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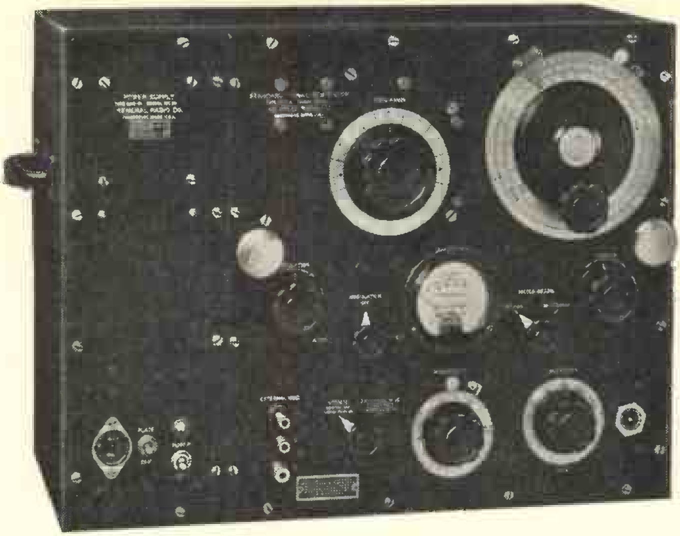

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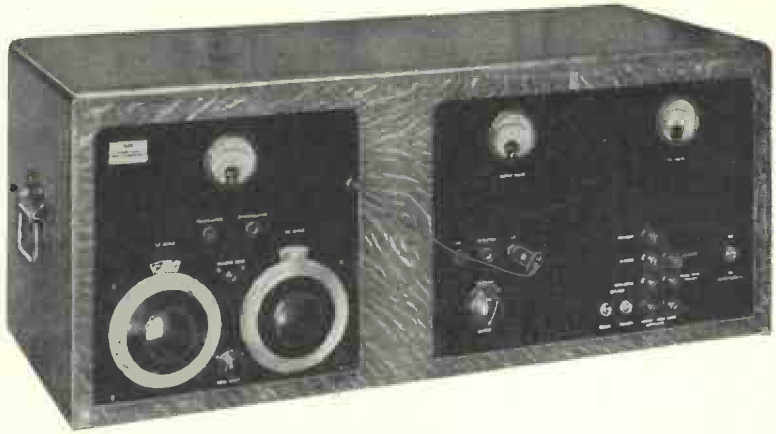

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The

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THE
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Editorial

The Magnetron

THE technical journals of the last few months bear witness to the great amount of research work, both theoretical and experimental, which is being devoted to the magnetron. To the mathematical physicist the split-anode magnetron offers problems enough in the calculation of electron paths and of the mechanism of oscillation and energy conversion. The experimenter will find an ample field in the development of magnetrons capable of producing on a commercial scale several hundred watts at a wave-length of a few centimetres, that is, at frequencies of 1,000 to 2,000 megacycles per second.

In the earliest magnetron oscillators (Hull and Elder 1924) the magnetic field was used in lieu of a grid, a varying field producing a varying anode current. The first to produce oscillations with a constant magnetic field was probably Žaček, but nearly all the subsequent development has followed the introduction by Habann in 1924 of the split-anode magnetron and its connection in a push-pull circuit by Manns in 1927. In a recent number of *Nature*[1], however, F. B. Pidduck gives a preliminary outline of a theoretical investigation of the single anode magnetron.

Much of the earlier lack of agreement as to the characteristics of the magnetron has now been cleared up by the discovery that it can function in at least two very different ways, one mode of operation occurring with longer waves and the other with shorter waves, with an intermediate region in which the action is probably a combination of both. The first type of oscillation is usually referred to as dynatron or circuit-frequency oscillations because the frequency depends on the constants of the oscillatory circuit, and the oscillation is maintained by the negative resistance characteristic of the magnetron. The second type, in which the frequency depends on the orbital periods of the electrons within the valve, is referred to as electron or transit-time oscillations.

A paper describing the general theory and the results of a number of experiments made at Oxford University was recently published by E. W. B. Gill and K. G. Britton[2]. An interesting account of the development of water-cooled split-anode magnetrons at the University of Jena has just been published by Pfetscher and Puhlmann[3]. Attempts to obtain greater outputs are generally limited by the temperature rise of the anode. The heating is often very local and the edges of the slits suffer severely, sometimes being melted although the anodes are made of

[1] *Nature*, June 6th, 1936, p. 945.

[2] *Jour. I.E.E.*, Vol. 78, p. 461, April, 1936.

[3] *Hochfrequenztechnik und Elektroakustic* 47, p. 105, April, 1936.

tantalum or molybdenum. To avoid this, cooling wings may be fitted to the edges, and in this way an output of 130 watts at a wavelength of 80 cm. has been obtained. These wings can also serve as the plates of air condensers to provide capacitive coupling between the split anode and the external circuit. For still higher powers water cooling must be employed, and the difficulty of doing this without introducing large losses of the high frequency energy can be overcome by making the oscillatory circuit serve as the cooling system. Instead of using sheet metal for the anode, massive copper blocks are employed, the cylindrical space being drilled out as shown in the Figures. For wavelengths of 100 metres or more two entirely separate copper blocks are employed (Fig. 1*a*), each sealed to the glass *G* by the thin foil *E*. The water passes up the inner tubes and away through the surrounding outer tubes. These copper tubes constitute the circuit, the length of which can be adjusted by an external bridge piece (Fig. 2*a*). For shorter wave lengths the whole oscillatory circuit must be contained within the valve which must be constructed for a fixed wave length. Such a valve is shown in Fig. 1*b*. The copper piece *S* constitutes the oscillatory circuit fed at its centre point by means of the outer water cooling pipe *K*. Fig. 2*b* shows two such valves for wavelengths of 19 and 46 cm. respectively.

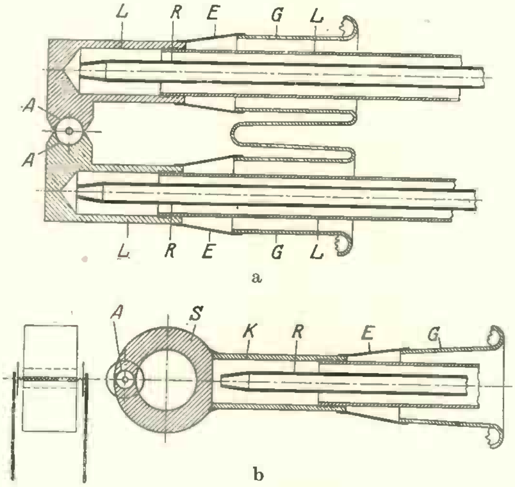


Fig. 1.—*Electrodes of water-cooled magnetrons.*

The coupling with the external load is made capacitively by means of plates near the split-anode ; these plates can be plainly seen in the photographs, and the connections to the load are those at the top of the photographs. The filaments are arranged as cylindrical spirals in order to get the necessary emission. The following table gives the data of these three valves.

A troublesome phenomenon referred to by several authors is the heating of the filament due to electronic bombardment which may be sufficient to enable the valve to continue to function without any other supply of power to the filament. Megaw (see later) protects the filament from bombardment by means of a grid. The effect of filament bombardment may act cumulatively and produce an unstable rise of filament temperature to a destructive value. It necessitates not only careful design but careful operation.

In the same number of *Hochfrequenztechnik*[4] H. G. Möller, the author of one of the leading German text books on electron valves, has a mathematical paper on the calculation of the electron paths in magnetrons. As he rightly remarks, one cannot obtain a clear idea of the mechanism of the magnetron until one knows the paths followed by the electrons under the varying conditions.

The same subject was recently investigated

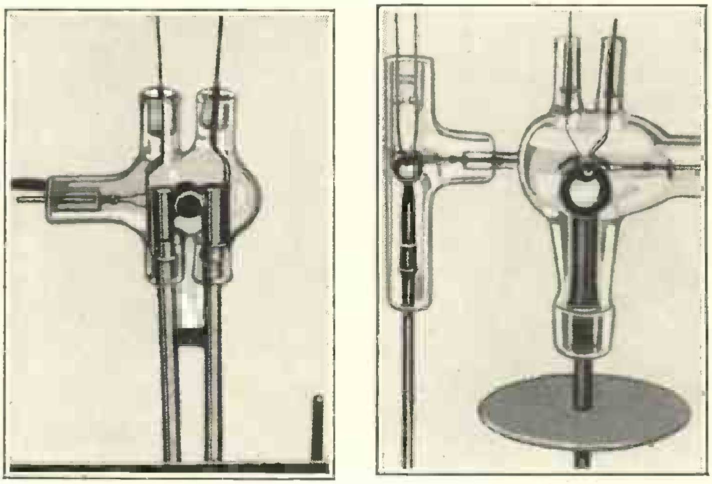
[4] Vol. 47, p. 115, April, 1936.

Valve.	Anode		Filament watts.	λ cm.	V_a volts.	I_a mA.	H	Output. watts.	Efficiency	
	diam. mm.	length mm.							η_1	η_2
A	10	17	140	100	3,600	430	1,400	850	55	50
B	6	20	100	46	3,700	300	2,050	450	40	37
C	4	15	50	19	2,200	180	3,200	80	20	18

Note.—η_1 is excluding and η_2 including filament watts. The field excitation losses are not included.

very thoroughly by F. Müller of Leningrad[5], in two papers, the first dealing with the longer-wave or circuit oscillations, i.e., those whose frequency is dependent upon the circuit constants, and the second with the short-wave or electron oscillations. In both these papers the author seeks to calculate the paths of the electrons under various conditions, including the inclination of the magnetic field to the axis of the magnetron.

In the current number of the *Telefunken Zeitung*[6], K. Fritz discusses the results obtained by Müller and gives a general explanation of the way in which the electrons are enabled to abstract energy from the field and give it out in the form of oscillations.



(a) (b)

Fig. 2.—*Water-cooled magnetrons.* (*a*) $\lambda = 1$ *to* 4 *metres;* (*b*) *left,* $\lambda = 19$ *cm,* *right,* $\lambda = 46$ *cm.*

A paper by Groszkowski and Ryzko[7] describes a type of magnetron in which an ordinary spiral grid surrounds the filament. This is used for modulating the oscillator in the manner commonly employed with triode oscillators, and experiments show a linear relationship between the grid voltage and the oscillatory current, thus permitting a deep and distortionless modulation. Attempts to modulate the magnetron by varying the anode voltage whilst keeping the magnetic field constant, or vice versa, have not proved very satisfactory on account of the critical relation between the two and the anode diameter upon which the oscillation of the magnetron depends. The authors even tried a conical anode in the hope that the oscillation would occur at the optimum value of the diameter for the momentary values of the anode voltage and magnetic field, but it was a vain hope. It would appear from their experiments that good linear modulation would be possible by simultaneously varying both anode voltage and magnetic field so that their ratio was always of the optimum value for the given valve, but this would be a very complicated method if indeed it could be accomplished. The authors therefore tried the grid magnetron and found that it gave excellent results. The grid voltages were varied between 0 and −100, and gave a linear decrease of the oscillatory current over a wide range, due, of course, to the decreased emission. The grid currents varied between 0 and 1.5 milliamperes. The experiments were made at a wavelength of 1.8 metres ($f = 167 \times 10^6$).

The modulating problem is also discussed by E. C. S. Megaw[8], in a very interesting review of the development of the magnetron.

He also advocates the use of a grid, but the type of grid employed consists of two wires running parallel with the filament, one on each side of it. When not employed for modulating, this grid is connected to the filament and serves to protect it from electronic bombardment.

Megaw discusses a matter on which the Russian authors admit they have not made any observations, viz., the effect of the modulation on the frequency. Megaw says that the variation may be as much as 2 per cent., but that it can be reduced by using an oscillatory circuit of high capacitance, or by simultaneous modulation of the

[5] *Elek. Nachrichten Technik*, pp. 131, 183, May, June, 1935.
[6] *Telefunken Zeitung*. March, 1936, p. 31.
[7] *Proc. I.R.E.*, May, 1936, p. 771.
[8] *G.E.C. Journal, VII*, p. 94, May, 1936.

Valve.	Anode diam.	Filament.	λ metres.	V_a	H	Output watts.
E465	2 cm.	5.5 V, 6.5 A	2—8	2,000	400—1000	150
CW11	1 cm.	3.7 V, 3.8 A	1—5	1,200	500—1,500	50
E639	1 cm.	3.7 V, 3.8 A	0.5—5	1,000—1,500	500—1,500	20—50

grid and anode voltages as already mentioned. This refers to wavelengths between 1 and 3 metres; for shorter waves employing electronic oscillations, Megaw says that good linearity up to 50 per cent. can be obtained by anode voltage modulation with 0.5 per cent. frequency variation; he also suggests employing frequency modulation with a constant amplitude as the possible best solution.

The General Electric Co. now produces commercially several types of magnetron valves suitable for different frequencies and outputs. They also have standardised suitable electromagnetic and permanent magnet systems for use with the valves.

The table above gives particulars of three types of magnetron manufactured by the General Electric Co. and described by Megaw.

"Feelers" for Ships

New Micro-Wave Equipment

THE accompanying photographs indicate the nature of a micro-wave beam equipment which has been installed by the Société Francaise Radioelectrique on the s.s. *Normandie* as an aid to navigation.

A beam transmitter operating on a wavelength of 16 centimetres transmits a modulated signal which, if it encounters an object in its path, is reflected at an angle and can be picked up by a similarly tuned receiver located at a short distance from the transmitter. The angle of the transmitter in relation to the receiver when tuned to maximum signals enables the distance and direction of the obstacle to be collected.

The Diode as Half-Wave, Full-Wave and Voltage-Doubling Rectifier*

With Special Reference to the Voltage Output and Current Input

By N. H. Roberts

(Lecturer at the University of Capetown)

INTRODUCTION.—Recently, in the course of the design of a Cathode Ray Tube equipment, the author discovered the lack of practical data relating to the construction of a diode rectifier which is to supply a low current to a high resistance load. Figures of the voltage output, the current input and the requisite reservoir capacity would have been of great use.

Before tests were conducted, the problem was investigated theoretically. The theory of the diode rectifier has been extended to the case of the voltage-doubling rectifier, and, while some of the expressions for the half- and full-wave rectifiers have previously been published in one form or another by various authors, they are here repeated for the sake of completeness. It is assumed that the rectifying diode characteristic is linear during the passage of current, and usually that the curve passes through the origin. If there exists in the diode what we may call a " back voltage " (analogous to a contact E.M.F.), the portion of the curve which is operative during the passage of current does not pass through the origin, even if produced. Formulae have been developed for the half- and full-wave cases, when this condition is applied. The capacity is taken to be of any value.

The experimental tests were carried out as described later, the main quantities determined being the R.M.S. current drawn from the source of E.M.F., the rectified output voltage across the load, and the ripple in the output voltage. The variables were the capacity, the load resistance and the rectifier resistance.

(1) Main Symbols Used

THE circuits considered are represented in Figs. 1, 2 and 4 for the half-wave, full-wave and voltage-doubler cases, respectively.

$E \sin pt$ = E.M.F. of source, $= E \sin \alpha$, where $\alpha = pt$.

ρ = resistance of diode together with the source, e.g. transformer, including primary resistance transferred to the secondary. In the full-wave case, the resistance of only one-half of the secondary is effective.

R = load resistance.

$n = \rho/R$.

C = capacity of the reservoir condenser. In the voltage-doubler, C is the capacity of each condenser.

$m = pCR = p \times$ time constant of the load resistance-reservoir condenser circuit.

i = instantaneous current in the rectifier.

i_1 = instantaneous current in the load resistance.

v = instantaneous P.D. across the condenser.

I = R.M.S. current drawn from the source (H.T. side). In the full-wave case, the current in either half of the H.T. winding is $\dfrac{I}{\sqrt{2}}$.

I_0 = mean rectified load current.

$f_e = I/I_0$.

v_m = mean rectified voltage across R.

V = " back-voltage " of diode (see Fig. 3) $= KE$.

V_r = magnitude of ripple (" trough to crest " value) in v_m.

(2) Half-Wave and Full-Wave Rectifiers

(a). Voltage Equations.

The treatment is given here in brief, as the expressions have been derived in various forms by several authors. (References 1, 2,

* MS. accepted by the Editor, October, 1935.

3 and 4). The "back-voltage" is not considered at this stage.

During the pulse of current through the rectifier, we have :—

$$E \sin pt = \rho i + v$$

and $$\frac{1}{CD}(i - i_1) = v = Ri_1$$

Hence we obtain the differential equation :

$$\left[1 + \rho\frac{1 + CRD}{R}\right]v = \left[1 + n\left(1 + \frac{mD}{p}\right)\right]v = E \sin pt.$$

Applying the initial condition that at the start of the pulse, $v = E \sin pt_1 = E \sin \alpha_1$ where $\alpha = pt$ and t_1 marks the start of the pulse, we may put the solution of this equation in the form :—

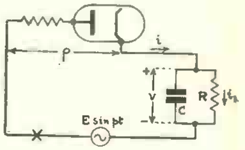


Fig. 1.

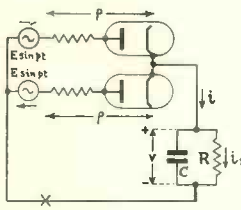


Fig. 2.

Circuits for half- and full-wave rectifiers.

$$\frac{v}{E} = \frac{\cos\phi}{1+n}\left[\sin(\alpha - \phi) + \left\{\frac{1+n}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1 - \phi)\right\}\epsilon^{\frac{-(\alpha - \alpha_1)(1+n)}{mn}}\right] \quad \ldots \quad \ldots \quad (1)$$

where $\tan\phi = \dfrac{pCR}{1 + R/\rho} = \dfrac{mn}{1+n}$.

During the discharge of the condenser, we have $v = \dfrac{1}{CD}(i - i_1) = Ri_1$ and, as $i = 0$, $(1 + CRD)v = 0$.

Applying the condition that, at the commencement of the discharge $v = E \sin pt_2 = E \sin \alpha_2$, we obtain the solution :—

$$\frac{v}{E} = \left[\epsilon^{\frac{-(\alpha - \alpha_2)}{m}}\right]\sin\alpha_2 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where α_2 marks the end of the pulse.

These equations are valid whether the steady state has been reached or not.

(b). Steady State Conditions.

Under steady state conditions, a new pulse commences at α_3, where $\alpha_3 = \alpha_1 + k\pi$, k being equal to 2 for a half-wave rectifier, and to 1 for a full-wave rectifier.

Applying the conditions (1) that the voltage at the end of the pulse must be equal to the voltage at the beginning of the discharge, and (2) that the voltage at the beginning of the second pulse must be equal to the voltage at the end of the discharge, we obtain the relations (3) and (4) given below :

$$\left[\frac{1+n}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1 - \phi)\right]\epsilon^{\frac{\alpha_1(1+n)}{mn}} = \left[\frac{1+n}{\cos\phi}\sin\alpha_2 - \sin(\alpha_2 - \phi)\right]\epsilon^{\frac{\alpha_2(1+n)}{mn}}.$$

This may be reduced to

$$\sin(\alpha_1 + \beta)\,.\,\epsilon^{\frac{\alpha_1(1+n)}{mn}} = \sin(\alpha_2 + \beta)\,.\,\epsilon^{\frac{\alpha_2(1+n)}{mn}} \quad \ldots (3)$$

where $$\tan\beta = \frac{\sin 2\phi}{1 + 2n - \cos 2\phi}.$$

The second relation is

$$\sin\alpha_1\,.\,\epsilon^{\frac{\alpha_1 + k\pi}{m}} = \sin\alpha_2\,.\,\epsilon^{\frac{\alpha_2}{m}} \quad \ldots \quad \ldots (4)$$

The form of the above equations is practically that used by Marique, (Reference 4), apart from a small change in notation and the simplification of relation (3).

The relations (3) and (4) must be satisfied simultaneously, if we are to find the values of α_1 and α_2 corresponding to any particular conditions. Although the approximate evaluation is greatly facilitated by the use of a graphical method such as that developed by Marique, the equations giving the effective current (derived later) demand a more accurate knowledge of α_1 and α_2, and one has to resort to a trial and error method. The labour involved in a sufficiently accurate calculation is so great that, when one takes into consideration the facts that the resistance of the diode is not exactly known, and that a strictly sinusoidal E.M.F. is the exception rather than the rule, one decides that the results of the arithmetic are too hardly won. In consequence, experimental results are to be preferred.

(c). Mean Rectified Voltage.

The mean rectified voltage v_m is obtained by integrating expression (1) between the limits $pt_1 = \alpha_1$ and $pt_2 = \alpha_2$, and expression (2) between the limits α_2 and $\alpha_1 + k\pi$. The sum of these integrals is then divided by $\frac{1}{2}kT$, where T is the periodic time $\frac{2\pi}{p}$.

For the first integral we obtain:

$$Int_1 = \frac{1}{p}\frac{\cos\phi}{1+n}\left[\cos(\alpha_1-\phi)-\cos(\alpha_2-\phi) - \frac{mn}{1+n}\left\{\frac{1+n}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1-\phi)\right\}\left\{\epsilon^{\frac{(\alpha_1-\alpha_2)(1+n)}{mn}}-1\right\}\right]$$

From (3), $\epsilon^{\frac{(\alpha_1-\alpha_2)(1+n)}{mn}} = \frac{\sin(\alpha_2+\beta)}{\sin(\alpha_1+\beta)}$. Using this expression, and substituting for ϕ, we obtain eventually:

$$Int_1 = \frac{(\cos\alpha_1-\cos\alpha_2)+mn(\sin\alpha_1-\sin\alpha_2)}{p(1+n)} \quad . (5)$$

For the second integral, we have

$$Int_2 = \frac{m}{p}\sin\alpha_2\left[1-\epsilon^{\frac{(\alpha_2-\alpha_1-k\pi)}{m}}\right]$$

Substituting the value of the exponential term from (4), we obtain:

$$Int_2 = \frac{m}{p}(\sin\alpha_2-\sin\alpha_1) \quad .. \quad .. \quad (6)$$

The mean voltage $v_m = E \,.\, 2\frac{Int_1+Int_2}{kT}$.

Therefore

$$v_m = E\frac{(\cos\alpha_1-\cos\alpha_2)+m(\sin\alpha_2-\sin\alpha_1)}{k\pi(1+n)} \quad .. \quad .. \quad (7)$$

The expression for v_m in Reference (4) equation (15) is erroneous, as it is derived only from an expression equivalent to (6) above, that is, on the assumption that the true mean voltage is the same as the mean over the discharge period. Although this is approximately true in most cases, it is not always so. To illustrate the point, let us consider the case of a half-wave rectifier devoid of reservoir condenser, i.e. $m = 0$. There being no storage, the pulse will last from $\alpha_1 = 0$ to $\alpha_2 = \pi$. If we substitute these values in (6) above or in equation (15) Ref. (4), we are led to believe that $v_m = 0$. Actually, v_m would be the mean value of one half-cycle averaged over one cycle, multiplied by the ratio of R to $(\rho + R)$, for the arrangement would act as a potential divider.

