of core used for the designs which have been worked out.

Transformers for use at frequencies above the audio-frequency range.

These may be designed along similar lines to the methods which have been described, but care must be observed that the greater importance of circuit capacitance at these frequencies is fully allowed for. In certain cases laminated iron or alloy cores may not be suitable, and cores of compressed iron or alloy dust, or even non-magnetic cores such as wood, may be advisable in order to keep the effective resistance low ; by these means a good Q value is obtained. Where wooden cores are used the core loss is very small, and the use of stranded conductor for the windings helps greatly to reduce the effective resistance.

Use of high permeability core materials.

There is now available quite a wide range of high permeability core materials which enable greatly improved characteristics to be obtained. The materials are expensive and are mainly limited in use to such cases

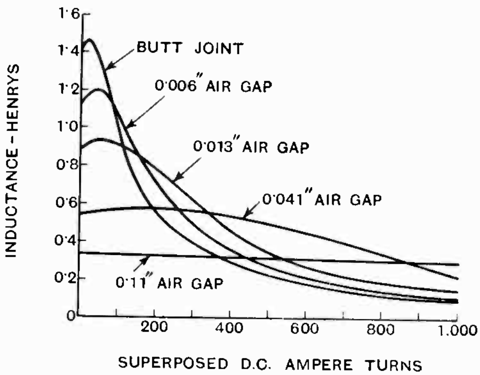

Fig. 23.—*Inductance of 1000 turn coil at 900~, P.D. = 3.5 V for various air gaps and D.C. amp. turns. Shell type Stalloy core of Fig. 10.*

where an improved characteristic is required, although there are instances where transformers may be greatly reduced in size without degrading their characteristics. The most useful feature of these alloys is their high initial permeability which enables transformers to be made with large inductance at low frequencies, but with low leakage and capacitance, so that the loss at high frequencies is small.

As a result, transformers can be designed having a sensibly flat response from 30 p.p.s.

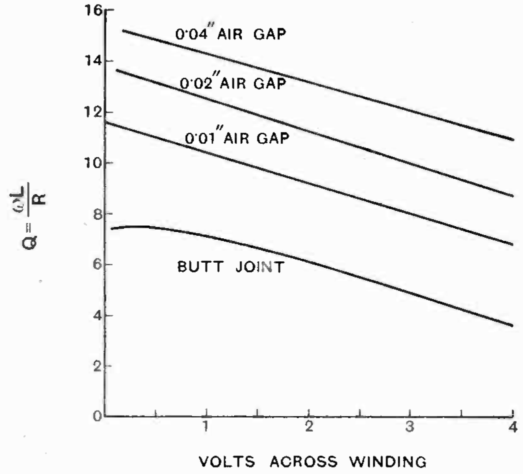

Fig. 24.—*Variations of Q for* 1000 *turn winding on shell type Stalloy core of Fig.* 10.

to 15 000 p.p.s. and even to much higher frequencies. The initial permeability and change of permeability with frequency vary largely with the different alloys available, and these variations must be carefully allowed for in design. Usually the higher values of inductance are accompanied by a value of D.C. resistance which is lower than would occur for a transformer with a Stalloy core for commercial speech frequencies; this makes for further improvement in efficiency. It is important, too, that full data be available on the changes occurring in the short-circuit characteristic with frequency, as from this the leakage factor is derived.

In addition to the use of high permeability core materials, there are two other factors which enable the high frequency end of the response curve to be improved; the more important is the use of sandwiched windings as shown in Fig. 13 (b) which, with a high permeability core, enables the leakage factor to be reduced to about 27 per cent. of the value for an ordinary winding at 300 p.p.s.: this is markedly better than can be obtained when a Stalloy core is used when the leakage factor is reduced to about 47 per cent. of the value for an ordinary winding. The second factor is the use of sectionalised windings to reduce the winding self-capacitance, the four-section winding of Fig. 13 (c) having about half the self-capacitance of a two-section winding. The improvement resulting from the use of sectionalised windings is not so great as that produced by sandwiching, because associated circuit capacitance forms such a large proportion of the total capacitance.

Generally, high permeability cores require careful handling because the permeability is reduced by mechanical shock. In concluding this section it is desired to stress the importance of testing the inductance of high permeability transformers at about 50 p.p.s.; this necessitates the use of a vibration galvanometer for detecting bridge balance: alternatively, tests at 200 p.p.s. or 300 p.p.s. (the lowest frequencies suitable for aural tests) may be made, if the ratio of inductance at those frequencies to that at 50 p.p.s. is known.

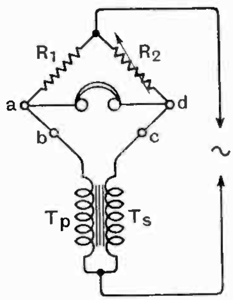

Fig. 25.—*Bridge for measuring turns ratio of transformer.*

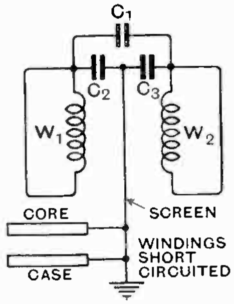

Fig. 26.—*Method of measuring interwinding capacity of transformer.*

7. Testing of Transformers

The article will be concluded with a brief description of the tests which should be applied to completed transformers. Apart from special tests which may be required, the following tests are considered to be adequate.

(*a*) *Direct Current Resistance.*

The D.C. resistance of the windings may be measured on a Wheatstone Bridge; they should not exceed 15 per cent. of the design value as this factor amply allows for variations in wire diameter, stretching of wire in winding, etc.

(*b*) *Inductance.*

The inductance of one winding should be measured and should not be less than 97 per cent. of the design value. The Maxwell Bridge is the most convenient for this test because of the wide range of inductance values for which it is suitable. It is necessary to measure the inductance of only one winding, because a fault in either winding will be revealed by reason of the mutual coupling between them.

(*c*) *Turns Ratio.*

The turns ratio should be within 2 per cent. of the correct value. A suitable bridge for measuring the turns ratio for closely coupled windings is shown in Fig. 25; the transformer windings are connected in series aiding and form two arms of the bridge: $\frac{T_p}{T_s}$ is given by the ratio of the resistances $\frac{R_1}{R_2}$. Sometimes it is necessary to add a variable resistance in between either *a* and *b*, or *c* and *d*, in order to obtain a good balance.

(*d*) *Insulation Resistance.*

The insulation resistance between windings, and case and windings, and windings and shield, should be at least 200 megohms.

(*e*) *Dielectric Strength.*

The transformer insulation should be tested at a suitable voltage to ensure that there will be no breakdown under working conditions.

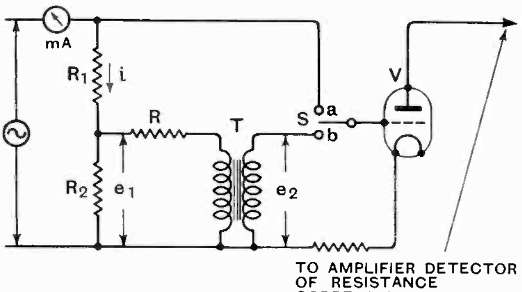

Fig. 27.—*Testing circuit for frequency response of input transformer.*

(*f*) *Inter-winding capacitance.*

Screened transformers should be tested to ensure that the screening is adequate. The inter-winding capacitance cannot be measured directly, for, as shown in Fig. 26, the effective inter-winding capacitance C_1 and the winding to case capacitances C_2 and C_3 are bound up together. The value of C_1 may however be found as follows, the windings being short circuited for the purpose of the measurement.

(i) With W_1 earthed, measure between earth and W_2, thus obtaining the value of $C_1 + C_3$.

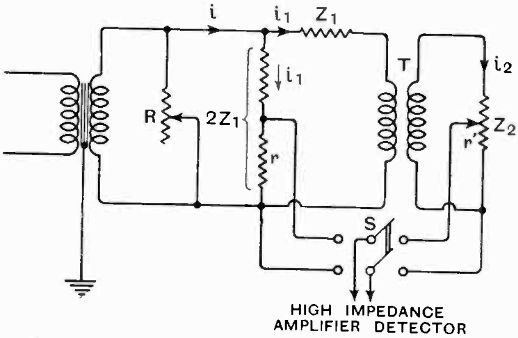

Fig. 28.—*Testing circuit for frequency response of line or output transformer.*

(ii) With W_2 earthed, measure between earth and W_1 to obtain the value of $C_2 + C_1$.

(iii) Join the windings W_1 and W_2 and measure between windings and earth; this gives the value of $C_2 + C_3$.

From (i) and (ii) the value of $2C_1 + C_2 + C_3$ may be derived, and as (iii) gives the value of $C_2 + C_3$ the value of C_1 may be determined.

Special tests such as winding self-capacitance, short circuit characteristics, variation of inductance with direct current, etc., are too lengthy to be included in routine tests and therefore will not be described, for the methods are explained in the literature obtainable on bridge measurements and general alternating current testing. It is thought, however, that it would be useful to describe methods of measuring the frequency response of transformers.

Frequency Response of an Input Transformer.

The testing circuit is shown in Fig. 27. T is the transformer under test and V the valve for which the transformer is designed. R is the value of the impedance on the primary side, hence it is necessary to keep

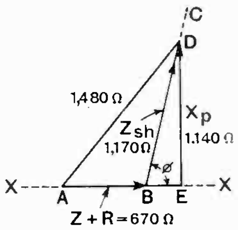

Fig. 29.—*Method of finding the value of Zsh in design of input transformer.*

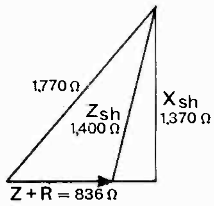

Fig. 30.—*Method of finding Lp in re-design of input transformer.*

R_2 low (say about 10 ohms). The switch S is operated alternately to " a " and " b " for each testing frequency and R_1 is adjusted until the amplifier-detector reads the same for both positions; then the voltage on the grid of the valve is the same for both switch positions, and :—

$(R_1 + R_2)i = e_2$ (since for practical purposes the current in R_1 is equal to the current in R_2)

$$e_1 = R_2 i$$

$$\therefore \frac{e_2}{e_1} = \frac{R_1 + R_2}{R_2}.$$

This ratio $\frac{e_2}{e_1}$ gives the voltage ratio of the transformer, which may be obtained at as many frequencies as desired.

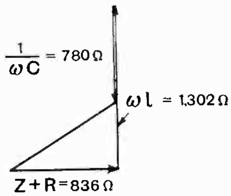

Fig. 31.—*Method of finding the value of* $\frac{1}{\omega C}$ *in re-design of input transformer.*

Frequency Response of Line Transformer or Output Transformer.

The testing circuit is shown in Fig. 28. T is the transformer of impedance ratio Z_1:Z_2 to be tested. The value of R is kept small so that the transformer is working as nearly as possible into its correct impedance Z_1. When r and r' are varied, suitable variations must be made to maintain Z_2 and $2Z_1$ constant. The method of measurement is to vary r and r' at each test frequency until the amplifier detector gives the same reading for both positions of the switch S.

Then, since $2Z_1$ and Z_2 are maintained constant,

$$ri_1 = r'i_2$$

$$\frac{i_2}{i_1} = \frac{r}{r'}$$

For an ideal transformer the current ratio would be given by $\sqrt{\frac{Z_1}{Z_2}}$ hence the

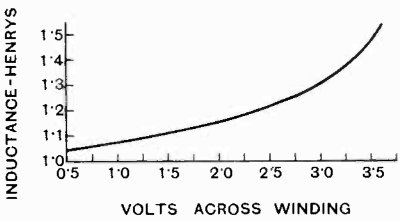

Fig. 32.—*Variation of inductance with applied voltage. Core of Fig. 10, f = 900 p.p.s. Winding of 1000 turns.*

transformer loss can be expressed in db. as

$$\text{Transformer Loss} = 20 \log_{10} \frac{\text{Ideal Current Ratio}}{\text{Actual Current Ratio}}.$$

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The Dynatron Oscillator*

By J. E. Houldin, B.Eng.

Introduction

WHEN the grid of a triode valve is at a higher potential than the plate (both being positive with reference to the cathode) the plate circuit will behave as a "negative resistance." That is, with a fixed grid potential, the plate current will decrease with increasing plate potential within certain limits of the latter. This is illustrated in Fig. 1, where for all plate voltages between A and B the plate circuit will behave as a "negative resistance." The magnitude of the "negative resistance" will be determined by the slope of the portion AB.

Between the grid and the cathode a second grid or control grid, may be introduced and a negative potential, with reference to the cathode, applied to it. The slope of the portion AB of the plate voltage-current curve may be altered by varying the magnitude of the negative potential on the control grid.

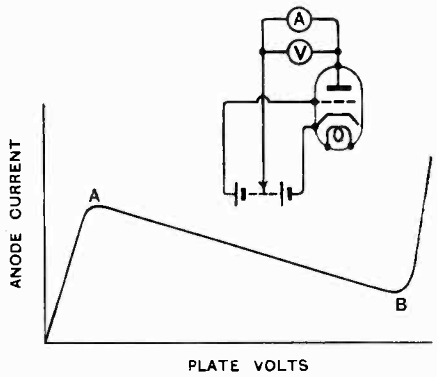

Fig. 1.

In Fig. 2 are shown experimental curves for a Mazda ACS2 valve with 120 volts on the screen grid, a filament current of 1 ampere, and four values of negative potential on the control grid. These curves are known as the "dynatron characteristics" of the valve.

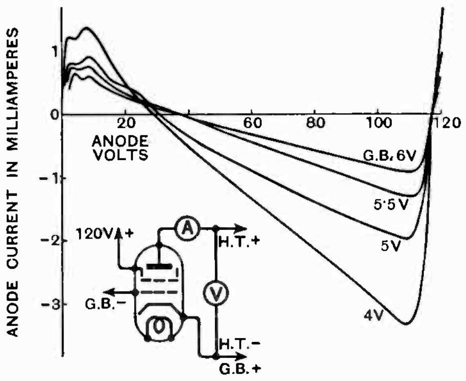

Fig. 2.

A parallel tuned circuit L, R, C may be introduced in the plate lead of the valve. If conditions are such that the "average negative resistance" of the valve, during excursions of the anode voltage, is sufficient to overcome the resistance losses in the tuned circuit, continuous oscillations will be set up in the circuit. The valve and its tuned circuit are known as a dynatron oscillator.

The frequency of the oscillations will depend on the following factors :—

(1) The natural frequency f_0 of the tuned circuit L, R, C.

(2) The negative potential applied to the control grid, *i.e.*, the grid bias on the valve.

(3) The working anode voltage.

(4) The screen voltage.

(5) The filament current.

The purity of the waveform of the oscillations will be influenced by :—

(1) The ratio of the inductance L to the capacitance C.

(2) The grid bias on the valve.

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

Variations in Frequency

(1) *The Tuned Circuit L, R, C.*

An attempt has been made to analyse the causes of frequency changes in a dynatron oscillator which exceed 1 part in 100.

Unless all supply voltages are kept steady the anode current flowing through the inductance L will vary. If air-cored chokes are used, for example, as in radio frequency oscillators, the frequency will not be affected, but in audio frequency oscillators, where, for the sake of compactness, iron-cored chokes are advisable, the inductance of the latter will depend on the anode current flowing through them. These variations of inductance will cause alterations in the frequency of oscillation amounting to as much as 3 per cent. or 4 per cent.

The variation of inductance with the direct current flowing through two examples of iron-cored chokes on the latter's inductance is shown in Table I.

TABLE I.

Iron-cored Choke.		Iron-cored Choke.	
Induct. *H*	Polarising Current. Milliamps.	Induct. *H*	Polarising Current. Milliamps.
1.5	0	53	0
1.51	3.6	57	4.0
1.55	6.1	57	6.5
1.58	8.4	59	10.0

An alternative circuit is given in Fig. 3, in which the direct current through the inductance is zero. Trouble may arise,

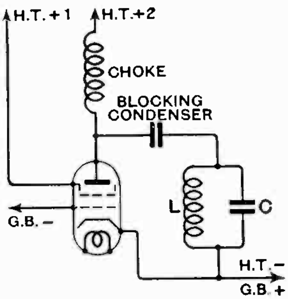

Fig. 3.

however, in the circuit due to the self-capacitance of the choke, which may in itself, form a tuned circuit.

The temperature of a coil (or condenser) will influence its inductance (or capacitance) to a certain extent, causing a steady drift of frequency. Since a coil or condenser may be heated up by neighbouring valves or power resistances, it is a good plan, especially in a radio frequency oscillator, to mount the valves, or power resistances, in small lagged chambers with special outlets and inlets for air circulation. When the whole apparatus is mounted in a single box, it is always advisable to run the oscillator for at least half an hour, before using. This enables the coils and condensers to come to a steady temperature and thus prevents a frequency drift.

(2) *Grid Bias.*

The frequency of the dyratron oscillator will not correspond with that of the tuned circuit L, R, C, unless the ratio of inductance to capacitance is low and the grid bias on the valve the highest possible that will maintain oscillations.

Let σ = negative conductance of the valve over that portion of the dynatron characteristic in the neighbourhood of the working voltage.

It may be shown theoretically that the variation in frequency depends on the term

$$\epsilon = \sqrt{L/C} \cdot \sigma$$

The larger the value of ϵ, the greater will be the difference between the actual frequency of the oscillations and the natural frequency of the tuned circuit.

As the term ϵ includes the negative conductance σ of the valve, any deterioration

TABLE II.

Inductance 1.5 H. Capacitance 0.1 μF. Natural Frequency 392 c/s.			Inductance 1.5 H. Capacitance 0.01 μF. Natural Frequency 1,240 c/s.		
G.B. Volts.	ϵ	Freq. c/s.	G.B. Volts.	ϵ	Freq. c/s.
1	3.3	334	0	12.5	938
2	2.8	352	1	10.9	1,009
3	2.4	354	2	8.6	1,072
4	1.5	356	3	5.4	1,088
			4	3.5	1,098

Inductance 13 H. Capacitance 0.01 μF. Natural Frequency 422 c/s.			Inductance 53 H. Capacitance 0.01 μF. Natural Frequency 220 c/s.		
G.B. Volts.	ϵ	Freq. c/s.	G.B. Volts.	ϵ	Freq. c/s.
0	36	187	0	65	64
1	34	219	1	51	68
2	24	265	2	32	93
3	15.2	312	3	20.5	140
4	9.7	346	4	12	178
5	5.7	381	5	6.9	207

of the valve or replacement of the valve will cause frequency changes, especially if ϵ is initially large.

The variations of frequency with grid bias for an audio frequency dynatron oscillator, using a Mazda ACS2 valve, and an iron cored inductance, is shown in Table II.

Tests were made with two valves, using different values of inductance, both air and iron cored, and capacitance, and Fig. 4 shows the relation between ϵ and the percentage change in frequency from the natural frequency of the tuned circuit, the curve being a mean of all readings taken. From Fig. 4, it will be seen that if the value of ϵ is large the frequency of oscillation will be very different from the natural frequency of the tuned circuit.

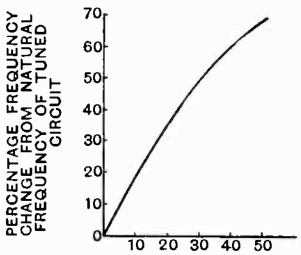

Fig. 4.

(3) *Screen and Anode Voltages.*

When designing an oscillator it is desirable to obtain a frequency which does not vary appreciably with variations of supply voltages. As already pointed out, the frequency of the oscillations is governed to a large extent by the value of $\epsilon = \sqrt{L/C} \cdot \sigma$ and so by the characteristic of the valve used in the circuit.

TABLE III.

ϵ measured at 120 V. screen voltage.

$\epsilon = 1.8$		$\epsilon = 8.6$		$\epsilon = 27.0$	
Screen Volts.	Freq. c/s.	Screen Volts.	Freq. c/s.	Screen Volts.	Freq. c/s.
135	339	135	933	135	1,277
130	341	130	940	130	1,307
125	342	125	942	125	1,343
120	342	120	953	120	1,370
115	342	115	960	115	1,410
110	344	110	1,067	110	1,417
—	—	—	—	105	1,473
—	—	—	—	100	1,473
—	—	—	—	95	1,453

The shape of the anode voltage/current characteristic, see Fig. 5, will depend on the voltage of the screen grid. Changes in the latter, therefore, cause variations in the frequency of oscillation.

It will be seen from Table III that this frequency variation increases with increasing values of ϵ.

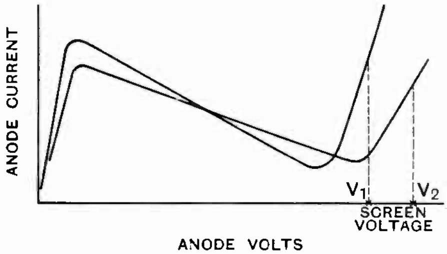

Fig. 5.

There is also considerable variation of frequency with the working anode voltage, at a fixed screen grid voltage. It will be seen from the characteristics of the Mazda ACS2 valve given in Fig. 2, that the "negative resistance" portion is not linear along its whole length.

If the anode working voltage be at P, see Fig. 6, then the amplitude of the oscillation will adjust itself, so that the effective "negative resistance" during an oscillation will be equal to the positive resistance due to the losses in the tuned circuit. The oscillations may actually take the anode

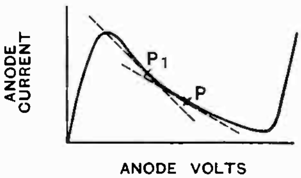

Fig. 6.

voltage over the bends of the characteristic curve into the region of positive resistance.

The value of σ in the expression

$$\epsilon = \sqrt{L/C} \cdot \sigma,$$

which determines the frequency variation from the natural frequency of the tuned circuit, will be given by the slope of the characteristic at P.

If now the operating anode voltage be altered to P_1, the amplitude of oscillation will change, and the frequency will be determined by the new value of σ given by the slope of the characteristic curve at the point P_1. This may differ considerably from that at P, in which case there will be considerable frequency variations with changes in the working anode voltage, see Table IV. The greatest variations in frequency will occur when the anode voltage approaches that corresponding to the bends of the characteristic curve.

TABLE IV.

ϵ measured at 58 V. anode voltage.

$\epsilon = 1.8$		$\epsilon = 8.6$		$\epsilon = 27$	
Anode Volts.	Freq. c/s.	Anode Volts.	Freq. c/s.	Anode Volts.	Freq. c/s.
20	351	10	660	10	600
30	348	20	733	20	1,050
40	345	30	800	30	1,200
50	343	40	843	40	1,325
60	343	50	870	50	1,400
70	345	60	872	60	1,385
80	349	70	823	70	1,360
90	353	80	827	80	1,200
—	—	90	897	90	1,330
—	—	100	967	100	1,575

(4) *Filament Current.*

A variation in the filament current to the valve will produce an effect similar to that produced by a variation in screen voltage, that is, a variation in the density of the space charge. In Table V are given the frequency variations caused by alterations of filament current. The magnitude of this variation also depends of course, on the value of ϵ.

TABLE V.

ϵ measured at 1.0 ampere filament current.

$\epsilon = 1.8$		$\epsilon = 8.6$	
Filament Current amps.	Frequency c/s.	Filament Current amps.	Frequency c/s.
0.8	343	0.8	917
0.9	343	0.9	897
1.0	342	1.0	877
1.12	342	1.12	867

Variations in Waveform

In general practice an oscillator is required which produces sinusoidal oscillations, but when a valve generator is used this is a practical impossibility owing to the non-linearity of the valve characteristics.

An exceptionally good waveform can be obtained with a dynatron oscillator if,

(a) the ratio of inductance to capacitance is low,

(b) the grid bias is the highest possible to maintain oscillation.

It will be realised that these two conditions have also to be satisfied if the frequency stability is to be good, so that sinusoidal oscillations and frequency stability are inseparable in a dynatron oscillator. Three sets of oscillograms, taken for an audio-frequency dynatron oscillator, are given in Fig. 7.

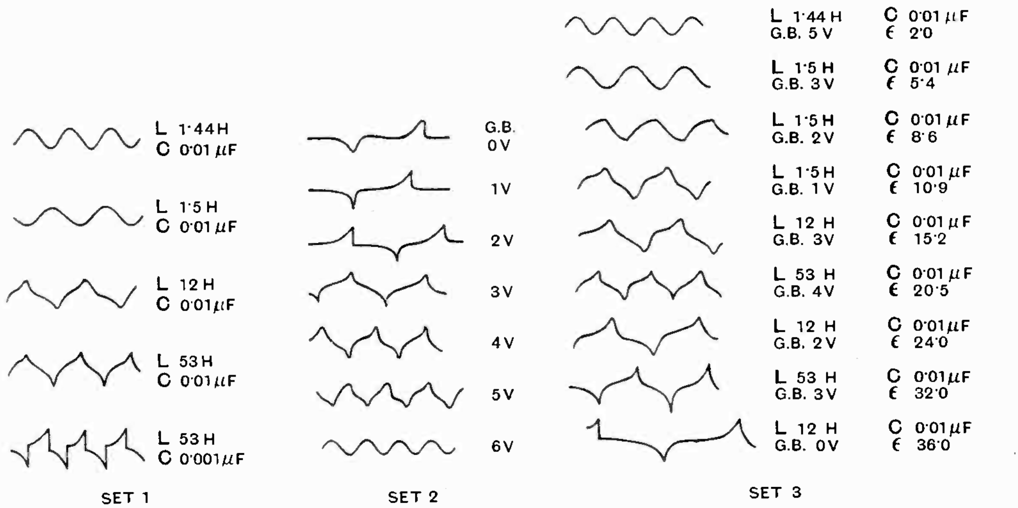

Fig. 7.

The first set shows the effect of the ratio of inductance to capacitance, with constant supply voltage.

The second set shows the effect of increasing grid bias, the oscillation being practically sinusoidal at 6V grid bias, and a "relaxation" oscillation at zero grid bias.

From the third set of oscillograms, which combines the results of many tests, it will be seen how the waveform depends on the value of $\epsilon = \sqrt{L/C} . \sigma$. For sinusoidal waveforms the value of ϵ must be as small as possible.

Effect of Tuning Coil Losses

Resistance losses in the tuning circuits (a) reduce the amplitude of oscillation, (b) reduce the maximum value of grid bias consistent with maintenance of oscillation.

The latter is shown by the following figures. An inductance of 1.4 henries and 42 ohms resistance was used, with a capacitance of 0.1μF, as a tuned circuit. The maximum grid bias for which oscillations could be produced was 4.6V. With 700 ohms resistance in series with the inductance the maximum grid bias was 2.9V, whilst with 2,260 ohms in series the circuit would not oscillate at all.

When ϵ is less than 0.1 a resistance of the order of 500 ohms in series with the inductance will stop oscillation. For ϵ between 0.1 and 1 the resistance to stop oscillation is of the order of 1,000 ohms.

With large values of ϵ (greater than 20) the addition of resistance even up to 30,000 ohms has little effect either on the maximum value of cut off, or on the waveform of the oscillation.

With values of ϵ between 1 and 20 the presence of high resistance in series with the inductance has little effect on the waveform except to improve it just at cut-off grid bias, but it produces two cut-off grid bias voltages. For example, with an inductance of 14H and a capacitance 0.01μF and an added resistance of 23,000 ohms, oscillation occurs only at a grid bias of 4.3 volts, higher resistances stopping oscillation completely.