That is, $v_m = \frac{1}{2}\frac{R}{\rho+R}E\frac{2}{\pi} = \frac{1}{1+n}\frac{E}{\pi}$.

Substitution of the values of α_1 and α_2 in (7) gives this same value of v_m.

(*d*). *R.M.S. Current drawn from Source.*

From the first unnumbered equation, we have $i = \frac{E\sin pt - v}{\rho}$. From this and from (1) we have:

$$\frac{\rho i}{E} = \sin\alpha - \frac{v}{E} = \sin\alpha - \frac{\cos\phi}{1+n}\sin(\alpha-\phi) - \left[\sin\alpha_1 - \frac{\cos\phi}{1+n}\sin(\alpha_1-\phi)\right]\epsilon^{\frac{-(\alpha-\alpha_1)(1+n)}{mn}} \quad .. (8)$$

which may be reduced to the form:

$$\frac{\rho i}{E} = \frac{\sin\phi}{m}\sqrt{1+m^2}\left[\sin(\alpha+\beta)-\sin(\alpha_1+\beta)\,\epsilon^{\frac{-(\alpha-\alpha_1)(1+n)}{mn}}\right] \quad .. \quad .. \quad (9)$$

The square of the R.H.S. is integrated between the limits α_1 and α_2. The expression then found may be simplified by the substitution of the values of the exponential terms (from 3 and 4) as before. This final expression when divided by $k\pi$ will give $\left(\frac{I\rho}{E}\right)^2$ where I is the R.M.S. current required. In the full-wave case, if k is put equal to 1, the value of I obtained will be that measured by an ammeter inserted between the centre-tap of the transformer secondary, and the negative pole of the reservoir condenser. To obtain the current in either portion of the secondary, one must put k equal to 2, as the pulse of current in any one portion occurs only once per cycle. This is equivalent to dividing the value of I first obtained by $\sqrt{2}$. No such difficulty arises in the case of the half-wave rectifier.

The expression derived is:—

$$\left(\frac{\rho I}{E}\right)^2 = \left[\alpha_2-\alpha_1-\frac{\cos(\alpha_1+\alpha_2+2\beta+3\phi)\sin(\alpha_2-\alpha_1)}{\cos\phi}\right]\frac{\sin^2\phi(1+m^2)}{2m^2}\frac{1}{k\pi} \quad .. \quad .. \quad (10)$$

(e) Rectified Current, Output Power and Efficiency.

If v_m be determined from (9), the rectified current I_0 is obtainable from the expression

$$I_0 = \frac{v_m}{R} \quad \ldots \quad \ldots \quad (11)$$

The output power $P_0 = \frac{v_m^2}{R} = I_0^2 R$ ..(12)

The losses in the rectifier and source

$$P_L = I^2\rho \quad \ldots \quad \ldots \quad (13)$$

where I is measured in the line between the centre-tap and the negative pole of the condenser.

The input power $P_i = I_0^2 R\left[1 + \frac{I^2\rho}{I_0^2 R}\right]$ (14)

The efficiency is $\eta = \dfrac{1}{1 + \dfrac{I^2\rho}{I_0^2 R}}$ .. (15)

The form factor of the current wave-form $f_e = \frac{I}{I_0}$ is obtainable from (10) and (11). (13), (14) and (15) may then be expressed by

$$P_L = I_0^2 R f_e^2 n \quad \ldots \quad \ldots \quad \ldots \quad (13a)$$

$$P_i = P_0(1 + nf_e^2) \quad \ldots \quad \ldots \quad (14a)$$

and $\eta = \dfrac{1}{1 + nf_e^2}$ .. .. .. (15a)

Expressions giving the efficiency, output power, etc. directly in terms of α_1, α_2, m, n and ϕ may be found from (7), (10), (11), etc., but as the designer of an equipment is concerned less with the efficiency than with v_m and I, such expressions are not derived here.

(3) Half- and Full-wave Rectifiers with "Back Voltage" considered.

McDonald (Ref. 5) has considered this case largely from an experimental standpoint, but it will be of interest to investigate the effect of introducing the back voltage into our treatment.

We must now consider the ideal diode current voltage characteristic shown in Fig. 3. The back voltage V will be of the order of 5 volts for most thermionic rectifiers. If the instantaneous current in the valve were low, V might fall to 1 volt or less, but as the resistance would then be definitely non-ohmic, our treatment would hardly be applicable. Our previous tacit assumption that V is zero, is more and more nearly justified as E becomes larger and larger in comparison with V.

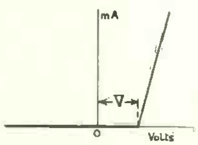


Fig. 3.—*Ideal diode characteristic.*

(a) Voltage Equations.

If we put $V = KE$, the first unnumbered equation becomes:

$E(\sin pt - K) = \rho i + v$, leading to the following expression which replaces (1):

$$\frac{v}{E} = \frac{\cos\phi}{1+n}\left[\sin(\alpha - \phi) - \frac{K}{\cos\phi} + \left\{\frac{1+n}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1 - \phi) - \frac{nK}{\cos\phi}\right\}\epsilon^{\frac{-(\alpha-\alpha_1)(1+n)}{mn}}\right] \quad \ldots \quad (1b)$$

This gives the condenser voltage during the current pulse. For the voltage during the discharge, we obtain, in place of (2):

$$\frac{v}{E} = (\sin\alpha_2 - K)\,\epsilon^{\frac{-(\alpha-\alpha_2)}{m}} \quad \ldots \quad \ldots \quad (2b)$$

(b). Steady State Conditions.

We find the relations which must exist between α_1 and α_2 in the same way as before. The first relation is:

$$[\sin(\alpha_1 + \beta) - aK]\,\epsilon^{\frac{(1+n)\alpha_1}{mn}} = [\sin(\alpha_2 + \beta) - aK]\,\epsilon^{\frac{(1+n)\alpha_2}{mn}} \quad \ldots \quad (3b)$$

where $a = \dfrac{1}{\cos\phi\sqrt{1+m^2}}$.

The second is:—

$$(\sin\alpha_1 - K)\,\epsilon^{\frac{\alpha_1 + k\pi}{m}} = (\sin\alpha_2 - K)\,\epsilon^{\frac{\alpha_2}{m}} \quad \ldots (4b)$$

From these relations we may determine the appropriate values of α_1 and α_2.

(c). Mean Rectified Voltage.

We proceed, as before, and eventually obtain the expression:

$$v_m = E\,\frac{\cos\alpha_1 - \cos\alpha_2 + m(\sin\alpha_2 - \sin\alpha_1) - K(\alpha_2 - \alpha_1)}{k\pi(1+n)} \quad \ldots \quad \ldots \quad (7b)$$

(*d*). *R.M.S. Current drawn from the Source.*

The expression, derived as before, is :

$$\left(\frac{\rho I}{E}\right)^2 = \left[(1 + a^2K^2)(\alpha_2 - \alpha_1) - \frac{\cos(\alpha_1 + \alpha_2 + 2\beta + 3\phi) \times \sin(\alpha_2 - \alpha_1)}{\cos\phi} - 4aK \sin\tfrac{1}{2}(\alpha_2 - \alpha_1)\{2\cos\phi \sin\tfrac{1}{2}(\alpha_1 + \alpha_2 + 2\beta) + \tan\phi \cos 2\phi \cos\tfrac{1}{2}(\alpha_1 + \alpha_2 + 2\beta)\} \right] \times \left[\frac{\sin^2\phi\,(1 + m^2)}{2m^2}\frac{1}{k\pi}\right] \quad (10b)$$

value for I, and (corresponding absurdity !) to $v_m = 1.2E$. This illustrates the need for a more exact knowledge of α_1 and α_2 than can be obtained by the graphical methods used to derive the curves of Fig. 6, Ref. 4.

On the assumption that $E = 230\sqrt{2} = 325.3$ volts, $\rho = 1{,}000$ ohms and $R = 100{,}000$ ohms, calculations by trial and error give the values tabulated below (Table 1).

The experimental results were actually taken for $m = 126$ ($C = 4$ microfarads), but as the curves are flat in this region, the difference will be small.

TABLE 1.

Case	V volts	K	α_1	α_2	$\frac{v_m}{E}$	I mA	I_0 mA	$I/I_0 = f_e$
1	0	0	61° 17.3′	112° 14.3′	0.9007	8.56	2.92	2.92
2	5.00	0.016	61° 31.62′	112° 5.35′	0.8838	8.20	2.88	2.85
3	5 (approx.)	0.016	Experimental		0.89	8.18	2.89	2.84

From the form of the above expressions (7b) and (10b), we might say that it is obvious that the presence of a back voltage V will reduce both v_m and I, as one would expect. Nevertheless, on account of the fact that the presence of V alters both α_1 and α_2, it is safer to defer our conclusions until we have considered some actual examples (worked out in (4) *a* and *b*).

(4) Examples on Half- and Full-Wave Rectifier Expressions.

Taking $m = 100$, $n = 1/100$ throughout, we find $\phi = 44° 42.90'$ and $\beta = 44° 42.73'$.

(*a*). *Half-Wave.* (*Table* 1.)

Using the curves of Fig. 6, Ref. 4, for $\frac{R}{\rho} = 100$, and $\frac{\theta}{T} = \frac{m}{2\pi} = 15.9$ we find $\alpha_1 = 60°$ and $\alpha_2 = 111°$. Substitution of these values in (7) and (10) leads to an imaginary

(*b*). *Full-Wave* (*Table* 2.)

Here the necessity for exactness in the calculation is demonstrated. In Case 1 the L.H. sides of relations (3) and (4) differed from the respective R.H. sides by less than 1 part in 2,000, i.e., 0.05 per cent., while in Case 2, the difference was less than 1 part in 100,000. The 0.05 per cent. difference gives rise to a 1.2 per cent. error in I, and to a 1.5 per cent. error in I_0. In Case 3, the difference was 1 in 250,000. Here $E = 128.6\sqrt{2} = 181.9$ volts, $\rho = 500$ ohms and $R = 50{,}000$ ohms.

The agreement between experimental and theoretical values is perhaps better than might have been anticipated.

(5) Voltage-Doubling Rectifier

The treatment is given practically in full, as it is believed to be original. The effect of back voltage is not considered, as it

TABLE 2.

Case	V volts	K	α_1	α_2	$\frac{v_m}{E}$	I mA	I_0 mA	$I/I_0 = f_e$
1	0	0	67° 36.25′	108° 36.25′	0.9509	7.944	3.458	2.297
2	0	0	67° 43.70′	108° 31.70′	0.9372	7.848	3.408	2.304
3	4.00	0.022	67° 54.09′	108° 24.09′	0.9169	7.314	3.334	2.194
4	4 (approx.)	0.022	Experimental		0.916	7.43	3.33	2.23

would introduce considerable additional complication, and we are justified in supposing that its general influence would be the same as in the previous cases, i.e. it would reduce both v_m and I.

The circuit considered is shown in Fig. 4, and Fig. 5 serves to illustrate the process of rectification. The output voltage is the sum of v' and v'' (see Fig. 5). v_1' and v_2' occur at the beginning and end, respectively, of the first current pulse, while v_3' occurs at the beginning of the second pulse. α_1, α_2, v_1'', etc., have similar meanings.

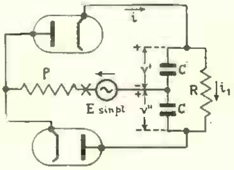


Fig. 4.—*Circuit for voltage doubler.*

(*a*) *Voltage Equations.*

During that pulse of current which passes through the upper diode, we have the following equations:

$$E \sin pt = \rho i + v'$$

$$v' = \frac{1}{CD}(i - i_1)$$

$$v' = Ri_1 - v''$$

and $$v'' = -\frac{1}{CD} i_1$$

From these we obtain:

$$[1 + C(R + 2\rho)D + \rho RC^2D^2]v'' = -E \sin pt$$

or

$$\left[1 + \frac{m}{p}(1 + 2n)D + n\frac{m^2}{p^2}D^2\right]v'' = -E \sin pt \quad \ldots \quad (16)$$

and

$$v' = -(1 + CRD)v'' = -\left(1 + \frac{m}{p}D\right)v'' \ldots \quad (17)$$

The solutions of (16) and (17) may be put in the form :—

$$\frac{v'}{E} = A\epsilon^{\gamma(\alpha-\alpha_1)} + B\epsilon^{\delta(\alpha-\alpha_1)} - mF\cos(\alpha + \theta) - F\sin(\alpha + \theta) \quad \ldots \quad \ldots \quad (18)$$

and

$$\frac{v''}{E} = xA\epsilon^{\gamma(\alpha-\alpha_1)} + yB\epsilon^{\delta(\alpha-\alpha_1)} + F\sin(\alpha + \theta) \quad \ldots \quad \ldots \quad (19)$$

where A and B are arbitrary constants, which will be evaluated later, when the voltage equations which apply during the "gaps" between the pulses have been found.

$$\gamma = \frac{-1 - 2n + \sqrt{1 + 4n^2}}{2mn}$$

$$\delta = \frac{-1 - 2n - \sqrt{1 + 4n^2}}{2mn}$$

$$F = \frac{1}{\sqrt{(m^2n - 1)^2 + m^2(1 + 2n)^2}}$$

$$\tan\theta = \frac{m(1 + 2n)}{m^2n - 1}$$

$$x = -\frac{1}{(1 + pCR\gamma)} = \frac{2n}{1 - \sqrt{1 + 4n^2}}$$

$$y = -\frac{1}{(1 + pCR\delta)} = \frac{2n}{1 + \sqrt{1 + 4n^2}}$$

During gap (1), if the condensers, which are assumed to be equal, carry charges q' and q'', respectively, we have :—

$$i_1 = -Dq' = -Dq'', \; v' = -\frac{1}{CD}i_1$$

and $v'' = -\frac{1}{CD}i_1$ whence

$$\left[\frac{1}{CD} + \frac{1}{CD} + R\right]i_1 = 0$$

The solution of these equations gives

$$\frac{v'}{E} = G\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} + H \text{ and}$$

$$\frac{v''}{E} = G_1\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} + H_1$$

As, during the discharge, both condensers carry the same current, the rates of change

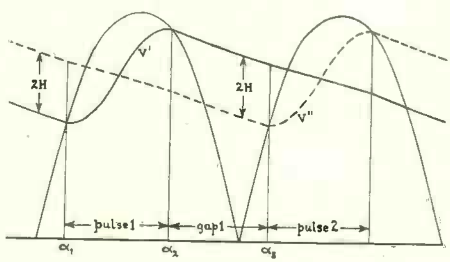


Fig. 5.—*Cycle of operation (doubler)*

of v' and v'' must be the same, for all values of α in the gap period. Accordingly, $G = G_1$. Also, if the discharge were allowed to continue indefinitely, the potential difference across R would eventually vanish. That is, as α tends to an infinite value, the sum of v' and v'' tends to zero. Hence $H_1 = -H$.

Accordingly $$\frac{v'}{E} = G\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} + H \quad .. \text{ (20)}$$

and $$\frac{v''}{E} = G\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} - H \quad .. \text{ (21)}$$

where G and H are arbitrary constants, to be determined from the initial conditions.

We may note that $\frac{v' - v''}{E} = 2H$, i.e. the discharge curves are a constant vertical distance apart, during any one gap. This distance will, however, not be the same for different gaps unless a steady state has been reached. That is, the value of H will vary from cycle to cycle until the attainment of a steady state.

If the values of H during the gaps immediately previous to pulse (1) and immediately following pulse (1) are H_0 and H respectively, then we have :—

for $\alpha = \alpha_1, \frac{v'' - v'}{E} = 2H_0$

and for $\alpha = \alpha_2, \frac{v' - v''}{E} = 2H$ (22) and (23)

We may now proceed with the evaluation of the A.C.s A and B, G and H.

At $\alpha = \alpha_1$, we have $\sin \alpha_1 = \frac{v'}{E} = A + B - mF \times \cos(\alpha_1 + \theta) - F \sin(\alpha_1 + \theta)$ from (18).

Therefore, $A + B = M_1$ .. .. (24)

where M_1 is the value of $\sin \alpha + mF \times \cos(\alpha + \theta) + F \times \sin(\alpha + \theta) = M$ at $\alpha = \alpha_1$.

M may be transformed into

$$mnF\sqrt{4 + m^2} \sin(\alpha + \psi)$$

where $$\tan \psi = \frac{m^2 + 2}{m(m^2n + 4n + 1)}.$$

Also, at the same moment, we have, from (22), $\frac{v''}{E} = \sin \alpha_1 + 2H_0$. Putting $\alpha = \alpha_1$ in (19), we have $\frac{v''}{E} = xA + yB + F \times \sin(\alpha_1 + \theta)$.

Whence $xA + yB = 2H_0 + N_1$ .. (25)

where $N = \sin \alpha - F \times \sin(\alpha + \theta)$
$$= \sqrt{m^2n^2 + 1}\, F\sqrt{4 + m^2} \sin(\alpha - \nu)$$

and $$\tan \nu = \frac{F \times \sin \theta}{1 - F \times \cos \theta}.$$

Solving (24) and (25) we obtain :—

$$\left.\begin{aligned} A &= \frac{2H_0 + N_1 - yM_1}{x - y} \text{ or} \\ 2H_0 &= A(x-y) - N_1 + yM_1 \\ \text{and } B &= \frac{xM_1 - 2H_0 - N_1}{x - y} \end{aligned}\right\} \text{ .. (26)}$$

For the sake of convenience in writing, these values of A and B are not substituted in (18) and (19).

The attaching of numerical values to A and B involves the assumption of values not only of α_1 (as was sufficient in the case of the half- and full-wave rectifiers) but also of H_0, as we might have expected, for (16) is of the second order. Except in the steady state the value of H_0 is not determinable in terms of α_1, unless we go back to the real beginning, i.e. to the moment when the equipment is first switched in.

We now evaluate G.

At $\alpha = \alpha_2$, $\sin \alpha_2 = \frac{v'}{E} = G + H$

from (20), or $G = \sin \alpha_2 - H$. (20) and (21) may now be rewritten :—

$$\frac{v'}{E} = (\sin \alpha_2 - H)\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} + H \quad .. \text{ (27)}$$

and $$\frac{v''}{E} = (\sin \alpha_2 - H)\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}} - H \quad .. \text{ (28)}$$

(*b*) *Steady State Conditions.*

When a steady state is reached, a new pulse commences at $\alpha_3 = \alpha_1 + \pi$. During this pulse, the form of v' is identical with the form which v'' had during the previous pulse and vice versa. Now, moreover, H is the same for all gaps. Accordingly $H_0 = H$.

In order to obtain the values of α_1 and α_2 which apply to any particular values of m and n, we require, in addition to (26), expressions involving the magnitudes of v' and v'' at the end of pulse (1) and also at the end of gap (1).

Putting $\alpha = \alpha_2$ in (18) and (19), and remembering that, at $\alpha = \alpha_2, \frac{v' - v''}{E} = 2H$, we get :—

$\sin \alpha_2 = Ac + Bd - mF \cos(\alpha_2 + \theta) - F \sin(\alpha_2 + \theta)$ or $Ac + Bd = M_2$ .. (29)

and $\sin\alpha_2 - 2H = xAc + yBd + F\sin(\alpha_2+\theta)$

or $xAc + yBd = N_2 - 2H$ .. .. (30)

if we put $\epsilon^{\gamma(\alpha_2-\alpha_1)} = c$ and $\epsilon^{\delta(\alpha_2-\alpha_1)} = d$.

On eliminating A and B from (24), (25) and (29), we get

$$H_0 = \frac{M_1(yc-xd)+M_2(y-x)}{2(c-d)} - \frac{N_1}{2} \quad (31)$$

and from (24), (29) and (30) we get

$$H = \frac{N_2}{2} - \frac{cdM_1(y-x)+M_2(xc-yd)}{2(c-d)} \quad (32)$$

Under steady state conditions, $H_0 = H$, and thus from (31) and (32), we obtain the first relation which must be satisfied if a pair of values of α_1 and α_2 is to correspond to particular values of m and n. It is :—

$$(N_1+N_2)(c-d) = M_1[(yc-xd)+cd(y-x)] + M_2[y-x+xc-yd] \quad .. \quad .. \quad (33)$$

At $\alpha = \alpha_3$, $\frac{v''}{E} = \sin\alpha_1$ (see Fig. 5).

From (28), at $\alpha_3 = \alpha_1 + \pi$ we have

$$\frac{v''}{E} = (\sin\alpha_2 - H)\,\epsilon^{\frac{-2(\alpha_1+\pi-\alpha_2)}{m}} - H.$$

Hence we obtain the second relation :

$$(\sin\alpha_1 + H)\,\epsilon^{\frac{2(\alpha_1+\pi)}{m}} = (\sin\alpha_2 - H)\,\epsilon^{\frac{2\alpha_2}{m}} \quad .. \quad (34)$$

where the value of H may be got from (32).

We obtain, by trial and error, values of α_1 and α_2, which satisfy relation (33) above. These values are then consistent with each other during the charging period. Substitution in (34) will reveal whether they are consistent with each other during the discharge, or not. If not, further trial is necessary, until a pair of values is obtained which satisfies both (33) and (34).

Actually, the relations in the form shown above are not very suitable for purposes of computation. The following is a better procedure. Those values of α_1 and α_2 which lead to the same value of H when substituted in (31) or (32) are found by trial. From (34), we have :

$$H\left[1 + \epsilon^{\frac{2(\alpha_1+\pi-\alpha_2)}{m}}\right] = \sin\alpha_2 - \epsilon^{\frac{2(\alpha_1+\pi-\alpha_2)}{m}}.\sin\alpha_1 \quad .. \quad .. \quad (35)$$

The same values of α are substituted in (35), and, if they are the correct values, the value of H then found will agree with the value derived from (31) or (32). Otherwise, further trial is necessary.

Once α_1 and α_2 are known, A and B may be found from (26).

(c) Mean Rectified Voltage.

We integrate $\frac{v'+v''}{E}$ during the pulse, between the limits α_1 and α_2, treating α as the variable. We then integrate $\frac{v'+v''}{E}$ during the gap, between the limits α_2 and $\alpha_3 = \alpha_1 + \pi$. The sum of these integrals, when divided by π, gives the value of $\frac{v_m}{E}$.

From (18) and (19)

$$Int_1 = \int_{\alpha_1}^{\alpha_2}\frac{v'+v''}{E}d\alpha = \int_{\alpha_1}^{\alpha_2}[A(1+x)\epsilon^{\gamma(\alpha-\alpha_1)} + B(1+y)\epsilon^{\delta(\alpha-\alpha_1)} - mF\cos(\alpha+\theta)]\,d\alpha$$

$$= \frac{A(1+x)(c-1)}{\gamma} + \frac{B(1+y)(d-1)}{\delta} - mF[\sin(\alpha_2+\theta) - \sin(\alpha_1+\theta)]$$

Now $x = \frac{-1}{1+m\gamma}$ $\therefore$ $\frac{1+x}{\gamma} = -mx.$

Similarly $\frac{1+y}{\delta} = -my.$

$\therefore Int_1 = m[xA(1-c) + yB(1-d) - F\sin(\alpha_2+\theta) - \sin(\alpha_1+\theta)]$

Subtracting (25) from (30), $xA(c-1) + yB(d-1) = N_2 - N_1 - 4H$ as $H = H_0$.

$\therefore Int_1 = m[4H + N_1 - N_2 - F\{\sin(\alpha_2+\theta) - \sin(\alpha_1+\theta)\}] = m[4H + \sin\alpha_1 - \sin\alpha_2]$

as $N = \sin\alpha - F\sin(\alpha+\theta)$.

$$Int_2 = \int_{\alpha_2}^{\alpha_1+\pi}\frac{v'+v''}{E}d\alpha = \int_{\alpha_2}^{\alpha_1+\pi}2(\sin\alpha_2 - H)\epsilon^{\frac{-2(\alpha-\alpha_2)}{m}}d\alpha$$

from (27) and (28).

$$= -m(\sin\alpha_2 - H)\left[\epsilon^{\frac{-2(\alpha_1+\pi-\alpha_2)}{m}} - 1\right]$$

Substituting for the exponential term from (34), we get :—

$Int_2 = m(\sin\alpha_2 - \sin\alpha_1 - 2H)$

$\therefore Int_1 + Int_2 = 2mH$

and $$\frac{v_m}{E} = \frac{Int_1 + Int_2}{\pi} = \frac{2mH}{\pi} \quad .. \quad (36)$$

As H has previously been determined, in the course of the evaluation of α_1 and α_2, we can immediately find $\frac{v_m}{E}$.

Regarding it from the general point of view, (36) is not as simple as it seems, for we should really substitute for H from (31) or (32).

(*d*) *R.M.S. Current drawn from the Source.*

From paragraph (5a), we have

$$\frac{\rho i}{E} = \sin \alpha - \frac{v'}{E}$$

and, using (18), we get

$$\frac{\rho i}{E} = - A\epsilon^{\gamma(\alpha-\alpha_1)} - B\epsilon^{\delta(\alpha-\alpha_1)} + \sin \alpha + mF \times \cos (\alpha + \theta) + F \times \sin (\alpha + \theta)$$
$$= - A\epsilon^{\gamma(\alpha-\alpha_1)} - B\epsilon^{\delta(\alpha-\alpha_1)} + M_0 \sin (\alpha + \psi).$$

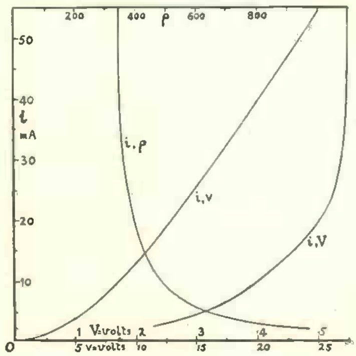


Fig. 6.—*Actual diode characteristic.*

We integrate the square of this expression between the limits α_1 and α_2, and obtain :—

$$\left(\frac{\rho I}{E}\right)^2 \pi = \int_{\alpha_1}^{\alpha_2} \left(\frac{\rho i}{E}\right)^2 d\alpha = \frac{A^2(c^2-1)}{2\gamma} + \frac{B^2(d^2-1)}{2\delta}$$
$$+ \frac{2AB(cd-1)}{\gamma+\delta} + \frac{M_0^2}{2}(\alpha_2 - \alpha_1)$$
$$- \frac{M_0^2}{4}\{\sin 2(\alpha_2 + \psi) - \sin 2(\alpha_1 + \psi)\}$$
$$- M_0\left(\frac{Ac\gamma}{1+\gamma^2} + \frac{Bd\delta}{1+\delta^2}\right)\{\cos(\alpha_2+\psi) - \cos(\alpha_1+\psi)\}$$
$$- M_0\left(\frac{Ac}{1+\gamma^2} + \frac{Bd}{1+\delta^2}\right)\{\sin(\alpha_2+\psi) - \sin(\alpha_1+\psi)\} \quad \ldots \quad (37)$$

The R.M.S. current I which may be calculated from this expression, is that supplied by the source. The current in any part of the supply side of the circuit not shared by the two diodes will be $0.707 \times I$.

Although it is possible to substitute for A, B, c, etc., from (24), (25), etc., in a way similar to that used to find the mean rectified voltage, the expressions thus derived by the author are no improvement on (37), and are therefore not given. Similarly, equations (31) and (32) have not been reduced to simpler forms. It is not implied that simplification of (37) or earlier expressions is impossible, but merely that a suitable inspiration has been lacking !

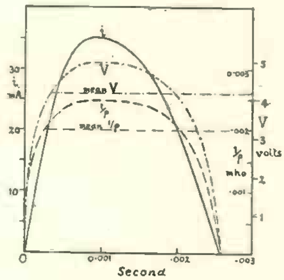


Fig. 7.—*Evaluation of mean V and ρ.*

(*e*) *Rectified Current, Output Power and Efficiency.*

The equations (11), (12), (13a), (14a), and (15a) of paragraph 2(e), are still applicable, if I_0 and I are obtained from (36) and (37) respectively. I is measured in the line between the source and the common pole of the condensers.

(6) Experimental Results

The tests were carried out in so obvious a way that only a brief description is necessary.

For the diodes, two Clarion UF4 full-wave rectifiers, being on hand, were used, the two anodes of each valve being strapped in order to give a low value of ρ. For one valve, Fig. 6 shows the current-voltage characteristic and the curves of ρ and the back-voltage V derived from the characteristic. ρ and V are plotted against the current. V was taken as the intercept on the voltage axis, of the tangent, the slope of which gives ρ. For the other valve, ρ, for currents above about 10mA, is about 100 ohms less, and V about the same. An external resistance of about 100 ohms was accordingly connected in series with the second valve, in order to equalise the resistances. The effectiveness of this adjustment was tested by examining oscillograms of the currents passed by the two valves, when the effect of a 10 ohm change in the added resistance was readily observed. For low currents, about 150 ohms were necessary in order to equalise the currents.

As both ρ and V vary during the pulse, oscillograms were taken, and examined to see whether mean arithmetical values could reasonably be attached to ρ and V. Fig. 7

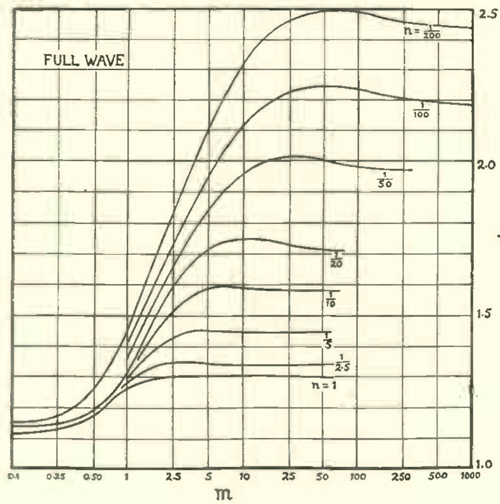


Fig. 8.

Curves of f_e for the three types of rectifier.

shows a tracing of such an oscillogram of a current pulse, for $R = 100{,}000$ ohms, $\rho = 1{,}000$ ohms, $C = 8{\cdot}38$ microfarad (i.e. $m = 263$ and $n = 0.001$), using a half-wave arrangement. Curves of $1/\rho$ and V are also plotted. The mean value of $1/\rho$ was 2,000 micro-ohm, that is, $\rho = 500$ ohms, and the mean value of V was 4.16 volts. The curves for the second valve were similar in shape, the mean values of ρ and V being 395 ohms, and 4.35 volts, respectively. With the 100 ohm external resistance in series with the second valve, the two in parallel gave a resistance of 250 ohms, to which was added a further 750 ohms. The not too extravagant variation of ρ and V during the pulse would be practically swamped by the additional 750 ohms in this case. We may therefore take it that our assumption of constant valve resistance during the pulse is not unjustified, except perhaps in those cases when no extra resistance is used, i.e. those corresponding to the lowest values of n. On the whole, however, the regular spacing of the curves, with the exception of that for $n = \frac{1}{800}$ (half-wave), seems to indicate that even, then our assumption is sensibly correct.

The power supply was obtained from a 5 kva transformer, so that the impedance of the source was negligible.

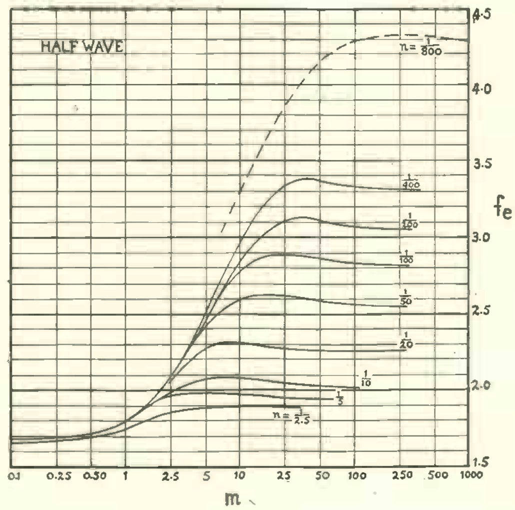


Fig. 9.

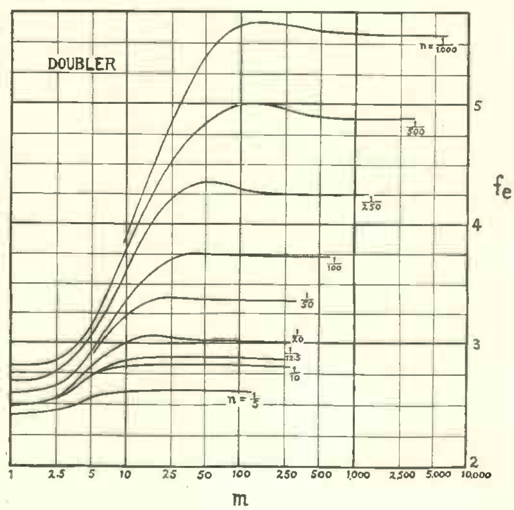


Fig. 10.

A thermo-milliammeter was placed in the circuit at the point marked X in Figs. 1, 2 and 4, and a d.c. milliammeter placed in series with R. Obvious switching arrangements were made, by which C, R and ρ could be varied between the limits given in the Table 3.

Figs. 12, 13 and 14 show the values of $\frac{v_m}{E}$ for the three cases. The effect of the back voltage V has been eliminated as far as possible, by taking readings at different supply voltages, but with the same V, i.e. with different values of K. Hence the effect of K on the output voltage was determined and eliminated. The fractional decrease in v_m is about equal to the numerical value of K.

TABLE 3.

	C	R ohms.	ρ ohms.
Half-wave	0.01 to 8μF	200,000 to 10,000	4,000 to 250
Full-wave	0.01 to 8μF	100,000 to 25,000	25,000 to 500
Doubler	0.01 to 4μF	1 meg. to 25,000	25,000 to 500

Values of $f_e = \frac{I}{I_0}$ for the half-wave, full-wave and voltage-doubler cases are shown in Figs. 8, 9 and 10, respectively, plotted against m for various values of n. The hump just beyond the knee of each curve corresponds to a change in the wave-form of the pulse from an approach to a sine wave, to a peaky wave, and then to a flatter wave. This change is illustrated by the oscillograms shown in Fig. 11, which were taken for a half-wave rectifier for which $R = 100{,}000$ ohms, $\rho = 250$ ohms $\left(n = \frac{1}{400}\right)$.

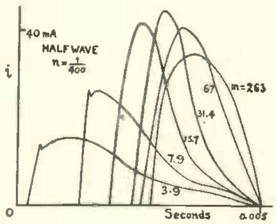
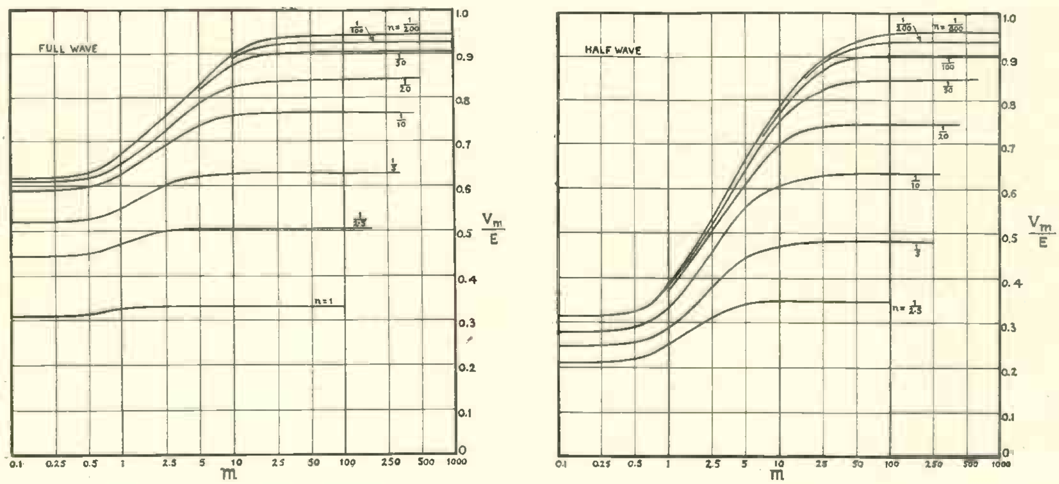


Fig. 11.—*Oscillograms of current pulses.*

It is to be noted that the curves for the voltage-doubler fall more steeply than those for the other cases, and moreover they fall to very low values. This difference in behaviour is due to the fact that, in the half- or full-wave case, there will be some rectified voltage $\left(\frac{E}{k(1+n)} \times \frac{2}{\pi}\right)$ even if the reservoir condenser be removed, whereas if the voltage-doubling condensers be removed, all connections between supply and load is broken, resulting in the disappearance of the output. For low values of m, the rectified voltage v_m may be estimated from the following considerations.



Figs. 12 and 13.—*Curves of* $\frac{v_m}{E}$ VERSUS m *for full and half-wave types.*

If m is low, i.e. C very small, then there is no appreciable gap between the current pulses, and no appreciable initial charge on that condenser which is in series with the load during any one pulse. The voltage v_L across the load will accordingly be

$$E\,(\sin pt) \times \frac{R}{\rho + R + \dfrac{1}{jpC}}$$

for ρ, C and R are in series across the supply, and transient terms will die out very rapidly. Multiplying top and bottom of jpC, we get :—

$$v_L = E\,(\sin pt)\,\frac{jm}{1 + jm(1 + n)}$$

and the value of v_m will be

$$v_m = \frac{2}{\pi} E \frac{m}{\sqrt{1 + m^2(1 + n)^2}}.$$

If $m = 1$, $n = 0.2$, then

$$v_m = \frac{2}{\pi} E \frac{1}{\sqrt{1 + 1.44}} = 0.406\,E.$$

From Fig. 14, $v_m = 0.416E$. For $m = 1$, n very small $v_m = 0.45\,E$ from the calculation, and $0.465E$ from Fig. 14.

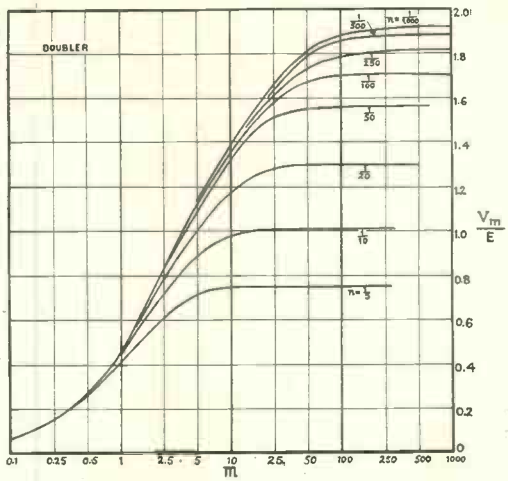


Fig. 14.—*Curves of* $\frac{v_m}{E}$ VERSUS *m for voltage-doubler.*

As m is decreased, v_m for a voltage-doubler circuit tends to zero, whereas in the half- and full-wave cases, v_m tends to the limits $\frac{1}{\pi}\frac{E}{1+n}$ and $\frac{2}{\pi}\frac{E}{1+n}$ respectively.

(*To be concluded.*)

Mutual Inductance*

By J. Greig, M.Sc., A.M.I.E.E.

In the study of elementary A.C. circuit theory it is the common experience that, while the fundamental character of mutual inductance is essentially simple, it is often a matter of some difficulty to write down with certainty the mesh equations for networks having a number of meshes with mutual inductance between several of the elements. This difficulty seems to arise largely from the somewhat inadequate definitions of mutual inductance frequently given in elementary text-books.

The present note represents an attempt to set out the fundamental theory using the so-called "double suffix" notation which appears to offer some advantages in the matter of clarity.

The mutual inductance between two coils may, without attempting complete definition, be said to be the e.m.f. induced in one of them by unit rate of change of current in the other. To specify the effect completely, the direction of the e.m.f. corresponding to unit positive rate of change of current must be stated, also, it is not obvious without demonstration that the e.m.f. induced in the secondary by unit rate of change of current in the primary is equal to the e.m.f. induced in the primary by unit rate of change of current in the secondary. These points are cleared up by the following simple theorem.

Consider two coils A and B as in Fig. 1 having self-inductances L_A and L_B.

Using the double suffix notation i_{12} represents a current in coil A flowing from 1 to 2, while e_{12} represents a real e.m.f. acting from 1 to 2 and v_{12} represents the fall in potential

* MS. accepted by the Editor, December, 1935.

across the coil terminals from 1 to 2. Thus i_{21} represents a current i flowing from 2 to 1 and $i_{21} = - i_{12}$. A similar interchange of suffixes reverses the signs of the other quantities. Now let the coupling be such that unit positive rate of change of current in coil A from 1 to 2—*i.e.*, $\frac{di_{12}}{dt} = +1$ induces an e.m.f. M_{AB} acting from 4 to 3 in coil B and suppose, for the time being, that $\frac{di_{34}}{dt} = +1$ produces an e.m.f. M_{BA} acting from 2 to 1 in coil A. Let a steady current I_{12} be established in coil A with coil B open circuited. Then establish a steady current I_{34} in coil B *meanwhile maintaining* I_{12} *constant*. This, of course, necessitates injecting into the circuit of coil A an e.m.f. at every instant equal and opposite to that induced by the rate of change of current in coil B. The work done by this e.m.f. will be positive as it acts *with* the current.

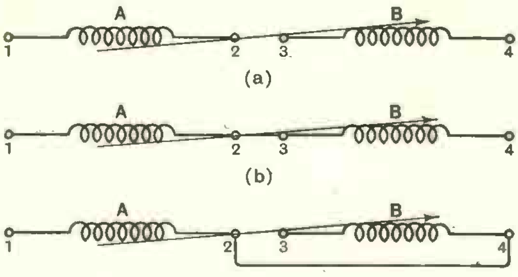


Fig. 1.

The total work done in establishing the two currents will be

$$\tfrac{1}{2} L_A I^2_{12} + \tfrac{1}{2} L_B I^2_{34} + \int_{t=0}^{t=\infty} I_{12} \frac{di_{34}}{dt} M_{BA} dt$$

$$= \tfrac{1}{2} L_A I^2_{12} + \tfrac{1}{2} L_B I^2_{34} + M_{BA} I_{12} I_{34}$$

Now let the two currents be established in the reverse order. The work done this time will be

$$\tfrac{1}{2} L_B I^2_{34} + \tfrac{1}{2} L_A I^2_{12} + M_{AB} I_{34} I_{12}$$

The total work done in establishing the two currents is obviously independent of the order in which they are started, therefore

$$M_{AB} = M_{BA} = M.$$

If it had been assumed that M_{BA} represented an e.m.f. acting from 1 to 2, $-M_{AB} = M_{BA}$ would have been obtained.

Thus it is seen that, if unit positive rate of change of current in the direction 1.2 in coil A produces an e.m.f. of magnitude $+M$ in the direction 4.3 in coil B, then unit positive rate of change of current in the direction 3.4 in coil B will produce an e.m.f. of $+M$ in the direction 2.1 in coil A or if the directions 1 to 2 and 3 to 4 are called the positive directions in each coil then unit positive rate of change of current in either coil will produce an e.m.f. of $-M$ in the other, *i.e.*, $e = -M\frac{di}{dt}$.

Now consider the case in which the two coils are connected in series as Fig. 1*b*.

$$i_{12} = i_{34} = i_{14}$$

The e.m.f. induced in coil A by any change in i_{14} is given by

$$e_{21} = L_A \frac{di_{12}}{dt} + M \frac{di_{34}}{dt}$$

and in coil B by

$$e_{43} = L_B \frac{di_{34}}{dt} + M \frac{di_{12}}{dt}$$

$$\therefore \quad e_{41} = e_{43} + e_{21} = \frac{di_{14}}{dt}(L_A + L_B + 2M)$$

Therefore the applied voltage or total fall of potential from 1 to 4 is

$$v_{14} = \frac{di_{14}}{dt}(L_A + L_B + 2M)$$

If the two coils are connected as in Fig. 1*c* the fall in potential becomes

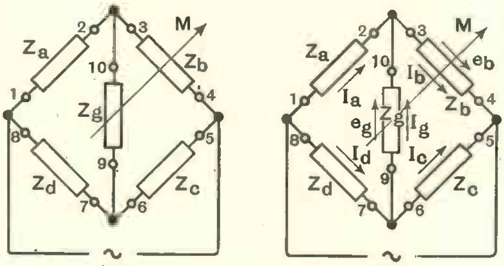
$$v_{13} = \frac{di_{13}}{dt}(L_A + L_B - 2M)$$

Thus if the numerical value of M is positive, the effective self-inductance of the two coils is greater than $L_A + L_B$ in the 1.2, 3.4 connection, which would be termed the "series aiding" connection and less in the 1.2, 4.3 connection, which would be termed the "series opposing" connection. If the two coils in the 1.2, 3.4 connection carry a sinusoidal alternating current I_{14} of frequency f, the fall in potential from 1 to 4 is given by $V_{14} = j\omega I_{14}(L_A + L_B + 2M)$ where $\omega = 2\pi f$. It is evident that for M to be completely specified it must be related to definite conventional positive directions of current flow in each of the elements between which the coupling exists. Practically, it is convenient to take M as the e.m.f. induced in the negative direction in either element by unit rate of change of current in the positive direction in the other.

Consider an A.C. bridge circuit (Fig. 2*a*) in which, as in the Heaviside unequal ratio bridge, mutual inductance exists between the detector arm and one of the main bridge arms. Let M be the e.m.f. induced in the direction 4.3 in z_b by unit rate of change of current in the direction 9.10 in z_g.