Oscillation occurs between 2.2 and 5.8 volts grid bias, 0.9 and 6.12 volts grid bias when 10,000 ohms and 5,000 ohms respectively is in series with the tuning coil. For all resistances less than 4,000 ohms oscillation occurs at zero grid bias.

Conclusions

If frequency stability and good waveform are required in an oscillator, then the value of $\epsilon = \sqrt{L/C} . \sigma$ must not be greater than 1.

If this condition is satisfied, frequency variations with changes in supply voltages (grid bias, anode voltage, screen voltage and filament voltage), will be small.

To obtain a small value of ϵ the ratio of inductance L to capacitance C should be as small as is practically possible (i.e. of the order 10^6 or less), if L is in henries and C in farads, and the grid bias should be as high as possible, consistent with the maintenance of oscillations at all the required frequencies. Low loss coils are essential in this type of oscillator.

If an oscillator is required whose waveform and frequency stability are not important, but in which easy control of frequency is desired, a tuning circuit of high inductance to capacitance ratio (i.e. greater than 10^9) may be employed. Frequency control may then be effected by means of a variable grid bias on the valve, with a fixed tuned circuit. The resistance in the inductances will now have a negligible effect on the waveform and on the cut-off grid bias, making low loss coils unnecessary.

Such an oscillator will, however, produce "relaxation" oscillations, which have a high harmonic content.

When a small grid bias is being used, care must be taken that the screen current does not exceed 15 milliamps for any length of time. It can be taken as a working rule that the anode voltage for maximum amplitude of oscillation is approximately half the screen voltage.

The experimental work was carried out in the Applied Electricity Laboratories at Liverpool University, under the supervision of Professor E. W. Marchant, D.Sc. The paper was written as a result of a study of the Iron-cored Choke Dynatron Oscillator described by Professor Marchant at the British Association meeting held at Blackpool last year. See *Engineering*, October 23rd, 1936, page 457.

Circuit for Cathode-Ray Tubes

A New Soft Time-Base Circuit

By F. de la C. Chard, M.Sc., A.M.I.E.E.

(Lecturer in Electrical Engineering at Bristol University)

THE principle of soft time-base circuits is the charging up of a capacitor and its discharge by means of the gasfilled tube. If the capacitor is charged through a resistance, the voltage across the capacitor rises exponentially and a non-linear time sweep results. A nearly linear time-sweep is obtained either by charging the capacitor through a constant current device, such as a saturated diode or tetrode, or by selecting the initial straight portion of the charging curve and applying the linear voltage change with time, to a push-pull amplifier.

With the first method, the gasfilled tube is given a permanent negative bias which results in an intense grid-cathode field, with consequent disintegration of the cathode, unless the anode-cathode voltage is limited to about 200 volts. With high vacuum tubes this gives an insufficient deflecting voltage. The second method overcomes this difficulty but at the expense of added complication in the amplifier. Both the above methods suffer from sluggish return stroke or fly-back. This is due to the current through the gasfilled tube being nearly proportional to its anode-cathode voltage so, as the capacitor becomes discharged, the current decreases and the voltage falls more slowly. This results in a fly-back which, though rapid initially, thickens very much at one end and gives confusing effects on the viewing screen.

The time-base here described is simpler than the foregoing method but has these important advantages:

(1) Owing to the grid of the gasfilled tube being made positive during the discharge, a quicker fly-back is obtained and the capacitor is discharged almost down to the ionising potential of mercury.

(2) Owing to the less intense grid-cathode field during discharge, a higher anode voltage may be used without cathode disintegration. Both the above combine to produce a bigger time-sweep voltage, sufficient for use with high vacuum cathode ray tubes.

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

The essentials of the circuit are shown in Fig. 1, where it will be seen that the charging current of the capacitor C flows through the inductance L and the resistance R while the bias battery B is connected so as to make the grid about 10V positive to the cathode. The cycle of operations is best considered by starting at the instant that the capacitor voltage reaches the striking voltage of the tube. Charging current is still flowing as shown by the " C " arrows.

(1) Tube strikes, passing discharge current D in direction shown.

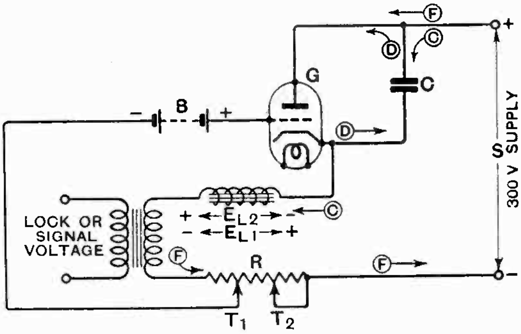

Fig. 1.—*G, hot cathode gasfilled tube ; C, capacitor ; L, inductance ; R, resistor ; B, grid bias battery.*

(2) The direction of current in the capacitor leads has reversed on striking, with consequent instantaneous stopping of the charging current. This produces an inductance voltage in direction E_{L2} which assists the bias battery to make the grid positive.

(3) Fig. 2 (b) shows how the grid is suddenly made positive and a surge of grid current flows. This surge of grid current is of such short duration that the tube cannot be damaged by it ; in any case the resistance of L is sufficiently high to afford protection.

(4) The capacitor becomes discharged and the supply voltage S maintains the tube discharge with a current (F). This " follow-on " current shown as a sudden peak in the curve of total current from the H.T. supply, Figs. 2 (c) and 4, causes maximum inductance

voltage in direction E_{L1} and a resistance voltage in the same direction.

(5) The grid is thus made very strongly negative and the discharge stops due to

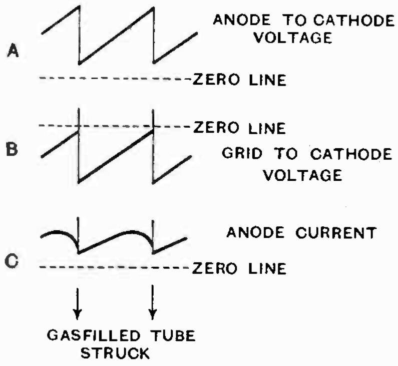

Fig. 2.

positive space-charge filling the intergrid spaces.

(6) The charging current C now flows, increasing as the inductance voltage E_{L1} dies away and decreasing as the capacitor becomes fully charged.

In order that linearity of capacitor voltage rise with time may be achieved, the supply current must produce a resistance voltage of such a form that, when added to the exponential inductance voltage E_{L1}, it gives a linear voltage change. It is apparent that the form of the current required to do this, from Fig. 3, is very similar to the actual photograph of supply current, Fig. 4. Fig. 2 (c) was drawn from the photograph Fig. 4, and a zero line added showing that the supply current never falls to zero as the follow-on current flows when the charging current ceases.

The value of inductance to obtain satisfactory linearity is not very critical 50 to 70H, and 19,000 ohms resistance being suitable for a range of capacity from 0.002 to 1.0 μF. An intervalve transformer (primary and secondary in series) has been used as the inductance with good results. As this already has a high resistance the resistance R should not exceed 10,000 ohms.

The time sweep frequency may be adjusted in three ways. Large variations may be obtained by switching extra capacitors in circuit. A more gradual adjustment is effected by altering the tapping position (T_1) of Fig. 1, which alters the grid bias. This causes the gasfilled tube to discharge earlier or later thus shortening or lengthening the timesweep. The length of sweep may also be controlled by biasing the grid positively by means of the battery B and any non-linear portions may be cut off. The third method of time-sweep frequency adjustment is the alteration of charging circuit resistance (T_2). This is useful as a fine adjustment.

The linearity was checked by operating the new time base and a standard time base on opposite pairs of deflector plates so that the spot moves horizontally with the new time base and vertically with the standard time base. If both time bases are linear and adjusted to the same frequency, the trace should be a diagonal straight line. In Fig. 5 the new time base is doing 50 sweeps per sec. and the standard 25 sweeps per sec. so that two horizontal sweeps occur for each vertical sweep and the straightness of the lines indicates the degree of linearity.

The operation of the new time base

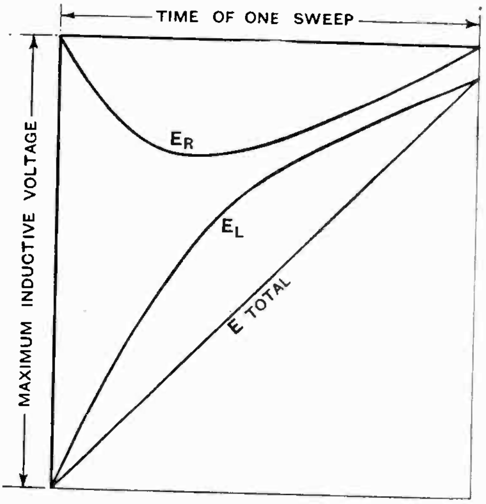

Fig. 3.—*Showing how the inductive voltage E_L when added to the resistance voltage E_R gives a straight line change of voltage with time across L and R.*

becomes more linear as the sweep frequency is raised and the frequency once adjusted is so constant that locking may be dispensed with even for the photography of a number of sweeps.

The discharge of the capacitor by the gasfilled tube is more rapid in the new circuit than with standard circuits. Fig. 4 shows the rapidity with which the follow-on current from the supply is interrupted and Fig. 6 is produced by operating the new time-base and a standard time-base at the same frequency. The base of the return stroke of the standard circuit can be seen but not that of the other.

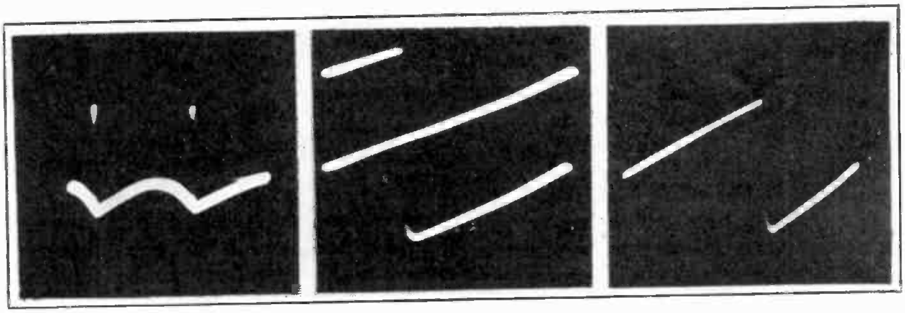

Fig. 4. Fig. 5. Fig. 6.

With two time bases of the type described, one operating on each pair of deflector plates a filled diagram may be obtained. If the vertical sweep frequency is 5,000 per sec. and the horizontal one 50 per sec., there will be approximately 100 almost vertical lines on the screen, very much like a television raster. If the grid of the tube which is operating at the higher frequency has its bias altered, the vertical lines will lengthen or shorten as the grid is made more negative or positive. Thus a voltage to be observed may be impressed on the grid-cathode circuit by means of the transformer shown in Fig. 1 or directly by producing a voltage drop across a resistance in that circuit. The lengthening and shortening of the lines will reproduce the impressed voltage variation on the screen.

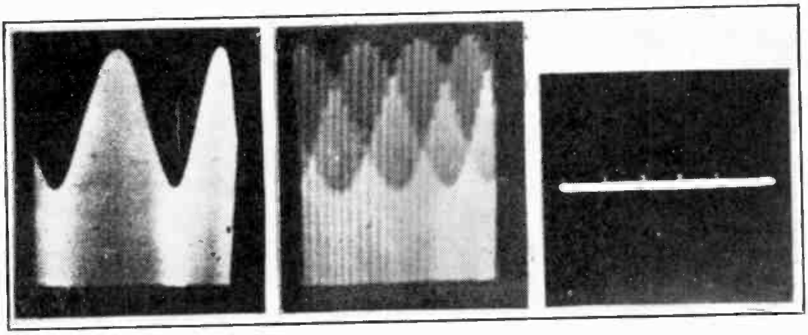

Fig. 7. Fig. 8. Fig. 9.

There are two main advantages of the filled diagram : firstly its clarity for demonstration purposes or photography and secondly a voltage variation of 5 to 10 volts is sufficient to obtain it, whereas 50 to 100 volts is required if the voltage to be observed is applied directly to the deflector plates.

Figs. 7 and 8 are examples of this method both photographed without any locking of either timesweep. In Fig. 7 the horizontal time sweep frequency is exactly half the frequency of the impressed voltage so that two complete cycles are visible. In Fig. 8 the horizontal sweep frequency is $\frac{2}{3}$ of the frequency of the voltage under observation giving a ghost effect which simulates the phase relation of 3-phase voltages.

The circuit is also suitable for use as a time marker for cathode ray oscillographs, by superimposing the voltage across a resistance in the anode circuit of the gas-filled tube on the voltage to be observed. This produces the diagram of Fig. 4 so reduced in scale that only the equidistant rushes of follow-on current are visible. Fig. 9 shows the undeflected line with timing marks produced in this manner.

Investigation of the Behaviour of a Hexode*

By H. Owen Walker, B.Sc.

(Manchester University)

Introduction.

RECENTLY an attempt was made to use the outer or modulation grid of the hexode valve for the amplification of audio-frequency voltages, the inner grid being effectively connected to the cathode. The actual circuit used is shown in Fig. 1 and the input voltage was introduced at *S*.

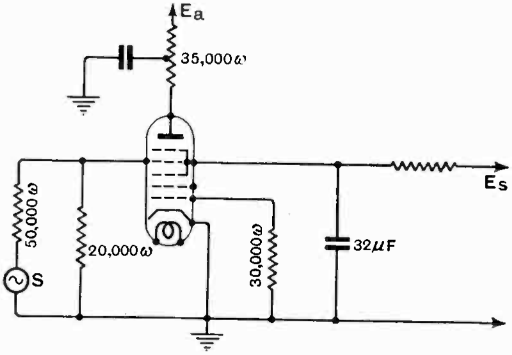

Fig. 1.

The output was fed to the *Y*-plates of a cathode-ray oscillograph. Sinusoidal input voltages then showed output voltages typified by the oscillogram of Fig. 2.

Thus faithful amplification was obtained over the greater part of the cycle but a discontinuity of very short duration occurred. This discontinuity was traced to a peculiarity in the grid current characteristic.

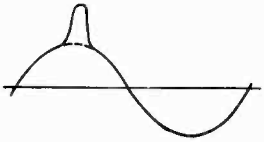

Fig. 2.

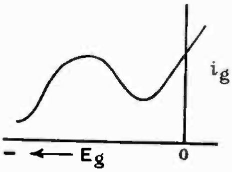

Fig. 3.

Fig. 3 shows a specimen characteristic obtained from the valve.

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

This peculiar curve was found to be due to very high frequency self oscillation of the circuit connecting screen and cathode. The following investigation of the effective impedance of the screen was therefore undertaken. The analysis is equally applicable to pentode valves in which the suppressor grid lead is brought out.

Mathematical Investigation of the Input Admittance of the Screen.

Fig. 4 shows the circuit to be analysed. The control grid has been omitted and the relevant inter-electrode or external capacity is shown by *C*. The impedance of the grid circuit is indicated by *Z*.

The static screen current grid volts and anode current grid volts characteristics are shown in Fig. 5.

On the straight part of the characteristic, we have

$$I_0 = I_s + I_p$$

to a reasonable degree of accuracy

$$I_s = I_0 - g(E'_g + E_g) \quad \quad \text{(i)}$$

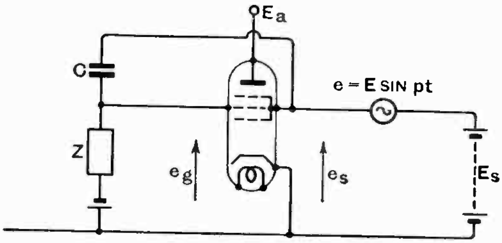

Fig. 4.

In equation (i), I_0 and '*g*' are dependent on the screen voltage. This renders the equation difficult of analysis, but in practice these variations can be neglected to the first order if the changes in screen potential are small in comparison with the mean screen potential.

With the conditions of Fig. 4

$$i_s = I_0 - g(Eg' + e_g)$$

$$= I_0 - g\left\{E_g' - E_g + \frac{Z}{Z1/jCp} \cdot E \sin pt\right\}$$

i_s contains a steady component and an oscillatory component. Let $i = I \sin (pt + \propto)$ be the oscillating component. Since E is the total voltage across the valve, Z and C combined, we find, using vector notation, that the vector admittance experienced by

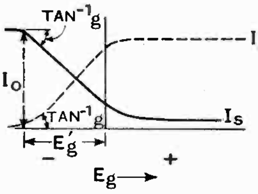

Fig. 5.

E is
$$\frac{I}{E} = a + jb = -\frac{gZ}{Z1/jCp}$$

It should be noted that $(a + jb)$ evaluates only that component of the total input admittance experienced by E which arises from thermionic action. There exists also a component of input admittance due to the circuit composed of Z and C in series which is independent of valve operation. This component is omitted in the interests of simplicity.

Putting $Z = R + jX$

We have
$$a + jb = -g\frac{R^2 + X^2 - \frac{X}{Cp} + j\frac{R}{Cp}}{R_2 + \left(X - \frac{1}{Cp}\right)^2}$$

Whence
$$a = -g\frac{\left(R^2 + X^2 - \frac{X}{Cp}\right)}{R^2 + \left(X - \frac{1}{Cp}\right)^2}$$

$$b = -\frac{gR/Cp}{R^2 + \left(X - \frac{1}{Cp}\right)^2}$$

Physically these conditions are interpreted as a resistance $\frac{1}{a}$ in parallel with a reactance $\frac{1}{b}$. With the generator in circuit these conditions are represented by Fig. 6.

Special Cases.

If either R or X are much greater than $1/Cp$.

Then $\frac{1}{a} = -\frac{1}{g}$; and $\frac{1}{b} = \propto$

The equivalent circuit is then non-inductive and possesses a negative resistance. Further, this resistance is numerically very low for $\frac{1}{g}$ may be 500 ohms or less. Thus if we connect a resonant circuit in the screen-cathode circuit oscillations will be maintained since the net resistance due to the dynamic circuit resistance and − 500 ohms in parallel is then negative.

Even if an oscillatory circuit is not deliberately introduced such a circuit will inevitably be present due to the interelectrode capacities and the external wiring. Unless great care is taken to ensure that the ratio of inductance to resistance of this circuit is kept as low as possible or "g" is kept small, the dynamic resistance of this "stray" oscillatory circuit will exceed $\frac{1}{g}$.

The natural frequency of this circuit will be very high tending to make $1/Cp$ very much less than either R or X, except when R O and X is a pure capacitance. If this latter is the case and writing $X = 1/C_2p$ where C_2 is the capacity used we have

$$\frac{1}{a} = -\frac{C + C_2}{C \cdot g}; \quad \frac{1}{b} = \propto$$

that is if "r" is the dynamic resistance of

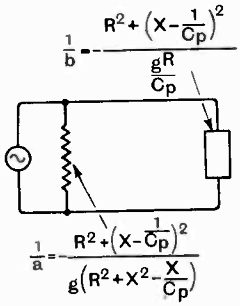

Fig. 6.

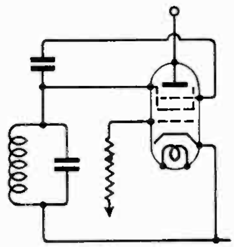
Fig. 7.

the screen circuit then the system is stable when

r is greater than $-1/a$

That is when r is greater than $\frac{1}{g}\left\{1 + \frac{C_2}{C}\right\}$

Such a case arises in the normal use of the hexode as a frequency changer.

Another case may be distinguished in which $R = 0$ and $X = Lp$, i.e., an inductance is placed in the grid circuit.

Writing $p_0 = \frac{1}{\sqrt{LC}}$

We have $\frac{1}{a} = -\frac{1 - \left(\frac{p_0}{p}\right)^2}{g}$

and $\frac{1}{b} = \infty$

Thus the equipment is inherently stable or unstable according as p_0 is greater or less than p. Since however p, the natural frequency of the screen circuit, will be very high, it will usually be impossible to make p_0 greater than p.

From the above investigation it would appear that the system may be stabilised either by reducing R and so increasing $1/a$ which requires resistance of a few thousand ohms or less. Or alternatively it is possible to reduce the dynamic resistance of the screen circuit by introducing resistance in the screen lead close to the tube. This method has been recommended and is applicable to all cases considered. If, however, the resistance required is considerable, the valve characteristics will be seriously affected.

Conclusions.

It follows from this investigation that when this valve is used for the amplification of audio-frequencies a shunt capacitance is required which is great compared with the inter-electrode capacitance. Experiments have indicated 0.001 F as a suitable value for the shunt capacitance. This shunt capacitance may seriously limit the frequency response of the amplifier.

The valve may also be used as an oscillator. This unusual behaviour of the screen-cathode circuit would appear to be the principle of the positive-mu oscillator recently described in an American technical journal. In this a pentode is used with an added capacity in the grid circuit as shown in Fig. 7.

It would also appear that the valve could be used as a short wave oscillator in which the oscillatory circuit contains the inter-electrode capacitance as the capacitance necessary. This deduction was very briefly tested by using the valve in such a circuit with a Lecher wire system connected to the cathode and the screen. Short wave oscillations of the type indicated were observed.

The writer wishes to acknowledge the facilities provided and the assistance offered by Professor R. Beattie and Dr. F. C. Williams of the Electro-Technical Dept. Manchester University.

Berco Toroidal Wound Power Potentiometer

INCLUDED among the products of the British Electrical Resistance Co., Ltd., Queensway, Ponders End, Middlesex, is a range of heavy-duty resistances and potentiometers having toroidal windings on a ring-type porcelain former. As the maximum rating of some of these is 100 watts they are suitable for use in transmitting equipment, high-power P.A. apparatus and radio relay installations, etc.

The special form of construction adopted provides the maximum possible ventilation, for the whole of the winding is surrounded by air. Heat is, therefore, rapidly dissipated provided the resistance is not mounted in a confined space.

Good insulation is provided between the spindle and the moving contact and all resistances are tested to withstand a difference in potential of 3,000 volts so that they can be mounted on metal panels even though the resistance is joined in high-voltage circuits.

Nickel and phosphor-bronze is used for the moving arm which carries a contact brush made of a copper-graphite mixture. In addition to providing a low resistance contact the presence of the graphite acts as a lubricant and minimises the likelihood of noise arising during use.

Silence in operation is also ensured by fitting a collector plate and not relying on the friction contact in the spindle bearing.

Provision is made for ganging several units for operation by a single control.

Tests have been made with a specimen resistance and these fully confirm the maker's claims regarding silence in action and good heat dissipation.

These resistances, which are described as the Type T are made in 50-watt and 100-watt sizes, the former being available in resistance values of from 3 to 7,800 ohms while in the larger size the values range from 3 to 17,000 ohms.

A Gas-Relay Operated Frequency Meter*

By E. J. B. Willey, D.Sc., Ph.D.

(Davy-Faraday Laboratory, The Royal Institution, London)

ALL of the standard methods for the measurement of frequency in A.C. circuits suffer to a greater or lesser degree from susceptibility to the wave-form of the current concerned. An arrangement accurate with a pure sine wave may, for example, become unreliable when there is only a small superposition of harmonics, and necessitate laborious recalibrations. It is the purpose of the following communication to show that this difficulty may be eliminated by the use of a simple thyratron or other gas relay bridge device, which is applicable from the lowest to frequencies of the order of some thousands per second.

Consider the arrangement shown to the left of the dotted line in Fig. 1, where two thyratrons or other gas relays are provided affect thyratron *A*, but may, if it is correctly adjusted with regard to the bias, etc., switch on the other thyratron (*B*). When this occurs, the drop of anode potential of *B* from the line voltage V_L to ca. 20 (since the impedance of a thyratron then passing anode current is so small), causes the transmission of a large negative potential surge through condenser C_1 to the anode of thyratron *A*, thereby momentarily reducing its potential below the value (V_D) requisite to the maintenance of the discharge, so that anode current stops. The next signal relights valve *B* and extinguishes *A*, etc., so that each thyratron responds to one-half of the total number of signals applied. This is the principle of Dr. C. E. Wynn-Williams' "scale of two" counter, successive pairs of thyratrons being

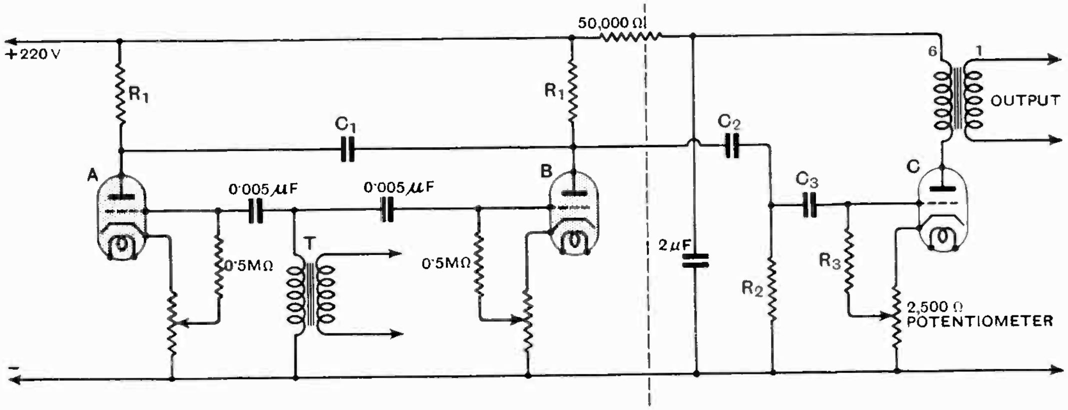

Fig. 1.

A and B, Osram GT1 relays; C, MH4; R_1, 5 000 ohms; R_2, 20 000 ohms; R_3, 100 000 ohms; C_1, 0.1 μF; C_2, 0.002 μF; C_3, 0.0003 μF.

with anode resistances R_1 and an anode condenser C_1. Suppose that one of them (e.g. *A*) be caused to strike, for example, by momentary removal of the grid bias. A signal which is then applied through the transformer *T*, or by some other means, to the grids of both simultaneously, will not coupled together until the rate of make and break of anode current becomes low enough to be recorded mechanically. (*Proc. Roy. Soc.*, 1932, **136 A.** 312).

Although this arrangement was originally developed for the counting of events irregularly distributed in time, i.e., the emission of α — particles, it can clearly be used for

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

the determination of purely rhythmic signals, and, in conjunction with a photocell and amplifier, has for some years been employed by the present author for the measurement of frequency in an impulse discharge through gases at low pressures. Here, where frequencies up to ca. 300 per second were anticipated, four pairs of thyratrons were used, until it was realised that three of these could be eliminated in the following manner.

When a thyratron is alternately started and stopped as above, its anode undergoes a cyclic change between V_L and V_D in a manner controlled only by the circuit constants and the valve characteristics. There is thus developed between anode and cathode an alternating E.M.F. whose amplitude and waveform are constant, its frequency only being determined by the nature of the incoming signal. In other words, *any* signal which can " trip " a thyratron will be reproduced in a perfectly constant fashion at the same frequency. Oscillographic tests have confirmed this supposition.

It is thus clear that an A.C. conducting path placed between anode and cathode will pass a current whose R.M.S. value will be proportional to the frequency of the signals operating the thyratrons, it being always understood that this auxiliary circuit shall be of impedance high enough to have no appreciable effect upon the main one. The latter condition means that since only a small current will flow, the A.C. instrument of the auxiliary circuit must be a sensitive one of the vacuum thermojunction type, and although a meter placed in series with condenser C_2 and connected to the H.T. negative may be perfectly effective under some conditions, it is generally preferable to use a simple amplifier as shown to the right of the dotted line in Fig. 1.