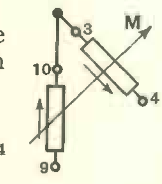
Then $e_{43} = M\frac{dI_{9\cdot10}}{dt} = j\omega MI_{9\cdot10}$

and $e_{10\cdot9} = \frac{MdI_{34}}{dt} = j\omega MI_{34}$



(a) (b)

Fig. 2.



(c)

The mesh equations using the double suffix notation then are :—

$$I_{12}Z_a + I_{10\cdot9}Z_g + I_{78}Z_d = e_{10\cdot9} = j\omega MI_{34}$$

$$I_{34}Z_b + I_{5\cdot6}Z_c + I_{9\cdot10}Z_g = e_{34} + e_{9\cdot10} = -j\omega M(I_{9\cdot10} + I_{34})$$

Alternatively, if the elements of the network are each labelled with a conventional positive direction as in Fig. 2*b*

$$e_b = -j\omega MI_g \text{ and } e_g = -j\omega MI_b$$

the mesh equations become :—

$$I_aZ_a - I_gZ_g - I_dZ_d = -e_g = j\omega MI_b$$

$$I_bZ_b - I_cZ_c + I_gZ_g = e_b + e_g = -j\omega M(I_g + I_b)$$

It will be noted that, with the conventional positive directions chosen for I_b and I_g, M represents the e.m.f. induced in the negative direction in either element by unit rate of change of current in the positive direction in the other. This means that, if the two elements considered are imagined to be disconnected from the bridge and connected in series as in Fig. 2*c*, the effective self-inductance of the combination will be $L_g + L_b + 2M$. This gives a convenient practical way of stating M for a four-terminal mutual inductance. Let the primary terminals be numbered 1 and 2 and the secondary terminals 3 and 4. Suppose the self-inductance of the two coils in series, with terminals 2 and 3 connected, to be, say, 12 mHy, while the self-inductance of each coil by itself is 5 mHy. Then the value of the mutual inductance is 1 mHy and the conventional positive directions in the two windings, to which this numerically positive value of M corresponds, may be indicated by writing $M_{12,34} = 1$ mHy.

Correspondence

Distribution of A.C. in Some Circuits

To the Editor, The Wireless Engineer

SIR,—I beg to advise you that a mistake has occurred in my letter in the May issue, where, at the end, the proportion $I_1 : I_2 : I = -2 : 3 : 1$ should appear in place of $I_1 : I_2 : I = 2 : 3 : I$.

Moscow. E. LIVSHITZ.

The Industry

THE Instrument Department of Ferranti, Ltd., Hollinwood, Lancs, has sent us details of a series of shunt boxes and multipliers for increasing the range of standard Ferranti instruments.

A contract for the supply of 7½ tons of non-corrosive cored solder has been awarded by the General Post Office to Ormiston's Alumina, Ltd., Great West Road, Brentford, Middlesex.

A direct-reading valve voltmeter of the high-impedance input type has been added to the range of apparatus produced by the Instrument Department of E. K. Cole, Ltd., Southend-on-Sea. Type TF314, as it is called, is operated from a 50-cycle supply, special precautions being taken to render the calibration independent of the mains voltage.

Half-wave Westectors, Types W4, W6 and WX6 have been reduced in price from 7/6 to 5/-.

Barnham & Adolph, 35, New Cavendish Street, London, W.1, issue leaflets describing selenium and electronic light-sensitive cells of various types.

Noise-Suppression in the Receiver*

A New American Development

By William N. Weeden

TO the radio enthusiast in America, as in Great Britain, atmospherics and local interference have long been troublesome. Although many schemes have been put forward for reducing them, only two have been in any way effective in remedying the latter—to suppress the interference at its source or to prevent it from reaching the receiver by erecting the aerial outside the field of interference. Neither course is always possible, however, and the claims of a new system operating in the receiver itself are consequently well worth examination.

This new silencer very effectively eliminates many types of "man-made" interference, much natural static, and what it cannot eliminate it greatly reduces. Of the many sceptical engineers and advanced amateurs who witnessed its performance, the writer has not heard of one who did not consider its action highly interesting. All this in spite of the very modest claims made by its inventor, James J. Lamb.

The development of the silencer was preceded by a lengthy examination of the wave form, peak and effective voltages, duration and other characteristics of many common forms of interference. Oscillographic examination showed that the sharp cracks heard in the loud speaker as the result of the spark occurring when an electric light or power circuit is closed, are really due to a series of damped wave trains having a duration of less than 1/1000th of a second. If the crack resulting from the spark were to be audible for no more than the duration of the electrical discharge, little harm would be done, but much of the trouble is caused by the fact that our loud speaker diaphragm will oscillate at its natural period—if shock-excited by an impulse of sufficiently great amplitude. Once the diaphragm has been set into vibration, its inertia causes the persistence of oscillation for an appreciable fraction of a second, thereby masking out a signal which may be present and of fair amplitude.

In addition to mechanical inertia in the loud speaker, the I.F. and H.F. tuned circuits, if of high-Q, possess such low decrement that they will oscillate for some time after the shock has ceased. Also, L.F. circuits may oscillate if their design is such as to exhibit resonance. While discussing the effect of shock-excitation, the quartz crystal filter, which is very popular in the United States for its remarkable selectivity and is employed in most high-grade communication and amateur receivers, owing to its remarkably low decrement, will prolong at least ten times the inoperative period of the receiver after the shock.

The next result was to discover that reception was hindered but little, if the amplitude of the interfering impulse did not greatly exceed that of the signal. Even when the amplitude of the noise was twice that of the signal, the communication value or intelligibility of the signal was affected but little. However, the amplitude of the annoying impulses was usually ten to twenty times that of the signal.

For the initial discussion of interference, only the single or isolated spark has been discussed. If this were the only form of noise with which we have to contend, the Lamb silencer would solve the problem completely. Unfortunately, there are many devices which create an entirely different form of noise, and the noise suppressor may not be able to deal with these as effectively.

Lamb's analysis further showed that in addition to the various effects of shock-excitation discussed above, those of valve overloading could also be very serious. Noise impulses of ten times the signal amplitude can easily cause one or more valves to draw grid current, and when it is realised that most of the grid circuits in

* MS. accepted by the Editor, May, 1936.

modern receivers include decoupling resistors and associated by-pass condensers which have a time constant of at least 1/10th second, it is easy to see that the receiver will only recover slowly if it is overloaded. The blocking and cross-modulation effects caused by the flow of rectified grid current frequently continue from one impulse to the next, thereby putting the receiver out of action until the interference ceases. Lamb therefore

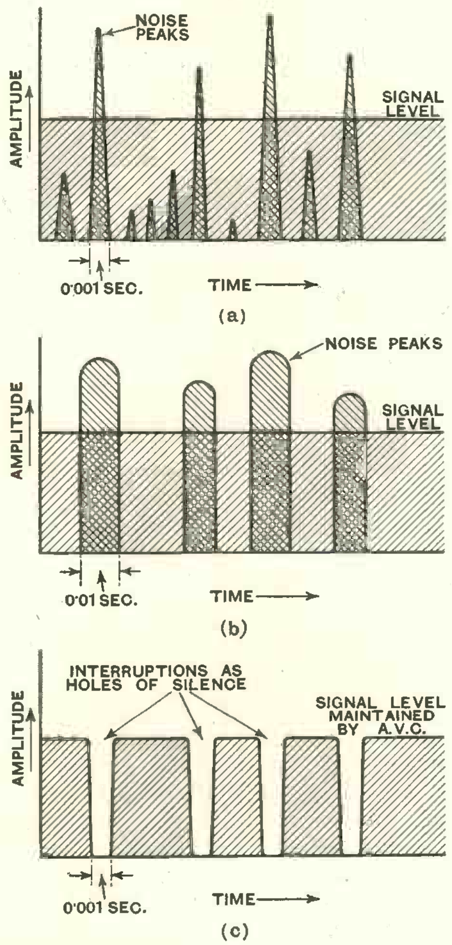


Fig. 1.—*The relationship between signal and noise in a typical case at the input of a receiver is shown at* (*a*), *and the form in which they appear from the loudspeaker at* (*b*). *The effect of the noise suppressor is indicated at* (*c*) *and it can be seen to remove the worst noise peaks.*

realised that if he were able to prevent this overloading, as well as preventing the speaker shock excitation previously mentioned, the problem of "noise" interference would be largely solved.

Schemes for limiting the receiver output have long been known, but none operated early enough in the receiver to prevent valve overloading. Therefore, Lamb proceeded to work on the idea of paralysing the receiver for the duration of each noise impulse—1/1000th second only. He determined that such periods of silence would not be noticeable to the ear, and that as many as 200 impulses per second could be handled if the time required to silence and subsequently restore the receiver operation were reduced to a few microseconds, the idea being as illustrated diagrammatically in Fig. 1. After several failures, the idea of using a supplementary A.V.C. circuit, delayed sufficiently to prevent it from operating on signal peaks, and so arranged that its time constant was nearly zero, was arrived at. While there were many obstacles to be overcome, it showed promise from the start, and after a year or more spent in refinement of design, the "Silencer" at last reached the form which is to be described in the remainder of this paper.

As shown in Fig. 2, the silencer consists of an auxiliary I.F. amplifier stage feeding a full-wave diode rectifier which rectifies the noise impulses, furnishing sufficient D.C. voltage across its load resistance to cut-off the plate current of the second I.F. valve, and reduce its gain to zero, for the duration of the noise impulse.

The auxiliary I.F. stage consists of a sharp cut-off H.F. pentode fed from the secondary of the I.F. transformer, with its grid connected in parallel with the grid of the second I.F. valve in the receiver. It is connected to the second stage, as the gain preceding the noise rectifier must be sufficient to insure the presence across the diode of sufficient voltage, on noise impulses, to furnish the necessary control voltage to reduce the gain of the controlled valve to zero on impulses of moderate value.

The noise rectifier is coupled to the auxiliary amplifier by means of transformer T3, which is flatly tuned and has a centre-tapped secondary for feeding the full-wave rectifier. This method of rectification was found necessary because of the almost complete balancing out of the fundamental frequency in the output circuit. As the time constant of the load resistance, filter and by-pass condensers must be kept down to a low value, it is difficult to obtain good filtering; and to prevent instability, the unrectified I.F. present in the diode output must be kept very small,—lower in value than can be achieved with a half-wave rectifier.

respect to signal variations, and yet permitting the silencing to take place on noise impulses which just reach objectionable amplitudes.

While the diagram shows a 6L7 valve in the second I.F. stage, this valve was not available during the early work on the

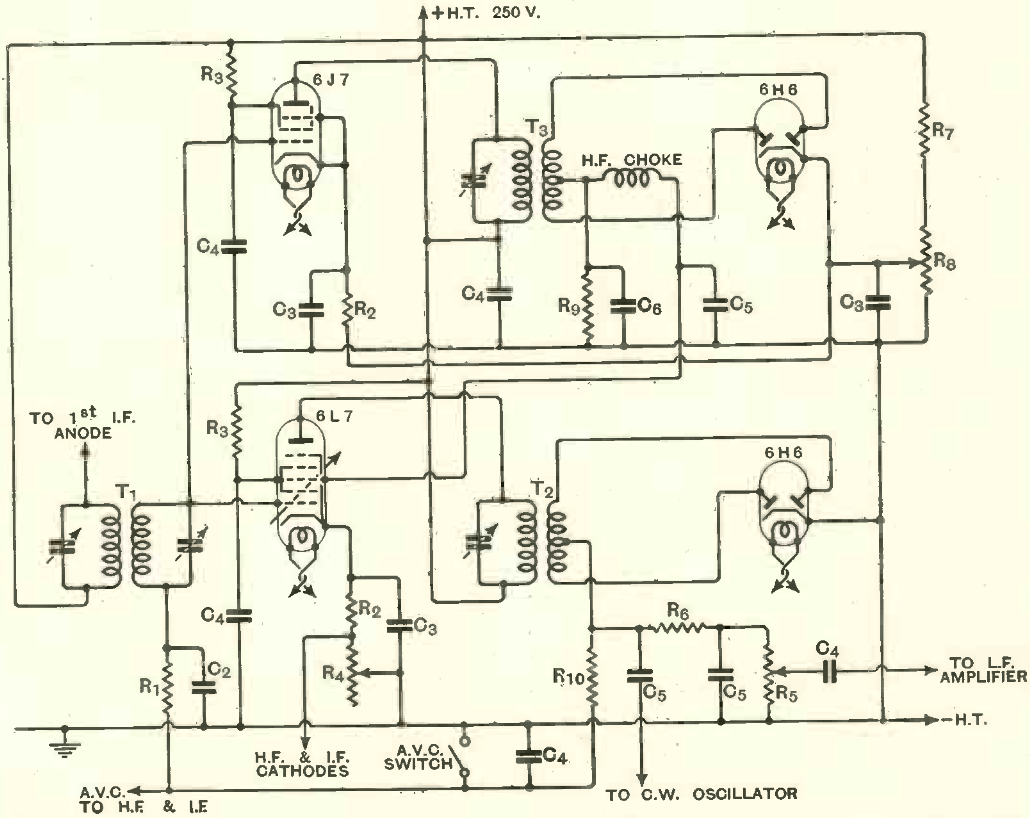


Fig. 2.—*The circuit of the noise suppressor applied to a superheterodyne. The 6L7 valve is the second I.F. stage of the receiver and its output feeds a diode detector in the usual way. The 6J7 valve and the second diode form the noise suppressor.* R_1 *— 100,000Ω, ½ Watt;* R_2 *— 350 to 1,000Ω, ½ Watt;* R_3 *— 100,000Ω, ½ Watt;* R_4 *— 5,000 Ω I.F. Gain Control;* R_5 *— 1,000,000Ω L.F. Vol. Control;* R_6 *— 50,000Ω, ½ Watt;* R_7 *— 20,000Ω, 1 Watt;* R_8 *— 5,000Ω, Noise Threshold Control;* R_9 *— 100,000Ω, ½ Watt;* R_{10} *— 1,000,000Ω, ½ Watt;* C_2 *— 0.01 μF 200 v.;* C_3 *— 0.1 μF 200 v.;* C_4 *— 0.1 μF 400 v.;* C_5 *— 50 μμF (mica);* C_6 *— 0 to 250 μμF (mica);* T_1 *— Double Tuned I.F.T.;* T_2 *— Either centre-tapped or normal single or double tuned I.F.T.;* T_3 *— Tuned Plate, very tight coupling, broad tuned; H.F.C. 20 mH. Choke.*

The anodes of the noise rectifier are made negative with respect to the cathode to prevent the rectification of desired signals. This negative bias, or delay, can be adjusted by the potentiometer R_8, and is normally set at about twice the peak value of the signal applied to each anode of the 6H6,—thus allowing a reasonable margin of safety with

silencer—so several other valves were tried with little success. The only other valve which can be used with any degree of success is the 6A7 (heptode), although when the number 1 grid was biased to cut-off by the noise rectifier, the gain was not reduced to a sufficiently low value to cause satisfactory silencing because of coupling between the number 1 and number 5 (to which the signal was applied) grids. At present, therefore, the success of the silencer is largely dependent on the use of the 6L7 as the controlled second stage I.F. valve, and no substitute can be recommended.

When checking the operation of the receiver with silencer, the voltages on the tube elements should first be measured. With a total plate supply voltage of 225, the 6L7 and 6J7 screens should be approximately 90 volts above earth; the cathode of the 6L7 should be 3 volts positive, while that of the 6H6 should normally be 6 volts positive. The rectified D.C. developed across R_9 and applied to the number 3 grid of the 6L7 should be 10 volts for total silencing. These voltages are correct for a signal voltage (peak) of 3 to 4 applied to each plate of the noise rectifier. The H.F. and I.F. valves should have their minimum bias and A.V.C. voltages adjusted so that the signal will be held at the proper level, for if a strong signal is not reduced sufficiently by the A.V.C. action, the signal peaks will be mutilated, while if the gain with weak signals is allowed to fall off, the detector input will be too low for optimum silencing, and the signal-noise ratio will not be as great as with the proper signal level.

The foregoing refers to the reception of telephony for which A.V.C. will normally be employed. For the greatest freedom from noise, therefore, a form of A.V.C. capable of keeping the detector input at a nearly constant level should be used. While the simpler forms may be employed, or in fact the receiver may be operated with manual gain control as is usually done for C.W. reception, it will be necessary to readjust the threshold or delay voltage more frequently, particularly when receiving signals which are but little above the noise level. However, this adjustment soon becomes automatic, so that with a little use, the listener will hardly be conscious of shifting the threshold for varying signal levels. While discussing the importance of A.V.C., it might be well to mention that in some cases better results are secured when the noise-amplifier valve is not controlled by the A.V.C. system.

This noise amplifier should be of the sharp cut-off H.F. pentode type, as the threshold (point at which the silencer goes into action) is much more sharply defined than would be the case were a valve of the variable-mu type used.

At this point, the receiver should operate just as efficiently as it did before adding the silencer—if the slider on R_8 is set well toward the positive end. It should be possible to reduce the voltage between R_8 and ground to 5 or 6 volts without affecting the receiver operation. However, if this voltage be reduced still further, and if a station of fair strength is received, a point will be reached at which the signal peaks will be silenced. The delay voltage to the noise rectifier, controlled by the slider on R_8, should now be increased to the point at which normal signals are not silenced.

A series of measurements on a receiver equipped with silencer showed that an improvement in signal to noise ratio of 20 to 30 db should be realised—varying with the signal strength, which was very weak to medium. Noise was furnished by an automobile spark coil, operated near the receiver. With the spark coil operating and the receiver tuned to the strongest local signals, nothing could be distinguished through the noise, until the silencer was put into operation. Oscillographic examination showed that the silencer prevented any noise impulse from exceeding the peak voltage of the signal, so that the requirements for "silencing" were more than fulfilled.

The silencing was equally successful from 30 megacycles down to 0.5 megacycle. The 14 and 28 megacycle bands were completely blanketed, at the time of the tests, by automobile ignition interference—which was so bad that *no signal* could be heard. When the silencer was put into operation, it was so effective that several hundred signals could be heard plainly, and could have been copied without difficulty. Also, European broadcasts were heard very well through the interference which but a moment before had been so devastating.

For the experimenter who would be interested in further improving the action of the silencer, it would seem that, if the delay voltage were to be maintained automatically at a constant difference from the signal voltage, the silencing action would be more nearly perfect over a wide range of signal strengths. In view of the range over which the cathode to ground voltage of the

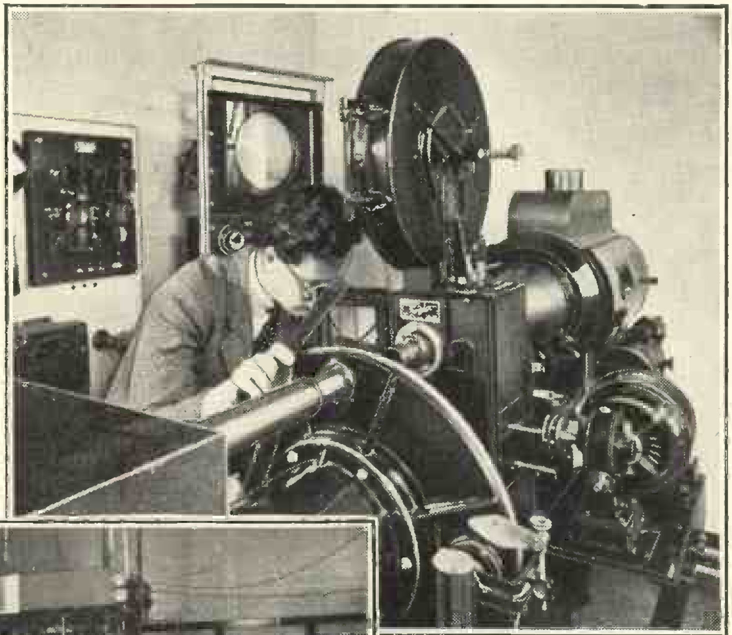
6H6 and 6J7 must be varied, it would probably be necessary to employ some form of amplified A.V.C. to accomplish this.

For communication purposes the silencer should prove a very useful improvement, but the listener interested in high quality reproduction of musical programmes should use every means at his disposal (aerial location, shielded lead-in with appropriate impedance-matching transformers, overall receiver shield, and mains filters) before calling on the silencer. However, if lifts, trams or other similar apparatus are responsible for the noise, the silencer may be the means for converting chaos into entertainment.

In closing, the writer would like to voice his personal views regarding the importance of the silencer, and since he had no part in its development, his opinion may be taken as unbiased. To him it would seem the most important step since the introduction of the superheterodyne or, perhaps, the screen grid valve, and would seem likely to be part of all future high-grade communication receivers, and also many of the best all-wave receivers.

Television Research

Work at G.E.C. Laboratories



In preparation for the high-definition television transmissions by the British Broadcasting Corporation, which are expected to start this month, the Wembley laboratories of the General Electric Company are engaged in development work, principally connected with the receiving side, but problems of transmission have, naturally, to be studied concurrently. The photographs show a high-definition scanning apparatus and, below, work in progress on large cathode-ray tubes. One tube is seen being exhausted, whilst on the right a new tube is being tested. Four of the large tubes can be seen in the foreground.

Automatic Tuning*

Some Applications of the Principle to Test Apparatus

By Frank L. Hill, B.Sc.

HAVING had some trouble with beat frequency oscillators employing a motor driven condenser to give a continuously varying output frequency, the author was led to examine the possibility of replacing this somewhat unwieldy component by something more flexible and more under the control of the operator.

The first step in the search for an alternative method of frequency variation is shown in Fig. 1 (a).

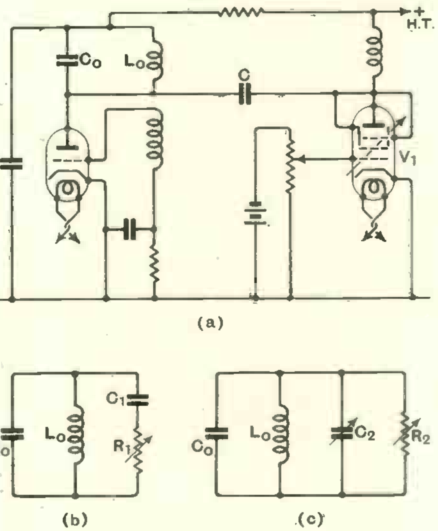


Fig. 1.

The oscillator shown is one of two which feed through buffer amplifiers into a common detector, producing a beat tone. The oscillator shown in Fig. 1 is the variable oscillator, the other operating at a fixed frequency. Across the valve and therefore virtually in parallel with the tuned circuit of the variable oscillator are connected in series a small condenser and a variable-mu pentode valve, connected as a triode. The anode of this valve is fed through a high inductance choke from the H.T. supply.