Given proper attention to bias, anode voltage, etc., the relation between output A.C. current and frequency, is linear over a very wide range, which can be prolonged by reduction of the capacity C_2. The greater this range of linearity, the less the slope, and vice versa, and since at first the departure from strict proportionality is but small, it may clearly be permissible when a limited range of frequencies is to be measured, to use a somewhat larger condenser than may be allowed for C_2 under other circumstances. This is very conveniently done by provision of three or four small capacities which can be brought into circuit by a simple switching arrangement.

Two precautions are necessary when using this circuit, as follows :—

(*a*) Since thyratrons and gas relays in general are not perfect rectifiers, it is inadvisable to apply to their grids signals which are of the same order of amplitude on both sides of the zero voltage axis. If for example raw A.C. be applied, small reverse peaks may be observed in oscillograms of the current through the relays, and in such cases, preliminary rectification of the signal is advisable.

(*b*) Serious inaccuracy may occur if the incoming signal consists of groups of waves whose peaks are of comparable magnitude and separated by a time interval greater than the critical " resolution " of the relay bridge. According to Wynn-Williams (*loc. cit.*) the interval wherein the bridge may be regarded as " dead " to an applied impulse, is of the order 0.7 to 0.8 C_1R_1. If then this time constant be too small, the bridge will respond not merely to the first peak and hence only once to the group, but to each individual member. Hence if the signal is suspected to consist of groups of damped oscillations, for example, this danger should be met either by judicious smoothing or else by adjustment of C_1 and R_1. In the author's experience, the maximum frequency which can be handled by this bridge, at any rate with mercury-filled relays, is ca. 3000 signals/sec., and for high speed work it is generally preferable to make the necessary reduction of C_1R_1 by decrease of R_1, since if the interanode condenser be too small, the extinction process becomes, as Wynn-Williams has observed, somewhat uncertain.

Calibration may easily be made by means of a photoelectric signal from a disc provided with narrow apertures and driven by a motor fitted with a revolution counter. It only remains to add that customary precautions as regards decoupling and shielding should be observed in any circuit for preliminary amplification of the signal to be handled.

Annual British Radio Exhibition—August 25th to September 4th at Olympia, London.

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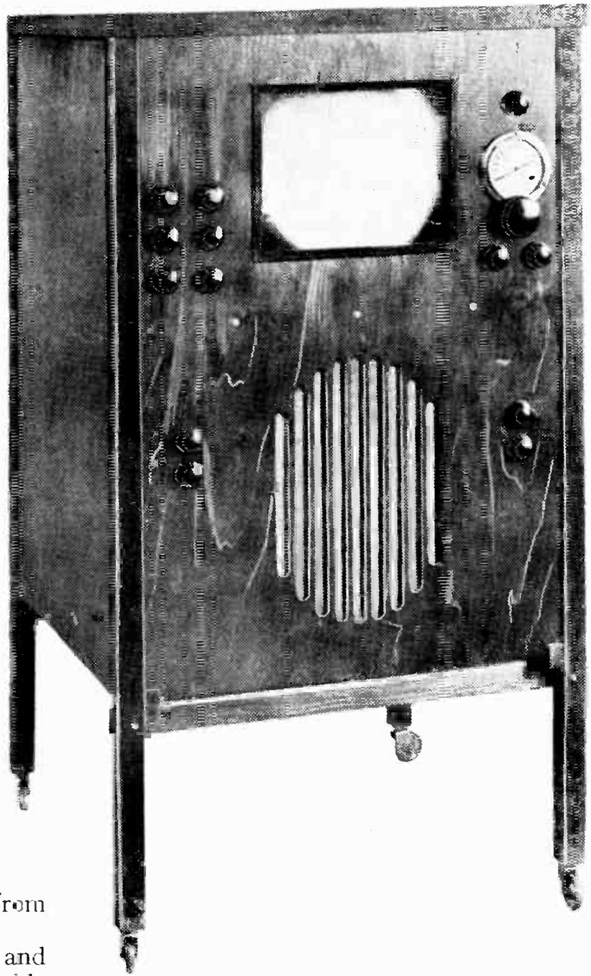
Television Receiver

Complete Vision and Sound Equipment



FOLLOWING a series of articles dealing with the design of television equipment, full constructional details of such apparatus were given in *The Wireless World* of July 2nd, 9th, 16th, 23rd and 30th, 1937. A 12in. tube with electrostatic deflection is used and the double time-base embodies gas-filled triodes for generating the scanning voltages; push-pull amplifiers are used to obtain balanced deflection.

The receiver is of the straight type with three R.F. stages, a diode detector and one vision-frequency amplifier. The D.C. component is replaced by a diode and a further valve acts as an amplitude filter for sync separation. The sound receiver is also a straight set of simple type and is entirely separate from the vision equipment.

The apparatus is readily accessible and extended tests have proved it to be reliable in operation and easy to handle, while setting an extremely high standard of performance.

National Physical Laboratory

THE annual visit to the National Physical Laboratory at Teddington took place on June 22nd last when an opportunity was afforded to inspect the past year's work.

Among matters of radio interest was a new automatic "Pulse" transmitter and receiver installed for investigating the ionisation at different levels in the ionosphere. The main interest in this equipment is the method of synchronising the transmitter and the receiver. Observations are made over a very wide band of radio frequencies, i.e., 1 to 20 Mc/s., yet the apparatus is entirely automatic in operation, the receiver following every change in transmitter frequency and recording the received signals.

Further work has been done with ultra-short-wave direction finding apparatus, and a portable set for use on wavelengths below 10 metres was demonstrated.

Apparatus for the measurement of the impedance between the anodes of a magnetron valve at ultra-high frequencies has been developed and there were to be seen also some new precision direct-reading measuring equipment for frequencies of from 1,000 kc/s to 75 Mc/s.

Portable apparatus for the measurement of sound is a new development. This consists of a modified rectifier circuit which in conjunction with a special meter gives readings of intermittent sounds closely approximating to those for sustained sounds of equal intensity.

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 the abstract.

PROPAGATION OF WAVES

2850. RADIO FADING AND SOLAR ERUPTIONS [Some Eruptions produce Fading, Others do Not: 54-Day Interval Not Recently Maintained].—J. H. Dellinger. (*Nature*, 22nd May 1937, Vol. 139, pp. 889–890: short note on recent observations.)

2851. OBSERVATIONS [on Ultra-High Frequencies around 40 Mc/s, received in Germany (and South Africa) over Very Long Distances] DURING A STRONGLY MARKED DELLINGER EFFECT [Fade-Out of Frequencies between about 13 and 30 Mc/s].—H. A. G. Hess. (*QST*, June 1937, Vol. 21, No. 6, pp. 69–70.) A letter announcing results on 5th–8th Nov. 1936.

2852. ON THE PERIODICITY OF GENERAL FADING [Japanese Observations of Dellinger Effect].—I. Ozeki. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 22.)

The general fading curves, always similar in type, indicate that the phenomenon has a tendency to occur at intervals of 27 days or less, which gradually lengthen to 28 days or slightly longer: after which it ceases. Assuming it to be caused by an explosion on the sun, it appears to occur only when the point of explosion is within about 40° east or west of the centre of the solar disc.

2853. INTERNATIONAL COOPERATION FOR CONTINUOUS OBSERVATION OF THE SUN, AND ITS FIRST RESULTS [Recent Work on Chromospheric Eruptions and Radio Fade-Outs].—L. d'Azambuja. (*Comptes Rendus*, 31st May 1937, Vol. 204, No. 22, pp. 1623–1625.)

2854. TERRESTRIAL EFFECTS ACCOMPANYING SEVERAL BRIGHT CHROMOSPHERIC ERUPTIONS [on 8th April, 25th Aug. & 6th Nov. 1936: Radio and Magnetic Effects].—A. G. McNish. (*Science*, 7th May 1937, Vol. 85, pp. 441–442.) Summary of paper at Washington meeting of the National Academy of Sciences. *See* also 1281 of April.

2855. MAGNETIC DISTURBANCES AND AURORAS [Notes of Disturbance on May 4/5].—J. P. Rowland. (*Nature*, 15th May 1937, Vol. 139, p. 835.) Including correction to declination range in letter referred to in 2450 of July.

2856. PERIODIC VARIATIONS IN LONGITUDE [deduced by Comparison of Observatory Time Signals: Large Longitude Variation corresponds to Large Variation in Solar Activity].—N. Stoyko. (*Comptes Rendus*, 24th May 1937, Vol. 204, No. 21, pp. 1577–1579.)

2857. THE PROPERTIES OF 10 m WAVES IN EUROPEAN TRAFFIC.—E. Fendler. (*Hochf:tech. u. Elek:akus.*, May 1937, Vol. 49, No. 5, pp. 171–172.)

For a previous communication *see* 2056 of June. Further data of the skip zone there mentioned are now given (Fig. 1). The occurrence of scattered radiation from emitters with long horizontal aerials and of partial reflection from E region is invoked to explain observational results obtained inside the 1000 km zone in November 1936.

2858. SOME EXPERIMENTAL DATA ON THE PROPAGATION OF SHORT WAVES DURING A SOLAR ECLIPSE.—V. P. Blagoveshchenski. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 22–28.)

A report on observations carried out during the solar eclipse of 19th June 1936 at a receiving station in Leningrad, where at the height of the eclipse 68% of the sun's surface was obscured. Reception from Russian and foreign stations operating on wavelengths between 10 and 50 m was observed, and the level of atmospherics noted. In addition to aural reception, oscillograms were taken, and some of these are reproduced. The main conclusions reached are as follows:—(1) Severe and prolonged fading of distant stations, followed by their complete suppression, was observed on wavelengths between 10 and 21 m; (2) complete suppression of distant stations, and lowered audibility, with severe fading, of stations situated at distances up to 600 km, was observed on wavelengths between 21 and 32 m; (3) no change in reception was observed on wavelengths between 32 and 45 m; and (4) the level of atmospherics increased considerably on wavelengths between 17 and 45 m, and in particular between 17 and 32 m.

2859. IONOSPHERIC CONDITIONS DURING THE SOLAR ECLIPSE OF 19TH JUNE 1936.—R. Naismith. (*Proc. Phys. Soc.*, 1st May 1937, Vol. 49, Part 3, No. 272, pp. 214–224.)

Data of vertical-incidence radio observations over a period centred on the eclipse are given, and discussed in relation to a large magnetic disturbance which occurred during the period. "The results of a number of field-strength measurements made on signals traversing the path of the eclipse are given and interpreted in relation to the ionospheric measurements. . . . The coincidence of the eclipse with sunrise over south-eastern England suggests that the minimum of ionisation thereby created made this the control region so far as the long-distance transmissions are concerned . . . a reduction in field strength was associated with the time during which the eclipse effect occurred in the path of the signals."

2860. ON THE ACTION OF ULTRA-VIOLET SUNLIGHT UPON THE UPPER ATMOSPHERE.—M. N. Saha. (*Proc. Roy. Soc.*, Series A, 18th May 1937, Vol. 160, No. 901, pp. 155–173.)

For a previous paper *see* 2446 of July. Here "it is shown that a satisfactory theory of upper air phenomena . . . must be based on a precise knowledge of the action of ultra-violet sunlight (below λ 3000) on molecular oxygen and nitrogen. . . . The nature of molecular ionisation and excitation and the heights at which they occur are discussed in detail." According to evidence available at present, "molecular ionisation of O_2 and N_2 by photochemical action does not take place at the lowest ionisation potential but at the second ionisation potential . . . the discussion brings out the necessity of carrying out well-planned laboratory experiments on the absorption spectra of O_2 and N_2 . . . the ultra-violet radiation from the sun differs widely from that of a black body . . . the ultra-violet spectrum of the sun may consist of a continuous background of faint light on which are superposed emission lines of H, He, He^+, Fe^+ and other elements . . . or by patches of ultra-violet continuous light . . . leaking through the solar atmosphere from a much hotter region inside the photosphere."

2861. SOME OBSERVATIONS OF THE VARIATION OF IONOSPHERIC EQUIVALENT HEIGHTS [Changes of Height of E-Region Echoes: Explanation by Group Retardation in D Region].—S. S. Banerjee & B. N. Singh. (*Zeitschr. f. Physik*, No. 5/6, Vol. 105, 1937, pp. 309–318.)

Measurements are given of the apparent height of E region for a wavelength of 78 m. This is found to increase near sunrise, while the echo sometimes disappears at midday in the summer. An explanation is given on the basis of group retardation and absorption in D region, which is assumed to attain its maximum ionisation exponentially and to keep this maximum value for a distance of 0.1 km, instead of decreasing immediately.

2862. CRITICAL FREQUENCIES OF LOW IONOSPHERE LAYERS.—N. Smith & S. S. Kirby. (*Phys. Review*, 15th May 1937, Series 2, Vol. 51, No. 10, pp. 890–891.)

"The critical frequency of at least one of these lower layers [below E region] has been observed . . . by the method of continuous automatic field-intensity recording, and this layer has been observed to provide regular radio transmission by the same refracting process as the well-known higher layers . . . in contrast to the behaviour of the 'non-deviating' low region postulated by other workers. The evidence we present is therefore the first proof of the existence of a truly refracting layer below the E layer . . . the phenomenon of change of layer in the morning and afternoon can be recognised (Fig. 1, top record, frequency 6060 kc/s). The lower record of Fig. 1 shows a similar effect in the broadcast frequency band (1040 kc/s)." The corresponding vertical-incidence critical frequency is less than 450 kc/s, equivalent electron density less than 2.5×10^3 per cm^3. Automatic field-intensity recording is suggested as a method of determination of the critical frequencies and other properties of these low layers of low ionisation densities.

2863. THEORY OF THE THREE REGIONS OF THE IONOSPHERE [Calculations of Ionisation in Thermodynamic Equilibrium with Solar Radiation agree with Observed F_1 & F_2 Regions but not with E Region].—E. O. Hulburt. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 689: abstract only.)

2864. DRIFT OF IONS AND ELECTRONS IN A MAGNETIC FIELD [Theory].—L. Tonks. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, pp. 744–747.)

The writer finds that Townsend's equations (*Proc. Roy. Soc.*, Series A, Vol. 86, 1912, p. 571) are inconsistent with the Boltzmann equations. He proposes other relations "according to which the gradient contributes a perpendicular component to the drift . . . These equations lead to the satisfactory result that the drift speed is the same as would occur if the components of concentration gradient and electric field perpendicular to it, as well as the magnetic field itself, did not exist." He also criticises the work of Huxley (1287 of April) for failing to set up the distribution function and for omitting the transverse gradient terms.

2865. REFLECTION OF ATMOSPHERICS AT AN IONISED LAYER [at about 80 km].—Laby & others. (*See* 2881.)

2866. BRITISH RADIO OBSERVATIONS DURING THE SECOND INTERNATIONAL POLAR YEAR 1932–33.—E. V. Appleton, R. Naismith, & L. J. Ingram. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 10th April 1937, Vol. 236, No. 764, pp. 191–259.)

The full account of work to which preliminary reference was made in Abstracts, 1933, p. 613 (Appleton, Naismith, & Builder), and 1934, p. 28 (Appleton). Details of the apparatus, programme, and observational results are given. The discussion is divided into (1) "all matters relating to normal variations of the ionosphere such as find a satisfactory explanation in terms of the ultra-violet-light theory of ionisation origin," (2) "all matters referring to the connection between magnetic activity and abnormal ionospheric effects," and (3) "abnormal region E phenomena." A further section deals with ionospheric phenomena and the sunspot cycle. Notable results obtained were that at Tromsö "at the time of the midnight sun in summer the maximum ionisation of region F_2 is greater at midnight than at noon," which may be "due to the cooling of the upper atmosphere at midnight causing a concentration of electrons"; also, "extremely low ionospheric reflection coefficients . . . were associated with intense magnetic disturbance"; "correlation factors between daily values of ionisation-density and magnetic-character figures both at Tromsö and Slough show in general an inverse relation which is specially marked for region F_2"—this "may be due to the inflation of the atmosphere due to increased temperature produced by the agency which causes the magnetic storm." When abnormal E region reflections "are in evidence, the stratum in question does not show true critical frequency but exhibits the phenomenon of partial reflection." Continuation of the experiments at Slough since 1933 has shown that, for region F_2, "the ionisation density is found to follow the sunspot cycle directly. Similar, though smaller, effects are found for regions F_1 and E . . . it is considered that these results show that there is a variation of the solar ultra-violet light during the sunspot cycle and that the effect is most marked for the most easily absorbed radiation, which is presumably of the shortest wavelength."

2867. GROUND AND IONOSPHERIC RAYS: A COMPUTATION OF THE RELATIVE INTENSITIES ON VARIOUS WAVELENGTHS FROM EXISTING DATA.—Ross. (*See* 2986.)

2868. THE PROPAGATION OF 200 KC/S WAVES IN NIPPON.—Inanami. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 61–69.)

A summary was referred to in 855 of March. "With 1 kw of radiation power the waves may be propagated to a distance of 300 km before dropping to an intensity of 40 db," compared with 150 km on waves around 1 Mc/s. From Tokio, the attenuation was practically the same in every direction, as far as 150 km: beyond that, the influence of the various paths came into evidence. Up to 150 km, fading was not strong enough (less than 10 db) to cause objectionable interference: around 250 km, 15–20 db of fading occurred. Other results are noted.

2869. GROUND-WAVE ATTENUATION AT BROADCAST FREQUENCIES [with results of Field-Strength Measurements over Various Types of Terrain in Oregon].—O. D. Perkins. (*Comm. & Broadcast Eng.*, May 1937, Vol. 4, No. 5, pp. 16–19.)

2870. DIELECTRIC CONSTANT AND CONDUCTIVITY OF SOIL AT HIGH RADIO FREQUENCIES [50–70 Mc/s: Measurements by Buried Lecher Wire System].—S. S. Banerjee & R. D. Joshi. (*Science & Culture*, Calcutta, May 1937, Vol. 2, No. 11, pp. 587–588.)

Conductivity increases with frequency and moisture content: for dry soil it ranged from 1.5×10^6 to nearly 2.6×10^6 e.s.u. The dielectric constant diminishes with rise of frequency but increases with moisture content, ranging from 4.5 (6.3%) to 17.3 (13.9%). The attenuation constant is of the order of 10^{-2} e.s.u.: its variation is not very regular, but generally it is higher for moist soil and higher frequency. "The values of conductivity and dielectric constant are small compared with the values obtained for English soils."

2871. INDEX OF REFRACTION OF WATER 8.79 FOR MICRO-WAVES OF 2–8 INCHES, COMPARED WITH ABOUT 1.6 FOR LIGHT.—H. W. Knerr. (*Science*, 7th May 1937, Vol. 85, Supp. p. 10.) Paragraph only.

2872. REVISED JAPANESE URSIGRAM CODE: TO TAKE EFFECT FROM APRIL 1ST, 1937.—(*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, pp. U-13–U-19.)

2873. CONTROL OF WIRELESS SIGNAL VARIATIONS [by Transmission on Adjacent Frequencies], *and* CONTROL OF PHASE-FADING IN LONG-DISTANCE RADIO COMMUNICATION [Optimum Control by imposing Two Modulations having Frequencies in 3 : 1 Ratio, and suppressing the Carrier].—Green & Builder: Green & Pulley. (*Journ. I.E.E.*, June 1937, Vol. 80, No. 486, pp. 610–622: pp. 623–633: Discussions pp. 633–635.)

Summaries were referred to in 1275 of April. Applications of the principle to ionospheric research, d.f., and broadcast telegraphy and telephony are discussed. An interesting point mentioned is that in some early ionospheric work in Australia the fact that the transmitter employed happened to be fully modulated at 1000 c/s (now found to be close to the optimum frequency for the suppression of phase-interference—and of the Appleton-Barnett artificial fading) led to a complete absence of sky wave and to the natural conclusion that the properties of the ionosphere over Australia were very different from those previously measured in England.

2874. TEMPERATURE VARIATIONS OF ATMOSPHERIC OZONE ACCORDING TO ITS ORIGIN [Polar or Subtropical: Displacement of Air Masses determinable from Ozone Absorption Spectra].—Barbier, Chalonge, & Vassy. (*Comptes Rendus*, 31st May 1937, Vol. 204, No. 22, pp. 1665–1667.)

2875. RELATIVE MEASUREMENTS OF THE ABSORPTION COEFFICIENTS OF OZONE IN THE REGION OF CHAPPUIS BANDS.—Arlette Tournaire-Vassy. (*Comptes Rendus*, 10th May 1937, Vol. 204, No. 19, pp. 1413–1414.)

2876. CORRELATION OF OZONE WITH ATMOSPHERIC PHENOMENA [Connection closest with Entropy and Potential Temperature in Stratosphere].—A. R. Meetham. (*Nature*, 29th May 1937, Vol. 139, p. 933: note on recent paper to *Roy. Met. Soc.*)

2877. THE GRAPHICAL RESOLUTION OF PROBLEMS OF WAVE PROPAGATION.—L. Bergeron. (*Génie Civil*, 15th May 1937, Vol. 110, No. 20, p. 448: summary of lecture.)

2878. Propagation of Potential Waves in Discharge Tubes: Negative Impulses travel Twice as Fast as Positive.—Beams, Snoddy, & Dietrich. (*Science*, 7th May 1937, Vol. 85, Supp. p. 10.) Paragraph only. For previous work *see* 876 of March.

2879. The Scattering of Light by Water.—L. H. Dawson & E. O. Hulburt. (*Journ. Opt. Soc. Am.*, June 1937, Vol. 27, No. 6, pp. 199–201.)

2880. The Optics of Thin Metallic Films [Theory of Method of Measurement of Product of Refractive and Absorption Indices by Intensity Measurements: Test of Maxwell's Theory: Optical Determination of Film Thickness].—H. Wolter. (*Zeitschr. f. Physik*, No. 5/6, Vol. 105, 1937, pp. 269–308.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2881. Reflection of Atmospherics at an Ionised Layer [at Height of about 80 km: Wave-Form Records show Multiply-Reflected Pulse: Fundamental Frequency about 10^4 c/s].—Laby, Nicholls, Nickson, & Webster. (*Nature*, 15th May 1937, Vol. 139, pp. 837–838.)

2882. Increase of Atmospherics on Short Waves during Solar Eclipse.—Blagoveshchenski. (*See* 2858.)

2883. Tracking Thunder [Invitation to Collaborate with Thunderstorm Census Organisation].—Morris Bower. (*Electrician*, 4th June 1937, Vol. 118, p. 756.)

2884. A Drum Camera for recording Transient Electrical Phenomena [1 m of Paper, 10 cm Wide, equivalent to 1000 ft of 35 mm Ciné Film].—F. E. Lutkin. (*Journ. Scient. Instr.*, June 1937, Vol. 14, No. 6, pp. 209–212.)

2885. A Lightning Flash and Its Component Strokes [Photographs and Analysis of Flash, Leader and Component Strokes].—J. G. Albright. (*Journ. of Applied Physics* [formerly *Physics*], May 1937, Vol. 8, No. 5, pp. 313–318.) Using the multi-camera apparatus dealt with in 1699 of May.

2886. Lightning.—Goodlet. (*Met. Vickers Gazette*, March & June 1937, Vol. 16, Nos. 287 & 290, pp. 378–380 and 450–460.) The full paper, a summary of which was referred to in 1700 of May. For appendices see *ibid.*, July 1937, No. 291, pp. 20–24.

2887. Experimental Investigation of a Spark Discharge, *and* Factors affecting the Damage of Direct Lightning Strokes.—Stekolnikov & Belyakov: Belyakov & Khanov. (*Elektrichestvo*, No. 22, 1936, pp. 16–20: pp. 20–24: in Russian.)

2888. The Influence of the Shunt Circuit to Earth of Lightning-Protection Apparatus in an Electric Network [Calculations including Effect of Non-Infinite Velocity of Propagation of Waves in Circuit: Wave Forms at Various Points: Error due to Usual Neglect of Resistance of Earth Connection].—G. Bodier. (*Comptes Rendus*, 24th May 1937, Vol. 204, No. 21, pp. 1552–1554.)

2889. The Distortions of Surges [on Lines, due to Stray Inductances or Capacities, to Neighbouring Conductors, or to Skin Effect: Treatment by Operational Calculus].—K. W. Wagner. (*Elektrot. u. Masch:bau*, 2nd & 9th May 1937, Vol. 55, Nos. 18 & 19, pp. 209–215 and 224–230.)

2890. On the Working Mechanism of Thyrite.—N. N. Sokolov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 7, 1937, pp. 465–475.)

2891. The Landing and Installation at the North Pole of a Soviet Scientific Mission, 21st May 1937.—(*Génie Civil*, 5th June 1937, Vol. 110, No. 23, p. 511.)

2892. Radio Equipment for the Harvard Radio-Meteorographs, *and* The 1936 Radio-Meteorographs of Blue Hill Observatory.—A. E. Bent: K. O. Lange. (*Bull. Am. Meteorolog. Soc.*, March 1937, Vol. 18, No. 3, pp. 99–107: pp. 107–126.)

2893. The Physical Processes at the Birth of *Nova Herculis*.—W. Grotian. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 18, 1937, pp. 146–160.)

2894. Recent Developments in Geiger-Müller Counters.—P. B. Moon. (*Journ. Scient. Instr.*, June 1937, Vol. 14, No. 6, pp. 189–193.)

PROPERTIES OF CIRCUITS

2895. On the Calculation of the Resonance Curves of Group II Multi-Stage Band-Pass Amplifiers operating at a Fixed Frequency.—L. V. Mittelman. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 1–12.)

The theory of two-stage filters as given by Beatty, Bligh, and Oatley is discussed, and the results obtained are applied to the case of a Group II amplifier, *i.e.* an amplifier consisting of a number of identical two-stage filters separated by valves. The equation of the over-all resonance curve of such an amplifier is derived, and various factors affecting the shape of the curve are discussed. Methods are indicated for designing the amplifier. Two cases are considered, differing in the sets of data and the quantities to be determined. The discussion is illustrated by numerical examples and charts are included in order to simplify the design work.

2896. Resistance-Capacity Circuits in Broadcast Technique.—R. Theile. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 147–150.)

2897. UNIVERSAL AMPLIFICATION CHARTS [for Gain/Frequency Characteristics of Conventional Resistance- and Transformer-Coupled Amplifiers].—F. E. Terman. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 34-35.)

2898. NEGATIVE RESISTANCE AND HIGH SELECTIVITY OBTAINED IN STABLE FASHION BY THE USE OF POSITIVE AS WELL AS NEGATIVE FEEDBACK.—Vecchiacchi. (*See* 2923.)

2899. SHORT-WAVE FILTERS MADE OF WIRE.—Mizuhasi. (*See* 2959.)

2900. CONSTANT RESISTANCE NETWORKS WITH APPLICATIONS TO FILTER GROUPS [Analysis].—E. L. Norton. (*Bell S. Tech. Journ.*, April 1937, Vol. 16, No. 2, pp. 178-193.)

"The use of the constant-resistance pairs of filters is indicated wherever the impedance at the junction of two filters is of major importance. Another application which is of some importance is that of separating the energy in a band of frequencies into two or more channels, delivering all of the energy into one or the other of the loads."

2901. THE DESIGN OF COUPLING FILTERS IN BROADCAST RECEIVERS [and the Conditions for Band Symmetry with Circuits Not Identically Similar: etc.].—G. W. O. H. (*Wireless Engineer*, June & July, 1937, Vol. 14, Nos. 165 and 166, pp. 289-292 and 347-350.)

Editorial on the writer's simple method (published in 1916) of explaining the action and calculating the performance of such filters, and on recent German papers (414 of 1935; 488, 2992 & 3357 of 1936, and 2085/2086 of June).

2902. ANALYTICAL CONSIDERATIONS OF BAND-PASS FILTERS IN SUPERHETERODYNE RECEIVERS.—Fukata. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 72-73: in English.) *See* 956 of March.

2903. ON THE WAVE SELECTOR CIRCUIT [Theory and Design of "Filter Bus-Bar" System of Filters in Cascade, to replace Usual Parallel Connection, with Its "Short-Circuit Effect" Defect].—H. Nukiyama & Z. Kamayachi. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 15-28: in English.)

2904. ELECTRICAL CIRCUITS WITH LUMPED CONSTANTS AND MUTUAL INDUCTANCE.—Gorokhov & Ionkin. (*Elektrichestvo*, No. 22, 1936, pp. 29-32: in Russian.)

2905. FILTERS FOR RECTIFIERS [particularly Hot-Cathode Mercury-Vapour Types of Output at least 100 Watts: leading to Design Suggestions].—Duinker. (*Philips Transmitting News*, May 1937, Vol. 4, No. 2, pp. 1-16: in German and English concurrently.)

Such a filter is used to attenuate the ripple voltage to a sufficiently high degree; in designing it, "attention should also be paid to the permissible peak values of the currents in the valves, both under transient and stationary conditions. Moreover, it is desirable to produce a d.c. voltage which, as far as possible, does not depend on the loading current. From these requirements, minimum values for LC, $\sqrt{L/C}$, and L respectively can be deduced. The influence of asymmetrical conditions on the ripple voltage, as well as the conditions that govern the number of filter sections, will be discussed." Only filters consisting of choke coils and condensers are considered, but a footnote refers to a recent paper on a smoothing system consisting of a choke and a battery. In order to limit the maximum peak currents which would impair the life of the values, the first condenser should be small, or omitted altogether so that the first element is an inductance (Fig. 1). For lower-power rectifiers, as used in broadcast receivers, this first condenser is generally included, since the high-vacuum diodes employed, added to the resistance of the mains transformer (which is comparatively big considering the small output) considerably limit the peak currents. The a.c. voltage required for producing a given d.c. voltage is lower if the first condenser is included.

2906. LATTICE ATTENUATING NETWORKS [Extension of McElroy's Design Formulae to Lattice or Bridge Type Section].—G. C. Omer, Jr. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 620-622.) *See* 3652 of 1935.

2907. TABLES OF FORMULAE FOR PASSIVE LINEAR QUADRIPOLES: FOR SYMMETRICAL QUADRIPOLES.—(*Alta Frequenza*, May 1937, Vol. 6, No. 5, pp. 333-339: June, No. 6, pp. 403-407.)

2908. THE EVOLUTION OF THE METHODS OF CALCULATION OF TRANSIENT PHENOMENA.—A. Blondel. (*Rev. Gén. de l'Élec.*, 20th & 27th Feb., 6th & 13th March, and 8th May, 1937, Vol. 41, pp. 227-240, 259-271, 298-311, 327-340, and 579-598: with long bibliography.) For a correction see *ibid.*, 22nd May, p. 650.

2909. ON THE USE OF THE METHOD OF LEAST SQUARES FOR ESTIMATING LINEAR DISTORTION.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 7, 1937, pp. 515-530.)

In the extensive literature on distortion it is frequent that no clear indication is given of the criterion by which the distortion is estimated. In the present paper the following expression is proposed for this purpose :—$\int_0^T (x - x_0)^2\, dt$, where x_0 ($= F/q$) is the undistorted recording of the signal F, x is the actual recording of the signal, and q is the term independent of p ($= d/dt$) in the general equation of the systems examined, $H(p)x = F$.

$F = 1$ is suggested for the test signal, and it is shown that when only positive powers of p are contained in $H(p)$ the integral can be evaluated from 0 to ∞, while when negative powers of p are also present the upper limit of the integral is determined by the practical conditions under which the system is operating. The discussion is illustrated by examples relating to systems with one degree of freedom. A short survey of the literature on distortion (mainly in oscillographs) is added. For previous work *see* 57 of January.

2910. A METHOD FOR THE INTEGRATION OF HOMOGENEOUS DIFFERENTIAL EQUATIONS.—H. Piesch. (*E.N.T.*, April 1937, Vol. 14, No. 4, pp. 145–155.)

The known method of Poincaré is discussed and amplified in relation to the graphical integration of second-order homogeneous differential equations. The definition and representation of the singular points (§ B), and of the limiting cycle (§ C) as the asymptotic limit of integral curves (Fig. 5), are discussed analytically. An analytical method of determining the limiting cycle is described (§ D), with a method of graphical approximation; it is illustrated by working through an equation given by van der Pol for non-linear oscillations (*Radio Review*, Vol. 1, 1920, pp. 701–710) and by a definite numerical example (§ E).

2911. A STUDY OF THE SINGLE-LAYER SOLENOIDS USED IN SHORT-WAVE CIRCUITS [Application of Principle of Similitude to Resonance Impedance and "Q" Value, with respect to Self Inductance and Natural Wavelength].—H. Seki. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 27.)

"For a given diameter D there exists a coil form which makes Q maximum, the maximum value of Q thus determined being proportional to $D^{0.87}$ . . . n and D/l are two factors for minimising the natural wavelength of a solenoid having comparatively high inductance. The larger the n, the shorter the natural wavelength. But with a given n, D/l must be 0.2 for a solenoid with both ends free, and 0.4 for a solenoid with one end earthed . . . Dielectric losses are proportional to f^3." The highest frequency attainable with ordinary receiving valves, ebonite frame, and variable condenser is estimated to be 60 Mc/s.

2912. DISTRIBUTION OF CHARGE ON A CYLINDER BETWEEN TWO CONDUCTING PLANES AT DIFFERENT POTENTIALS [Calculations: Capacity of System as Function of Distance between Planes].—E. Hallén. (*Ann. der Physik*, Series 5, No. 2, Vol. 29, 1937, pp. 117–128.) For the importance of the capacity referred to in relation to h.f. oscillations in coils, *see* 3711 of 1936.

2913. CURRENT RELATIONS IN THE SWITCHING AND REGULATING OF ELECTRICAL RESISTANCE WELDING MACHINES *via* CURRENT RECTIFIERS [with Oscillograms of Transient Phenomena occurring with Transformers: etc.].—W. Schilling. (*Arch. f. Elektrot.*, 22nd April 1937, Vol. 31, No. 4, pp. 213–232.)

TRANSMISSION

2914. THE DYNAMICS OF TRANSVERSELY- AND LONGITUDINALLY-CONTROLLED ELECTRON BEAMS: PART II—ULTRADYNAMIC CONDITIONS.—H. E. Hollmann & A. Thoma. (*Hochf:tech. u. Elek:akus.*, May 1937, Vol. 49, No. 5, pp. 145–160: Supplement pp. 161–162.)

For I *see* 2498 of July. The theory there developed is here extended to the "ultradynamic" conditions in which an alternating field is superposed on the constant controlling field, the alternating frequency being so high that the transit time of the electrons can no longer be neglected. The general equations for the ultradynamic displacement current are deduced (§ I) with particular reference to the cases of purely longitudinal and purely transversal control. The ultradynamic resistance between the plates is discussed in § II; for transversal control, inversions of this resistance are found to occur (Figs. 2, 3). § III considers the connection of the plates of a cathode-ray tube to an oscillating system, *e.g.* Lecher wires. The detuning of the system caused by connecting the plates is worked out (Fig. 6) and the conditions are found under which the tube and Lecher wires together will generate oscillations. Under certain working conditions, "the inductive component of the ultradynamic plate resistance gives with the statical capacity between the plates a resonance system of definite natural frequency. When the oscillating voltages on the deviating plates have reached a sufficient amplitude, a convection current arises which may assist in exciting the oscillations."

The general theory of resistance inversion is then applied to longitudinal control (§ IV), in particular to the retarding-field method of producing ultra-short waves. The ultradynamic characteristics of the displacement current are worked out (Fig. 8); the convection current can also assist in the production of oscillations (§ IVb). The inversion theory is applied to the magnetron (§ V); the relevant equations of motion of the electrons are solved by operational methods. The inversion maxima are shown in Fig. 11. The formulae for push-pull control in the tube (§ VI) with electrostatic and magnetic retarding field (Habann generator) are worked out. The energy relations are discussed in § VII; the efficiency in the case of a push-pull retarding-field tube may rise to 25 per cent. This would be further increased by the action of the convection current, so that the high values obtained experimentally for the efficiency of a Habann generator can be explained. The generator of Arsenjewa-Heil (3380 of 1935), in which the oscillating energy is "coupled out" of the electron beam, is analysed (§ VIII) and brought into line with the inversion theory; the phenomena are found to be analogous to the "grid damping" in a space-charge valve. In the supplement the theory is shown to be fundamentally coincident with those of certain other writers.

2915. THE ELECTRON-BEAM MAGNETRON.—Okabe. (*See* 2960.)

2916. THE HABANN TUBE [Split-Anode Magnetron] AND ITS USE FOR THE GENERATION OF DECIMETRE WAVES [including Frequency Modulation and Its Reception].—F. W. Gundlach. (*E.T.Z.*, 17th June 1937, Vol. 58, No. 24, pp. 653–658.) A lecture given in February last. For a previous paper *see* 477 of February.

2917. A NEW MICRO-WAVE OSCILLATOR.—T. V. Jonescu. (*Comptes Rendus*, 10th May 1937, Vol. 204, No. 19, pp. 1411–1413.)

The oscillator described is shown diagrammatically; it consists of a tube of glass containing three electrodes, two aluminium plates p_1, p_2 with a copper ring a between them. The electrons come through a hole in p_1 from a hot tungsten filament f

The tube is along the axis of a Helmholtz coil M_1, M_2 so that the electric and magnetic fields are parallel. The electrodes are connected to Lecher wires l_1, l_2, carrying two movable metallic plates. On moving the plates, strong oscillations are obtained for positions of the lamp L indicated on the diagram. The wavelength of the oscillations obtained is about 36 cm.

2918. THE HARMONIC MODE OF OSCILLATION IN BARKHAUSEN-KURZ TUBES [Resonating Helical Grid Type, with Plate cut transversely into Three Sections: Frequency Doubling: Filament Circuit tuned to give Max. Power Output: etc.].—W. D. Hershberger. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 564–569.)

Extension of work dealt with in 3330 of 1936. It is shown that the fundamental or Barkhausen frequency may be elicited by exciting the grid at its central portion, but that if the grid is excited at its ends, either symmetrically or unsymmetrically, the oscillations occur at double the Barkhausen frequency; this doubled frequency is that usually generated by valves of this type. It is found that the steady and the varying components of current in the valve are not subject to the same boundary conditions at an electrode.

2919. A VOLTAGE STABILISED HIGH-FREQUENCY CRYSTAL OSCILLATOR CIRCUIT [Stability within 1 in 20 Million at 7 Mc/s for 10% Voltage Variations: Simple Method of Frequency Adjustment: Analysis of Koga's L.F. Circuit leads to Required Design].—S. Sabaroff: Koga. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 623–629.)

2920. NOTES ON HIGH-POWER ELECTRON-COUPLED OSCILLATORS: A PRACTICAL COLPITTS ARRANGEMENT WITH PARALLEL-COIL BAND CHANGING.—C. Schmelzer. (*QST*, June 1937, Vol. 21, No. 6, pp. 51–52 and 94, 96.)

2921. FREQUENCY MODULATION IN SHORT-WAVE RADIO-TELEGRAPHY.—S. Amari. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 25.)

"Since to make a transmitter work efficiently as a Class C amplifier is incompatible with obtaining pure amplitude-modulated waves, the Company, a year ago, adopted a special frequency modulation method by means of which deep and pure frequency modulation could be imparted to the quartz crystal oscillator of the transmitter." A rotating condenser is used: the modulation frequency is about 300 c/s and the index of frequency modulation about 1.5. No complaints regarding interference have been received.

2922. SOME CONSIDERATIONS ON MODULATION AND ON ITS RELATED PROBLEMS [Discussion by Static Characteristic Method (for Comparatively Wide Working Range) and by Taylor's Series Method (for Very Small Input Voltages): Definition of "Modulation-Distortion Factor"].—S. Uda & K. Numazawa. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 52–60: in English.) The full paper, a summary of which was dealt with in 942 of March.

RECEPTION

2923. NEGATIVE RESISTANCE AND HIGH SELECTIVITY OBTAINED IN STABLE FASHION BY THE USE OF POSITIVE AS WELL AS NEGATIVE FEED-BACK.—F. Vecchiacchi. (*Alta Frequenza*, June 1937, Vol. 6, No. 6, pp. 351–364.)

"By the simultaneous use of positive and negative retroaction, the former voltage-controlled and the latter current-controlled, it is possible to obtain a negative resistance of very stable value; that is to say, very little dependent on the characteristic parameters of the valve, which are so subject to the influence of various causes. The negative resistance thus obtained can be used to give a very considerable increase in the selectivity of a given resonator, without decrease in stability and in particular without danger of self-oscillation." Fig. 5 shows such an arrangement, the resonator to be improved in selectivity being the circuit LCR, the negative-resistance generator being represented by the whole circuit to the left of this. The latter differs from the basic circuit of Fig. 4 in that the transformer η_p (Fig. 4), giving the voltage-controlled positive feedback, is replaced for the sake of simplicity by an inductance L_2 coupled to the inductance L of the resonator. The other transformer η_n, providing the current-controlled negative feedback, remains unchanged. "In Fig. 9 is shown a simple version of a practical circuit corresponding to Fig. 5 [or rather to Fig. 6, a simplified special case of Fig. 5, the negative feedback transformer having a positive ratio of unity and being replaced by a direct connection] by the use of a single amplifying valve [a pentode]. Experiments have been carried out with such a circuit, not so much to obtain an obvious confirmation of the theoretical conclusions as to arrive at a better idea as to the ease of practical working of the principle. With such a circuit, working at a frequency of 5000 c/s, it was possible to obtain without difficulty an increase of selectivity in the ratio of 1 : 100." The fact that these tests were carried out on low frequencies does not imply that the arrangement is too difficult to employ at high frequencies. "While it may be assumed that the working and regulation of the circuit will not require particularly fine adjustments at frequencies, say, of the order of 100 000 c/s, the attainment of a large increase of selectivity at frequencies above this value will need a suitable technique, which seems undoubtedly to deserve systematic investigation." The paper is concluded in the July issue.

2924. THE DESIGN OF COUPLING FILTERS IN BROADCAST RECEIVERS.—G. W. O. H. (*See* 2901.)

2925. MAKING VISIBLE THE FREQUENCY PASS CURVES OF RECEIVERS [with Circuit including Loop Oscillograph].—G. Schober. (*Hochf:tech. u. Elek:akus.*, May 1937, Vol. 49, No. 5, pp. 162–164.)

The frequency curve of a receiver can be seen and photographed by using the circuit shown in Fig. 1 (for a receiver with retroaction) or Fig. 2 (for an intermediate-frequency amplifier) to connect the receiver to a loop oscillograph. Examples of oscillograms are given.

2926. THE IDEAL SET: WHAT READERS THINK.—"Decibel." (*World-Radio*, 28th May 1937, Vol. 24, p. 11.) Summarising the whole correspondence referred to in 2547 of July.

2927. ADVANCED RECEIVER DESIGN [including Double-Frequency Superheterodyne, Variable Selectivity, Contrast Expansion (by Author's Method of controlling Loudspeaker Field Current), Noise Suppression (Author's Method—*see* 1754 of 1936), etc.].—E. G. Beard. (*Radio Review of Australia*, Jan. 1937, Vol. 5, No. 1, pp. 3–12.)

2928. FOR THE "SINGLE-SPAN" RECEIVER [an Improvement for Case where there is a Very Strong Local Station: Rearrangement of Complete Input Circuit (including Wave Traps) to allow Effective Screening].—K. Nentwig. (*Radio, B., F. für Alle*, June 1937, No. 184, pp. 93–95.)

2929. THE OVERSEAS SUPERHET, A SPECIAL PROBLEM IN RECEIVER DESIGN [Reception of German Short-Wave Transmissions].—(*Funktech. Monatshefte*, May 1937, No. 5, pp. 153–157.)

Practical experience has shown that an "overseas" receiver must have a sensitivity of at least 4–5 μV, preferably of 1 μV; it must be tropic-proof (*e.g.* electrolytic condensers are barred), and among other things it should be arranged to draw its valve-heating current from any available type of accumulator, from 2 to 7 volts, in a fool-proof way. The Telefunken T 677 BK receiver, purchasable only outside Germany, is described as an example.

2930. AND NOW WE HAVE FULL-RANGE SUPERHET SELECTIVITY [Electro-Mechanical I.F. Circuits for Continuously Variable Band-Width from below 100 c/s to over 10 kc/s.].—J. J. Lamb. (*QST*, June 1937, Vol. 21, No. 6, pp. 16–21 and 122, 124, 126.)

2931. EASY TUNING OF AVC RECEIVERS [without Use of Visual Indicators: Tuning to Maximum Volume by Methods involving the Cutting-Out or Reduction of AVC Action: by Methods maintaining AVC throughout: by Methods based on Modifications to "Silent Tuning" Circuit].—O. Köhler. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 157–161.)

The writer begins by pointing out that visual tuning indicators are undesirable or impossible in certain cases, *e.g.* in car receivers, receivers for the blind, and remote-control receivers. Various patents are mentioned.

2932. THE MEGASCOPE: VISUAL TUNING INDICATOR ACTING ALSO AS ADDITIONAL A.F. AMPLIFIER STAGE, WITH GAIN CONTROLLED BY AVC.—Lajoinie. (*Toute la Radio*, June 1937, No. 41, p. 206.)

2933. THE BEGINNINGS OF AVC [Early Attempts to maintain Constant Signal Strength].—(*Wireless World*, 25th June 1937, Vol. 40, pp. 599–600.)

2934. A LARGE-SURFACE TUNING SCALE [with Room for Wavelength, Frequencies, and Station-Names] OCCUPYING LITTLE SPACE.—Wiegand & Weenink. (German Pat. 637 820: *Funktech. Monatshefte*, May 1937, No. 5, p. 168.)

The flexible scale is made in the form of a deep-threaded spiral, so rotated in a container which (for part of its circumference) is forked that the turns are gradually transferred from one branch of the fork to the other, which is provided with a window.

2935. TONE FIDELITY SWITCH [giving Sharp or Broad Tuning (in R.F. or I.F. Circuits) and increasing or decreasing Both Low-Note Response and High-Note Response of A.F. Amplifier].—A. G. Manke. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 34–36 and 48.)

2936. THE PADDING CONDENSER [Simple Mathematical Investigation leading to Method of "Perfect" Tracking by Semicircular Condenser coupled to Shaft of Main 2-Gang Condenser].—L. B. Sklar. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 40–41 and 100.) "Resulting in a highly efficient output and exceptionally good selectivity."

2937. BRITISH STANDARD SPECIFICATION FOR MAINS-OPERATED APPARATUS FOR RADIO, ACOUSTIC, AND VISUAL REPRODUCTION (SAFETY REQUIREMENTS).—(*British Standards Institution*, No. 415–1936: Nov. 1936: 18 pp.)

2938. THE YEAR IN EUROPEAN BROADCASTING: MORE THAN 3 000 000 ADDITIONAL SETS PURCHASED.—(*World Radio*, 4th June 1937, Vol. 24, p. 4.)

2939. NON-LINEAR CROSSTALK IN THE SIMULTANEOUS TRANSMISSION OF SEVERAL MODULATED CARRIER WAVES [Calculations].—F. Strecker. (*Hochf:tech. u. Elek:akus.*, May 1937, Vol. 49, No. 5, pp. 165–171.)

The crosstalk considered is that produced by third-order non-linearities in the amplifiers during simultaneous transmission of several modulated oscillations with the carrier wave and both side-bands. The analysis deals with the formation of third-order combination tones from four oscillations (§ B) and the disturbances produced by third-order combination tones with two programmes (§ C), with calculations of the "klirr" factor in various cases. Non-linear crosstalk with three or more programmes is discussed in § D. The disturbance produced in a wireless programme by the audible modulation of another carrier is worked out, with its attenuation, which is found to depend on the amplitude but not on the frequency, so that the crosstalk can be well understood. Calculations are also made (§ D3) of the carrier powers which can be obtained from amplifiers with and without distortion correction, for given crosstalk attenuation. Permissible and actual degrees of crosstalk are discussed (§ D5). An experimental curve for the attenuation of the depth of modulation is given (Fig. 5).

2940. RELAY RACKS FOR TELEGRAPHY ON FOUR-FOLD AND EIGHT-FOLD CABLES [and the Types of Distortion occurring].—E. H. B. Bartelink. (*E.N.T.*, April 1937, Vol. 14, No. 4, pp. 134–144.)

A description of the relay circuits used at the end of the cables in the Dutch long-distance cable network for use with apparatus for high-speed telegraphy, for the purpose of reproducing the original telegraphic signs as closely as possible. The types of distortion occurring in the cables are first discussed and classified into (1) characteristic distortion, in which the delay time for each separate impulse has a definite value; (2) irregular distortion, in which the delay times vary irregularly; (3) one-sided distortion (Fig. 1), in which the delay times for the transition from quiescent to working conditions are all the same and all uniformly larger or smaller than the times of the reverse transition. The requirements to be satisfied in transmission, superintendence, and working are described. The relay circuit is shown in Fig. 2 and fully described; double-current excitation is used. Measured curves of characteristic and irregular distortion are given in Figs. 3–7. The arrangements for measuring the one-sided distortion are described. The technical construction of the relay is shortly indicated.

2941. ABNORMAL ADJUSTMENTS AND WHISTLES IN SUPERHETERODYNES.—Lambrey. (*L'Onde Élec.*, May 1937, Vol. 16, No. 185, pp. 276–317.)

A summary was referred to in 1768 of May. The writer sums up his general conclusions as follows:—the seriousness of the disturbances depends essentially on (i) the i.f. chosen, (ii) the structure of the characteristics of the frequency-changing valve (and not on its action as auto-oscillator), and (iii) the i.f. retroaction. "The classification proposed in this article defines a method of systematic study."

2942. BRITISH STANDARD SPECIFICATION FOR THE CHARACTERISTICS AND PERFORMANCE OF APPARATUS FOR THE MEASUREMENT OF RADIO INTERFERENCE.—(*British Standards Institution*, No. 727–1937: March 1937: 28 pp.)

2943. A NEW KIND OF INTERFERENCE [External Cross Modulation: American Investigations, and a P.O. Investigation of Example in North London].—(*Wireless World*, 4th June 1937, Vol. 40, pp. 531–532.)

For Foster's paper, here discussed, *see* 2521 of July. In the London block of flats a temporary cure was made by thorough bonding of lead-caulked drainpipe joints and of the sections of a lead strip on the roof.

2944. THE EARTH LEAD AND EARTHING OF A BROADCAST RECEIVER INSTALLATION, AND THE LIABILITY TO INTERFERENCE.—F. Bergtold. (*E.T.Z.*, 17th June 1937, Vol. 58, No. 24, pp. 662–664.)

The question whether a real earth or a counterpoise earth will give least interference depends very much on local conditions and can only be decided by trial. The present paper deals only with the real earth and its connection. The use of a lead from the earth terminal of the receiver, branching off into two parts which are joined again for connection to a single earth, is first discussed: it is found that if each branch is equally subject to interference the result is the same as that given by a single lead, while if one branch is less subject than the other the best thing to do is to use that branch and that only. The use of two or more branches, each to a separate earth, does not give any improvement. The writer then considers the "multiple earthing" of the installation, by the ordinary earth connection to the receiver earth terminal as well as by a lead connecting the top end of the downlead-screen to a separate earth: the mere fact of multiple earthing has in itself neither a good nor a bad effect, but closer consideration of the equivalent circuit (Fig. 15) shows that such an arrangement may have an influence on the interference. The conclusion reached is that *such multiple earthing will be advantageous* if there is appreciable interference at the upper point of earthing, since the addition of the lower earth connection will reduce this to a half; it will be detrimental if there is little interference at the upper point, while the screened lead below that point is badly exposed to disturbance. In the latter case the bad result of adding the lower earth connection is not due to a double-earthing effect but to the fact that the earthing of the receiver terminal itself increases the magnetic action on the screened lead.

2945. ELECTRICAL INTERFREENCE WITH BROADCAST AND TELEVISION RECEPTION.—F. R. W. Strafford. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 221–225.)

2946. INDUSTRIAL INTERFERENCE [Its Propagation along a Circuit: Method of Calculation of Suppressors for Various Types of Source: etc.].—E. Dechange. (*Rev. Gén. de l'Élec.*, 15th May 1937, Vol. 41, No. 20, p. 158D: summary only.)

2947. THE ROTATION NOISE OF REGULATING RESISTANCES.—H. Sachse. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 155–157.)

From the Siemens & Halske laboratories: for previous work *see* 3740 of 1936. "The results reported show that there are available to-day variable resistances [mercury-globule contact best, followed by carbon] which fulfil in practice the high requirements set for them, provided that they are loaded only with the voltage to be regulated. If, to these voltages, extra voltages are added (*e.g.* in diode regulation, the d.c. voltage due to the carrier wave is superposed on the a.f. voltage which is to be regulated), then these voltages also will be modulated by the disturbance due to rotation, and the limit of permissible noise will be exceeded. It is the task of skilful circuit design to arrange that such additional voltages should be kept away."

2948. PROGRESS IN INTERFERENCE SUPPRESSION [at Source, at Receiver, in Car Radio].—(*Radio, B., F. für Alle*, June 1937, No. 184, Supp. pp. 44–50.) In the new series "Fortschritte der Funktechnik II".

2949. NOISE INTERFERENCE IN RADIO RECEIVERS.—G. Builder. (*Radio Review of Australia*, Dec. 1936, Vol. 4, No. 12, pp. 3–7: Discussion pp. 23, 24.)

2950. A DOUBLE-FREQUENCY-CHANGE METHOD OF TELEPHONIC AND TELEGRAPHIC RECEPTION ALLOWING ELIMINATION OF PARASITIC DISTURBANCES.—Lévy. (French Pat. 807 487, pub. 13.1.1937: *L'Onde Élec.*, May 1937, Vol. 16, No. 185, p. 336.)

On arrival at the receiver the incoming wave is immediately changed from its frequency F to a frequency $F \pm nf$ (where nf is a supersonic frequency, say 100 kc/s) by detuning the receiving circuit by an amount nf according to a method (not given) covered by Patent 602 012. "The parasites which 'impulse' the tuned circuit thus produce a current modulated in frequency, whereas the signals, of constant frequency F, are modulated only in amplitude" and can therefore be separated out. "The system avoids the difficulties in the construction of superheterodyne receivers with single-knob tuning, since a constant frequency-difference need no longer be obtained."

2951. NOISE IN SUPER-REGENERATIVE DETECTION.—Y. Ito. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 43–51: in English.) *See* 947 of March.