Fig. 1 (b) shows the equivalent circuit, C_1 being the capacity of the condenser C, in Fig. 1 (a) and R_1 the anode impedance of the valve V_1. This is equivalent to the circuit of Fig. 1 (c) where

$$R_2 = R_1 + \frac{1}{\omega^2 C_1^2 R_1} \text{ and } C_2 = \frac{C_1}{1 + \omega^2 C_1^2 R_1^2}$$

The capacity C_2 is shunted across the tuned circuit, and it will readily be seen that if R_1 is varied from infinity to zero, C_2 will vary from zero to C_1. R_1 may be conveniently varied by varying the bias on V_1. At the same time R_2 varies from infinity when R_1 is infinite through a minimum value of $2R_1$ when $R_1 = \frac{1}{\omega C_1}$ to infinity when R_1 is zero.

This shows one of the disadvantages of this circuit; the damping on the tuned circuit varies as the frequency is varied. From the above it is shown that the shunt resistance is a minimum and hence the damping a maximum when $R_1 = \frac{1}{\omega C_1}$ and the shunt resistance never falls below $\frac{2}{\omega C_1}$. Hence if the condenser is small, the maximum damping may be made small compared with the damping already existing in the circuit. For example, if the working frequency is 100 kc/s., and C_1 is 64 $\mu\mu$F. the minimum value of R_2 is 50,000 ohms. If the initial damping is fairly high this amount of extra damping will not vary the output of the oscillator to an appreciable extent. With the above values of capacity, in order to obtain a range of beat frequency from zero to 10,000 cycles per sec. (a 10 per cent. frequency change), 64 $\mu\mu$F. must represent

* MS. accepted by the Editor, February, 1936.

20 per cent. of the total capacity if R_1 is to vary from infinity to a small value. Hence C_0 is 320 $\mu\mu$F. and L_0 is about 8mH.

A second and more serious trouble with this circuit is due to rectification in the control valve V_1, which results in waveform distortion in the output. To overcome this the circuit of Fig. 2 was used. Here the control valve is shunted across the tuned circuit as before, but is now connected as a

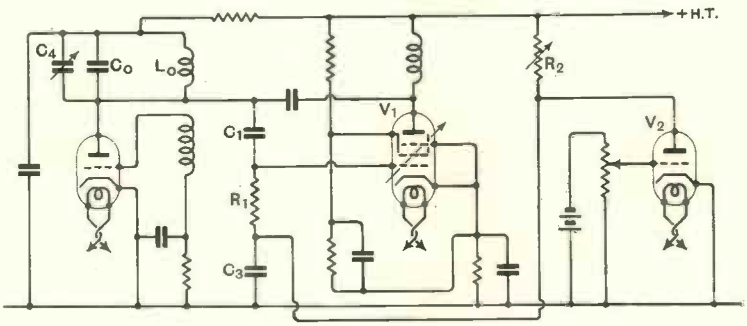


Fig. 2.

pentode and owing to its high impedance has only a small shunting effect on the tuned circuit.

The principle of action of the circuit is as follows: the condenser C_1 is such that its reactance at the working frequency is high compared with R_1 so that the current round the circuit C_1R_1 C_3 due to the oscillatory voltage across the tuned circuit is very nearly 90° out of phase with this voltage, and since the voltage across a resistance is in phase with the current through it, the voltage applied to the grid of V_1 is 90° out of phase with the voltage across the tuned circuit. (C_3 is very large compared with C_1.) The alternating component of the anode current of V_1 is in phase with the grid voltage since the external circuit impedance is low compared with the internal valve impedance. Hence the current through V_1 is 90° out of phase with the voltage across the valve and the valve functions as a reactance, and is equivalent to a condenser shunted across the tuned circuit.

Suppose the voltage across the tuned circuit is E volts R.M.S. The voltage applied to the grid of V_1 is $R_1E\Big/\sqrt{R_1^2 + \frac{1}{\omega^2C_1^2}}$ or, since $\frac{1}{\omega C_1}$ is large compared with R_1 the voltage is approximately $R_1\omega C_1E$. The alternating anode current is $gR_1\omega C_1E$ where g is the mutual conductance of V_1. Now since the voltage across V_1 is E and the current through it is $gR_1\omega C_1E$ the impedance is $\frac{1}{gR_1\omega C_1}$, and since the current is 90° out of phase with the voltage this impedance is a reactance and is equivalent to a condenser of capacity gC_1R_1 across C_0.

It is evident that by using this circuit it is possible to vary the capacity and hence the frequency by varying the grid bias, without altering the damping and without introducing distortion.

Having obtained an arrangement whereby the frequency is controlled by voltage, it remains to provide a means of varying the voltage with time. The circuit used is shown in Fig. 2, and it will be seen that it is essentially the same as the familiar cathode ray time base circuit. The condenser C_3 is charged through the high resistance R_2 from the high tension supply, until the voltage across C_3 reaches the flash voltage of the thryatron V_2, when C_3 is discharged and the process repeated. The high tension voltage is high compared with the flash voltage of V_2 so that the voltage across C_3 increases in an almost linear manner with time, and this voltage is applied to the grid of the control valve V_1.

In an actual oscillator the cathode of V_1 is kept at + 50 volts by a potentiometer arrangement, and the grid bias is varied from − 50 to − 3 volts by the arrangement described above. Over this range the mutual conductance increases approximately exponentially and since the change in capacity is proportionate to the mutual conductance, the beat frequency-time curve is nearly logarithmic, that is the beat frequency passes through equal numbers of octaves in equal times.

The controls are (1) a trimmer C_4 across C_0 to control the initial frequency, (2) grid bias on the thyratron to control the frequency at the end of the sweep and (3) the charging resistance to regulate the rate of sweep. Various settings of C_4 give three conditions, as shown in Fig. 3, in which the frequency scale is logarithmic from 10,000 cycles to 100 cycles and linear below 100 cycles. In curve (a) the frequency of the variable oscillator is initially lower than the

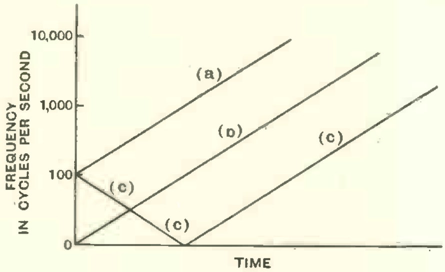


Fig. 3.

fixed oscillator so that the beat frequency increases from 100 cycles to 10,000 cycles/sec. In curve (b) the two oscillators are initially at the same frequency and the beat changes from zero to the upper limit. In curve (c) the variable oscillator is set to a higher frequency and the beat tone starts at say 100 cycles per sec. and decreases to zero and then increases to the higher frequencies. This is very useful for loud speaker testing as the lower frequencies, where rattles and buzzes are likely to occur are traversed twice. Also the gliding tone goes through the low frequencies slowly and the high frequencies more rapidly. Unlike the motor driven condenser, this arrangement returns instantaneously to the initial conditions at the end of the sweep.

The time of sweep for loud speaker testing is adjusted to between 10 and 15 seconds.

In setting up the apparatus the "time of sweep" control is set at about one second to facilitate the adjustment of the upper and lower limits. C_4 is adjusted first to give a curve similar to that of Fig. 3 (c). Bias on V_2 is then adjusted to give the required highest frequency which may be anything up to 10,000 cycles per second.

Another application of this circuit is for observing resonance curves of receivers, band pass filters, and similar apparatus, and for alignment of receivers by cathode ray oscillograph. A typical circuit is shown in Fig. 4. Here there is only one oscillator and this is arranged to sweep over a limited range of frequencies on each side of the resonant frequency by means of a circuit similar to that described above. The output is fed into the receiver, the H.F. output from which is rectified by a diode and passed through a low pass filter, the resulting D.C. being applied to the vertical deflecting plates of the oscillograph; the deflection being proportional to the gain at any particular frequency.

The frequency change in the oscillator is proportional, over a small range, to the capacity change, which is in turn proportional to the mutual conductance of V_1. If the voltage change across C_3 is fairly small the change of mutual conductance with grid bias may be made almost linear. If now the voltage across C_3 is applied to the horizontal deflecting plates of the oscillograph, the spot will move across the screen so that the deflection is approximately proportional

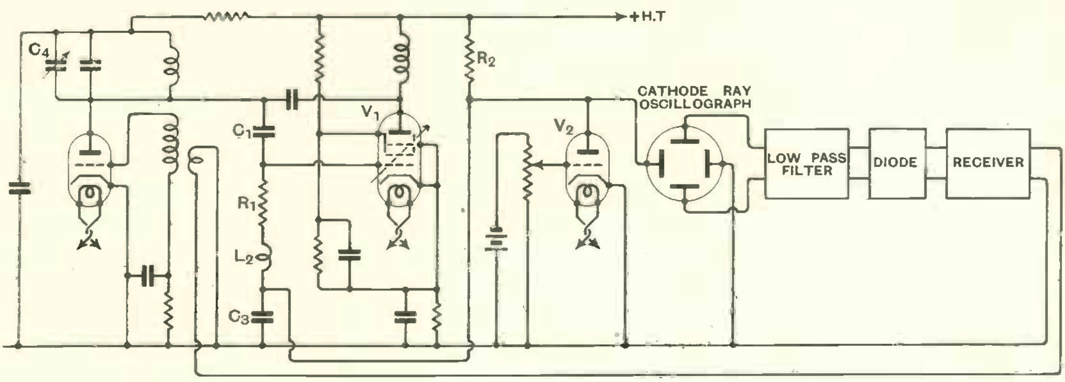


Fig. 4.

to the change of frequency, so that the curve traced out on the screen will be a frequency-response curve on a linear frequency-base.

For use with the oscillograph the period of the time base is made very short, say 25 to 50 periods per second in order to give a continuous curve. To obtain sufficient change of frequency with only a small change of bias it is necessary to increase C_1 or R_1 so that a greater A.C. voltage is applied to the grid of V_1, but a limit is imposed by the fact that unless R_1 is small compared with the reactance of C_1 the grid voltage will not be 90° out of phase with the anode voltage, so that the valve will function as a capacity and resistance in series, and the damping and hence the output will vary with bias, giving a distorted curve. A small inductance L_2 (Fig. 4) may be used to correct the phase angle and so increase the frequency range.

The use of a set-up such as this is very much more convenient than the rotating condenser ganged to a potentiometer for frequency shift and time base respectively of the usual factory gear for cathode ray ganging, from the point of view of both the operator and the maintenance man.

The instances given are but two uses to which the change of frequency by valve circuits has been applied to test equipment, but the possibilities are by no means exhausted, and other uses will doubtless be found, particularly with the growing tendency to use cathode ray tubes for test gear.

Book Review

Wireless Servicing Manual.

By W. T. Cocking. 213 pages, 90 photographs and diagrams. Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 5s. net.

The outstanding feature of this book is the very wide ground that it covers. The title might suggest that it was built up on the lines of some of the Service Manuals issued with commercial sets, and that it prescribed a series of routine tests with a view to the mechanical discovery of a fault. But the book is intended to provide guidance for fault-finding in sets of every type and class ; such a method of approach would lead to impossibly complicated tables of tests, so that the writer has very wisely tackled his subject from quite a different angle.

Beginning with a description of the apparatus required for checking and adjusting a set—meters for currents and voltages and a test-oscillator are the chief—the book briefly but very sufficiently covers the checking of voltages and anode currents, and points out very completely the deductions that can be made from these readings. The next chapter, on faults in valves, is the only one in the book that the reviewer feels in the least inclined to criticise ; it is very brief, and suggests as the sole test the measurement of mutual conductance. But probably this is accounted for by the large amount of elaborate apparatus needed for a really complete series of tests on a valve, so that the serviceman would in any case have to fall back on the old and very effective trick of trying a new valve in the set.

All this is barely one-fifth of the book ; the rest of it deals with the symptoms, cause and cure of every kind of fault. It is particularly to be noticed that the treatment does not limit itself to finding the cause of breakdown in a set that has previously been satisfactory ; the discussion is always broad enough to cover the localisation of a fault in a newly built set and to provide information as to the way in which the trouble can be overcome by a suitable modification in design. The book should, therefore, be every whit as valuable to the home-constructor and the amateur set-designer who tries to put his own ideas into practice as to the serviceman who knows the design to be sound and has only to find which component has broken down. Even the professional designer will find within its covers a ready solution of many of his perplexities.

The treatment of the causes and cure of the various whistles likely to appear in a superheterodyne is particularly valuable, being both clear and comprehensive. The two tables which show the frequencies upon which each of the English stations can produce whistles should be extremely helpful in tracking down the mechanism by which such interference arises. Considerable attention is paid to the ill-effects of feed-back of I.F. harmonics from the second detector—a very important point that seldom gets the emphasis it deserves.

The difficult subject of ganging is dealt with in a particularly lucid and helpful way, every stage in the process of aligning a set, whether a " straight" set or a superheterodyne, being made clear in principle and explicit in practical detail. Though the serviceman is completely catered for here, the designer should note that little emphasis is laid on the possibility of incorrect coil-inductance, especially in connection with the superheterodyne.

Such obscure faults as modulation hum, oscillation at a frequency controlled by a reaction winding instead of the tuned circuit, and the upsetting of ganging by wrong choice of value for a by-pass condenser are all discussed, together with their cures. There is, indeed, hardly any misbehaviour of a set, whether inherent in the original design or arising through the breakdown or deterioration of a component, the cause and cure for which cannot be found somewhere in the two hundred pages of this book.

The book winds up with three extremely useful appendices—a dozen pages of potted facts and figures—and an adequate index. Finally, it is to be hoped that the strictly professional implication of the title will not discourage the purchase of the book by the wide circle of amateur enthusiasts who would find it both interesting and useful.

A. L. M. S.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

2502. HYPER-FREQUENCY WAVE GUIDES—GENERAL CONSIDERATIONS AND EXPERIMENTAL RESULTS [Propagation of Micro-Waves of 15 cm and Under along " Guides " (without Return-Current Path) consisting of Insulator alone or Insulator (*e.g.* Air) surrounded by Conductor].—G. C. Southworth. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 284–309.)

" For short-distance transmission or for use as antennas or projectors of radio waves or for selective elements analogous in nature to the tuning elements so commonly used in radio, there are not the same economic conditions [discussed earlier] limiting the size of structure. For such uses, then, structures of this type deserve serious consideration." One interesting type of wave (out of the four, at least, existing) is seen by theory to have progressively less attenuation as its frequency is increased: but this type requires a higher range of frequencies, for a given " guide," than the other three, and is therefore even more difficult to deal with as regards economic and practical problems. *See* also 2503 and 2504, and *Wireless Engineer*, June, 1936 (Editorial).

2503. ELECTRIC WAVE GUIDES [and the Holmdel Experiments].—G. C. Southworth. (*Bell Lab. Record*, May, 1936, Vol. 14, No. 9, pp. 281–287.)

See also above. " The open end of a guide may be made to radiate wave power much the same as sound waves issue from a pipe. To enhance this effect the pipe may be expanded into a cone, thus producing an electrical horn. Tests show that it may be used as an efficient radiating load for the generator to which it is connected."

2504. HYPER-FREQUENCY WAVE GUIDES—MATHEMATICAL THEORY.—J. R. Carson, S. P. Mead and S. A. Schelkunoff. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 310–333.)

History and mathematical analysis of the wave transmission dealt with above (2502 and 2503). " Out of this research there emerged the remarkable fact that with hollow conducting guides there exists *one* and only *one* type of wave the attenuation of which *decreases* with increasing frequency ; a unique characteristic which does not attach to dielectric wires nor, so far as the writers are aware, to any other type of guided wave."

2505. SELECTIVE FADING ON ULTRA-SHORT WAVES [Slow Fading, Rapid " Scintillation " : Winter Fall of Signal Intensity : Multiple Path Transmission demonstrated by Frequency Sweep Method : Explanation by Atmospheric Stratification, supported by Dielectric Constant Measurements at Different Heights].—C. R. Englund, A. B. Crawford, and W. W. Mumford. (*Nature*, 2nd May, 1936, Vol. 137, pp. 743–744.) For previous work *see* 3314 of 1935.

2506. THE DIFFRACTIVE PROPAGATION OF RADIO WAVES.—Wwedensky. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 163–176.) *See* 1703 of May.

2507. AN URBAN FIELD-STRENGTH SURVEY AT THIRTY AND ONE HUNDRED MEGACYCLES [Apparatus and Results : Attenuation Values for 1–10 Miles' Range : Effect of Elevation Profiles : Transmitter Power for 100 μV Input in Typical Houses : etc.].—R. S. Holmes and A. H. Turner. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 755–770.)

2508. THE D REGION OF THE IONOSPHERE [Reflecting Region at Heights 5–50 km].—R. C. Colwell and A. W. Friend. (*Nature*, 9th May, 1936, Vol. 137, p. 782.)

The writers have used 60-per second pulses each lasting 10 μsec., and received them at 200 m distance with a special receiver with a wide band-pass and short lag characteristics. Frequencies used were 1 614 and 3 492.5 kc/s. Visual observation upon a cathode-ray oscilloscope with a rapid sweep showed the " ground " wave to be resolved into " two or three parts, one or two of which are waves reflected from a low-lying [D] region in the ionosphere. These layers are about 20 km and 45 km above the ground on the average and are strongly reflecting for waves in the broadcast band. The lower one rises and falls with changes in the barometric pressure," and causes fading on nearby broadcasting stations. When the intensity of D reflections increases, that of E and F regions decreases. *See* also 2509 and 2510.

2509. Return of Radio Waves from the Middle Atmosphere [Very Complex Echo Systems due to Return from Heights between 6 and 60 km: Apparent Existence of Three Regions, approx. 6–10 km, 15–50 km, and 60 km: Middle (and probably Lowest) Region replenished by Local Thunderstorms].—Watson Watt, Bainbridge-Bell, Wilkins and Bowen. (*Nature*, 23rd May, 1936, Vol. 137, p. 866.)

Reporting results in England confirming and amplifying the American indications dealt with in 2508. The observations were mainly in the frequency range 6–12 Mc/s, but " in some isolated trials on notably higher frequencies—including those proposed for television services—we have not yet attained a frequency so high that its return from the middle atmosphere can be regarded as unusual." *See* also 2510.

2510. Return of Radio Waves from the Middle Atmosphere [Reference to Indian Observations of Reflection at and much below 55 km: " C " Region suggested as Name].—S. K. Mitra. (*Nature*, 23rd May, 1936, Vol. 137, p. 867.)

Referring to the American results dealt with in 2508, attention is called to the Indian work dealt with in 2539 of 1935 and 2078 of June. Since the new region is quite distinct from the absorbing, non-deviating " D " region in the E layer (*see* 3750 of 1935), the writer suggests that it should be called the C region. If echoes have actually come from well within the troposphere, it is doubtful if they were due to the Eccles-Larmor mechanism, for the necessary high degree of ionisation, if it existed, could scarcely have been missed in aeroplane and balloon observations.

2511. The Division of the Appleton (F) Region of the Ionosphere into Two Parts.—J. Fuchs. (*Naturwiss.*, 10th April, 1936, Vol. 24, No. 15, pp. 236–237.)

The writer refers to a previous paper (1705 of May: *see* also 2084 of June) in which he estimated the temperature of F_1 region as 400° K and that of F_2 region as 1400° K. He here attributes the formation of F_2 region to the thermal expansion and rise of photoelectrically excited particles; the non-excited particles are found to remain at their original height as F_1 region. After sunset F_2 region contracts again and unites with F_1 region.

2512. Ionospheric Electron Temperatures and the Hals-Störmer Echoes.—J. Fuchs. (*Gerlands Beiträge z. Geophysik*, No. 1/2, Vol. 47, 1936, pp. 1–14.)

Author's summary:—" In a former investigation [1705 of May: *see* also 2511, above] the author was able to show that the gas temperatures of the ionosphere are very high and can reach values from 400° K to more than 1000° K. This fact makes it necessary to examine also the influence of the temperature of the free electrons in those regions. It is found that at times of high solar activity the electron temperature may reach values of the order of 40 000 and thus, by the resulting action on the rate of recombination of the electrons, may fundamentally alter their distribution in the ionosphere. On the basis of this conception the Hals-Störmer echoes present themselves as phenomena of extreme conditions which occur mainly at times of very strong ultra-violet radiation from the sun (sunspot maxima)." At such times the increased electron temperatures produce a vertical gradient of the recombination coefficient, and a consequent displacement of the zone of maximum electron density upwards, *i.e.* to regions of smaller air pressure. At these higher levels the damping of the radio signals is so reduced, owing to the smaller collision frequency, that the long-delay echoes can occur.

2513. The Origin of the Long-Delay Echoes (Hals Echoes).—J. Fuchs. (*Ann. des Postes T. et T.*, April, 1936, Vol. 25, No. 4, pp. 346–355.) French version of the German paper dealt with in 356 of 1935: for later papers *see* 2166 of 1935 and 1705 of May; *also* 2512, above.

2514. The Accurate Determination of Ionospheric Equivalent Heights [and Detailed Investigation of E Region].—E. C. Halliday. (*Proc. Phys. Soc.*, 1st May, 1936, Vol. 48, Part 3, No. 266, pp. 421–432.)

Improved accuracy (±0.5 km) of equivalent height measurement was attained by using an open-scale time base, of which the circuit is given. Frequent snap photographs of the echo pattern were taken " in order to obtain a faithful record of quick variations of equivalent height." No sudden changes of height of E_1 or F_2 region were found; a secondary maximum of ionisation, a few kilometres below the maximum of E_1 region, was discovered. The height of E_1 region was shown to be less in winter than in summer, which may be due to " a general increase in molecular density in the atmosphere caused by the lower temperature of winter time "; the diurnal variation of height showed a height minimum several hours after midday. Data of the " abnormal E " region are also given.

2515. Ionosphere Studies during Partial Solar Eclipse of February 3, 1935.—Kirby, Gilliland and Judson. (*Journ. of Res. of Nat. Bur. of Stds.*, March, 1936, Vol. 16, No. 3, pp. 213–225.)

For a previous reference *see* 2161 of 1935. " The decrease of equivalent electron density in each region during the eclipse was compared with the decrease in the exposed area of the sun's disc, and found to indicate that the ionisation of the normal E region was diminished when the ionising agency was decreased, by recombination of + and − charges, while the ionisation of the F_2 region and a high stratum of the E was diminished, by a process of attachment of electrons to neutral particles."

2516. MEASUREMENTS OF THE INCIDENT ANGLE OF DOWNCOMING RADIO WAVES [Apparatus used and Results obtained].—Y. Kusunose and S. Namba. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, pp. 115–127.)

2517. ANALYSIS OF SIGNAL FADING OBSERVATIONS [of Calcutta 370.4 m Night Signals over 240 km: Partly (at least) due to Interference between Ground and Downcoming Waves with Constant Amplitudes and Random Phase Difference (Phase Fading): Ratio of Vertical Electrical Forces produced by Downcoming and Ground Waves estimated as between 3 and 4].—Sen Gupta and S. R. Khastgir. (*Indian Journ. of Phys.*, March, 1936, Vol. 10, Part 2, pp. 133–139.) In the authors' summary the ratio is erroneously reversed.