2952. SOME CONSIDERATIONS ON SUPER-REGENERATION [Origin of Noises: Relation between Suppression of Noise and Sensitivity (Not Incompatible): Causes of Lack of Selectivity (Optimum Quenching Frequency): "Abrupt Decaying Method" for High Quenching Frequency without Decreased Sensitivity].—T. Hayasi. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 27.) For previous papers on super-regeneration *see* 496 of February and back reference.

2953. NOISE IN FREQUENCY MODULATION [Analysis of Effect of Noise Signal, Simultaneously Amplitude- and Frequency-Modulated, on (a) an Amplitude-Modulated and (b) a Frequency-Modulated Signal: Necessity for Wide-Band Frequency Modulation and Effective Amplitude-Limiting Action if Noise is to be Eliminated: Interference between Frequency-Modulated Transmissions, and the Necessary Channel Spacing].—H. Roder. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 22–25 and 60, 62, 64.)

2954. APPLICATION OF THE AUTOSYNCHRONISED OSCILLATOR TO FREQUENCY DEMODULATION [Local Oscillator drawn into Exact Synchronisation by Incoming Frequency-Modulated Signal: Successful Tests in Simultaneous Reception of Two Programmes on Common Carrier: Other Applications].—J. R. Woodyard. (*Proc. Inst. Rad. Eng.*, May, 1937, Vol. 25, No. 5, pp. 612–619.)

See also 1613 of 1936. The defects of "off-resonance" and other methods of frequency demodulation are pointed out. The device can be used also for the detection of very slight frequency changes (*e.g.* unwanted frequency modulation in amplitude-modulated transmissions) and, with slight modifications, for automatic tuning correction.

2955. "RADIO SERVICE ENCYCLOPEDIA" [Book Review].—Mallory & Company. (*Electronics*, May 1937, Vol. 10, No. 5, p. 51.) More than 12 000 models are dealt with.

AERIALS AND AERIAL SYSTEMS

2956. DISTRIBUTION OF ULTRA-HIGH-FREQUENCY CURRENTS IN LONG ANTENNAE.—L. S. Palmer & K. G. Gillard. (*Nature*, 5th June 1937, Vol. 139, p. 967.)

"If a concentrated high-frequency e.m.f. be applied at any point P [of the aerial], then it can be shown that the currents in the portions of the wire above and below P are distributed sinusoidally with current nodes at half-wavelength intervals measured from both A and B" [the ends of the aerial]. The mode of interdependence of the currents in the two parts is given; this current distribution is "applicable to long transmitting aerials if they are coupled by a coil of small dimensions to an ultra-high-frequency oscillator."

A theoretical expression is given for the amplitude variation of the current distribution along a long isolated receiving aerial in a uniform ultra-high-frequency e.m. field. "The general expression shows that current nodes occur at intervals of one whole wavelength measured from both ends of the antenna." The mode of overlapping of the nodes is described; their disposition "will presumably determine the best positions for tapping points for the passage of energy to and from the antenna." In practice the resistance and leakage of the aerial modify the results slightly.

2957. TELEVISION AERIALS [Design Data for Dipole Aerials].—H. B. Dent. (*Wireless World*, 28th May 1937, Vol. 40, pp. 506–508.)

2958. SHIELDING OF ULTRA-SHORT-WAVE AERIALS AGAINST INTERFERENCE FROM MIXED LONGER WAVES, BY WIRE LATTICE OR SPIRAL.—Telefunken. (Swiss Pat. 178 912: *Funktech. Monatshefte*, May 1937, No. 5, p. 168.)

2959. SHORT-WAVE FILTERS MADE OF WIRE [Theory of T, Pi and Lattice Types, for Short and Ultra-Short Waves: Applications].—T. Mizuhasi. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 24.)

These filters are eminently suitable for outdoor use: they have been employed already in transmitting waves of different frequencies through a common feeder (*cf.* 2960, below) and separating them out at the receiving end; also in suppressing a higher or lower harmonic of waves travelling along the feeder of a transmitting aerial, liable to cause interference with other waves.

2960. COMMON FEEDER SYSTEMS USED FOR TWO ADJACENT SHORT-WAVE ANTENNAS.—Kato, Mizuhasi, & Huzikura. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 26.)

For concentric-tube feeders the writers recommend filters of concentrated and distributed constants, suitably combined: for parallel-wire feeders, filters made of wires, *i.e.* of wholly distributed constants (*see* 2959, above).

2961. Crosstalk between Coaxial Transmission Lines.—Schelkunoff & Odarenko. (*See* 3004.)

2962. On the Calculation of the Fields produced by an Aerial.—E. F. Ghiron: Alford. (*Alta Frequenza*, June 1937, Vol. 6, No. 6, pp. 380–383.)

Criticism of some of Alford's conclusions (*see* 4047 of 1936). "The two methods recalled and compared by Alford are: the one derived more directly from Maxwell's theory and based on the use of retarded potentials (scalar and vector potentials), and the one developed by Hertz and founded on the study of the radiation from an elementary dipole. The sympathies of the author [Alford] are all in favour of the second method, which he affirms is less known and less often employed—though, as a matter of fact, it is preferred by many workers, both Italian and foreign. According to Alford, the two methods lead to identical results when the conductors are considered as the seat of stationary waves of sinusoidal distribution; but in the new types of aerial studied by himself and others, using progressive waves, the two methods will give discordant results, and it will be the first method which will be erroneous.

"It is perhaps well to show that even the first method leads to results at least approximately correct (and fully in agreement with those obtained by the second method) provided it is properly applied." Equation 2 is given by Alford as the type of solution of the general equation 1′, and as applied by him to equation 1 (derived from Maxwell's equations) leads to equation 3. "But it must be remembered that 2 is not the most general solution of 1′, and that it is only valid (together with 3) if certain important limitations are satisfied. Alford actually mentions, at one point, that the field τ must include the whole volume of the conductor, but he does not give a precise meaning to this rather vague phrase, and seems later to be surprised at encountering the corresponding limitation. . . ."

2963. Determination of the Radiating System which will produce a Specified Directional Characteristic [by Application of Fourier's Theorem: Two-Dimensional Pattern: Three-Dimensional Pattern—a Beam: Pattern specified in All Directions in Space].—I. Wolff. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 630–643.)

2964. The Fading Characteristics of the Top-Loaded WCAU Antenna [Guyed Cantilever Tower with Tuned Hat: Effective Night Service Area more than Doubled: Curves, etc.: Necessity for Both High- and Low-Speed Records in Fading Investigation].—G. H. Brown & J. G. Leitch. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 583–611.)

2965. A Note on the High Insulation of Outdoor Antennas [Causes of Deterioration in Tropics, particularly near Sea: Design of Successful Aerial and Lead-In Insulators made of Ebonite and Sulphur].—C. V. Rajam. (*Current Science*, Bangalore, May 1937, Vol. 5, No. 11, pp. 593–595.)

VALVES AND THERMIONICS

2966. The Electron-Beam Magnetron [Electrons moving in Squat Cylindrical Anode with Coiled Coaxial Filament and Semicircular or Quadrantal Plate Electrodes (at Negative Potential) facing Each End].—K. Okabe. (*Electrotechnical Journal*, Japan, June 1937, Vol. 1, No. 1, pp. 30–31: in English.)

This journal replaces the "Abstract Section" of the *Journ. I.E.E. Japan*. The new magnetron is highly efficient (usually from 20–50%, though 60% has been obtained), and the electrode arrangement is such that the anode can be designed to be water-cooled directly from outside. The magnetic field is parallel to the common axis of filament and anode. The oscillations contain none of the "dynatron" type found in the split-anode magnetron, and the characteristics peculiar to the usual "B-type" oscillations are accentuated. The shortest wavelength given by the quadrantal type (Fig. 1b) is about half as long as that obtainable with the semicircular type (Fig. 1a) and is equal to nearly twice the wavelength corresponding to the time required by an electron to make one revolution.

2967. A New Micro-Wave Oscillator.—Jonescu. (*See* 2917.)

2968. On the Accuracy of the Focusing of Electron Streams in a Kubetski [Electron Multiplier] Tube.—Voroshilov. (*See* 3059.)

2969. A Y-Shaped Electron Multiplier.—RCA. (French Pat. 810 432, pub. 22.3.1937: *Rev. Gén. de l'Élec.*, 29th May 1937, Vol. 41, No. 22, p. 176D.)

2970. Experiments on D.C. Magnetic Secondary Electron Multipliers, *and* Experiments on A.C. Electrostatic and Magnetic Secondary Electron Multipliers.—S. Chiba & S. Morita. (*Electrotechnical Journal*, Japan, June 1937, Vol. 1, No. 1, pp. 30–31: pp. 31–32.)

This journal replaces the "Abstract Section" of the *Journ. I.E.E. Japan*. In the first paper the writers give their results with 2–5 stage Zworykin multipliers, and describe the similar results obtained by replacing the separate accelerating electrodes by a single long electrode sloped so as to give an approximately uniform field: this modification is convenient for manufacture. It has the advantage, also, that it enables the usual collecting electrode across the end of the cylinder to be replaced by an extra secondary-emission surface, the single sloping electrode acting both as accelerator and as collector: thus an additional multiplier stage is added. The multiplying power of each stage was measured for different voltages, and the proportionality between output and amount of light was tested and found to be exact. This type of multiplier requires higher voltage than the a.c type, but its action is far steadier and more reliable.

The second paper deals with tests on a slightly modified Farnsworth type (requiring no magnetic field), an Okabe type, and the same Okabe multiplier with a slightly different circuit. Their characteristics are all very much alike; they all show a considerable dark current, sometimes as much as 10 mA or more. They all act as excellent detectors of strong ultra-short waves. The necessary conditions for the amplification of photocurrents are described, together with the limitations of these multipliers for such a purpose; chief among these is the small output current (usually a few micro-amperes) compared with the dark current.

2971. Secondary Electron Emission of Metals with a Low Work Function [Experimental Investigation of Contradictory Announcements that They have Large and Small Capacity for Secondary Emission].—H. Bruining & J. H. de Boer. (*Physica*, June 1937, Vol. 4, No. 6, pp. 473–477: in English.)

A preliminary communication. From Table 7 (results with pure metals) "it may be seen that the maximum of the secondary emission for the metals with a low work function is *less* than that for metals with a high work function [agreeing with Farnsworth]. This shows that with primary velocities of several hundred volts the secondary emission is not determined primarily by the work function. . . . One may expect that the secondary electron emission will be smallest with those metals whose lattice constant is large and whose atomic weight is small." Tests on the influence of "impurities" showed that with electrons possessing these velocities "the capacity for secondary emission is much greater for the compounds of the metal than for the pure metals themselves. Copeland and Warnecke apparently carried out their experiments with such impure surfaces." The writers also examine secondary emission as a function of the thickness of the electro-positive layer deposited or adsorbed.

2972. Secondary Electron Emission of Soot in Valves with Oxide Cathodes [Low Secondary-Emission Capability of Sprayed Soot Surface increases at first on covering with Barium Atoms: Soot directly precipitated from Flame shows No Such Increase: etc.].—Bruining de Boer, & Burgers. (*Physica*, April 1937, Vol. 4, pp. 267–275: in English.)

The low secondary emission of soot in general is due to its surface being rich in labyrinths, from which it is almost impossible for the secondaries to escape. Directly precipitated soot has even more labyrinths: it is also a worse thermal conductor than sprayed soot, so that bombardment by primary electrons produces very strong local rises of temperature, resulting in the sublimated barium migrating to deeper layers The effect of sintering the soot surface was also studied.

2973. The Division of Primary Electron Current between Grid and Anode of a Triode.—D. M. Myers. (*Proc. Phys. Soc.*, 1st May 1937, Vol. 49, Part 3, No. 272, pp. 264–278.)

Description of "a method of determining the distribution, between the grid and anode, of the current emitted by the cathode of a cylindrical triode. Measurements of the temperature of the anode are used to verify that this distribution depends on the ratio of the potentials applied to the anode and grid, and not on their absolute values. A direct method is then described in which the grid and anode currents are measured in conditions such that there is no flow of secondary current; by this means, the distribution of primary current from the cathode, and the value of any secondary current flowing between the anode and grid, can be deduced in any conditions of operation. Curves are obtained . . . showing the variation, with impact energy, of the secondary-emission ratio for both nickel and molybdenum anodes. The effect of the (anode-potential)/(grid-potential) ratio on the distribution of primary current is determined for a particular triode, and an empirical relation is found to hold for a considerable range of potential ratios. This relation is of the same form for any cylindrical triode."

2974. On Measuring the Plate Loss of Air-Cooled Transmitting Valves [Several Methods found Not Very Accurate at High Frequencies: Ordinary Thermometer on Bulb gives Fairly Accurate Results].—Morimoto, Kurokawa, & Makino. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts p. 25.)

2975. An Amplifier without Phase Distortion [for use with Oscillograph for tracing Valve Characteristics: No Cathode- or Screen-By-Pass Condensers, No Decoupling Condensers: No Output Condenser in Plate-Supply Filter: Frequencies 10–30 000 c/s].—Schade. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 26–27.)

2976. An Electrometer Valve.—Yu. A. Katzmann. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 7, 1937, pp. 405–406.)

The insulation of the control grid of an electrometer valve must be very high, and the valve envelope is therefore usually made of special glass having a high specific resistance. In the present paper a brief description is given of a valve developed in the U.S.S.R. in which ordinary molybdenum glass is used and the necessary insulation resistance (10^{14}–10^{15} ohms) is obtained by a special construction of the insulators supporting the control grid and its connecting lead. With this type of insulation an additional advantage is that it is not necessary to maintain the lead-in in a perfectly dry condition. It appears that in respect of its operating constants the valve is comparable to those of the best foreign manufacture.

2977. New Receiving Valves and Vacuum, Gas-Filled, and Cathode-Ray Tubes [at the Feb. 1937 Exhibition of Components, Accessories, and Valves, Paris].—Adam. (*Rev. Gén. de l'Élec.*, 29th May 1927, Vol. 41, No. 22, pp. 689–704.) Including beam-power, metal, metal-and-glass, acorn (including pentodes, single and push-pull) and magnetron valves, electron multipliers, and photocells.

2978. GAS-FILLED TRIODES [with Indirectly Heated Cathode: Gauze "Cathanode" close to Gauze Grid, and Anode, all three Rectangular: Steep Slope even at 200 m: No Pronounced Noise: Suitable for One-Valve Transmitters, Anode Voltage 110 V, Output 6 Watts at 670 m].—H. G. Boumeester & M. J. Druyvesteyn. (*Philips Transmitting News*, May 1937, Vol. 4, No. 2, pp. 20–24.) Philips version of the "RK 100" referred to in 2649 of 1935. In a summary in *Electronics*, May 1937, p. 66, it is stated that "important differences in operation" between the two "are not brought out."

2979. THE WATER-COOLED PENTODE TYPE PA 12/15 [Output about 15 kW: Satisfactory Television Output on 6 m].—(*Philips Transmitting News*, May 1937, Vol. 4, No. 2, p. 19.)

2980. TRANSMITTING TUBE ENGINEERING [Survey].—Warnecke. (*Bull. de la S.F.R.*, No. 1, 11th Year, 1st Quarter 1937, pp. 1–28.) In French and English concurrently. The French version was dealt with in 1817 of May.

2981. FRANK TALK ABOUT THIS BUSINESS OF TRANSMITTING TUBE RATINGS.—E. C. Hughes, Jr. (*QST*, June 1937, Vol. 21, No. 6, pp. 28–29 and 104, 106, 108, 110, 112, 114.) By the manager of the Amateur Radio Section of the RCA Manufacturing Company.

2982. INVESTIGATION OF THERMIONIC EMISSION BY THE STUDY OF SINGLE ELECTRONS WITH A HEATED COUNTING TUBE.—H. Haberland & W. Walcher. (*Zeitschr. f. Physik*, No. 5/6, Vol. 105, 1937, pp. 348–357.)

The counting tube used is shown in Fig. 1; the counting cylinder (cathode) is heated by a hot filament wound round it and the separate electrons it emits are counted, using the circuit shown in Fig. 2. The effect was studied at various temperatures; Richardson's law was confirmed in the region of single-electron emission. The sensitivity to light increased with the cylinder temperature (Fig. 12).

2983. ELECTRON EXCITATION AND CARRIER REFLECTION FOR THE IMPACT OF K^+-CARRIERS ON METALS [Measurements].—W. Veith. (*Ann. der Physik*, Series 5, No. 2, Vol. 29, 1937, pp. 189–208.)

2984. THE EFFECT OF SLOW POSITIVE POTASSIUM IONS ON METALLIC SURFACES [Production of Passivity to Various Vapours].—W. Brummack. (*Zeitschr. f. Physik*, No. 7/8, Vol. 105, 1937, pp. 468–469.)

2985. REMARKS ON THE PAPER BY E. B. BAKER & H. A. BOLTZ: "THERMIONIC EMISSION INTO DIELECTRIC LIQUIDS" [Experiments indicate an Electrolytic Process rather than an Electronic Current in the Fluids].—K. H. Reiss. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, p. 781.) *See* 1820 & 1903 of May.

DIRECTIONAL WIRELESS

2986. GROUND AND IONOSPHERIC RAYS: A COMPUTATION OF THE RELATIVE INTENSITIES ON VARIOUS WAVELENGTHS FROM EXISTING DATA [primarily for Estimation of Effective Ranges (free from Polarisation Errors) of Closed-Loop D.F. Apparatus].—W. Ross. (*Wireless Engineer*, June 1937, Vol. 14, No. 165, pp. 306–314.)

2987. RECEIVING SYSTEM FOR RADIO BEACONS [using the Property of Thyrite to give a Unidirectional Current which is a Function of the Asymmetry of the Impressed Wave].—P. H. Thomas. (*Alta Frequenza*, June 1937, Vol. 6, No. 6, pp. 418–420: long summary of a patent.)

ACOUSTICS AND AUDIO-FREQUENCIES

2988. BRITISH STANDARD SPECIFICATION FOR MAINS-OPERATED APPARATUS FOR RADIO, ACOUSTIC, AND VISUAL REPRODUCTION (SAFETY REQUIREMENTS).—(*British Standards Institution*, No. 415–1936: Nov. 1936: 18 pp.)

2989. ON THE WAY TO BETTER LOUDSPEAKER MUSIC: AN INTERESTING DESIGN OF LOUDSPEAKER [Duode Loudspeaker with Copper Speech Coil mounted on Elastic Layer on Aluminium Cylinder fixed to Cone].—Wigand: A. C. Barker. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 162–163.)

The copper speech coil vibrates to frequencies up to about 5000 c/s, and its large movements are transmitted through the elastic layer to the aluminium cylinder (and thus to the cone) with practically no losses due to the elasticity of the coupling. Above 5000 c/s the inertia of the speech coil prevents it from working, and it remains practically at rest but induces in the aluminium cylinder (acting as a short-circuited winding) the currents necessary to drive this and its attached cone. The elastic layer allows these small rapid vibrations to occur without the copper coil taking part in them. The response curve, taken at the N.P.L., is given.

2990. "DUAL" LOUDSPEAKER WITH PERMANENT MAGNET SUPPLEMENTED BY CENTRAL POLE, WITH MAINS WINDING, PROVIDING ADDITIONAL FLUX.—J. Neill & Company. (*Electrician*, 21st May 1937, Vol. 118, p. 671.) Requiring only 4 watts against the 20 watts of an ordinary "energised" type: hum is minimised. The mains winding also serves as a smoothing choke.

2991. HISTORY AND APPLICATION OF PIEZOELECTRICITY.—M. Tournier. (*Elec. Communication*, April 1937, Vol. 15, No. 4, pp. 312–327.)

2992. THE APPRAISEMENT OF LOUDSPEAKERS: PART II.—Brittain. (*G.E.C. Journ.*, May 1937, Vol. 8, No. 2, pp. 121–130.) For Part I *see* 159 of January.

2993. THE FREQUENCY OF TRANSVERSE VIBRATION OF A LOADED FIXED-FREE BAR: IV—THE EFFECT OF SHEARING OF THE BAR [Theory].—R. M. Davies. (*Phil. Mag.*, June 1937, Series 7, Vol. 23, No. 158, pp. 1129–1145.) Continuation of work referred to in 2213 of June.

2994. WNYC's 100-WATT P.A. TRUCK [for Municipal Functions, etc.].—A. Nadell. (*Comm. & Broadcast Eng.*, May 1937, Vol. 4, No. 5, pp. 5–7.)

2995. INTER-OFFICE COMMUNICATION [Audio, Carrier, and Wired Carrier Systems: Capabilities and Limitations].—J. Rosenbaum. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 26–29.)

2996. APPLICATION OF LORENZ COMMUNICATION TECHNIQUE AT THE OLYMPIC GAMES, GERMANY, 1936.—H. Dewald. (*Elec. Communication*, April 1937, Vol. 15, No. 4, pp. 279–283.)

2997. THE PHILIPS-MILLER SYSTEM OF SOUND RECORDING [Mechanical Engraving of Prepared Film].—R. Vermeulen. (*Elektrot. u. Masch:bau*, 25th April 1937, Vol. 55, No. 17, pp. 205–206: summary only.) *See* also 1024 of March, 602 & 2220 of 1936; *also* Shurin, 1832 of 1936.

2998. THE PHILIPS-MILLER RECORDING SYSTEM.—(*Comm. & Broadcast Eng.*, May 1937, Vol. 4, No. 5, pp. 11–12 and 27.)

2999. SOUND RECORDING ON MAGNETIC TAPE [and particularly an Improved Method (Perpendicular Magnetisation) giving Good Frequency-Response Characteristic up to 8000 c/s with Tape Speed of only 16 Inches/Second: Speech with only 8 Inches/Second].—C. N. Hickman. (*Bell S. Tech. Journ.*, April 1937, Vol. 16, No. 2, pp. 164–177.)

3000. AN OSCILLOGRAPH WITH ELECTRICAL COMPENSATION [for Sound-on-Film Recording].—I. I. Nikitin. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 7, 1937, pp. 411–417.)

3001. "A TREATISE ON PRACTICAL WAX RECORDING."—E. K. Barnes. (At Patent Office Library, London: Cat. No. 77 481.) 32 pp: from the Universal Microphone Company.

3002. THE REJUVENATION OF GRANULAR CARBON IN MICROPHONES.—Nishina & others. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 71–72: in English.)

3003. A SIMPLE [Oscilloscopic] DEMONSTRATION IN SOUND [of Existence of Harmonics in Tuning Fork and Their Suppression by Closed Resonating Air Column].—J. C. Mouzon. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 686: abstract only.)

3004. CROSSTALK BETWEEN COAXIAL TRANSMISSION LINES [Development of Formulae: Limiting Cases: Application to Particular Examples, with Experimental Confirmation: Long Lines].—Schelkunoff & Odarenko. (*Bell S. Tech. Journ.*, April 1937, Vol. 16, No. 2, pp. 144–164.) Dealing with a specific aspect of the general theory (435 of 1935).

3005. NEW VIEWPOINTS FOR THE CONSTRUCTION OF CABLES, PARTICULARLY FOR SMALL CURRENTS, COMPRISING CONCENTRICALLY ARRANGED LAYERS [for Transmission of Music, etc: Avoidance of Deformation due to Unequal Stretching of Spiral and Straight Components: Formulae].—F. Unterbusch. (*Ann. des Postes, T. et T.*, May 1937, Vol. 26, No. 5, pp. 449–453.)

3006. CONSTRUCTION OF THE COAXIAL CABLE [New York/Philadelphia], *and* INSTALLING THE COAXIAL CABLE.—C. Kreisher: T. C. Henneberger. (*Bell Lab. Record*, June 1937, Vol. 15, No. 10, pp. 325–328: pp. 329–333.)

3007. RELAY RACKS FOR TELEGRAPHY ON FOUR-FOLD AND EIGHT-FOLD CABLES [and the Types of Distortion occurring].—Bartelink. (*See* 2940.)

3008. THE TRANSFORMATION RATIO OF THE OUTPUT TRANSFORMER.—H. Pitsch. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 143–146.) Practical extension of the work dealt with in 1828 of May.

3009. AUDIO-FREQUENCY TRANSFORMERS [Principles, Application to Practical Design Methods, and Essential Tests].—E. T. Wrathall. (*Wireless Engineer*, June & July 1937, Vol. 14, Nos. 165 & 166, pp. 293–298 and 363–369: to be concluded.) For a correction *see* p. 370.

3010. AMPLIFIER CORRECTION AND WAVE FORM [Distortion resulting from Drastic High-Note Accentuation: Oscillograms].—J. H. Reyner. (*Wireless World*, 25th June 1937, Vol. 40, pp. 602–603.)

3011. CLASS A PUSH-PULL CALCULATIONS [Simplified Method].—E. W. Houghton. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 18–19 and 33.)

3012. VOLUME LIMITER CIRCUITS [primarily for Voice-Frequency Telegraph Systems: Types 1A and 1B].—G. W. Cowley: Doba. (*Bell Lab. Record*, June 1937, Vol. 15, No. 10, pp. 311–315.)

3013. ADJUSTABLE ARTIFICIAL REVERBERATION, AND ITS APPLICATIONS IN ELECTRO-ACOUSTICS [Lecture].—Sollima. (*Génie Civil*, 29th May 1937, Vol. 110, No. 22, pp. 492–493.)

3014. SOUND TRANSMISSION THROUGH THIN SINGLE PARTITIONS [Theoretical Rise, with Frequency, of Curve of Sound-Stopping Effect is Not Observed: Values below Those given by "Weight" Curve: Result of Partial Resonances: Effect of Porosity: etc.].—E. Lübcke & A. Eisenberg. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 18, 1937, pp. 170–174.) Extension of the work dealt with in 1843 of 1936.

3015. THE RELATIONS BETWEEN THICKNESS OF WOOD, VIBRATION FORM, AMPLITUDE OF BODY MOVEMENT, AND TONE OF A VIOLIN.—H. Meinel. (*E.N.T.*, April 1937, Vol. 14, No. 4, pp. 119–134.)

Typical vibration forms for various frequencies are shown in Figs. 3–15; they may be divided into three types, (1) those with sharply marked nodal lines, (2) those with less sharply marked nodal lines, and (3) transition conditions between the states of (1). The violin studied was built so that the thickness of its back could be gradually decreased; thickness variations were found not to alter the vibration types but to lower the frequencies to which they belong. A close connection was found between the positions in the frequency scale of the maxima of body amplitude and the vibration types; the amplitude maxima were found to move in the direction of lower frequencies as the thickness of the wood decreased, while the amplitudes themselves increased. The tone spectra were investigated with Riegger's h.f. circuit; it was found that if the exciting frequency produced very sharp nodal lines on the violin body, the body amplitude and the share of the fundamental in production of the tone were both a maximum. As the thickness of the wood was decreased, the relative importance of the higher frequencies diminished and the fundamental became the most powerful component. The spectral composition of a good tone was found to vary with the frequency. The practical application of the results to violin construction is discussed (§ v); tone spectra of two Stradivarius violins are shown (Figs. 22 a, b.)

3016. THE VIBRATIONS OF THE VIOLIN BRIDGE.—Minnaert & Vlam.—(*Physica*, May 1937, Vol. 4, No. 5, pp. 361–372: in English.)

3017. ADDITION AND CORRECTION TO MY PAPER "VIBRATIONS OF A VIOLIN STRING."—Witt. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 7, 1937, pp. 542–545.) *See* 185 of January.

3018. ELECTRIC INSTRUMENT INVENTED TO TAKE PLACE OF FRENCH HORN [Gaseous Discharge "Oscillion"].—Danforth. (*Sci. News Letter*, 22nd May 1937, Vol. 31, pp. 327 and 332.)

3019. A NEW ELECTROPHONOMETER FOR MEASUREMENTS IN APPLIED ACOUSTICS BY EITHER THE SUBJECTIVE OR THE OBJECTIVE METHOD.—A. Bernini. (*La Ricerca Scient.*, No. 5/6, Series 2, 8th year, Vol. 1, pp. 206–212.)

The equipment consists of (i) a very sensitive electromagnetic microphone, which functions as the receiver in the objective method and as a source of sound in the subjective method; (ii) a new type of potentiometer, with four sliding contacts, of non-inductive resistance variable from 10 to 20 000 ohms; (iii) a three-stage amplifier; (iv) a microammeter (10–100 μA) with a circuit of copper-oxide rectifiers; (v) a neon-tube oscillator of adjustable resistance and capacity; (vi) a second potentiometer, with two sliders; and (vii) a telephone receiver connected across this potentiometer. Whereas previous objective meters have been limited to sounds of about 30 db above the threshold, the writer's instrument can deal with energies a hundred times smaller. Thus transmission measurements on partitions of low acoustic transparency can be made without the use of high-power sound sources. Moreover, the rapid change-over from the objective to the subjective method, and *vice versa*, is very valuable on certain occasions. Other advantages are mentioned.

3020. LOUDNESS MEASUREMENTS [and the Rational Scale based on One-Ear Listening being Half as Loud as Two-Ear].—W. A. Munson: Fletcher. (*Bell Lab. Record*, June 1937, Vol. 15, No. 10, pp. 306–310.)

3021. DIRECT-READING TRANSMISSION MEASURING SETS [Types 74105–A & B], *and* A DISTORTION-FACTOR METER [Type No. 74300–A].—(*Elec. Communication*, April 1937, Vol. 15, No. 4, p. 362: p. 363.)

3022. A STANDARD SOURCE OF SOUND AND THE MEASUREMENT OF MINIMUM AUDIBILITY.—E. N. da C. Andrade & R. C. Parker. (*Proc. Roy. Soc.*, Series A, 15th April 1937, Vol. 159, No. 899, pp. 507–526.)

The source of known amplitude, here described in detail, is based on "a sounding tube open to the air at one end, the amplitude being measured by observing the traces of smoke particles at an antinode." The air vibrations are maintained by a loudspeaker diaphragm closing one end of the tube and supplied by a dynatron oscillator with a single-stage push-pull amplifier. The use of the standard source to measure the minimum audible energy is described, with a calculation of the acoustic pressure at a point at a given distance from the open end of the tube along its axis. The results are found to agree with those of Fletcher & Wegel, as reproduced by Waetzmann & Geffcken (1933 Abstracts, p. 333).

3023. "VIBRATION AND SOUND" [Book Review].—P. M. Morse. (*Electronics*, May 1937, Vol. 10, No. 5, p. 51.) In the "International Series in Physics."

3024. CONTRIBUTION TO THE RESEARCH ON THE NATURE OF THE VOWELS [Experimental Investigation].—Innamorati & Uccello. (*Alta Frequenza*, June 1937, Vol. 6, No. 6, pp. 398–399: summary only.)

3025. THE PHYSICAL CONSTANTS OF THE OSSICLES OF THE HUMAN EAR [Dimensional Data].—O. Stuhlman. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 688: abstract only.)

3026. DIFFRACTION OF LIGHT BY SUPERSONIC WAVES: A TEST FOR POLARISATION.—Parthasarathy. (*See* 3068.)

3027. Theory of the Diffraction of Light by Supersonic Waves.—Extermann. (*See* 3067.)

3028. Thermal Waves in Liquids [Conduction of Heat effected chiefly by Transversal Waves].—R. Lucas. (*Comptes Rendus*, 31st May 1937, Vol. 204, No. 22, pp. 1631–1632.) For previous work *see* 2250 of June.

3029. Contributions to the Technique of the Determination of Supersonic-Wave Velocity in Liquids by means of Standing Waves [including Results with Various Liquids at 6157 kc/s].—R. Wyss. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 10, 1937, pp. 237–252: in German.)

3030. Dispersion of Sound Velocity in Liquids [Relation between Supersonic Velocity and Hypersonic Velocity of Spontaneous Sound Waves of Thermal Origin differs in Different Liquids].—B. V. R. Rao. (*Nature*, 22nd May 1937, Vol. 139, p. 885.)

3031. Flow of Air at Supersonic Velocities through Holes of Very Small Diameter [comparable to Mean Free Path: Transition from Molar to Molecular Phenomena].—L. Agostini. (*Comptes Rendus*, 3rd May 1937, Vol. 204, No. 18, pp. 1311–1313.)

3032. Insertion on Charts of Echo Soundings and the Calibration of Echo Sounding Machines, *and* Plotting and Publication of Echo Soundings [Replies to Circular Letters].—(*Hydrographic Review*, May 1937, Vol. 14, No. 1, pp. 71–86: pp. 87–95.)

3033. A Quantitative Study of the Doppler Effect in Sound Waves [Sound from Rotating Whistle impressed on Microphone: Oscillographic Record of Current].—N. F. Smith. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 686: abstract only.)

PHOTOTELEGRAPHY AND TELEVISION

3034. Electronic Transmission of Pictures and Signs with Insulating or Semiconducting Films.—M. Knoll & F. Schröter. (*Physik. Zeitschr.*, 1st May 1937, Vol. 38, No. 9, pp. 330–333.)

The writers have investigated the two possible methods of using thin homogeneous films of insulating or semiconducting material to transmit pictures or signs by cathode-ray scanning. The first method, chiefly used for good insulators, was referred to in 3037 of 1936. The tube used is shown in principle in Fig. 1; the electron picture to be scanned was formed by a beam of thermionic electrons of circular cross section. Fig. 2 shows the image given by a film of Al_2O_3, 0.01 mm thick, Fig. 3 that of a cross-shaped stop in the electron beam produced by a glass plate 0.1 mm thick. The image appears to be formed by a negative charge on the insulating or semiconducting surface which is conducted away by the scanning electron beam. Mica and quartz also gave picture transmission; a Cu_2O-film, however, did not.

The second method arises from the change in resistance of a thin semiconducting film on illumination. The experimental arrangement for photosensitive semiconducting films is shown in Fig. 4. The picture to be transmitted is projected on to a metallic plate *P* covered with the thin film. The film need not consist of many pieces insulated from one another, as in the iconoscope, but can be in one piece. A sharply-focused electron beam is deviated in such a way that it produces a "raster" on the picture side of the plate. The secondary electrons emitted connect the element of film being scanned with the anode; this signal current is greater, the greater the conductivity of the film produced by the internal photoelectric effect. The image is projected on to the screen of a cathode-ray tube *via* the resistance *R*. Fig. 5 shows the variation of plate current with intensity of illumination, for an electron beam at rest, Figs. 6 and 7 two examples of images produced with a moving electron beam. For transmission of a positive image, the amplifier must have an *even* number of stages. It was verified experimentally that the image could not have been produced by variation of the dielectric constant under illumination; all phenomena could be explained by the conductivity increase of the semiconducting film under illumination, caused by the internal photoelectric effect. Semiconductors without this internal effect did not permit of picture transmission by this method.

3035. Image Brightness in Picture-Projection Technique [Test Results].—J. Rieck. (*Zeitschr. V.D.I.*, 1st May 1937, Vol. 81, No. 18, p. 522: summary only.)

3036. I.R.E. sees Projection Television [at 25th Anniversary Convention].—(*Electronics*, June 1937, Vol. 10, No. 6, pp. 7–13.)

3037. A Method of obtaining Stereoscopic Images on a [Cinema] Screen.—V. Yuzhakov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 7, 1937, pp. 418–419.)

Two films, prepared for the right and the left eye respectively, are projected simultaneously. An endless ribbon with opaque shields attached to it is moved in front of the projectors and of the spectators, blocking alternate objectives of the projectors and the corresponding eyes of the spectators. *Cf.* Martin, *Recherches et Inventions*, April 1937, Vol. 17, No. 269, pp. 103–107.

3038. "Electronic Television."—G. H. Eckhardt. (At Patent Office Library, London: Cat. No. 77 498: 184 pp.)

3039. The Telecinema, or Intermediate-Film Television: the System of the Établissements Grammont.—C. Chouquet. (*Génie Civil*, 29th May 1937, Vol. 110, No. 22, pp. 484–487.)

3040. The E.M.I. Television Receiver [and Its "Straight" (Tuned R.F.) Vision Amplifier: Reasons for Adoption: etc.].—G. H. Watson. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 230–234.) Including a Discussion.

3041. TELEVISION RECEIVERS: PART I [Description of G.E.C. Receiver].—D. C. Espley & G. W. Edwards. (*G.E.C. Journ.*, May 1937, Vol. 8, No. 2, pp. 160–172.)

3042. THE COSSOR TELEVISION RECEIVER [and the Question of "Interline Flicker" and "Stroboscopic Effect" with Interlaced Scanning].—L. H. Bedford. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 226–229.)

"The question is, how far must the viewing angle be reduced? [to eliminate "stroboscopic effect," often probably confused with "interline flicker"]. If it were found necessary exactly to halve the viewing angle, then the interlacing process would present exactly no advantage. Our experiments indicated that a reduction of 1½ times was sufficient to render the stroboscopic effect innocuous."

3043. SOME ASPECTS OF THE DESIGN OF THE MIHALY-TRAUB TELEVISION RECEIVER [including Illumination Data for Mirror-Drum, Mihaly, and Mihaly-Traub Systems].—M. J. Goddard. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 235–250.) Including a Discussion.

3044. BRITISH STANDARD SPECIFICATION FOR MAINS-OPERATED APPARATUS FOR RADIO, ACOUSTIC, AND VISUAL REPRODUCTION (SAFETY REQUIREMENTS).—(*British Standards Institution*, No. 415–1936: Nov. 1936: 18 pp.)

3045. TELEVISION STUDIO CONSIDERATIONS: PARTS II AND III.—Eddy. (*Comm. & Broadcast Eng.*, May & June 1937, Vol. 4, Nos. 5 & 6, pp. 14–15 and 27: pp. 20–22: to be contd.) For Part I *see* 2669 of July.

3046. ELECTRICAL INTERFERENCE WITH BROADCAST AND TELEVISION RECEPTION.—F. R. W. Strafford. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 221–225.)

3047. TELEVISION TERMINOLOGY.—(*Electronics*, June 1937, Vol. 10, No. 6, pp. 14–17 and 68.)

3048. TELEVISION: AN ACCOUNT OF THE DEVELOPMENT AND GENERAL PRINCIPLES, AS ILLUSTRATED BY A SPECIAL EXHIBITION HELD AT THE SCIENCE MUSEUM, JUNE-SEPTEMBER, 1937.—G. R. M. Garratt & G. Parr. (A sixpenny booklet published by H.M. Stationery Office: 64 pp.)

3049. TELEVISION EXHIBITION [Science Museum, South Kensington].—(*Wireless World*, 18th June 1937, Vol. 40, pp. 577–578.)

3050. THE DEVELOPMENT OF TELEVISION [1895–1930].—Begrich. (*Funktech. Monatshefte*, May 1937, No. 5, Supp. pp. 37–41: to be contd.) For a previous instalment *see* 2674 of July.

3051. THE PROGRESS OF TELEVISION DURING 1936 [in Various Countries].—(*Bull. Assoc. suisse des Élec.*, No. 12, Vol. 28, 1937, pp. 265–267: long summary only.)

3052. TELEVISION AERIALS [Design Data for Dipole Aerials].—H. B. Dent. (*Wireless World*, 28th May 1937, Vol. 40, pp. 506–508.)

3053. CONSTRUCTION OF THE COAXIAL CABLE [New York/Philadelphia], *and* INSTALLING THE COAXIAL CABLE.—C. Kreisher: T. C. Henneberger. (*Bell Lab. Record*, June 1937, Vol. 15, No. 10, pp. 325–328: pp. 329–333.)

3054. CROSSTALK BETWEEN COAXIAL TRANSMISSION LINES.—Schelkunoff & Odarenko. (*See* 3004.)

3055. ON THE DESIGN OF A WIDE FREQUENCY BAND TELEVISION AMPLIFIER.—R. G. Schiffenbauer. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 13–18.)

A critical survey is presented of the works by various authorities, including the author himself, on the distortion taking place in resistance-coupled amplifiers using four-electrode and five-electrode valves. The methods proposed for correcting the frequency and phase distortion at both high and low frequencies are discussed, and formulae are quoted determining the relationship between the various constants of the compensating circuits. The conditions necessary to ensure that distortions do not exceed the permissible limits are established, and in one or two cases methods are indicated for simplifying the calculations involved. The complete design of an amplifier is thus outlined, and a numerical example added.

3056. MEASUREMENTS OF THE AFTERGLOW OF CATHODE-RAY OSCILLOGRAMS WITH SCREENS OF LONG DECAY TIME.—M. von Ardenne. (*Zeitschr. f. Physik*, No. 3/4, Vol. 105, 1937, pp. 193–201.)

Measurements are given of the afterglow of screens of long decay time, when they have been briefly illuminated by light- and cathode-rays. Fig. 3 shows the experimental arrangement used. With illumination by light, the amount of light stored up in the fluorescent material rapidly decreases when the illumination time falls below the time required for full excitation of the material (Fig. 2). In the case of excitation by cathode rays, Fig. 4 shows the measured relation between the duration of recognisable fluorescence and the recording velocity of the cathode-ray spot, for various cathode-ray powers and a favourable screen material. "The measurements show than an increase of recording velocity cannot, as the result of a further saturation phenomenon, be compensated for by a corresponding increase in the cathode-ray power." A relation is found between the screen excitations produced by light and by cathode rays.

3057. THE TURNER PRE-HEATED THERMO-LUMINESCENT SCREEN FOR TELEVISION.—F. S. Turner. (*Radio-Centrum*, 21st Jan. 1937, Vol. 3, No. 3, p. 35: in Dutch.) A short article based on English Pat. 452 368.

3058. ERRATA AND ADDENDA TO "ELECTRON OPTICS."—Rodda. (*Journ. Television Soc.*, March 1937, Vol. 2, Part 7, pp. 253–254.) *See* 2328 of June. Myers and the author discuss the approximate practical formula for the focal length of the cylinder lens.

3059. ON THE ACCURACY OF THE FOCUSING OF ELECTRON STREAMS IN A KUBETSKI [Electron Multiplier] TUBE.—L. V. Voroshilov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 7, 1937, pp. 536–541.)

The currents flowing in the leads connected to the electrodes of a Kubetski tube (2583 of July) can be measured, and it is shown that their sum $\sum_{k=1}^{k=n} i_k$ is equal to the sum of the stray electrons falling on the glass, and thus represents the loss taking place in the tube. The expression $\left(\sum_{k=1}^{k=n} i_k\right)^2 / i_n^2$, in which i_n is the output current of the tube, therefore serves as a measure of the efficiency of the tube; in addition, since the losses in the tube are determined by the accuracy with which the electron streams are focused, it also gives an indication of the accuracy of focusing. This provides an easy method for determining experimentally the best operating conditions of the tube.

3060. A Y-SHAPED ELECTRON MULTIPLIER, *and* EXPERIMENTS ON ELECTRON MULTIPLIERS.—RCA: Chiba & Morita. (*See* 2969/2970.)

3061. SECONDARY ELECTRON EMISSION OF METALS WITH A LOW WORK FUNCTION, *and* SECONDARY ELECTRON EMISSION OF SOOT IN VALVES WITH OXIDE CATHODES.—Bruining, de Boer, Burgers. (*See* 2971/2972.)

3062. THE GRADIENT OF THE SUPER-HIGH-PRESSURE MERCURY DISCHARGE, *and* THE TOTAL RADIATION OF THE HIGH-PRESSURE MERCURY DISCHARGE AS FUNCTION OF INPUT POWER, DIAMETER, AND PRESSURE.—W. Elenbaas. (*Physica*, April 1937, Vol. 4, No. 4, pp. 278–284: June, No. 6, pp. 413–417: both in German.)

3063. LAW OF EMISSION [as a Function of Direction] OF A CONTINUOUS-SPECTRUM RADIATION (WHITE LIGHT) BY XENON TUBES.—Laporte. (*Comptes Rendus*, 24th May 1937, Vol. 204, No. 21, pp. 1559–1560.) For the experimental production of the continuous xenon spectrum *see* 2657 of July.

3064. THE KERR EFFECT OF NITROBENZOL IN BENZOL [Theory: Measurements at All Concentrations: Method of preparing Purified Solution and determining Concentration: Marked Decrease of Molecular Kerr Constant at Low Concentrations explained on Debye's Theory of Molecular Structure of Liquids].—H. Friedrich. (*Physik. Zeitschr.*, 1st May 1937, Vol. 38, No. 9, pp. 318–329.)

3065. REMARKS ON THE VARIATION WITH FIELD STRENGTH OF THE DIELECTRIC CONSTANT AND KERR EFFECT.—Bouwkamp & Mijboer. (*See* 3185.)

3066. PHOTOELECTRIC INVESTIGATION OF THE "ALLISON MAGNETO-OPTIC EFFECT" [with Photoelectric Method of balancing out Fluctuations in Light Source].—Comstock: Allison. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, pp. 776–777.) *See*, for example, 1932 Abstracts, p. 660, l-h column; *also* 2304 of 1936.

3067. THEORY OF THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—R. C. Extermann. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 10, 1937, pp. 185–217: in French.)

"In an earlier article [583 of February] we partially solved the problem. . . . We now propose to deal with it by a more general method . . . similar to that used by Ewald & Laue in the theory of the propagation of X-rays in crystals." *See* also 2658 of July.

3068. DIFFRACTION OF LIGHT BY ULTRASONIC WAVES: A TEST FOR POLARISATION [Negative Result, in accordance with Theory].—S. Parthasarathy. (*Current Science*, Bangalore, Nov. 1936, Vol. 5, No. 5, p. 243.)

A previous paper by the same writer is referred to, in which he showed that at oblique incidences the light undergoes characteristic reflections in accordance with a simple formula of the Bragg type.

3069. SECONDARY PHOTOCELLS: SENSITIVITY COMPARABLE WITH GAS-FILLED TYPES: THEIR USE IN TELEVISION [Osram C.W.S. 24 Secondary-Emission Cell].—(*Electrician*, 21st May 1937, Vol. 118, pp. 673–674.)

3070. THE TIME LAG OF THE VACUUM PHOTOCELL.—Houstoun. (*Proc. Roy. Soc. Edinburgh*, Part 2, Vol. 57, 1937, pp. 163–171.) *See* also 1888 of May.

3071. WATER VAPOUR IN THE CONSTRUCTION OF MORE SENSITIVE PHOTOELECTRIC CELLS OF ALKALI METALS [Five-Fold Increase].—J. Kunz. (*Journ. Opt. Soc. Am.*, June 1937, Vol. 27, No. 6, p. 224: summary only.)

3072. THE DEVELOPMENT OF PHOTOELECTRIC CELLS [Summarising Account: Electron-Optics].—R. Sewig. (*Naturwiss.*, 21st May 1937, Vol. 25, No. 21, pp. 321–324.)

3073. INVESTIGATIONS ON BARRIER-LAYER PHOTOCELLS WITH SOFT X-RAYS.—H. Felsinger. (*Ann. der Physik*, Series 5, No. 1, Vol. 29, 1937, pp. 81–96.)

The apparatus here described (circuit Fig. 1) is suitable for investigations of the effect on cuprous-oxide and selenium barrier-layer cells of X-rays of a wide range of energy. The photocells were built into the vacuum of the X-ray tube itself (Fig. 2). Measurements are given (Figs. 3–13) of the photocurrents and photovoltages of the cells as functions of the anticathode current and the tube voltage; these are discussed in relation to the behaviour, with visible light, of the various types of barrier-layer photocells. Current yield of the same order as for visible light is obtained with "vorderwand" (anterior-wall) cells; it is concluded that they would be suitable for measurements of the intensity of soft X-rays with low anticathode powers.

3074. ON THE MANUFACTURE OF BARRIER-LAYER SELENIUM PHOTOCELLS.—B. T. Kolomiets. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 7, 1937, pp. 393–404.)

In view of the growing demand for barrier-layer selenium photocells a large-scale production of these may become necessary, and in the present paper possible suitable manufacturing methods are proposed. These methods have been used in the production of about 1000 photocells having a sensitivity up to 450 μA/lumen and active surfaces of 10, 20, and 40 cm². The various stages of the manufacturing process are described in detail, and changes in the spectral sensitivity characteristic (Fig. 6) due to the addition of sulphur and tellurium are discussed. The effect on the sensitivity of the cells of various methods of purifying selenium is also investigated.

3075. PHOTOELECTRIC MEASUREMENTS WITH METALLIC ANTIMONY.—V. Middel. (*Zeitschr. f. Physik*, No. 5/6, Vol. 105, 1937, pp. 358–377.)

Thin films of metallic antimony were produced by cathode spraying; Debye-Scherrer photographs (Figs. 1, 2) showed that their structure was crystalline. Films on mica (Fig. 4a) and quartz (Fig. 4b) gave an internal photoelectric effect with resonance maximum about 3700 Å. The change of resistance under illumination was investigated and confirmed by an approximate determination of the absorbing power. Schönwald's method (1933 Abstracts, p. 107) was used to demonstrate the primary photoelectric current. The external photoelectric effect was also measured; no resonance maximum was found down to 2000 Å, in agreement with theory.

3076. ACTION OF LIGHT ON THIN METALLIC FOILS [Metallic Photo-Resistance]. — Majorana. (*La Ricerca Scient.*, No. 5/6, Vol. 1, Series 2, 8th Year, 1937, pp. 229–232.) For previous work *see* 492 of 1935 and back references.

3077. ELECTRON-MICROSCOPIC STUDY OF THE PHOTOEMISSIVE SURFACE, [Ag]-Cs_2O-Cs [Different Appearances when Illuminated by Light of Various Kinds].—Y. Moriya. (*Electrotechnical Journal*, Japan, July 1937, Vol. 1, No. 2, p. 65.) Perhaps the most striking difference is between illuminations by 3000–4000 Å and by wavelengths more than 6000 Å, the latter giving a spotty appearance showing very non-uniform emission over the surface.

3078. VAPOUR PRESSURE OF CAESIUM BY THE POSITIVE ION METHOD [Positive Ion Currents measured for Range of Tungsten Filament Temperature in Saturated Caesium Vapour: Empirical Formulae for Vapour Pressure].—J. B. Taylor & I. Langmuir. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, pp. 753–760.)

3079. THE PHOTOELECTRIC PROPERTIES OF POTASSIUM FILMS OF ATOMIC THICKNESS ON PLATINUM: I.—H. Mayer. (*Ann. der Physik*, Series 5, 1937, No. 2, Vol. 29, pp. 129–159.)

For preliminary descriptions of the method used *see* 3161 of 1935 and 666 of 1936. The present detailed paper describes the photoelectric behaviour of potassium films of thickness 0–30 atoms under illumination from mercury-arc lines between 6000 and 2400 Å. The effect of occlusion of gas molecules in the films is also discussed. A value is found for the "optimum covering" of the platinum surface, for which the work function is a minimum. The selective effect begins to show at a film thickness of 2–3 atoms. Data are given of limiting wavelength, work function, maximum emission, etc. The effect of "wandering" of the adsorbed potassium atoms is described; the velocity distribution of electrons emitted from films of various thicknesses is determined from photoelectric current/voltage curves and discussed in relation to general photoelectric problems.

3080. THE THEORY OF THE ATOMIC PHOTOELECTRIC EFFECT [Calculations for Electron Emission from *K*-Ring].—F. Renner. (*Ann. der Physik*, Series 5, No. 1, Vol. 29, 1937, pp. 11–24.)

3081. THE EFFECT OF SLOW POSITIVE POTASSIUM IONS ON METALLIC SURFACES [Production of Passivity to Various Vapours].—W. Brummack. (*Zeitschr. f. Physik*, No. 7/8, Vol. 105, 1937, pp. 468–469.)

3082. THE OPTICAL CONSTANTS OF SODIUM.—Ives & Briggs. (*Journ. Opt. Soc. Am.*, May 1937, Vol. 27, No. 5, pp. 181–185.) Extension to sodium of the work dealt with in 3105 of 1936.

3083. THE ENERGY DISTRIBUTION OF PHOTOELECTRONS EMITTED BY CALCIUM AND CALCIUM OXIDE.—I. Liben. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, pp. 642–647.)

Energy distribution curves of the photoelectrons from pure Ca, CaO, and a number of stages between the oxide and the pure metal were obtained, using a magnetic velocity analyser and radiation of wavelength λ 2536. "The theories of Fowler, DuBridge, Mitchell & Nottingham were found to compare favourably with the data for pure Ca on the high-energy side, but to depart from the data at low energies. The photoelectric work function obtained for pure Ca was 3.21 electron volts. The failure of all attempts to fit the above theories to the data for the oxide indicates that the Sommerfeld theory of a metal is not applicable to CaO."

3084. THE EFFECT OF TEMPERATURE ON THE PRIMARY PHOTOELECTRIC CURRENT IN CRYSTALS [of Alkali Halides: Measurements showing, in Certain Temperature Ranges, the Same Sign and Order of Magnitude of the Temperature Coefficient as in Metals].—R. W. Pohl. (*Ann. der Physik*, Series 5, No. 3/4, Vol. 29, 1937, pp. 239–245.) For other work on colour centres *see*, for example, 264/6 of January.

3085. THE PRIMARY PHOTOELECTRIC CURRENT IN ALKALI HALIDE CRYSTALS AS A FUNCTION OF TEMPERATURE AND OF THE CONCENTRATION OF THE COLOUR CENTRES [Measurements: Properties of Electron Paths in Crystals].—G. Glaser & W. Lehfeldt. (*Göttinger Nachrichten, math.-phys. Klasse*, New Series, No. 7, Vol. 2, 1936, pp. 91–108.) *See* also 3084.

MEASUREMENTS AND STANDARDS

3086. DIRECT-READING ELECTRONIC FREQUENCY METERS [Survey of Circuits, including the R.I.E.C. Meters].—F. Vecchiacchi. (*Alta Frequenza*, May 1937, Vol. 6, No. 5, pp. 279–312.)

The thermionic valve has made possible the design of various types of direct-reading frequency meters, all based on the principle that the average current I_m passing through a condenser is a function of the frequency f and the "excursion" of the applied voltage—that is, the difference V between the maximum and minimum values. Thus the frequency is given by reading the values of these two quantities I_m and V. But the second reading can be eliminated if steps are taken to stabilise V to a fixed value, in which case the frequency is given by a single reading of I_m. The writer describes the two main methods of stabilisation of the voltage "excursion," namely automatic amplification control (like the AVC of broadcast receivers) and the use of square-topped waves. Particular attention is given to the latter method, various "electronic commutator" and other circuits for the production of such wave forms being discussed (Section 4). The next two sections deal with the rectification of the alternating current (for measurement by a d.c. meter) and with some diode frequency-meter circuits obtained by combining different methods of square-topped-wave generation with different diode-rectifier circuits.