2518. THE AUTOMATIC RECORDING OF FADING PHENOMENA [with Constructional Details for Amateurs].—R. Theile. (*Funktech. Monatshefte*, April, 1936, No. 4, pp. 121–130.)

2519. THE DIELECTRIC CONSTANT OF A SPACE CONTAINING ELECTRONS [Variation with Electron Concentration and Frequency].—S. P. Prasad and M. N. Verma. (*Zeitschr. f. Physik*, No. 7/8, Vol. 99, 1936, pp. 552–561.)

The usual experimental method was followed of measuring the capacity between two plates with and without electrons in the intervening space. Two electrodes of a screen-grid valve were used for the plates, so that no gas was present to produce positive-ion films on the plates. The circuit used is described and shown in Fig. 1. The small changes of capacity were measured by comparison with a variable air condenser with parallel plates (Fig. 2). The dielectric constant was found to decrease both with increasing concentration and with decreasing frequency. A dielectric constant greater than unity was never observed. These results are found to agree with theory at high but not at low frequencies (Fig. 5).

2520. ELECTRON MOTION IN A PLASMA [Equation including Effect of Electron Pressure: Possible Frequencies of Free Vibration].—E. G. Linder. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, pp. 645–646: abstract only.)

2521. INTERACTION OF RADIO WAVES, THE "LUXEMBOURG EFFECT" [Survey of Data (including Swiss) and Theories].—V. Hardung. (*Bull. Assoc. suisse des Élec.*, No. 10, Vol. 27, 1936, pp. 268–272: in German.)

2522. COMMUNICATION *re* THE RADIO EXPERIMENTS ON THE DANUBE BETWEEN VIENNA AND PASSAU [Traffic between Ships on a Wavelength of 15 m].—V. Fritsch. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, pp. 89–91.)

For previous work *see* 1933 Abstracts, p. 319. The present note describes the network of stations and communications set up along the Danube between Vienna and Passau for the use of ships. The plan of the stations is seen in Fig. 1; Figs. 3, 4 show in greater detail two stretches of the river on which experiments with signals on a wavelength of 15 m were made. These are described; communication on this wavelength was reliable along certain stretches, but in others, which seemed geographically equivalent, various absorption and shadow phenomena were observed. However, satisfactory traffic could be maintained along the river on this wavelength.

2523. PHASE CHANGES IN OPEN OSCILLATING CIRCUITS AS A POSSIBLE METHOD OF ALTITUDE DETERMINATION FOR AIRCRAFT, *and* PHASE DIFFERENCES, AT DISTANT RECEIVER, OF TWO FREQUENCIES EMITTED AS COPHASAL MODULATIONS.—Bärner: Honoré. (*See* 2653 and 2652.)

2524. HELIUM CONTENT OF THE STRATOSPHERE AND OF THE AIR AT THE EARTH'S SURFACE [Probable Slight Increase of Sum of Helium and Neon in Stratosphere above that at Ground Level: Greater Constancy at Ground Level than in Stratosphere].—A. Lepape and G. Colange. (*Nature*, 14th March, 1936, Vol. 137, p. 459.) *See* also 3788 of 1935; and Paneth & Glückauf, 30 of January.

2525. THE ULTRA-VIOLET SPECTRUM OF THE NIGHT SKY [Intensity Curve: No Lines or Bands of Wavelength shorter than 3030 Å].—A. Arnulf. (*Comptes Rendus*, 27th April, 1936, Vol. 202, No. 17, pp. 1412–1414.)

2526. INFLUENCE OF TEMPERATURE ON THE ABSORPTION SPECTRUM OF OZONE [No Effect of Pressure on Measurements of Atmospheric Ozone: Data of Absorption Coefficients].—É. Vassy. (*Comptes Rendus*, 27th April, 1936, Vol. 202, No. 17, pp. 1426–1428.)

2527. MEASUREMENTS OF THE OZONE CONTENT OF THE LOWER ATMOSPHERIC LAYERS DURING THE WINTER AT ABISKO (SWEDISH LAPLAND) [Data: No Correlation discovered with Other Meteorological Data].—D. Barbier, D. Chalonge and É. Vassy. (*Comptes Rendus*, 4th May, 1936, Vol. 202, No. 18, pp. 1525–1527.)

2528. THE EVALUATION OF ULTRA-VIOLET SOLAR RADIATION OF SHORT WAVELENGTHS [and the Stability and Homogeneity of Atmospheric Ozone].—W. W. Coblentz and R. Stair. (*Proc. Nat. Acad. Sci.*, April, 1936, Vol. 22, No. 4, pp. 229–233.)

2529. RING AND DISK SOURCES [of Wave-Trains: Solutions of Wave Equation for Various Types of Source].—G. Green. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 922–934.) *See* also 31 of 1935.

2530. ON A FUNDAMENTAL PROBLEM IN DIFFRACTION [Plane Waves incident normally on Plane Screen pierced by Small Circular Aperture: Theoretical Solution as a Problem in Heat Conduction: Applicability to Other Wave Problems, in particular Acoustics].—G. Green. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 934–947.)

2531. PHOTOGRAPHIC PENETRATION OF HAZE [Hulburt's Results on Attenuation of Light in Lower Atmosphere extended to Eye Visibility of 20 Miles].—Nora Mohler. (*Journ. Opt. Soc. Am.*, May, 1936, Vol. 26, No. 5, pp. 219–220.) *See* 2547 of 1935.

2532. TRANSPARENCY AND REFLECTING POWER OF THIN SILVER FILMS FROM INFRA-RED TO ULTRA-VIOLET [Optical Constants of Silver: Film Structure].—F. Goos. (*Zeitschr. f. Physik*, No. 1/2, Vol. 100, 1936, pp. 95–112.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2533. LIGHTNING AND LIGHTNING CONDUCTORS.—P. Grenier. (*Bull. de la Soc. franç. des Élec.*, May, 1936, Vol. 6, No. 65, pp. 512–534: Discussion pp. 535–546.) Survey, including the work of Dauzère and of Viel & Gibrat. Lightning conductors, including the "radioactive" types, are discussed, together with the results obtained.

2534. DETERMINATION OF THE ZONES EXPOSED TO LIGHTNING STROKES, BY MEASUREMENTS OF THE ELECTRICAL CONDUCTIVITY OF THE AIR.—G. Viel. (*Ann. des Postes T. et T.*, April, 1936, Vol. 25, No. 4, pp. 356–380.) *See* also 895 of March.

2535. BREAKDOWN AND GAS DISCHARGE [Theory including Effect of Space Charge: Ionisation Effects].—W. Rogowski. (*Zeitschr. f. Physik*, No. 1/2, Vol. 100, 1936, pp. 1–49.)

2536. CLOUD-CHAMBER INVESTIGATIONS OF ELECTRICAL BREAKDOWN IN GASES [Confirmation, for Larger Electrode Distances, of Previous Conclusions].—E. Flegler and H. Raether. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 635–642.) *See* 3783 of 1935 and 1198 of March.

2537. ATMOSPHERIC ELECTRICAL DATA [for the Lower Atmosphere] IN THE NORTH GERMAN PLAIN.—K. Kähler. (*Naturwiss.*, 17th April, 1936, Vol. 24, No. 16, pp. 246–251.)

2538. AIR MASS ANALYSIS DEMANDS NEW WEATHER MAP [marked on Pile of Eight Glass Plates slightly Separated, each representing 2000 ft. of Height].—(*Sci. News Letter*, 4th April, 1936, Vol. 29, pp. 211–212.)

2539. A NEW RADIO SOUNDER [Radiometeorograph for Exploring Balloons].—V. Väisälä. (*Societas Scientiarum Fennica, Commentationes Physico-Mathematicae*, Vol. 8 [Nos. 13–24], 1936, No. 14, pp. 1–12: in German.)

Further development of the work referred to in 1933 Abstracts, p. 151. The new transmitter, which is light and cheap, gives a continuous record of several elements; each of these controls its own condenser, which is thrown in its turn into the oscillating circuit by means of a commutator. An important refinement is the inclusion of two fixed condensers, giving two "comparison" wavelengths: this plan eliminates, as it were, the transmitter and the unwanted variations to which it is subject, and reduces the measurements to a comparison of capacity values. A hot-wire thermometer is employed; the use of a condenser with a temperature-sensitive dielectric was tried but not adopted, owing to its greater inertia. The barometer is of aneroid type, specially designed.

2540. THE RADIO SOUNDERS FOR THE EXPLORATION OF THE STRATOSPHERE [Duckert Exploring-Balloon Transmitters].—A. Ehrismann: Telefunken. (*Funktech. Monatshefte*, April, 1936, No. 4, pp. 133–135.)

PROPERTIES OF CIRCUITS

2541. SOME RELATIONS BETWEEN TRANSIENT PHENOMENA IN SYSTEMS WITH SIMILAR FREQUENCY CHARACTERISTICS [Calculations of Relations between Limitations of Frequency Characteristic and Associated Transient Errors].—H. G. Baerwald. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 833–869.)

In these calculations "upper limits are obtained for the errors of transient responses to prescribed excitations when upper limits are given for the errors of the characteristic in limited frequency ranges, and when some relatively inferior information is supplied about the rest."

2542. THEORETICAL ANALYSIS OF AMPLIFICATION OF PULSES FROM AN IONISATION CHAMBER [Calculation of Shape of Output Pulse: Signal-to-Noise Ratio, &c].—E. A. Johnson. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 638: abstract only.)

2543. A FURTHER STUDY OF OSCILLATORY CIRCUITS HAVING PERIODICALLY VARYING PARAMETERS. PART II.—W. L. Barrow, D. B. Smith and F. W. Baumann. (*Journ. Franklin Inst.*, April, 1936, Vol. 221, No. 4, pp. 509–529.)

For I *see* 2106 of June. The present section gives experimental results on the spontaneous oscillation of resonant electrical circuits containing a varying inductance, and a theoretical and experimental treatment of forced oscillations with a sinusoidal motive force.

2544. DISTRIBUTION OF A.C. IN SOME CIRCUITS [Harmonics in Valve Oscillator: Möller's Error due to Neglect of Phase Differences between Currents in the Circuit Branches: Rayleigh's Special Case].—E. Livshitz. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, pp. 257–258.)

2545. A NOTE ON THE GRAPHICAL ANALYSIS OF ALTERNATING-CURRENT NETWORKS [and the Use of Circle Diagrams].—K. Spangenberg. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 657–662.)

Recent graphical analyses (*e.g.* Roder, 1933 Abstracts, p. 327) depend on the property, here proved, that: "In a network consisting of any number of linear bilateral impedances, connected in any manner whatsoever, and any number of generators of the same frequency, the locus of any voltage or current in the system will be a circle as any one self-impedance is varied so that its locus is a straight line in the complex plane."

2546. The Critical Conditions for Coupled Oscillating Circuits (Band Filters of Variable Band Width) [Remarks on Paper by Frühauf: Reply to Backhaus's Criticism].—H. Backhaus: H. Frühauf. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, pp. 94–95.) *See* 488 of February.

2547. Symmetrical F-Filters [Corrections to Footnote and Diagrams].—E. Selach and M. Zimbalisty. (*E.N.T.*, February, 1936, Vol. 13, No. 2, p. 73.) *See* 3816 of 1935.

2548. Cascade Push-Pull Amplifier in Class B Connection.—F. Schierl: Telefunken. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, p. 104: German Patent 621 463 of 1.9.1933.)

The distortion produced by transformers is lessened by connecting the cascade (Fig. 8) "so that the positive grid current of stages 3, 4 occurring during the transmission of one half-wave flows in a closed circuit with and in the same direction as the anode current of stages 1, 2 occurring during the same half-wave."

2549. Electro-Mechanical Analogies [and the Solution of Problems in Oscillatory Mechanics by Use of Equivalent Networks].—Warshavsky and Fedorovich. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1936, pp. 51–63.)

TRANSMISSION

2550. A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation [Theory and Practical Realisation: New York/Haddonfield Demonstrations: Simultaneous High-Quality Broadcast Programme and Facsimile Service: etc.].—E. H. Armstrong. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 689–740.) For previous references to the work *see* 941 of March.

2551. Frequency Control [of Short and Ultra-Short Waves] by Low Power Factor Line Circuits.—C. W. Hansell and P. S. Carter. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 597–619.) The full paper, a summary of which was dealt with in 2968 of 1935: *see* also 3846 of 1935.

2552. Ultra-High-Frequency High-Power Transmitter using Short Transmission Lines [for Frequency Stabilisation within 0.001%: 40–60 Mc/s: Final Amplifier using AW-200 Valves, having Useful Output around 40 kW for Class B Operation].—J. Evans. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 682–683: summary only.) *See* also *Electronics*, May, 1936, pp. 11–12.

2553. A Multi-Tube Ultra-High-Frequency Oscillator [Independent Oscillators pulled into Step by Concentric-Line Circuit: 54 Watts at 20% Efficiency on 120 cm Waves].—P. D. Zottu. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, p. 687: summary only.) *See* also *Electronics*, May, 1936, pp. 12 and 13.

2554. Description and Characteristics of the End-Plate Magnetron.—Linder. (*See* 2611.)

2555. A New Method of Modulating the Magnetron Oscillator [by Varying the Potential of Auxiliary Electrode: the "Grid Magnetron"].—J. Groszkowski and S. Ryżko. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 771–777.)

Experiments with an anode in the form of a truncated cone, in the hope of obtaining a uniform increase of oscillating current with rise of anode voltage, were unsuccessful—probably owing to space-charge effects. The auxiliary electrode scheme was tried next, with success.

2556. Micro-Wave Modulation by Speech Voltages on Grid and Plate separately, causing No Frequency Change.—Morita. (*See* 2866.)

2557. The Dual Nature of Modulation.—E. Z. Stowell and A. F. Deming. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 947–958.)

"The paper endeavours to establish the equivalence of the two points of view brought forth in the [side-band] controversy, namely, that a [amplitude-] modulated wave may consist either of a carrier of constant amplitude accompanied by side-bands or of a wave of a single frequency but with varying amplitude. The response of a resonant circuit is computed for both types of excitation and is found to be the same for each. . . . Practical examples of both points of view are given and the conditions under which it is advantageous to adopt one point of view in preference to the other are discussed." For references to the controversy *see*, for example, 970 of 1935.

2558. Modulation Distortion [and an Analysis of Double- and Single-Sideband Transmissions, and Their Behaviour as regards Detection, Fading, AVC, etc.].—P. J. Wuite. (*Tijdschr. Nederlandsch Radiogenoot.*, April, 1936, Vol. 7, No. 4, pp. 99–114: in Dutch.)

2559. The Effect of Carrier Control [*e.g.* "Floating Carrier" Modulation] on the Quality of Reception.—W. Lampe. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, p. 533: summary only.) Tests with many different kinds of receiver. A satisfactory compromise between economy and quality is obtained by a suitable choice of "carrier ratio." The work of Brückmann (2610 of 1935) is not mentioned.

2560. Distortion in H.F. Class B Amplifiers: Part I [Linear Distortion in the Lower and Upper Parts of the Musical Spectrum, Causes and Prevention: Non-Linear Distortion and the Curvature of the Dynamic Characteristics].—L. Rubin. (*L'Onde Élec.*, May, 1936, Vol. 15, No. 173, pp. 299–315.) To be continued: practical results at the Lyon-Tramoyes station will be included.

2561. Automatic Compensation for Class B Bias and Plate Voltage Regulation.—R. J. Rockwell and G. F. Platts. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 553–558.)

The system described provides a bias source requiring a much smaller amount of power, and a bias system with essentially perfect regulation; it also provides over-compensation by which the plate-voltage regulation can be corrected, thus preventing distortion during heavy modulation.

2562. Calculation and Design of Class C Amplifiers.—F. E. Terman and W. C. Roake. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 620–632.)

Extension of the method dealt with in 1934 Abstracts, p. 325. It is assumed that the total space current $I_p + I_g$ is proportional to $(E_g + E_p/\mu)^a$, where the constant a is usually close to three halves. The accuracy of the method is seen to be satisfactory for all ordinary design requirements.

2563. Supplementary Notes on "Analysis of the Operation of Vacuum Tubes as Class C Amplifiers" [Exact Location of Dynamic Characteristic satisfying "Double Equilibrium" Condition].—I. E. Mouromtseff and H. N. Kozanowski. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 654–656.) *See* 3389 of 1935.

2564. The Frequency Constancy of a Quartz-Controlled Broadcasting Transmitter [Leipzig Stabilising Equipment and Results].—H. Jacobs. (*E.T.Z.*, 30th April, 1936, Vol. 57, No. 18, p. 500: summary only.)

2565. The New Portable Transmitting Equipment of the German State Broadcasting Company [for Outside Broadcasts: as used at Olympic Winter Games].—Hoffmann and Tuchel. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, pp. 514–517.)

RECEPTION

2566. Amplification on Ultra-Short Wavelengths [Performance of USW Superheterodyne greatly Improved by Single Stage of Signal-Frequency Amplification].—W. T. Cocking. (*Wireless World*, 17th April, 1936, Vol. 38, pp. 384–385.)

2567. A Novel Low-Cost Ultra-High-Frequency Receiver [Super-Regenerative Circuit using Pentagrid Converter, Oscillator Section on Quench Frequency and Pentode Section as H.F. Detector].—R. O. Williams. (*QST*, May, 1936, Vol. 20, No. 5, pp. 22–23 and 84.)

2568. German Reflex Receiver for 10 Metres [with One H.F. Pentode as Untuned Pre-Detector Stage and L.F. Output Valve: for Headphones].—(*World-Radio*, 24th April, 1936, Vol. 22, p. 12.)

2569. The HRO Receiver of the Société Française "National" [American Type, with Crystal-Controlled I.F. Stage].—P. Besson. (*L'Onde Élec.*, May, 1936, Vol. 15. No. 173, pp. 316–331.) For telegraphy, the crystal gives very sharp selectivity: for telephony, it is used to cut out a particular interfering station without harming the quality of reception.

2570. Crystal Filter Design [for High-Fidelity Superheterodyne Receivers].—W. W. Waltz. (*Rad. Engineering*, Jan., Feb., March and April, 1936, Vol. 16, Nos. 1/4, pp. 7–10, 14–17, 16–17, and 12–14.)

2571. Regeneration and Quality [and the Future Application of Principles of the Stabilised Feedback Amplifier to Broadcast Receivers].—Black. (*Rad. Engineering*, April, 1936, Vol. 16, No. 4, p. 2: Editorial note.)

2572. Improving Diode Detector Performance [Effect of A.C.-Load/D.C.-Load Ratio on "Modulation Capability"].—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 18–19.)

2573. Advanced Design of Class AB Amplifiers [Avoidance of Distortion due to Coupling Transformer, by replacing by Non-Inductive Coupling Network: Use of High-Power-Sensitivity Metal Valves Type 6F6: etc.].—M. Apstein. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, pp. 12–14.) "By an unfortunate coincidence in the design of conventional test equipment, this type of distortion is usually least serious in the region of frequencies [around 400 c/s] at which most amplifier and tube ratings are made."

2574. Valves for Tone Correction [Severe Harmonic Distortion, due to Low Anode-Circuit Load at Certain Frequencies, avoided by Combination of Suitable Valve and Correct Circuit Constants].—W. Winder. (*Wireless World*, 8th May, 1936, Vol. 38, pp. 465–466.)

2575. The 1936 Battery-Operated Receiver.—E. E. Horine. (*Rad. Engineering*, February, 1936, Vol. 16, No. 2, pp. 8–13.) The battery-operated receiver "has finally come into its own."

2576. The Battery Variable-Selectivity IV.—W. T. Cocking. (*Wireless World*, 8th and 15th May, 1936, Vol. 38, pp. 458–461 and 480–483.)

2577. German Receiver Development for the European Market.—(*Funktech. Monatshefte*, April, 1936, No. 4, pp. 141–143.)

2578. Tested Circuits for 2-Volt Screen-Grid Valves ["K" Series] of Special Suitability for Small Portable Receivers.—E. W. Stockhusen. (*Funktech. Monatshefte*, April, 1936, No. 4, pp. 148–151.)

2579. THE VALVES IN BROADCAST RECEIVERS: PART III—MULTIPLE AMBIGUITY IN THE MIXING VALVE [Image Signals and Harmonic Whistles, and Their Avoidance: Choice of Intermediate Frequency or Frequencies: Pre-Selection: High I.F. Amplification: Volume Control in front of the Mixing Valve: etc.].—K. Wilhelm. (*Telefunken-Röhre*, March, 1936, No. 6, pp. 58–70.) For previous parts *see* 3447 of 1935 and 152 of January.

2580. VARIABLE SELECTIVITY AND THE I.F. AMPLIFIER. PART III—THE AMPLIFIER AS A WHOLE.—Cocking. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, pp. 237–247.) *See* 2147 of June.

2581. DUAL-DIVERSITY 'PHONE RECEPTION WITH SINGLE-CONTROL TUNING: AN ADVANCED TYPE RECEIVER MINIMISING FADING EFFECTS AND FURTHER IMPROVING SIGNAL/NOISE RATIO.—J. L. A. McLaughlin and J. J. Lamb. (*QST*, May, 1936, Vol. 20, No. 5, pp. 39–43 and 102, 106.)

2582. DELAYED DETECTOR OPERATION [for Inter-Station Noise Suppression: Chief Methods and Their Characteristics].—J. H. Reyner. (*Wireless World*, 10th April, 1936, Vol. 38, pp. 364–366.)

2583. A STUDY OF NOISE CHARACTERISTICS [Peak Value of Hiss, as well as R.M.S. Output, proportional to Square Root of Frequency-Band Width].—V. D. Landon. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, p. 684: summary only.) Crest factor is found to be 3.4, independent of band width. Noise due to impulse excitation behaves differently as regards peak values: these are directly proportional to the first power of frequency band width.

2584. "METHODS OF MEASURING RADIO NOISE" [Report of Joint Co-ordination Committee of E.E.I., N.E.M.A. and R.M.A.].—(*Electronics*, April, 1936, Vol. 9, No. 4, p. 34: review of pamphlet.)

2585. SIMPLIFIED VOLUME EXPANSION, *and* INEXPENSIVE VOLUME EXPANSION.—W. N. Weeden: R. H. Tanner and V. T. Dickens. (*Wireless World*, 24th April, 1936, Vol. 38, pp. 407–408: 22nd May, Vol. 38, p. 507.) Using the increase in resistance of the metal filaments of ordinary lamps when heated. *Cf.* 2153 of June.

2586. IS AUTOMATIC VOLUME CONTROL WORTH WHILE? [Advantages not always So Great as Commonly Supposed].—W. T. Cocking. (*Wireless World*, 22nd May, 1936, Vol. 38, pp. 502–504.)