Section 7 then deals with the derivation of circuits used in the R.I.E.C. types of frequency meter, the basic circuit (Fig. 26) being derived from that of Fig. 21 (square-topped-wave generation, using an "electronic commutator" of two triodes with grids controlled by a two-secondary transformer, combined with diode rectification) by dispensing with the direct measurement of the current through the condenser, and thus with the diode portion of Fig. 21; the meter being transferred to the anode circuit of the two triodes of the "electronic commutator" (anode spaces in series). Figs. 29 and 30 show R.I.E.C. circuits which are variations of the above basic circuit, the two-winding transformer being eliminated and the "commutator" grids being controlled in the first case by an ohmic potential divider, and in the second by an auxiliary pentode 2. Finally, section 8 deals with the chief characteristics of such electronic frequency meters, whether of the diode or the R.I.E.C. type: these include very large ranges of frequency, up to and over 100 kc/s; linear calibration; and independence, within wide limits, of the value of the applied voltage and of its wave form. Regarding this last, exceptional cases are mentioned, such as when the wave form consists of two half waves of very different duration: methods of avoiding error from such causes are discussed. Fig. 31 illustrates a method of differential working by which the instrument can be used to indicate very small variations from a set frequency.

3087. FREQUENCY MEASUREMENT: A NEW EQUIPMENT FOR THE RANGE 1–70 Mc/s.—H. A. Thomas. (*Wireless Engineer*, June 1937, Vol. 14, No. 165, pp. 299–305.)

From the National Physical Laboratory. The general scheme of design follows that of the P.O. equipment for 1–25 Mc/s (3386 of 1935). The method of locking the 1 kc/s and 90–110 kc/s oscillators is very satisfactory: tetrodes are used and the locking signal is applied to the screen grid (De Young, 3847 of 1935).

3088. A SIMPLIFIED CIRCUIT FOR FREQUENCY SUBSTANDARDS, EMPLOYING A NEW TYPE OF LOW-FREQUENCY ZERO-TEMPERATURE-COEFFICIENT QUARTZ CRYSTAL.—Hight & Willard. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 549–563.) The full paper, a summary of which was dealt with in 2713 of July.

3089. A VOLTAGE-STABILISED HIGH-FREQUENCY CRYSTAL OSCILLATOR CIRCUIT.—Sabaroff. (*See* 2919.)

3090. A CONTRIBUTION TO THE "MULTIPLE VIBRATION" PROBLEM OF QUARTZ PLATES [Investigation by Dust Figures].—K. Balzer. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 18, 1937, pp. 169–170 and Plate.)

Two square plates of equal sides but different thicknesses were investigated: they were cut so that the thickness direction coincided with the direction of the electrical axis. Typical results are illustrated: three types of figure were found. The first (Figs. 1–5) correspond to the theory of the vibration of plates; the second (Figs. 6–9) are clearly the result of combinations of two of the first-type vibrations. In addition, however, there was a third kind of figure (Figs. 10–12) which could not be allocated to either of the previous types. Further investigation of vibrations of this third type is necessary: it is noticeable that the figures are (for the same exciting frequency) exactly the same for the thick and the thin plates, so that they depend evidently on the dimensions in the plane of the plate and not on the thickness. In all cases the exciting frequency was kept well below the "thickness" resonance frequency. Figures obtained with circular plates are also given: these are less easy to interpret, and are only briefly mentioned.

3091. THE PIEZOELECTRIC CONSTANT OF QUARTZ [Charge (in Electrostatic Units) per Kilogram Load measured to 0.1% at 17°, 60°, and 90° C: Small Linear Variation with Temperature].—J. Clay & J. G. Karper. (*Physica*, April 1937, Vol. 4, No. 4, pp. 311–315: in English.)

Using, for the measurement of the small charges, the special steel-cylinder precision condenser dealt with in 4175 of 1936. "We were surprised to find that every time the charge for the first 5 kg is a little less than for the second 5 kg. We cannot yet provide a reason for this deviation from linearity." Pressures up to 10 kg/cm² were used. At 60° C the charge was 0.06636 ± 0.00007 per kg load.

3092. ON THE CALCULATION OF THE VELOCITIES OF PROPAGATION OF ELASTIC WAVES IN CRYSTALS [Tetragonal, Hexagonal, Cubical Systems].—E. Goens. (*Ann. der Physik*, Series 5, No. 3/4, Vol. 29, 1937, pp. 279–285.)

3093. THE PIEZOELECTRIC EFFECT WITH AMMONIUM CHLORIDE CRYSTALS NEAR THE TRANSITION TEMPERATURE—30.5° C [Effect increases from Zero to Its Full Value within a Range of 2°].—S. Bahrs & J. Engl. (*Zeitschr. f. Physik*, No. 7/8, Vol. 105, 1937, pp. 470–477.)

3094. HISTORY AND APPLICATION OF PIEZOELECTRICITY.—M. Tournier. (*Elec. Communication*, April 1937, Vol. 15, No. 4, pp. 312–327.)

3095. THE U.R.S.I. PROGRAMMES OF SHORT-WAVE STATION W1XAL, *and* WWV SERVICES AGAIN EXPANDED.—(*See* 3171/3172.)

3096. A STUDY OF THE SINGLE-LAYER SOLENOIDS USED IN SHORT-WAVE CIRCUITS.—Seki. (*See* 2911.)

3097. MEASURING RF RESISTANCE [Simple and Rapid Dynatron Method for Mass-Produced Coils].—P. H. Pettifor. (*Wireless World*, 18th June 1937, Vol. 40, pp. 580–581.) From the Siemens Works, Woolwich.

3098. RADIO RESISTOR MEASUREMENT [Suitable Tests for Fixed Carbon-Composition Resistances, and Practical Methods].—E. B. Schwartz. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 37–39 and 106, 107.)

3099. DISTRIBUTION OF CHARGE ON A CYLINDER BETWEEN TWO CONDUCTING PLANES AT DIFFERENT POTENTIALS [and Calculation of Capacity].—Hallén. (*See* 2912.)

3100. A NEW TYPE OF VALVE PHASEMETER [and Its Application to the Measurement of Inductances and Capacities].—Opitz. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 163–166.) *See* 2310 of June.

3101. ON MEASURING THE PLATE LOSS OF AIR-COOLED TRANSMITTING VALVES.—Morimoto & others. (*See* 2974.)

3102. ON A NEW THREE-ELEMENT THERMOCOUPLE FOR PRECISION TEMPERATURE MEASUREMENT [compensating the Error due to Thermal Conduction found in Ordinary Thermocouples].—M. Tanaka & K. Okada. (*Electrotechnical Journal*, Japan, July 1937, Vol. 1, No. 2, pp. 42–48.) This journal replaces the "Abstracts Section" of the *Journ. I.E.E. Japan*.

3103. THE CURRENT TRANSFORMER FOR THE MEASUREMENT OF HIGH-FREQUENCY CURRENTS [Special Transformer, using Commercial H.F. Iron Core (for Broadcast Receivers), with Dry-Plate Rectifier and D.C. Meter].—M. Jung. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 137–142.)

3104. A COMPARATOR OF MANY USES [for Direct Reading of Percentage Differences between Currents, Voltages, and Impedances: Differential Action of Twisted-Twin Primary of Air-Cored Transformer with Two Symmetrical Secondaries].—F. Neri. (*L'Elettrotec.*, 10th May 1937, Vol. 24, No. 9, pp. 262–265.) For previous work on the same principle *see* 2697 of July.

3105. A POTENTIOMETER FOR THE MEASUREMENT OF SMALL ELECTROMOTIVE FORCES AND RESISTANCES.—C. H. Johansson. (*Journ. Scient. Instr.*, June 1937, Vol. 14, No. 6, pp. 194–198.)

3106. DIELECTRIC CONSTANT AND CONDUCTIVITY OF SOIL AT HIGH RADIO FREQUENCIES.—Banerjee & Joshi. (*See* 2870.)

3107. THE DIELECTRIC CONSTANT AND DIPOLE LOSSES OF GLASSES AT HIGH FREQUENCIES [25 kc/s to 30 Mc/s: Extension, to Solids, of Barretter Method of measuring Conductivity and Dielectric Constant: Results for Various Glasses: Linear Increase of Conductivity with Frequency: Explanation in Terms of Dipole Losses].—W. Hackel. (*Ann. der Physik*, Series 5, No. 1, Vol. 29, 1937, pp. 63–80.)

3108. ABSORPTION BANDS IN POLAR SUBSTANCES AT VERY HIGH RADIO-FREQUENCIES [4–22 m Wavelength].—L. Cavallaro. (*La Ricerca Scient.*, No. 5/6, Series 2, 8th Year, Vol. 1, pp. 234–237.)

3109. REMARK ON THE PAPER BY G. RÖSSELER:—A PRECISION MEASURING ARRANGEMENT FOR DETERMINING THE MOLECULAR POLARISATION OF NON-DISSOCIATING LIQUIDS [Comparison of Accuracy of Experimental Results].—F. H. Müller. (*Zeitschr. f. Physik*, No. 7/8, Vol. 105, 1937, pp. 513–515.) For the paper referred to *see* 655 of February.

3110. AN ELECTROMETER VALVE WITH SPECIAL DESIGN OF CONTROL-GRID INSULATORS.—Katzmann. (*See* 2976.)

3111. A SIMPLE ELECTROSTATIC VOLTMETER FOR HIGH VOLTAGES [using Hollow Copper Sphere (Ball-Tap Float)].—C. W. Lampson. (*Review Scient. Instr.*, May 1937, Vol. 8, No. 5, pp. 165–169.)

3112. "ELECTRICAL MEASUREMENTS" [Book Review].—H. L. Curtis. (*Electronics*, June 1937, Vol. 10, No. 6, p. 33.) In the "International Series in Physics."

3113. PROGRESS IN MEASURING TECHNIQUE.—(*Radio, B., F. für Alle*, June 1937, Vol. 184, Supp. pp. 50–59.) In the new series "Fortschritte der Funktechnik II."

3114. SURVEY OF THE MEANING OF THE INTERNATIONALLY ARRANGED CHANGE IN THE ELECTROMAGNETIC UNITS.—J. Fischer. (*Physik. Zeitschr.*, 1st May 1937, Vol. 38, No. 9, pp. 336–345.)

3115. STANDARDISATION OF ALPHABETICAL AND GRAPHICAL SYMBOLS.—Société des Radioélectriciens. (*L'Onde Élec.*, May 1937, Vol. 16, No. 185, pp. 273–275.)

SUBSIDIARY APPARATUS AND MATERIALS

3116. CONTRAST EQUALISATION IN OSCILLOGRAMS WITH WIDELY VARYING RECORDING SPEEDS [by making Spot Brightness porportional to Momentary Speed].—Hollmann. (*Zeitschr. f. Instr:kunde*, No. 5, Vol. 57, 1937, pp. 202–207.)

The electrical pulse is differentiated with respect to time (*e.g.* by a suitable transformer or condenser), reversed in phase (by two opposed rectifiers) and used to modulate the ray intensity. An added footnote mentions the appearance of Alberti's work on the same lines (1516 of April).

3117. A NEW HIGH-SPEED CATHODE-RAY OSCILLOGRAPH [Sealed-Glass High-Vacuum, Hot-Cathode Type, recording Transients at Recording Speeds up to 250 Kilometres/Second: External Photography].—Kuehni & Ramo. (*Elec. Engineering*, June 1937, Vol. 56, No. 6, pp. 721–728.)

3118. A NEW CATHODE SUPPORT FOR CATHODE-RAY TUBES.—von Ardenne. (*Hochf:tech. u. Elek:akus.*, May 1937, Vol. 49, No. 5, pp. 177–178: Industry Review.)

Fig. 6 shows a new 4-volt cathode with the position of the plane emissive surface exactly defined. The cathode is held by a quartz tube and a spring action in the leads which pushes it against a projection in the tube. Fig. 3 shows a micrometer microscope for measuring the distances and angles of inclination of the electrodes.

3119. CATHODE-RAY OSCILLOGRAPH WITH A NEW TYPE OF ANODE-VOLTAGE SUPPLY [Multi-Cylinder Electron-Accelerator driven by 8-Watt Micro-Wave Generator (400 Mc/s), using Type 316-A Valve].—Awender. (*Funktech. Monatshefte*, May 1937, No. 5, pp. 151–152.) Some anticipated difficulties and necessary precautions are mentioned at the end. The potential aimed at is 1000 volts.

3120. THE PATHS OF CHARGED PARTICLES IN THE ALTERNATING FIELD OF A CONDENSER, INCLUDING THE EFFECT OF SCATTERING FIELDS.—Hintenberger. (*Zeitschr. f. Physik*, No. 7/8, Vol. 105, 1937, pp. 501–512.)

Author's summary:—The paths of charged particles in the alternating field of a condenser are calculated. It is shown that, for a wide range of velocity, the actual condenser field can be replaced by an ideal homogeneous alternating field. The length and position of this ideal field are given for the cases (1) when very thin condenser plates are used (as in the cathode-ray tube) and (2) when very thick plates are employed, and the scattering field is screened by earthed stops (these condensers are as used in velocity filters for cathode- and canal-rays.)

3121. ERRATA AND ADDENDA TO "ELECTRON OPTICS."—Rodda. (*See* 3058.)

3122. BRIGHTNESS OF CATHODO-LUMINESCENCE AT LOW CURRENT DENSITIES AND LOW VOLTAGES [Measurements on Artificial Willemite: an Empirical Law: Method of measuring Potential of Surface of Luminescent Target].—Brown. (*Journ. Opt. Soc. Am.*, May 1937, Vol. 27, No. 5, pp. 186–192.) The full paper, a summary of which was dealt with in 1965 of May.

3123. MEASUREMENTS OF THE AFTERGLOW OF CATHODE-RAY OSCILLOGRAMS WITH SCREENS OF LONG DECAY TIME.—von Ardenne. (*See* 3056.)

3124. THE ABSORPTION AND FLUORESCENCE SPECTRA OF IONS OF THE RARE EARTHS IN SOLID BODIES, PARTICULARLY IN THE INFRA-RED [Measurements: Explanation].—Gobrecht. (*Ann. der Physik*, Series 5, No. 8, Vol. 28, 1937, pp. 673–700.)

3125. THE FLUORESCENCE OF GADOLINIUM SALTS AND THEIR SOLUTIONS; *also* THE FLUORESCENCE OF RARE EARTHS IN SOLUTION: I; *and* ANALYTICAL PROOF OF [Presence of] THE RARE EARTHS BY ABSORPTION AND FLUORESCENCE.—Gobrecht, Tomaschek, & others. (*Ann. der Physik*, Series 5, No. 3/4, Vol. 29, 1937, pp. 306–310, 311–323, 324–331.)

3126. TIME SWEEP OF A CATHODE-RAY OSCILLOGRAPH: CALIBRATION USING A VALVE TIME-BASE [to eliminate Errors due to Imperfect Linearity of Sweep or to Screen Curvature: Mains-Driven Circuit giving Equal-Time-Interval Dots along Axis].—Williams & Wolfenden. (*Wireless Engineer*, June 1937, Vol. 14, No. 165, pp. 315–317.)

3127. A HIGH-FREQUENCY SWEEP CIRCUIT OF THE BRAUN TUBE [Saw-Tooth Voltage obtained from Sine Wave: Return Line eliminated: Synchronisation by Use of Pentode: Frequencies up to 7 Mc/s or over].—Kobayashi. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 29–36: in English.)

3128. AN AMPLIFIER WITHOUT PHASE DISTORTION.—Schade. (*See* 2975.)

3129. A DRUM CAMERA FOR RECORDING TRANSIENT ELECTRICAL PHENOMENA.—Lutkin. (*Journ. Scient. Instr.*, June 1937, Vol. 14, No. 6, pp. 209–212.)

3130. A NEW QUARTZ MANOMETER [for Pressures of order of 10^{-3} mm Hg: using Magnetically Started Torsional Swings of Quartz Plate].—Nickliborc. (*Acta Physica Polonica*, Fasc. 1, Vol. 6, 1937, pp. 19–27: in German.)

3131. THE DAMPING OF TORSIONAL OSCILLATIONS IN QUARTZ FIBRES [Theory: Measurements: Coefficients of Viscosity for Quartz].—Downsbrough. (*Phys. Review*, 15th May 1937, Series 2, Vol. 51, No. 10, pp. 877–883.)

3132. THERMIONIC CONTROL OF AN IONISATION GAUGE FOR VACUUM MEASUREMENT: METHOD APPLICABLE TO VARIETY OF LOW-POWER CIRCUITS.—Ridenour & Lampson. (*Review Scient. Instr.*, May 1937, Vol. 8, No. 5, pp. 162–164.)

Control of the power delivered by the mains transformer to the load is exercised by change of the grid voltage on a pair of triodes forming a short-circuited full-wave rectifier in the secondary of an auxiliary transformer which is connected in the primary circuit of the mains transformer.

3133. A QUARTZ-TO-PYREX JOINT [as used for Window in Photoelectric Cell for Investigation of Shenstone Effect].—Weber & Bazzoni. (*Review Scient. Instr.*, May 1937, Vol. 8, No. 5, pp. 170–171.)

3134. A MODIFIED SMYTHE [Adjustable] VACUUM LEAK.—Bazzoni: Smythe. (*Review Scient. Instr.*, May 1937, Vol. 8, No. 5, p. 171.)

See 681 of February. Smythe's principle of leakage through the wall of a glass-encased, unglazed porcelain tube, with adjustment by variation of the height of a mercury column in the bore of the tube, is adhered to.

3135. A STUDY OF THE THYRATRON INVERTER [Behaviour predicted by Operational Calculus: Calculation of Frequency and Wave Shape: Possibility of Omission of Circuit Elements: Production of Sine Wave).—Sledd & Peebles. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, pp. 684–685: abstract only.)

3136. FILTERS FOR RECTIFIERS.—Duinker. (*See* 2905).

3137. GRID CONTROL OF RADIO RECTIFIERS.—Durand & Keller. (*See* 3178.)

3138. A UNIQUE APPLICATION OF MERCURY-ARC RECTIFIERS [to give 15 000–20 000 Amperes for Short Time Intervals], *and* ELECTRONIC SWITCHING IN MERCURY-ARC RECTIFIERS [by Perforated Metal or Graphite Disc].—Keller. (*Electronics*, May 1937, Vol. 10, No. 5, p. 68: p. 70: summaries only.)

3139. ROTATING COMMUTATOR "REMEMBERS" IGNITRON FAILURES ["Memnoscope," for Cathode-Ray-Tube Recording of Voltage Conditions 1/30th Second before Arc-Back sets Camera in action].—Westinghouse Laboratories. (*Electronics*, June 1937, Vol. 10, No. 6, p. 30.)

3140. ELECTRICAL BREAKDOWN OF VARIOUS GASES AT HIGH PRESSURES [Measurements of Breakdown Voltage between Plane and Concentric Electrodes: Carbon Dioxide the Best Insulator in High Voltage Technique].—Finkelmann. (*Arch. f. Elektrot.*, 22nd April 1937, Vol. 31, No. 4, pp. 282–286.)

3141. AN INVESTIGATION OF THE PROPERTIES OF ELECTROLYTIC CONDENSERS.—Tvertsyn & Morozov. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 47–52.)

Tests were carried out to determine the effect of temperature variation from $-60°$ C to $+55°$C on (a) the leakage current; (b) the d.c. capacity (measured by the ballistic method) and the a.c. capacity (at $\omega = 100\pi$ and 17 000); and (c) the angle of loss (at the same frequencies). The condensers tested were of 10 μF capacity, the working voltages varying from 15 to 450 volts. The primary forming of the anodes was not taken into account, and the condensers were tested with the working electrolyte (solution of boracic acid in glycerine). The tests are described and tables are given showing the results obtained. The article is summed up as follows:—

(1) The losses in the condensers are determined to a great extent by the viscosity and specific resistance of the electrolyte; (2) there is a temperature range, depending on the type of condenser, within which the temperature variation does not greatly affect the electrical properties of the condensers; and (3) an electrolyte of high viscosity is totally unsuitable for low temperatures. At the higher temperatures the only advantage of high viscosity is the reduction of the leakage current.

3142. ETCHED FOIL FOR ELECTROLYTIC CONDENSERS [giving Increased Anode Area].—Schnoll. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 30–31 and 48.)

3143. ALUMINIUM OXIDE—AN INSULATING MATERIAL FOR USE AT HIGH FREQUENCIES.—Bogoroditski & Katz. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 53–57.)

The chemical composition and the preparation of the material are discussed, and an account is given of electrical tests. The angle of loss at a frequency of 3×10^6 c/s was found to be of the order of 2 minutes, and the dielectric constant of the order of 12. In this connection the importance of correct baking of the material is emphasised. The effect of a temperature rise, up to 500° C and higher, on the angle of loss and specific resistance was investigated, and experimental curves are given. A table is also included showing the physical and mechanical properties of the material. It appears from this investigation that aluminium oxide is as suitable as quartz for operation at high frequencies and high temperatures, and has the additional advantage of being more adaptable for machining.

3144. TIME-CONSTANTS OF CONDENSERS.—Horst. (*Arch. f. Elektrot.*, 22nd April 1937, Vol. 31, No. 4, pp. 273–281.)

Measurements of the time constants of various condensers used in technical practice are given. Air condensers with time constants of the order of 10^7 sec. can be made if the drying process is sufficiently long, amber insulation is used, and the volume/capacity ratio is small. The physical causes of discharge are discussed.

3145. HIGH-FREQUENCY TIKOND CONDENSERS.—Bogoroditski. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1937, pp. 44–47.)

For previous work on this dielectric *see* 3914 of 1936. The present paper deals with an experimental investigation to determine the suitability of Tikond for r.f. fixed condensers for radio receivers. The manufacture of these condensers is described, and the results of tests are shown in a number of tables and curves. The following are the main points of interest with regard to Tikond:—(1) the temperature coefficient of capacity is equal to -6.8×10^{-4} per degree Centigrade; the characteristic curve of capacity passes through practically the same points whether it is plotted for rising or falling temperature; (2) the angle of loss, of the order of 5 min. at 25° C, increases only very slightly when the temperature rises to 100–120° C, but a considerable increase takes place at temperatures above 150–200° C; (3) the angle of loss increases with increase of the operating wavelength; and (4) humidity has little effect on the electrical properties of the material. The general conclusion reached is that in the majority of cases Tikond condensers may well replace mica condensers for use in radio receivers.

3146. THE DIELECTRIC CONSTANT AND DIPOLE LOSSES OF GLASSES AT HIGH FREQUENCIES.—Hackel. (*See* 3107.)

3147. Effect of the Humidity of the Air on the Critical Voltage of Porcelain and Pyrex Glass Insulators.—Alessandri. (*L'Elettrotec.*, 25th May 1937, Vol. 24, No. 10, pp. 301–305.)

3148. Moisture in Textiles [leading to a More Comprehensive Theory for the Conduction of Electrical Current through the Moisture Paths in a Textile].—Walker. (*Bell S. Tech. Journ.*, April 1937, Vol. 16, No. 2, pp. 228–246.)

3149. Discussion on "The Properties of a Dielectric containing Semiconducting Particles of Various Shapes" [Race's Conclusions as to Applicability of Maxwell-Wagner Theory].—Sillars: Race. (*Journ. I.E.E.*, June 1937, Vol. 80, No. 486, p. 609.) *See* 2363 of June.

3150. Remarks on the Paper "Thermionic Emission into Dielectric Liquids."—Reiss: Baker & Boltz. (*See* 2985.)

3151. Concerning an Anomaly in the Magnetostriction of Iron.—van Cakenberghe: Beauvais: Chevalier & Laporte. (*L'Onde Élec.*, May 1937, Vol. 16, No. 185, pp. 317–318.)

By expressing the anomaly found by Beauvais (1071 of March) in the form: "for certain values of magnetisation of a bar of iron, there occurs an inversion of the magnetostrictive effect produced by an alternating current of frequency equal to that of the mechanical oscillations of the bar," the phenomenon may be brought into relation with the other phenomenon, reported by Chevalier & Laporte (4227 of 1936 and 1227 of March), in the anomalous magnetisation of a small needle close to a wire carrying a condenser discharge. In both cases everything happens as if there were a relaxation time in the orientation of the elementary magnetic dipoles—a time which was a function of the intensity of the magnetisation. For oscillation periods shorter than this relaxation time the dipoles no longer "respond," and the magnetic condition of the bar is determined by the induced currents which are formed and which, by Lenz's law, produce a magnetic field in the sense opposed to that producing them. These currents die out very rapidly.

3152. Preparation of Iron Oxide as a Source of High-Purity Iron.—Cleaves & Thompson. (*Journ. of Res. of Nat. Bur. of Stds.*, May 1937, Vol. 18, No. 5, pp. 595–607.)

3153. Powder Patterns on Ferromagnetic Crystals [Effect of Surface Strains].—Sixtus. (*Phys. Review*, 15th May 1937, Series 2, Vol. 51, No. 10, pp. 870–877.)

3154. Magnetic Powder Experiments on Rolled Nickel Iron: II.—Snoek & Louwerse. (*Physica*, April 1937, Vol. 4, No. 4, pp. 257–266: in English.) Further development of the work referred to in 2410 of 1936.

3155. Nickel-Iron Alloys of High Permeability, with Special Reference to Mumetal [including Industrial Applications, *e.g.* to Shielding in Cathode-Ray Tubes].—Randall. (*Journ. I.E.E.*, June 1937, Vol. 80, No. 486, pp. 647–658: Discussion pp. 658–667.)

The very long Discussion includes a number of interesting points on widely different subjects, such as the possibility of interleaving with material of higher saturation (to combine quick response with greater power, in relay armatures), damage by over-magnetisation, use in a.f. transformers and chokes for broadcast and other receivers, etc. An American paper by Elmen (743 of 1936) is referred to.

3156. Magnetic Stability [including Tests on Two Very Different Nickel-Iron Alloys, of Initial Permeabilities 8000 and 80].—Goldschmidt. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 10, 1937, pp. 225–236: in German.)

The writer concludes: "Perhaps technical development will succeed in obtaining here also an improvement, so that we may arrive at highly permeable materials of the highest stability—technical single crystals."

3157. Abnormally High Magnetic Permeability of Nickel Wire obtained by Surface Treatment [Heating in Stream of Hydrogen, without and with Thin Copper Coating: Permeability measured periodically when Cold: Great Maximum Permeability with Copper Coating].—Wall. (*Nature*, 29th May 1937, Vol. 139, p. 928.)

3158. Study of Magnetic Losses at Low Flux Densities in Permalloy Sheet [Frequencies up to 10 kc/s].—Ellwood & Legg. (*Bell S. Tech. Journ.*, April 1937, Vol. 16, No. 2, pp. 212–227: *Journ of Applied Phys.* [formerly *Physics*], May 1937, Vol. 8, No. 5, pp. 351–358.)

3159. Nickel-Containing Magnets: Recent Developments in Production Technique and Industrial Application.—(*Electrician*, 21st May 1937, Vol. 118, pp. 671–672.)

Including their use in magnetron oscillators and loudspeakers (*see* 2990, above).

3160. A New Powerful Electro-Magnet with Low Energy Consumption [35 000 Oersted Field for 100 Watts: Very Low External Leakage Field].—Steubing. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 18, 1937, pp. 160–164.)

3161. A Small Electro-Magnet giving High Field Strength.—Lange. (*Physik. Zeitschr.*, 15th May 1937, Vol. 38, No. 10, pp. 384–386.)