2587. "WIRELESS SERVICING MANUAL" [Book Review].—W. T. Cocking. (*Electrician*, 15th May, 1936, Vol. 116, p. 636.)

2588. "PERPETUAL TROUBLE SHOOTER'S MANUAL—VOLUME VI" [Radio Receiver Servicing: Book Review].—J. F. Rider. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, p. 812.)

2589. RADIO PANEL LAMPS AND THEIR CHARACTERISTICS.—J. H. Kurlander. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 584–590.) Finally, the need for an accessible position is stressed.

2590. BALLAST TUBES: SOLVING PILOT-LAMP PROBLEMS IN A-C, D-C RECEIVERS.—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, p. 10.)

2591. COIL MANUFACTURING COSTS: A COMPLETE ANALYSIS OF ONE OF THE MOST IMPORTANT PHASES OF SET MANUFACTURE.—M. E. Fagan. (*Rad. Engineering*, April, 1936, Vol. 16, No. 4, pp. 10–11.)

2592. PRODUCTION-LINE VENTILATION [Removal of Resin Dust and Lead Fumes from Assembly Plant].—W. A. Murdoch. (*Rad. Engineering*, April, 1936, Vol. 16, No. 4, p. 15.)

2593. EUROPE'S ONE HUNDRED MILLION LISTENERS [with Table up to End of 1935].—(*World-Radio*, 10th April, 1936, Vol. 22, p. 4.)

AERIALS AND AERIAL SYSTEMS

2594. HYPER-FREQUENCY WAVE GUIDES.—Southworth: Carson, Mead and Schelkunoff. (*See* 2502/2504.)

2595. THE "TURNSTILE" ANTENNA, A NEW ULTRA-HIGH-FREQUENCY RADIATING SYSTEM WHICH ECONOMISES ENERGY BY CONCENTRATING IT IN A HORIZONTAL PLANE EQUALLY IN ALL DIRECTIONS.—G. H. Brown. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 14–17 and 48.) *See* also 1617 of April.

2596. THE RADIATION RESISTANCE OF AERIALS WHOSE LENGTH IS COMPARABLE WITH THE WAVELENGTH.—E. B. Moullin. (*Journ. I.E.E.*, May, 1936, Vol. 78, No. 473, pp. 540–563: Discussion pp. 563–566.) The full paper, notes on which were dealt with in 997 of March and 1438, 1439 of April.

2597. PARABOLIC REFLECTORS (WITH AUXILIARY REFLECTOR RODS) FOR 68-CM WAVES.—Morita. (*See* 2866.)

2598. EFFECTIVE RESISTANCE OF CLOSED ANTENNAS [Radio-Beacon Loops: Analysis of Total Resistance: Greatest Losses are Dielectric Losses in Earth and Near-By Objects: Formulae for These, and Means of Reducing Them: Further Applications of Closed Aerials].—V. I. Bashenoff and N. A. Mjasoedoff. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 778–801.)

Conclusion of the work dealt with in 1931 Abstracts, p. 500. The efficiency factor can be increased by a tuned or untuned screen between the loop and the ground. "The possibility of reception using a closed antenna with a mast height ranging around $\lambda/10$ and efficiency factor ranging from 40 to 50% is of some interest, independently of its use as a radio beacon. In some cases the closed antenna with a relatively high efficiency factor (particularly in co-operation with an open antenna for radiation with a cardioid diagram) might serve as a very simple but sufficiently effective radiating antenna, operating at medium and medium high frequencies. Intensive radiation of a closed antenna upwards could be used at night-time. Especially great possibilities could be derived from a closed antenna in radio transmitters with a combined wave range if, for the short-wave range, it is excited by high harmonics" [USSR Pat. 28 551].

2599. THE "SHUNT EXCITED" ANTENNA [Vertical-Radiator Type Broadcasting Aerial operating with Base earthed: eliminating Base Insulator, Protective Devices, etc.].—J. F. Morrison and P. H. Smith. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, p. 685: summary only.)

2600. PROPAGATION OF THE WAVES EMPLOYED IN BROADCASTING, AND "ANTIFADING" AERIAL SYSTEMS [Survey, including Tower Aerials and the "Triangular" Aerial].—J. Loeb. (*Ann. des Postes T. et T.*, April, 1936, Vol. 25, No. 4, pp. 313–334.)

2601. A STUDY OF THE ELECTROMAGNETIC FIELD IN THE VICINITY OF A RADIATOR [by Summation of Effects of Infinitesimal Elements composing Finite Radiator: Integration by Mathematical or Graphical Method: Tables for shortening Latter Process].—F. R. Stansel. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 802–810.)

2602. DIRECTIVE AERIALS WITH IDENTICAL DIRECTIONAL DIAGRAMS BUT DISSIMILAR CURRENT DISTRIBUTIONS: "EQUIVALENT AERIALS" [and Their Calculation from the Constants of the Given Aerial].—K. Posthumus. (*Tijdschr. Nederlandsch Radiogenoot.*, April, 1936, Vol. 7, No. 4, pp. 115–139: page sequence "scrambled" in some copies: in Dutch.)

2603. DIRECTIONAL ANTENNA DESIGN [Practical Design and Application of Two-Element Arrays in Broadcast and Communication Service], *and* DIRECTIONAL RADIATION PATTERNS.—E. A. Laport: A. J. Ebel. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 22–25 and 48: pp. 30 and 29.)

2604. ARRANGEMENT FOR THE DIRECTIVE SENDING AND RECEIVING OF OSCILLATING ENERGY [Occurrence of Secondary Maxima in Antenna Array diminishing by spacing Elements more than a Half-Wavelength Apart and decreasing Amplitudes from the Middle to the End].—A. Esau and W. Berndt. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, p. 68: German Patent 618 777 of 24.2.33.)

2605. THE PROPORTIONING OF SHIELDED CIRCUITS FOR MINIMUM HIGH-FREQUENCY ATTENUATION [Coaxial and Balanced Shielded Circuits].—E. I. Green, F. A. Leibe and H. E. Curtis. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 248–283.)

The treatment of balanced shielded circuits includes not only the usual shielded pair but also the shielded stranded pair, pair with shield return, double coaxial circuit, pair with round conductors and oval shield, pair with quasi-elliptical conductors and circular shield, and shielded quad.

2606. TWO-WIRE SHIELDED TRANSMISSION LINE FOR USE WITH SHORT-WAVE RECEIVING AERIALS.—L. Sh. Natadze. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1936, pp. 15–24.)

A theoretical discussion is presented on a transmission line consisting of two parallel wires inside a shielding tube. The advantage of such a line is that being symmetrical it can be connected to a symmetrical aerial, of the rhombic type for instance, without the interposition of a matching network. Formulae are derived for the various constants of the line, such as the attenuation factor, characteristic impedance, capacity and resistance per unit length and the ratio of the velocities of propagation of the waves in air and along the line. The leakage current and the optimum ratio of the spacing between the wires to the internal diameter of the shielding tube are also determined. In conclusion an account is given of experiments carried out to verify the theoretical results obtained.

2607. THE PRE-SELECTOR ANTENNA: A NEW USE FOR THE RESONANCE WAVE COIL IN AMATEUR RECEPTION [Aerial compressed into Vertical Helix on 33″ Rod 1″ in Diameter, with Sliding Secondary (Coupling) Coil].—I. Creaser. (*QST*, May, 1936, Vol. 20, No. 5, pp. 44–46.) Can be used with or without extension rod capacitively coupled to winding, giving increased pick-up as well as impedance-matching adjustment.

2608. DETERMINATION OF THE NATURAL WAVELENGTH OF AN ANTENNA BY THE REACTANCE METHOD [Coil and Variable Condenser in Series with Aerial: Capacity Values observed which Tune the Circuit to Various Wavelengths].—G. Sinclair. (*Canadian Journ. of Res.*, April, 1936, Vol. 14, No. 4, Sec. A, pp. 87–92.)

Direct measurement and the "intercept" method (added inductances) having given inconsistent results, the present method was evolved. When the entire circuit of coil, condenser, and aerial is in resonance at the natural wavelength of the aerial, the coil reactance equals the condenser reactance. Therefore if the curves of the coil reactance and of the condenser reactance are plotted, with wavelengths as abscissae, these curves will intersect at the natural wavelength of the aerial. Values of natural wavelength thus found agree well with direct measurement. The data obtained in this method can be used to provide points on the "intercept" method graph for relatively small values of inserted inductance. These points do not fall on a straight line, probably owing to variations occurring in the aerial input inductance and capacity near the natural wavelength.

2609. UNIVERSAL ABAC, INDEPENDENT OF THE CONSTANTS OF THE METAL, FOR THE MECHANICAL CALCULATION OF OVERHEAD LINES.—S. Alber: Blondel. (*Rev. Gén. de l'Élec.*, 2nd May, 1936, Vol. 39, No. 18, pp. 643–647.)

2610. SPECIAL SAND AND GRAVEL AGGREGATE FOR CONCRETE FOUNDATIONS SUBJECTED TO H.F. CURRENTS.—(*Electronics*, May, 1936, Vol. 9, p. 9.) Also *ibid.*, p. 66.

VALVES AND THERMIONICS

2611. Description and Characteristics of the End-Plate Magnetron [2.5 Watts at 3000 Mc/s with Efficiency 12% with respect to Plate Dissipation: Greater Stability against Supply Fluctuations, and Other Advantages: Analysis of Effect of Space Charge on Electron Motion and Valve Performance: Output Limitation by Instability traced to Bombardment of Filament: etc.]—E. G. Linder. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 633–653.) *See* also 1934 Abstracts, p. 437; and 986 of 1935.

2612. On the Calculation and Geometrical Construction of the Static Characteristics of a Split-Anode Magnetron.—I. V. Brenev. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 302–318.)

A detailed theoretical investigation of the flow of electrons in the space between the two semicylindrical anodes of a magnetron. The effects of the following factors on the electron current are isolated and studied separately: (a) radial and transverse electric fields, *i.e.* the fields due to the potential differences between the anode and the filament and between the two anodes respectively; (b) radial electric field and magnetic field, and (c) transverse electric field and magnetic field. This is followed by a study of the combined effect of the three fields, as a result of which data are obtained for calculating and plotting the static characteristic of a magnetron from its geometrical configuration and operating conditions. A numerical example is given and a comparison between the calculated and experimental curves shows very close agreement.

2613. On a New Type of Electronic [Micro-Wave] Oscillator Tube with Parallel Plane Grids.—W. A. Leyshon. (*Proc. Phys. Soc.*, 1st May, 1936, Vol. 48, Part 3, No. 266, pp. 469–475: Discussion pp. 475–476.)

The electrode system of the tube "consisted of two parallel plane grids with two symmetrically arranged cathodes external to them." With Lecher wires (which determined the wavelengths of the oscillations generated) attached to the two grids, B-K oscillations were obtainable with the tube used as a triode; another mode of oscillation was with both cathodes emitting and the grids at the same positive potential. Experimental results are given.

2614. New Valves for Short and Ultra-Short Waves [Types ESW 501 and 204 for Full Rated Dissipation (60 and 250 Watts respectively) down to 5 Metres].—Edison Swan Company. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, pp. 166–167.)

2615. The Dielectric Constant of a Space containing Electrons, *and* Electron Motion in a Plasma [Equation including Effect of Electron Pressure: Possible Frequencies of Free Vibration].—Prasad & Verma: Linder. (*See* 2519 and 2520.)

2616. The Amplification of a Plane-Electrode Triode at Ultra-High [Micro-Wave] Frequencies. Part I [Approximate Theory]: Part II [Full Solution].—H. Zuhrt. (*Hochf: tech. u. Elek: akus.*, February, 1936, Vol. 47, No. 2. pp. 58–64: March, No. 3, pp. 79–88.)

The behaviour of a triode with negative grid, on wavelengths below one metre, is calculated with special application to the behaviour of the valve as an amplifier. In Part I a physical explanation of the phenomena is given and an approximate formula is deduced for the steepness of the characteristics (equivalent circuit Fig. 1). Fig. 6 shows graphically the magnitude and phase of the various approximate solutions and Fig. 7 the steepness as a function of electron transit time or frequency. In Part II the full theoretical solution is given; in § I it is shown that the triode can be theoretically replaced by two diodes, connected by the boundary conditions at the control grid (Fig. 8). The wavelength must however be large compared with the dimensions of the valve. § II gives general calculations of the transit of an electron between plane electrodes; § III applies the results to a negative-grid triode. Formulae are obtained which enable all stationary and alternating quantities in the valve to be worked out. In § IV the amplification factor is calculated; the resulting formula (eqn. 93) is tested by evaluating the limiting case of zero transit time. This reduces to the form (eqn. 102) obtainable by elementary methods from the equivalent circuit of the triode (Fig. 10). Figs. 14 a, b give curves of the amplification factor as a function of frequency. Its low values at high frequencies are due to the influence of the grid/anode capacity, rather than to the electron transit time. § V discusses the effect of compensation of the grid/anode impedance (Fig. 11) on the amplification factor (results Figs. 13 a, b). In § VI the results are generally discussed in the light of a numerical example. Figs. 12 a, b, c illustrate the relative slope of the characteristics as a function of frequency for various transit-time ratios. For amplification at micro-wave frequencies it is advisable to make the anode transit time small in comparison with that to the grid. By suitable adjustment the amplification may be made greater than normal; it may give rise to self-excitation.

2617. New Electron Multipliers ["Multipactors"].—Farnsworth. (*See* 2723.)

2618. Shot Effect of Secondary Emission. II [Application of Theory developed in I].—M. Ziegler. (*Physica*, May, 1936, Vol. 3, No. 5, pp. 307–316: in English.)

See 2190 of June. Among the results now obtained, it is shown that a certain fraction of the primary electrons should each cause the emission of at least n_K secondary electrons, n_K being the smallest whole number greater than the "coefficient of secondary current fluctuation" (depending on the primary voltage and the constitution of the emitter, and determinable by experiment).

2619. Secondary Electron Emission from a Hot Nickel Target due to Bombardment by Hydrogen Ions.—Monica Healea and E. L. Chaffee. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 646.)

2620. A METHOD OF MEASURING SECONDARY-ELECTRON EMISSION FROM FILAMENTS [Special Electrode Arrangement: Data for Tungsten and Tantalum].—L. R. G. Treloar. (*Proc. Phys. Soc.*, 1st May, 1936, Vol. 48, Part 3, No. 266, pp. 488–496: Discussion p. 497.)

2621. APPROXIMATE METHOD FOR THE CALCULATION OF THE WORK FUNCTION OF ELECTRONS FROM METALS.—E. H. B. Bartelink. (*Physica*, April, 1936, Vol. 3, No. 4, pp. 193–204: in German.)

Author's summary:—After defining the terms "true" and "effective" work function, it is shown that an exact calculation cannot be carried out [owing to mathematical difficulties]. Previous approximate methods are briefly discussed. A method is then described in which the charge to be extracted is divided up [into arbitrarily small "charge elements"], extracted in parts and reassembled at a distance from the metal. Owing to the polarisation, there are at first no electrons immediately near the emerging charge, while at a greater distance they are distributed according to the Fermi equation. A solution of this equation is therefore required: this is obtained by an approximation method.

The result is a semi-convergent series development for the work function in powers of $\beta^{1/6}$, where β is the reciprocal of the atomic volume [$W = 17.6\,\beta^{1/3} + 15.6\,\beta^{2/3} \ldots\ldots$]. Numerical calculation here gives values departing from the measured values by amounts up to about 40%. For exact quantitative calculation, therefore, the method is not serviceable" [it is, on the whole, less accurate than the method of Tamm & Blochinzev—1933 Abstracts, p. 395: its advantage lies rather in its simplicity and the clearness of its fundamental assumptions].

2622. STATISTICAL FLUCTUATIONS IN MULTIPLE SPACE CHARGE [Fluctuations other than Cathode Shot Effect operate within Electron Stream].—E. W. Thatcher and H. S. Howe. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 646: abstract only.) *See* also 1878 of 1935, and Llewellyn, 1930 Abstracts, p. 279.

2623. MEASUREMENTS OF EMISSION CURRENT BY THE METHOD OF SHORT-PERIOD LOADING.—J. Groszkowski and S. Ryżko. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 17, 1936, pp. 155–159.)

The short-pulse method has been developed by various workers, some using oscillographs (Chaffee, in 1922), others peak voltmeters or bridge methods (Guéritot, in 1923). Recent work is by Patai and Frank (3908 of 1935). The present writers find that the method is liable to lead to errors which may amount to some hundreds per cent., owing to the fact that when an anode voltage is first switched on the cathode emission starts at a high initial value and only gradually sinks to its stationary condition. This phenomenon is traced to that "latent heat of electron evaporation" which has been utilised by Gribanov to measure the Richardson work function (*see* 2191 of June). The electron emission produces a drop in cathode temperature: the length of time required for the cathode to arrive at a steady temperature, giving the "stationary" value of emission, depends both on the thermal inertia of the cathode and on the size of the emission current. The writers, working with a tungsten cathode of 0.1 mm diameter, found that a stationary value of 150 mA was reached in 6/50ths second from an initial current of 260 mA, while a 200 mA emission was reached in 7/50ths second from an initial value of 400 mA. A cathode of 0.2 mm diameter gave similar results but after about twice the delay.

When tested by the "short-pulse" method, the cathode temperature is thus unable to reach equilibrium and the emission current measured is too large. To obtain correct results the emission needs to be observed over a suitable time, as can be done by an oscillograph. Unluckily this suitable time may in many cases be long enough to damage the valve.

2624. THERMIONIC EMISSION FROM BARIUM-COATED TUNGSTEN [Electron and Positive-Ion Emission from Tungsten in Stream of Barium Vapour: Evaporation of Barium from Tungsten].—L. N. Dobretzov and G. A. Morozov. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 352–361: in English.)

2625. ADSORPTION OF NITROGEN ON TUNGSTEN [Behaviour similar to Hydrogen].—J. K. Roberts. (*Nature*, 18th April, 1936, Vol. 137, pp. 659–660.) *See* 170 of January: *also* 1810 of May.

2626. "THERMIONIC EMISSION" [Book Review].—T. J. Jones. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, p. 258.)

2627. RECORDING FIELD-CURRENT ELECTRONS WITH A GEIGER-MÜLLER COUNTER.—R. T. K. Murray. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 195: abstract only.)

2628. THE PREPARATION AND INVESTIGATION OF OXIDE CATHODES OF COLLOIDAL STRUCTURE [Electrophoretic Method].—E. Patai and Z. Tomaschek. (*Kolloid-Zeitschr.*, March, 1936, Vol. 74, No. 3, pp. 253–265.)

Authors' summary:—"For the precision preparation of alkaline-earth oxide cathodes a new, electrophoretic method is given. As starting material a colloidal aqueous solution of an alkaline-earth carbonate is used: the carrier is immersed in this solution and the carbonate layer deposited by an electric current. Exhaustive investigations on the influence of the composition and concentration, the current density, the temperature, and the cathode material are described. The mechanical properties of the colloidal cathode layers are very favourable: firm adhesion, smooth surface, and uniform fine structure. A new method for an exact temperature determination is given [depending on measurements first *in vacuo* and then in one or more neutral gases]. The determination of the Richardson constants and the discussion of practical applications [*e.g.* wherever local over-heating, with its consequences, is to be avoided; or where it is desired to bring the control grid very close to the cathode surface] are supplemented by microphotographs." Curves for a Philips short-wave transmitting valve are given, for cathodes made by the colloidal and paste processes respectively.

2629. Determination of the Temperature Maximum in the Neighbourhood of a Decrease in Cross-Section of an Incandescent Wire in an Inert Gas [Calculations].—L. Prásnik. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 710–713.) *See* also 1934 Abstracts, p. 95.

2630. Current Distribution: Theory of Multi-Grid Valves.—H. Rothe and W. Kleen. (*Telefunken-Röhre*, March, 1936, No. 6, pp. 1–23.)

For previous papers *see* 3907 of 1935 and 147 of January. The present work is divided into two parts. Authors' summaries: Part I—The current distribution between two positive electrodes (grid 1 with anode 2 behind it) is, apart from geometrical relations, dependent only on the ratio of the two voltages. The curve of current "take-over" from one electrode to the other is divided into two separate parts, in which two different effects are predominant. In the Below region, where the anode potential is small compared with that of the grid, the current distribution is determined by the reversal of electrons in the grid/anode space. For this region the equation is $i_2/i_{ges} = C_1\sqrt{u_2/u_1}$ [where i_{ges} is the total current and C_1 a constant depending on the geometry of the valve]. The current component taken direct from the grid can be assumed to be constant.

In the Tank region, on the other hand, where the potential u_2 is comparable with u_1, all electrons which pass once through the grid plane arrive at the anode. The ratio of voltages then affects only the current component taken direct from the grid. In this region the equation is $i_2/i_1 = C_2\sqrt{u_2/u_1}$. These two laws can be applied to the current distribution in multi-grid valves, pentodes working predominantly in the Tank region and hexodes in the Below region.

Part II—The anode-current/anode-voltage characteristic of pentodes is calculated with the help of the current-distribution law. In the normal working zone it can be represented, with very close approximation, by a parabola of high order. From the characteristic curve the internal resistance R_i is calculated. It is found to be inversely proportional to the anode current, directly proportional to the anode voltage, and independent of the s.g. voltage. Consequently the product $R_i \cdot i_4/u_4$ is a constant for each valve, dependent only on constructional data: it may be called the "internal-resistance constant b." Since the anode-current slope can also be calculated from the known equations for the cathode-current slope, independently of R_i, the valve constant $(\partial u_1/\partial u_4)_{u_1, i_4}$ = const., generally known as "durchgriff" D, is seen to be a pure mathematical quantity with no relation to the electrostatic anode "durchgriff." It is therefore suggested that for multi-grid valves the term "durchgriff" should no longer be applied to this quantity, but that the quantity $(\partial u_4/\partial u_1)_{u_2, i_4}$ should be employed, with the title "amplification factor μ," the term "durchgriff" being confined to purely electrostatically defined quantities. The calculations are experimentally checked and well confirmed.

2631. Theoretical Investigations on the "Klingen" [Microphonic Effect] of Amplifier Valves [Analysis of the Effect of Electrode Movements on Anode Current, Slope and Amplification Factor: Deductions affecting Design and Circuits: H.F. as well as A.F. Effects: Method of Localising the Defective Electrode: Test-Bench Apparatus for Measurement of Microphonicity].—W. Graffunder and H. Rothe. (*Telefunken-Röhre*, March, 1936, No. 6, pp. 36–57.)

2632. On the Linearising of the Characteristic Curves of Amplifier Valves.—W. A. Schneider. (*Berlin Thesis*, 1935: at Patent Office Library, London: Cat. No. 76 075: in German.)

2633. On the Mathematical Expression of the Characteristic of a Thermionic Valve—I. E. Srednii. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 344–351.)