3162. A New Type of Electro-Magnet ["Roll" Magnet in which Transformer-Iron Strip (with Insulating Varnish on One Side), coiled into Roll with Rod at Centre, forms Core and Winding].—Allison. (*Review Scient. Instr.*, May 1937, Vol. 8, No. 5, p. 172.)

The electrical resistance may be reduced if necessary by plating a thin coat of copper on the iron. The magnetism of such a magnet is strongest at the centre of the pole, diminishing steadily to the edge.

3163. TEMPERATURE-COMPENSATED COILS [Failure of Bimetallic Coil Plan owing to Expansion and Contraction of Mounting: Method using Bimetallic Short-Circuited Turn or Turns inside Ordinary Coil].—Int. Gen. Elec. Company. (German Pat. 635 458: *Funktech. Monatshefte*, May 1937, No. 5, p. 167.)

3164. A STUDY OF THE SINGLE-LAYER SOLENOIDS USED IN SHORT-WAVE CIRCUITS.—Seki. (*See* 2911.)

3165. RADIO RESISTOR MEASUREMENT.—Schwartz. (*See* 3098.)

3166. THE ROTATION NOISE OF REGULATING RESISTANCES.—Sachse. (*See* 2947.)

3167. A PRACTICAL APPARATUS FOR RADIO-TECHNICAL APPLICATIONS [Philips Calculating Disc].—(*Philips Transmitting News*, May 1937, Vol. 4, No. 2, pp. 17–18.)

3168. IMPROVED SCALE-OF-EIGHT RECORDING CIRCUITS.—Brammer & Ruark. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, p. 688: abstract only.)

STATIONS, DESIGN AND OPERATION

3169. THE ULTRA-HIGH-FREQUENCY DOMAIN [and Its Utilisation for Educational Broadcasting: Claims of Television, Facsimile, etc.] *and* PRACTICAL LIMITATIONS OF THE BROADCAST ALLOCATION STRUCTURE.—Goldsmith: Jolliffe. (*Elec. Engineering*, June 1937, Vol. 56, No. 6, pp. 662–666: pp. 666–670.)

3170. RADIOELECTRIC CONTROL EQUIPMENT FOR COASTAL FOG SIGNALS [using 90 cm Micro-Waves from Two M. 406 Magnetrons in Parallel, received on Special Duo-Diode].—Michel. (*Bull. de la S.F.R.*, No. 2, 10th Year, 2nd Quarter 1936, pp. 31–41.) In French and English concurrently.

3171. THE U.R.S.I. PROGRAMMES OF SHORT-WAVE STATION W1XAL [Boston].—Kennelly. (*Science*, 30th April 1937, Vol. 85, pp. 419–421.) Including an outline of "Basic English" and the desirability of its use in such programmes.

3172. WWV [National Bureau of Standards Station, Beltsville, near Washington] SERVICES AGAIN EXPANDED: STANDARD TIME INTERVAL, MUSICAL PITCH, AND IONOSPHERE BULLETINS ADDED.—(*QST*, June 1937, Vol. 21, No. 6, pp. 10 and 82, 84, 86.)

3173. THE AMERICAN RADIOTELEPHONIC INSTALLATIONS [of the France/U.S.A. Short-Wave Beam Service].—Magal. (*Ann. des Postes, T. et T.*, May 1937, Vol. 26, No. 5, pp. 385–422.)

3174. THE CUNARD WHITE STAR R.M.S. "QUEEN MARY" RADIO INSTALLATION.—Loring, McPherson, & McAllister. (*Elec. Communication*, April 1937, Vol. 15, No. 4, pp. 331–353.) Extracted from the I.E.E. paper referred to in 2424 of June.

3175. RADIO EQUIPMENT ON NEW TRANSPORTS ["Mainliners" of United Air Lines].—(*Comm. & Broadcast Eng.*, May 1937. Vol. 4, No. 5, pp. 13 and 19.)

3176. A FREQUENCY SYNCHRONISING SYSTEM FOR SMALL BROADCASTING STATIONS [Common Wave Stations controlled by Master Station (with Independent Programme) of Different Frequency in Certain Relation to Common-Wave Frequency].—Kayano. (*Rep. of Rad. Res. in Japan*, Dec. 1936, Vol. 6, No. 3, Abstracts pp. 27–28.)

3177. TWO-KILOWATT BROADCASTERS IN BULGARIA [Varna and Stara Zagora].—Gantcheff & Czeglédy. (*Elec. Communication*, April 1937, Vol. 15, No. 4, pp. 308–311.)

3178. GRID CONTROL OF RADIO RECTIFIERS [Mercury-Arc Rectifiers for Radio Transmitters: Grid Control for Automatic Starting at Reduced Voltage, Automatic Voltage Regulation, and High-Speed Electronic Protection].—Durand & Keller. (*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 570–582.)

3179. THE NEW RECEIVING CENTRE OF THE RADIO-ORIENT SOCIETY AT RAZ BEYROUTH, LEBANON.—(*Bull. de la S.F.R.*, No. 1, 11th Year, 1st Quarter 1937, pp. 29–32.)

3180. A COMPLETE DRY-BATTERY PORTABLE STATION WITH CRYSTAL-CONTROLLED TRANSMITTER [particularly for Emergencies], *and* A BATTERY-OPERATED EMERGENCY RIG OF PROVED PERFORMANCE.—Van Deusen: Jacobs. (*QST*, June 1937, Vol. 21, No. 6, pp. 11–13 and 86, 88: pp. 14–15.)

GENERAL PHYSICAL ARTICLES

3181. ON THE CHOICE OF THE ACTION FUNCTION IN THE NEW FIELD THEORY [Theory leading to Identification of Gravitational with Electromagnetic Mass].—Hoffmann & Infeld. (*Phys. Review*, 1st May 1937, Series 2, Vol. 51, No. 9, pp. 765–773.)

3182. A NEW PRECISION DETERMINATION OF e/m FOR ELECTRONS.—Shaw. (*Phys. Review*, 15th May 1937, Series 2, Vol. 51, No. 10, p. 887.)

3183. THE MASS OF THE ELECTRON AT REST.—Laboccetta. (*La Ricerca Scient.*, No. 5/6, Vol. 1, Series 2, 8th Year, 1937, pp. 228–229.)

3184. THE ELEMENTARY EXPRESSION FOR THE ENERGY AFFECTING A MAGNETIC PARTICLE OF VERY SMALL DIMENSIONS IN A MAGNETISING FIELD.—Guilbert. (*Comptes Rendus*, 19th May 1937, Vol. 204, No. 20, pp. 1463–1465.)

The theoretical expression here deduced from first principles groups together the energy in the particle itself and that in the surrounding space due to the influence of the particle; in using the expression, the particle may be regarded as an element of volume of a homogeneous medium of indefinite extent, and its effect on surrounding space is automatically taken into account.

3185. Remarks on the Variation, with Field Strength, of the Dielectric Constant and Kerr Effect [Correct Formula for Calculation of Dipole Moment: Incorrect Approximation used by Born].—Bouwkamp & Nijboer. (*Physica*, May 1937, Vol 4, No. 5, pp. 379–388: in German.)

3186. On the Relative Probability of Excitation of the Three L-Levels of Tungsten as a Function of the Velocity of the Cathode Rays.—Huizinga. (*Physica*, April 1937, Vol. 4, No. 4, pp. 317–324: in English.)

MISCELLANEOUS

3187. On the Connection Formulas and the Solutions of the [One-Dimensional] Wave Equation [Asymptotic Solutions: Critical Discussion of Wentzel-Kramers-Brillouin Analysis].—Langer. (*Phys. Review*, 15th April 1937, Series 2, Vol. 51, No. 8, pp. 669–676.)

3188. Studies in Practical Mathematics: I—The Evaluation, with Applications, of a Certain Triple Product Matrix.—Aitken. (*Proc. Roy. Soc. Edinburgh*, Part 2, Vol. 57, 1937, pp. 172–181.)

3189. Modifications of Tschebyscheff's Quadrature Formula.—Bernstein. (*Comptes Rendus*, 24th May 1937, Vol. 204, No. 21, pp. 1526–1529.)

3190. Heaviside Calculus and Carson's Integral.—Nerken. (*Elec. Engineering*, June 1937, Vol. 56, No. 6, pp. 768–769.)

3191. Approximate Values of the Potential and Current induced in the *n* Parallel Lines [Method of obtaining Approximate Roots of a System of *n* Linear Equations].—Ogawa. (*Electrotechnical Journal*, Japan, June 1937, Vol. 1, No. 1, pp. 23–25: in English.) This journal replaces the "Abstract Section" of the *Journ. I.E.E. Japan*.

3192. A Mechanical Device for the Rapid Tracing of Linear Functions and the Derivation of Their Real Roots.—Poggi. (*La Ricerca Scient.*, No. 7/8, Vol. 1, Series 2, 8th Year, 1937, pp. 300–303.)

3193. A Method for the Integration of Homogeneous Differential Equations.—Piesch. (*See* 2910.)

3194. On the Approximate Solution of Common Differential Equations.—Blaess. (*Zeitschr. V.D.I.*, 22nd May 1937, Vol. 81, No. 21, pp. 587–596.)

3195. The Median as a Statistic.—Savur. (*Current Science*, Bangalore, Feb. 1937, Vol. 5, No. 8, pp. 419–421.)

3196. On the Significant Figures of Least Square and Correlations, *and* On the Use of the Method of Least Squares for estimating Linear Distortion.—Deming: Kharkevich. (*Science*, 7th May 1937, Vol. 85, pp. 451–454.) Deming's letter is prompted by that of Moulton (2018 of May). For Kharkevich's paper *see* 2909, above.

3197. D.C. Amplifier for measuring Potentials in Living Organisms [Modified Wynn-Williams Microvoltmeter].—Lane. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 31–32.) Used in Yale School of Medicine: has led to detection of cancer in mice before its gross appearance, and other new results.

3198. Biological Effects of Atmospheric Electricity and Artificial Ionisation [Summary of Contents of Book by A. Schmid, Bern-Leipzig, 1936].—Kähler. (*Naturwiss.*, 5th & 12th Feb. 1936, Vol. 25, Nos. 6 & 7, pp. 92–96 and 110–112.)

3199. Individualism in Research [Misapprehension of Certain Aspects of Industrial Research, by Medical Research Worker: Major Problems rarely Concrete: Secretiveness reduced to Minimum: Advantages of Division of Labour and Collaboration: etc.].—Jewett. (*Bell Lab. Record*, June 1937, Vol. 15, No. 10, pp. 333–334.)

3200. Inaugural Address [Development of Communication Industry in Japan during Last 20 Years: Investment of Government: Future Progress: etc.].—Nakayama. (*Nippon Elec. Comm. Eng.*, March 1937, No. 5, pp. 3–14.) By the new President of the Institute of Communication Engineers of Japan.

3201. Silver Anniversary Convention of the IRE: Summaries of Technical Papers, *and* Story of the Development of the IRE.—(*Proc. Inst. Rad. Eng.*, May 1937, Vol. 25, No. 5, pp. 537–548: *Electronics*, May 1937, Vol. 10, No. 5, pp. 15–21.)

3202. Multilingual Dictionary on the "One Language" System [Each Language has One Volume, in Two Parts: First Part gives Terms in Alphabetical Order, each with a Number, Second Part gives Numbers in Order, with Corresponding Terms].—(*E.T.Z.*, 17th June 1937, Vol. 58, No. 24, p. 680: Book Review.)

3203. "VDE-Fachberichte 1936" (Book Review].—(*E.T.Z.*, 27th May 1937, Vol. 58, No. 21, p. 588.)

3204. "Radioeléctricité Générale" [Vol. II, 2nd Section: Book Review].—Mesny. (*L'Onde Élec.*, May 1937, Vol. 16, No. 185, pp. 329–330.)

3205. "Les Ondes Hertziennes et la Structure Moléculaire: I—Méthode d'Étude du Spectre Hertzien: II—Absorption et Dispersion dans le Spectre Hertzien" [Book Review].—Freymann. (*Current Science*, Bangalore, March 1937, Vol. 5, No. 9, pp. 490–491.)

3206. "International Broadcast and Sound Engineer—1937 Yearbook" [Book Review].—Bernaert (Edited by). (*Electronics*, June 1937, Vol. 10, No. 6, p. 36.)

3207. THE PARIS SHOWS: "SALON DE LA T.S.F." AND THE "FOIRE DE PARIS."—Aisberg. (*Wireless World*, 4th June 1937, Vol. 40, pp. 528–530.)

3208. NIKOLA TESLA'S 80TH BIRTHDAY.—(*Bull. de la S.F.R.*, No. 2, 10th Year, 2nd Quarter 1936, pp. 43–50.) In French and English concurrently.

3209. PHOTOELECTRIC SPECTROPHOTOMETRY [Apparatus, and Application to Chemical Problems].—Hogness & others. (*Journ. Phys. Chemistry*, March 1937, Vol. 41, No. 3, pp. 379–415.)

3210. PHYSICAL METHODS IN CHEMICAL LABORATORIES: XXXIV—PHOTOELECTRIC SPECTROPHOTOMETRY.—Kortüm. (*Angewandte Chemie*, 6th March 1937, Vol. 50, pp. 193–204.)

3211. PHOTOELECTRIC GUIDING OF ASTRONOMICAL TELESCOPES.—Whitford & Kron. (*Review Scient. Instr.*, March 1937, Vol. 8, No. 3, pp. 78–82.) *See* also 832 of February.

3212. THE FLASH TIME CHARACTERISTICS OF INDIRECTLY IGNITED PHOTOGRAPHIC FLASH LAMPS [measured by Photocell and Cathode-Ray Oscillograph].—van Liempt & de Vriend. (*Physica*, May 1937, Vol. 4, No. 5, pp. 353–360: in English.)

3213. A PHOTOCONDUCTIVE PHOTOMETER—A NEW METHOD AND APPARATUS FOR THE QUANTITATIVE ESTIMATION OF CHLOROPHYLL.—Singh & Rao. (*Current Science*, Bangalore, Feb. 1937, Vol. 5, No. 8, pp. 416–418.)

3214. PHOTOCELLS IN WEFT-STRAIGHTENING CONTROL OF COTTON CLOTH FINISHING, *and* "CROSS-BEAM" REFLECTOMETER FOR SURFACE COMPARISONS [*e.g.* Hiding Power of Paints].—(*Electronics*, June 1937, Vol. 10, No. 6, p. 30: pp. 30–31.) On the first subject see also *Gen. Elec. Review*, June 1937, p. 305.

3215. AN ELECTRONIC PROBLEM IN FLUE-GAS CONTROL [Success of Installation detecting Density Changes within 5%: Extension required, involving Beam Passage through 40 ft of Rapidly Moving Gases: Solutions invited].—Wilder. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 42–43.)

3216. TWO APPLICATIONS OF THE IGNITRON [Half-Cycle Current for magnetising Permanent Magnets and for Welding].—Watanabe & Kasahara. (*Electrotechnical Journal*, Japan, July 1937, Vol. 1, No. 2, pp. 61–64.)

3217. THYRATRON CONTROL EQUIPMENT FOR RESISTANCE WELDING.—Palmer. (*Gen. Elec. Review*, May 1937, Vol. 40, No. 5, pp. 229–235.)

3218. THE HEYMANN-REUTLINGER ELECTROMAGNETIC VIBROGRAPH. — (*Engineering*, 23rd April 1937, Vol. 143, p. 463.)

3219. VIBRATION-MEASURING INSTRUMENTS: FUNDAMENTAL CONSIDERATIONS IN THEIR DESIGN.—Greentree. (*Elec. Engineering*, June 1937, Vol. 56, No. 6, pp. 706–710.)

3220. TO KEEP ELECTRONIC DEVICES OPERATING.—Jenks. (*Electronics*, May 1937, Vol. 10 No. 5, p. 68: summary only.)

3221. ON THE COMPENSATING METHOD OF TELEMETERING [with Photocell Transmitter].—Garkusha & Kornilov. (*Izvestiya Elektroprom. Slab. Toka*, No. 1, 1937, pp. 23–28.)

3222. THE TRANSMISSION OF TWO DIFFERENT READINGS OVER A SINGLE HIGH-FREQUENCY CHANNEL [Frequency-Impulse Method].—Evdokimov. (*Automatics & Telemechanics* [in Russian], No. 5, 1936, pp. 13–21.)

3223. COMPARISON BETWEEN TELEMETERING SYSTEMS FOR D.C. AND A.C.—Dallmann. (*E.T.Z.*, 22nd April 1937, Vol. 58, No. 16, pp. 423–424.)

3224. THE ADAPTATION OF HIGH-TENSION LINES TO THE PROPAGATION OF HIGH-FREQUENCY CURRENTS [for Carrier Telephony, Remote Control, or Telemetering].—Bossa. (*Alta Frequenza*, June 1937, Vol. 6, No. 6, pp. 365–379.)

Author's summary:—The high frequency-current transmission characteristics of a high-tension line are examined when the latter presents (i) a branching-off point, (ii) a cable section between sections of overhead lines, and (iii) a sectionalising point; the circuits adopted for making the high-tension line more suitable for high-frequency transmission are described. As regards the "block" and "bridge" circuits generally employed, certain improvements are suggested which should make them more efficient, especially for telephonic transmission. Some experimental results are given.

3225. TRAFFIC CONTROL: LIGHT-RAY SIGNALLING SYSTEM INSTALLED AT LIVERPOOL.—(*Electrician*, 21st May 1937, Vol. 118, p. 689.)

3226. INFRA-RED PHOTO-ALARM PROTECTS 13 000 SQ. FT. [only One 32 CP Lamp Used].—Signaphone Corporation. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 43 and 52, 54.)

3227. ELECTRONIC DEVICE FOR PHOTOGRAPHY [times and controls Printing Exposures, measures Negative Densities and Shutter Speeds: etc.].—Fink. (*Electronics*, June 1937, Vol. 10, No. 6, pp. 22–25.)

3228. USE OF BARRIER-LAYER PHOTOELEMENTS FOR RADIOACTIVITY MEASUREMENTS.—Bonét-Maury. (*Comptes Rendus*, 31st May 1937 Vol. 204, No. 22, pp. 1641–1643.)

3229. THE DOUBLE PHOTOELECTRIC RECORDER [for Simultaneous Recordings of Electrical or Mechanical Quantities: Power Consumption 0.001 Microwatt].—Carson. (*Gen. Elec. Review*, May 1937, Vol. 40, No. 5, p. 228.) Developed from the recorder referred to in 1933 Abstracts, p. 581 (La Pierre).

3230. AN ELECTRONIC PAINT-THICKNESS GAUGE [on Penetration Principle].—Powers. (*Electronics*, May 1937, Vol. 10, No. 5, pp. 54 and 58.)

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

462 459.—Portable wireless equipment comprising a loop aerial formed of tapering hollow conductors.

L. L-K. Honeyball. Application date 4th June, 1935.

462 571.—Screened down-lead from a single aerial adapted to receive both medium and short wave signals.

K. C. Bridges. Application date 14th January, 1936.

464 769.—"Roll-up" wireless aerial for aeroplanes.

K. Schuchter. Convention date (Austria) 12th September, 1935.

RECEPTION CIRCUITS AND APPARATUS

460 787.—Variable selectivity and fidelity control in a wireless receiver.

E. K. Cole and A. E. Falkus. Application date 14th September, 1935.

460 821.—Variable selectivity control, allowing the response curve to be widened symmetrically with relation to the carrier wave, or unsymmetrically so as to favour the upper or lower sidebands.

Hazeltine Corporation (assignees of J. F. Farrington). Convention date (U.S.A.) 7th May, 1935.

460 915.—A.V.C. system in which the output volume is automatically decreased as the band-width of the signal input is increased.

W. S. Percival. Application date 7th August, 1935.

461 089.—Variable-selectivity couplings for the amplifier stages of a wireless receiver.

E. K. Cole; G. Bradfield; and F. A. Inskip. Application date 18th September, 1935.

461 256.—Transformer coupling with movable iron core for automatically controlling selectivity in accordance with signal strength.

Ferranti and E. G. O. Anderson. Application date 13th August, 1935.

461 443.—Automatic tuning arrangement for a wireless receiver with means for preventing "drift" in the tuned circuits.

E. K. Cole and G. Bradfield. Application date 3rd October, 1935.

461 448.—Automatic tuning arrangement in which the "difference" current which corrects the tuning also controls the lighting of a station-indicator lamp.

E. K. Cole and A. W. Martin. Application date 29th October 1935.

461 910.—Automatic switching means for varying the selectivity of a set in accordance with signal strength.

E. K. Cole and H. Hunt. Application date 24th *September* 1935.

461 966.—Muting circuit for automatically cutting-out all signals below a predetermined level of strength.

British Tungsram Radio Works and J. H. Reyner. Application date 22nd August, 1935.

462 323.—Receiver in which the automatic volume control is varied from one setting to another of the wave-change switch so as to preserve uniformity on all wavelengths.

Marconi's W. T. Co. (assignees of L. R. Kirkwood). Convention date (U.S.A.) 29th September, 1934.

462 455.—Wireless receiver provided with self-monitoring means which give a warning signal on the breakdown or improper functioning of any component.

A. H. Stevens (communicated by Wallace and Tiernan Products Inc.). Application date, 4th June, 1935.

462 475.—Semi-automatic control for ensuring the accurate tuning of a wireless set.

E. K. Cole and G. Bradfield. Application date 7th October, 1935.

463 202.—High-frequency coupling designed to give an adjustable band-pass effect.

Johnson Laboratories Inc. (assignees of A. Crossley and H. E. Meinema.) Convention date (U.S.A.) 10th August, 1935.

464 157.—Rejector circuit for eliminating heterodyne whistle in a wireless receiver.

E. K. Cole; G. Bradfield; and A. E. Falkus. Application date 14th December, 1935.

VALVES AND THERMIONICS

460 623—Oscillation generators of the kind in which interaction occurs between the electron streams from two electrode systems in the same bulb.

Standard Telephones and Cables (assignees of A. L. Samuel). Convention date (U.S.A.) 25th July, 1935.

463 514.—Electron-multiplier or "multifactor" of the kind in which an electron stream is caused to oscillate between electrodes of opposite voltage and to produce secondary emission at each impact.

Farnsworth Television Inc. Convention date (U.S.A.) 7th May, 1935.

DIRECTIONAL WIRELESS

462 015.—Indicating equipment for spaced direction-finding aerials of the Adcock type.

Marconi's W. T. Co. and S. B. Smith. Application date 31st August, 1935.

464 740.—Directional navigation system in which the effect of side wind on an aeroplane in flight is automatically compensated.

Telefunken Co. Convention date (Germany) 29th August, 1935.

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

463 493.—Resistance - capacity - coupled low - frequency amplifier with means for introducing a 90° or 270° phase-change at one of the stages.

J. Massolle G.M.B.H. and J. Massolle. Convention date (Germany) 3rd December, 1934.

464 231.—Push-pull amplifier designed to give an increased output free from harmonic distortion.

Standard Telephones and Cables (assignees of V. M. Cousins). Convention date (U.S.A.) 1st May, 1935.

TELEVISION AND PHOTOTELEGRAPHY

460 709.—Method of deriving the synchronising impulses in a simple manner from the scanning apparatus at the transmitter.

Radio-Akt. D. S. Loewe. Convention date (Germany) 4th and 11th August, 1934.

460 741.—High-definition scanning system utilising only a narrow frequency-band.

E. Michaelis. Convention date (Germany) 21st February, 1935.

461 105.—Scanning arrangement for a cathode-ray tube having a mosaic cell electrode set at an inclination to the electron stream.

C. Lorenz Akt. Convention date (Germany) 23rd May, 1935.

461 128.—Mechanical scanning system in which a single mirror is vibrated simultaneously in two directions.

W. H. Priess. Convention date (U.S.A.) 11th May, 1934.

461 312.—Method of making two-dimensional mosaic electrodes for television and like transmitters.

V. A. Jones and Baird Television. Application date, 14th August, 1935.

461 374.—Means for safeguarding the cathode-ray tube of a television receiver against "implosion."

The General Electric Co. and L. C. Jesty. Application date 5th December, 1935.

461 629.—Increasing the modulation sensitivity of cathode-ray television receivers.

A. C. Cossor and W. H. Stevens. Application date 19th August, 1935.

461 907.—Guard ring for the edges of the deflecting electrodes in a cathode-ray television receiver.

Marconi's W. T. Co. and A. J. Young. Application date 31st August, 1935.

461 909.—Smoothing condenser arrangement for the high-tension supply to a cathode-ray tube.

C. Szegho; W. P. Anderson and Baird Television. Application date 29th August, 1935.

462 243.—Cathode-ray tube provided with means for rotating the cathode relatively to the other electrodes.

H. P. Barasch. Application date 2nd September, 1935.

462 247.—Amplifying circuit having a gain characteristic which is complementary to the modulation characteristic of a cathode-ray television receiver, in order to obviate distortion.

A. J. Brown and Baird Television. Application date 4th September, 1935.

462 275.—Cathode-ray tube in which the deflecting electrodes are bridged by a highly resistant layer which encloses the sides parallel to the electron steam.

M. von Ardenne. Convention date (Germany) 28th August, 1935.

462 330.—Television system of the kind in which the received picture is reproduced on a chequer-board of light sources.

Marconi's W. T. Co. and R. J. Kemp. Application date 7th September, 1935.

462 536.—Amplifier for handling a wide range of frequencies including the so-called "zero" frequency in television.

E. L. C. White. Application date 7th September, 1935.

462 600.—Cathode-ray tube constructed so as to reduce the risk of "implosion" or collapse due to external pressure.

British Thomson-Houston Co.; H. W. H. Warren; and W. J. Scott. Application date 11th September, 1935.

463 625.—Back-coupled valve with at least two grids arranged to generate saw-toothed oscillations suitable for television scanning.

Marconi's W. T. Co. and G. B. Banks. Application date 2nd August, 1935.

464 105.—Method of coating the electrodes say of a cathode-ray tube in such a way that they do not reflect light on to the fluorescent screen.

S. T. Henderson. Application date 9th October, 1935.

464 141.—Generating scanning impulses with a short "flyback" period by using a back-coupled screen-grid or pentode valve.

Ferranti and J. C. Wilson. Application date 29th October, 1935.

464 692.—Television transmitter of the Iconoscope type in which the conversion ratio of the intensity of illumination to the picture signal is maintained constant throughout.

I. Shoenberg. Application date 22nd October, 1935.

SUBSIDIARY APPARATUS AND MATERIALS

462 970.—Interference suppressor, designed to be housed in a casing connected in the leads from the source of disturbance.

Hydrawerk Akt. Convention date (Germany) 14th June, 1934.

463 348.—Construction of high-frequency coils fitted with powdered-iron cores.

Siemens and Halske Akt. Convention date (Germany) 18th March, 1935.

463 410.—Mains-supply unit for a wireless receiver adapted for use with either a D.C. or A.C. supply at different voltages.

The British Thomson-Houston Co. Convention date (Belgium) 25th August, 1934.

463 478.—Rectifying units or assemblies of the dry-contact type with spot-welded connections.

Westinghouse Brake and Signal Co. (assignees of Cie des Freins Westinghouse). Convention date (France) 3rd July, 1935.

463 649.—Microphone with a curved diaphragm adapted to receive sounds over a wider angle than usual.

The British Thomson-Houston Co. and L. B. Ault. Application date 3rd October, 1935.