When a triode circuit is regarded as a non-linear system, as, for instance, in the case of a self-excited oscillator, the conception of a straight-line characteristic cannot be used. Methods have therefore been suggested for representing the valve characteristic by power series. These methods are, however, rather cumbersome, and in the present paper the author derives a number of equations which determine the characteristic of a valve with a sufficient degree of accuracy for practical purposes. This is confirmed by a numerical example in which the calculated and experimental results are compared. The method proposed is further illustrated by an investigation of the operating conditions of a self-excited oscillator.

2634. The Limit of Charge Sensitivity in the Valve Electrometer. II [More Accurate Calculations].—H. Alfvén. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 714–716.) For I *see* 1791 of May.

2635. Papers on Class B and Class C Amplifiers.—(*See* under "Transmission.")

2636. The Beam Power-Output Tube [6L6 All-Metal Tetrode, using Potential Barrier in place of Suppressor Grid: 34 Watts Push-Pull Output without Grid-Driving Power, 60 Watts with 400 Milliwatt Input].—J. F. Dreyer, Jr.: Schade. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 18–21 and 35: Editorial p. 5.) With low 3rd harmonic and practically negligible higher order distortion: specially useful in reversed feed-back amplification. *See* also *Rad. Engineering*, April, 1936, Vol. 16, No. 4, pp. 6–7 and 18–19; *also* 2637, below.

2637. A New Audio Power Tube [6L6 "Beam" Type].—RCA Radiotron. (*QST*, May, 1936, Vol. 20, No. 5, p. 50.) *See* also 2636.

2638. New Developments in Applied Electron Optics [including the Reduction of Grid-Current/Anode-Current Ratio from 1:5 to 1:500 by Specially Profiled Cathodes yielding Electron Rays opposite Grid Openings: "K" Valve Series].—P. Hatschek. (*Funktech. Monatshefte*, April, 1936, No. 4, Supp. pp. 28–30.)

2639. New Tubes: the 6R7 Diode-Triode: 6G5 Tuning Indicator: Change in 5Z4 Size: New 2-Volt R.F. Tubes.—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, p. 13.)

2640. Operation of 6A8 [All-Metal Pentagrid Converter] as Mixer-Oscillator.—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 8–9 and 12.)

2641. Pentode Transmitting Valves [Advantages of These Recently Introduced Valves].—(*Wireless World*, 17th April, 1936, Vol. 38, pp. 394–395.)

2642. Operating Notes on the 35T [at 14 and 28 Mc/s].—(*QST*, May, 1936, Vol. 20, No. 5, pp. 53 and 88, 90.)

2643. The Valves in Broadcast Receivers: Part III.—Wilhelm. (*See* 2579.)

2644. Cathode-Ray Valve Tester.—J. H. Reyner. (*Wireless World*, 8th May, 1936, Vol. 38, pp. 462–463.)

2645. A New Water-Cooled High-Power Vacuum Tube [400 kW Output: Type UV-171].—Y. Imaoka. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, pp. 129–136.)

2646. Power-Tube Manufacturing Problems: Discussing Ways and Means to produce More Efficient Transmitter and Rectifier Tubes at Lower Cost [Use of Svea Metal].—L. L. McMaster, Jr. (*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 11–12.) *See* also 1895 of 1935.

2647. Advances in Metal/Glass Seals [by the Use of Kovar].—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 14–15.) *See* also 1004 of March; also 2781, below.

2648. Brazed Seals for All-Metal Tubes.—RCA Radiotron. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, p. 17.)

2649. Hydrogen Furnaces for Tube Parts.—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 6–7.)

DIRECTIONAL WIRELESS

2650. A New System for Blind Landing of Airplanes [Ultra-Short-Wave Note-Modulated Signals from Aeroplane, received on Crossed Loops on Ground, govern Depth of Modulation of Short and Long Long-Wave Signals from Ground: Aeroplane follows "Equi-Signal" Course thus given: Similar Principle for Vertical Glide Path].—K. Baumann and A. Ettinger. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 751–754.)

2651. The S.F.R. Obstacle-Detector Type D.16, working on Micro-Wave Reflection.—(*Bull. de la S.F.R.*, Aug./Sept./Oct. 1935, 9th year, No. 4, pp. 110–118.)

Capable of detecting obstacles at distances up to 7–10 km, giving their direction within less than 5°. The positive grid of the transmitter is modulated by a 30 kc/s frequency, on which is superposed a note of 800 c/s. The quarter-wave aerial, 4 cm long, is inside the bulb, which lies in a parabolic reflector. The exploring mechanism, alternatively hand- or motor-controlled, covers a zone of 80°. "The reception of the 30 kc/s frequency, and its comparison with the same frequency on its emission, allows, with the help of a cathode-ray oscillograph, an idea to be formed of the distance of the obstacle." *Cf.* 1468 of April; *also* 2652, below.

2652. Distance Determination by Electromagnetic Waves [Measurement of Phase Difference, at Receiver, of Low-Frequency Currents emitted as Cophasal Modulations of Two Different Frequencies].—E. A. H. Honoré. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, p. 68: French Patent 790 386 of 11. 8. 34.)

Compare Fayard, 150 of 1935. For other methods of distance determination, excluding all those using sound waves in any way, *see* Abstracts, 1929, pp. 168 (Koulikoff & Chilowsky) and 453 (Burstyn); 1930, p. 586 (Chamberlain); 1933, p. 451 (Weigl); and 1934, pp. 42 (Hell) and 620 (Leib, Nicholson). For a "micro-wave feeler" *see* 1468 of April, and 2651, above.

2653. Experimental Investigations on the Variation of Phase Changes in Open Oscillating Circuits with Distance from the Ground [with Application to Determination of Height of Aircraft].—K. Bärner. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, pp. 45–55.)

The object of the work here described was to determine experimentally the phase changes produced in simple wire circuits, excited electromagnetically, by changes in their distance from the ground, and to investigate how far the changes could be used to determine the height, with particular application to aircraft. Horizontal wire systems (Fig. 8) and wavelengths 15–25 m were used. An apparatus for phase measurement was first constructed (§ II: circuit principle Fig. 1, as constructed Fig. 2, view Fig. 3); it was a development of Trautwein's "Valve Phasemeter" (*Zeitschr. f. tech. Physik*, 1922, p. 125). Its working is described; phase curves (Figs. 6, 7) were taken with an oscillating circuit with variable condenser (circuit Fig. 4, vector diagram Fig. 5) and agreed well with calculation. The theory of the variation of h.f. phase with distance from the ground is discussed in § III; calculated variations for various wavelengths are shown in Fig. 10, the corresponding measurements in Fig. 11. Experimental curves taken with a parallel-wire system, a linear wire with various additional condensers and coils, and a linear wire below a metallic surface (Fig. 18), are given in Figs. 12–17, 19–24. The general conclusions are: "Systems on which the action of the wave system reflected from the earth is not measurable give a phase change with variation of distance from the earth corresponding to the capacity change, analogous to that in closed oscillating circuits. The distance can then be uniquely determined from the reading of the phase indicator and the determination is only limited by the sensitivity of the measuring instrument. As the effect of the reflected field increases there is however an additional periodic phase change . . . which makes it impossible to determine the distance of the ground without auxiliary apparatus." A photograph of the whole arrangement used is given in Fig. 9.

2654. DIRECTIONAL RECEPTION APPARATUS WITH TWO OPPOSITELY CONNECTED DIPOLES [Asymmetry due to Earth Capacities of Lower Halves of Dipoles corrected by connecting Upper Halves by Horizontal Wires and Variable Condenser].—P. Hermanspann: Telefunken. (*Hochf:tech. u. Elek: akus.*, February, 1936, Vol. 47, No. 2, p. 68: German Patent 618 799 of 31.12.33.)

2655. EFFECTIVE RESISTANCE OF CLOSED ANTENNAS [Radio-Beacon Loops].—Bashenoff and Mjasoedoff. (*See* 2598.)

ACOUSTICS AND AUDIO-FREQUENCIES

2656. AN OPERATIONAL PROOF OF THE WAVE-POTENTIAL THEOREM, WITH APPLICATIONS TO ELECTROMAGNETIC AND ACOUSTIC SYSTEMS [Velocity-Potential of Surface Sources, *e.g.* Loudspeaker Membranes: Erroneous Textbook Arguments].—S. Ballantine. (*Journ. Franklin Inst.*, April, 1936, Vol. 221, No. 4, pp. 469–484.)

2657. SPEAKER DESIGN: RECENT DEVELOPMENTS IN THE LOUDSPEAKER INDUSTRY [and the Pros and Cons of the Recently Introduced "Curved Cone" Diaphragms].—J. Q. Tiedje. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, pp. 11, and 14.)

2658. MAKING AN "EXPONENTIAL" CONE.—E. C. Richardson. (*Wireless World*, 15th May, 1936, Vol. 38, pp. 487–488.)

2659. A NEW TREATMENT OF THE HORN/DIAPHRAGM COUPLING CHAMBER FOR RECEIVER [or Loudspeaker] MEASUREMENTS.—C. K. Stedman. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 265–270.) Enabling Fay & Hall's method (1934 Abstracts, p. 212) to be extended to measure the mechanical impedance of the diaphragm, and giving a clearer picture of the phenomena.

2660. ACOUSTIC DISTORTION AT HIGH AMPLITUDES [*e.g.* at Throat of High-Power Horn Loudspeaker: Necessary Care in Design].—N. W. McLachlan. (*Wireless World*, 15th May, 1936, Vol. 38, pp. 485–486.)

2661. THE "NIPERMAG" LOUDSPEAKER: MAGNETIC ALLOY INTRODUCED INTO THIS COUNTRY IS BASIS OF UNIQUE DESIGN.—(*Rad. Engineering*, March, 1936, Vol. 16, No. 3, p. 20.)

2662. PERMANENT MAGNET LOUDSPEAKERS [especially the Perm-O-Flux, using an Aluminium-Nickel-Cobalt-Iron Alloy].—I. B. Serge. (*Rad. Engineering*, April, 1936, Vol. 16, No. 4, pp. 16–17.)

2663. LOUDSPEAKER BAFFLES [Size and Shape in relation to Frequency Response].—(*Wireless World*, 22nd May, 1936, Vol. 38, pp. 508–509.)

2664. ANALYTICAL AND GRAPHICAL METHODS FOR DESIGNING TRANSDUCERS FOR LOUDSPEAKER CONTROL [and the Design of Constant-Impedance Attenuators].—F. Z. Vashinski. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1936, pp. 34–41.)

In audio-frequency measurements and also for loudspeaker control, attenuators are often required whose input and output impedances do not vary with the attenuation. In the present paper the calculation of the component resistances of such attenuators is discussed.

The T type attenuator (Fig. 1a) is considered first and general equations are derived determining the required resistances for given impedances and attenuation. When the attenuation is varied the corresponding solutions of these equations can be found easily by graphical methods indicated in the paper. The Pi, lattice and bridged T types of attenuator (Figs. 5b, 6b and 10b) are also considered and methods are proposed (both analytical and graphical) for deriving the required values from an equivalent T type attenuator.

2665. "WIRELESS WORLD" PA AMPLIFIER [12 Watts, Resistance-Coupled, Push-Pull Output: Feeder Unit incorporating Wide-Range Tone Correction Unit].—W. T. Cocking. (*Wireless World*, 3rd and 10th April, 1936, Vol. 38, pp. 332–335 and 356–360.)

2666. ADVANCED DESIGN OF CLASS AB AMPLIFIERS.—Apstein. (*See* 2573.)

2667. THE ELECTRO-ACOUSTICAL INSTALLATION IN THE GERMAN OPERA HOUSE [Berlin] AND ITS TASK IN THE MODERN THEATRE.—I. Kirstaedter. (*E.T.Z.*, 14th May, 1936, Vol. 57, No. 20, pp. 558–562.)

2668. RECORDING SYSTEMS FOR USE IN BROADCASTING [Marconi-Stille and Marguerite Sound Studio System (using Cellulose-Coated Disc)].—(*World-Radio*, 10th and 17th April, 1936, Vol. 22, pp. 10, 11: 12, 13.)

2669. LOW-NOISE RECORDING [of Gramophone Discs: Improvement of 15 db by Very Fine-Grain Nitro-Cellulose Material with High Percentage of Synthetic Resin, softened by Vapour Immersion before Engraving].—Ranger. (*Electronics*, April, 1936, Vol. 9, No. 4, p. 28.) Withstanding 100 playings without injury, compared with 30 for usual cellulose record.

2670. IMPROVED REPRODUCTION FROM DISCS [Increased Playing Time and Decreased Surface Noise, using certain Correcting Measures and Piezoelectric Pick-Up].—F. N. G. Leevers. (*Wireless World*, 24th April, 1936, Vol 38, pp. 402–403.)

2671. MEASUREMENT OF SPEED FLUCTUATIONS IN SOUND RECORDING AND REPRODUCING EQUIPMENT [and an Improved "Wow-Meter"].—E. W. Kellogg and A. R. Morgan. (*Journ. Acous. Soc, Am.*, April, 1936, Vol. 7, No. 4, pp. 271–280.)

2672. ON THE DISTORTION IN SOUND REPRODUCTION FROM FILMS.—M. V. Laufer. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 41–46.)

The first of a series of papers in which it is intended to present a general theory of the distortion which takes place in sound reproduction from films. In this paper is considered the distortion due to uneven illumination of the scanning slit. In the theoretical discussion the width of the slit is, contrary to previous investigations, taken into account.

2673. "DYNAMIC" [Contrast-] REGULATED AMPLIFIERS AND "CLEAR TONE" ["Noiseless" Sound-on-Fi,m] RECORDING [and the Disturbing Action of the Transients arising Therein].—Burck, Kotowski and Lichte. (*E.N.T.*, February, 1936, Vol. 13, No. 2, pp. 47–73.)

Authors' summary:—The field of application of transmission systems embodying amplitude-dependent regulation is first discussed. Existing practical methods are described. It is then shown that such methods of regulation produce transients which may cause disturbances. These transients are therefore investigated more closely. The relations between regulation-time constants, non-linear distortion factor, and transmission frequency band are examined mathematically for "Klarton" regulation [for sound-on-film recording] and for simple cases of "contrast" regulation, and are also found to be confirmed experimentally. The various types of contrast control are described, on the basis of investigations by the authors and by other workers [numerous patent and literature references are given throughout the paper], and their special properties discussed; the combination of regulations is also investigated and a general survey of circuit possibilities is given.

For the practically important case where a certain contrast compression is used without subsequent contrast expansion, the following design rules are found for the controlled a.f. amplifiers:—From the measurements of physiological regulation times, values are found, for the "on" and "off" regulation-time constants, which should be reached and not exceeded, respectively (0.3 ms and 50 ms). The "off" regulation time is large compared with the "on" regulation time; this is due to the fact that the physiological building-up time is large compared with the dying-out time. The above values do not always hold good, however, since with the given short "on" time the quality of the reproduction may be affected by clicks, while with the corresponding "off" time it may be affected by non-linear distortion, unless the symmetry of the circuit is very perfect. Practical, larger regulation-time constants are therefore arrived at, namely 2–30 ms for "on" and 100–500 ms for "off" regulation. The design data for other cases of regulation may be obtained on the same lines.

2674. SPONTANEOUS RESISTANCE FLUCTUATIONS IN CARBON MICROPHONES AND OTHER GRANULAR RESISTANCES [Commercial Grid Leaks, Sputtered Metal Films, etc.]—C. J. Christensen and G. L. Pearson. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 197–223.)

"These facts and deductions lead us to the hypothesis that there exist two mechanisms of conduction between particles in contact, a primary conduction which accounts for the major portion of the current, and a secondary conduction wherein a relatively small portion of the total current is transferred and in which the noise mechanism [fluctuating contact or boundary resistance] is found." A formula is derived which gives results consistent with experiment. Brillouin's mechanism (to explain Bernamont's results with thin metal wires—1968 of May) is considered not to apply: it would give different amplitude values and a different frequency distribution. The writers' work has led to the building of "square" assemblages—parallel paths with elements in series in each path—which allows a control of the noise of an assemblage without altering its overall resistance, and suggests a principle applicable to the design of low-noise grid leaks and carbon microphones.

2675. THE CALIBRATION OF MICROPHONES [Report of Sub-Committee].—American Standards Association. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 300–305.)

2676. MODERN MICROPHONES AND TELEPHONES.—H. Jacoby and H. Panzerbieter. (*E.N.T.*, March, 1936, Vol. 13, No. 3, pp. 75–84.)

A description of the improvements in microphones and telephones developed during the last few years by Siemens & Halske A.G. Improvement of the frequency curve of a microphone by adding resonators is discussed and illustrated by Fig. 3 (*see* also Hartmann, Abstracts, 1931, p. 561). Fig. 4 shows the construction of a microphone including a Helmholtz resonator with a sieve in its opening (attenuation curve Fig. 5). The pick-up of external noise is decreased by making the mouthpieces deep and narrow. Requirements of decreased non-linearity and noise in the microphone itself, good wearing qualities and constancy, were met by improvements in the carbon chamber itself and are shortly discussed.

Improvements in the telephone frequency curve were made by increasing the natural frequency of the membrane; a light non-magnetic membrane is used, to which a small magnetic brace is attached (Fig. 9). Fig. 10 shows the membrane with an arrangement for resonance damping. The loss of acoustic intensity produced thereby must be compensated for by improvements in the magnetic material and construction. The electro-mechanical equivalent circuit of a magnetic telephone is discussed (Fig. 16; *see* also Hähnle, 1932, p. 636). The intelligibility results finally attained are shown in Table 1.

2677. A NEW CONDENSER MICROPHONE [with Frequency Response Curve for the Range 30–10 000 c/s].—Preuss: Budich Company. (*Hoch:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, p. 67: Industry Review.)

2678. The Condenser employed as Microphone [and the Solution of Its Equation].—J. B. Pomey. (*Rev. Gén. de l'Élec.*, 16th May, 1936, Vol. 39, No. 20, pp. 720–722.)

2679. High-Gain Amplifiers: Approaching the Audio-Gain Limit with Commercial Electronic Devices [120-db Gain P. A. Amplifiers for Crystal and Ribbon Microphones].—H. L. Shortt. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, pp. 20–21.)

2680. Hearing Aid for the Deaf [Construction of Two-Valve Portable Amplifier with Microphone].—T. S. Littler. (*Wireless World*, 17th April, 1936, Vol. 38, pp. 380–382.)

2681. Hearing Aids for the Deaf.—T. S. Littler. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, pp. 144–155.)

2682. Treatment for Deafness [Simultaneous Application of Sound Waves to Ear and Equivalent Electrical Impulses to Auditory Nerves].—G. G. Blake. (*Electrician*, 17th April, 1936, Vol. 116, p. 507.) From the paper referred to below (2683).

2683. Electrically Produced Music, Heterodyne Method.—G. G. Blake. (*Journ. Roy. Soc. Arts*, 1st May, 1936, Vol. 84, pp. 630–650.) The paper referred to in 2226 of June.

2684. Elastic Impact of a Pianoforte Hammer [General Theory developed by Heaviside Operational Methods].—R. N. Ghosh. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 254–260.)

2685. Precision Measurements [of Variability of Fundamental and Overtones with Mode of Blowing] with Primitive Musical Instruments [Panpipes: Use of Electrical Tone Generator for Measurement of Small Tone Intervals].—M. Bukofzer. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 643–665.)

2686. A New Method for the Representation and Measurement of Non-Linear Distortions [using a Cathode-Ray Oscillograph and Two Modulating Frequencies].—K. Wilhelm and E. Kettel. (*Telefunken-Röhre*, March, 1936, No. 6, pp. 24–35.)

Authors' summary:—" A method is described by which the curve of the working slope of a valve with ohmic load is shown on the screen of a cathode-ray tube [*see* also Bartlett, 1518 of 1935: the present paper was written without acquaintance with this]. From the diagrams thus obtained it is easy to determine the individual harmonics, the 'klirr' factor, and the modulation factor. Changes in the depth of modulation and in the load, as regards their effect on the distortions, can readily be observed. A separation of the distortions into 'slope distortion' [distortion due to curvature of the static characteristic] and 'amplification-factor distortion' [as in pentodes: due to the taking-up of current by the screen grid] is possible, and is shown for a triode and a pentode. In the case of a complex load it is only possible to obtain the modulation factor." For Kleen's method of analysis of the working characteristic, employed here, *see* 3452 of 1935 and back reference.

2687. Klirr Factors [of Non-Linear Distortion] of Audio-Frequency Amplifier and Output Valves [Triodes and Pentodes, by Bridge Method].—H. Hertel. (*Funktech. Monatshefte*, April, 1936, No. 4, pp. 135–140.)

2688. An Electrical Harmonic Analyser of the Fundamental Suppression Type [Simple to Build and Operate: analyses Voltages of Less than 0.5% Distortion].—J. H. Piddington. (*Australian Radio Research Board*, Report No. 9, 1936, pp. 66–71.) For other papers in this Report *see* 2888. For the above paper *see* also *Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 591–596.

2689. The Loudness of Sequences of Cracks [Calculation from Frequency Spectrum: Measurements: Agreement with Theory of Linear, Aperiodic Ear].—W. Bürck, P. Kotowski and H. Lichte. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, pp. 33–37.)

For previous work *see* 219 of January and 1825 of May. Here the work is extended from the single sounds previously discussed to sequences of cracks, *i.e.* transition cases between cracks and continuous tones. The circuit of a generator of acoustic impulses (cracks) is shown in Fig. 2; the loudness results are given in Fig. 5a as a function of the number of cracks per second. Calculations of the loudness are given in §§ III, IV (results Fig. 5c). Good agreement is found throughout with the theory previously given.

2690. Acoustic Phenomena with a Continuous Frequency Spectrum [and the Search for Suitable Sound Source for Investigation of Acoustic Properties of Rooms].—H. Thiede. (*E.N.T.*, March, 1936, Vol. 13, No. 3, pp. 84–95.)

For investigation of the acoustic properties of rooms, a source of sound containing all frequencies is desirable. This should also have equal amounts of energy in equal intervals of the spectrum and be analogous to white light in optics. The present paper seeks such a source. The general theory of sounds with a continuous frequency spectrum is first given; these are sounds produced by separate impulses following one another in a statistical sequence as regards time, such as shot effect, microphone noise, etc. Curves showing the Fourier spectra of various forms of impulse are given in Fig. 1; a change in the number of impulses merely alters the intensity of the sound but not its tone-colour. The variations of these statistical noises are investigated theoretically, with reference to noise measurement by a hot-wire instrument; the variations increase as the time-constant of the instrument decreases.

Experimental investigations were made of the noise spectra of radioactive decay processes (Figs.

4, 5), of the Barkhausen effect (Fig. 6), of carbon microphone noise (Fig. 7) and of the shot effect (Figs. 8–10). The last-mentioned was found to be the most suitable source for a constant continuous spectrum up to 10^4 c/s. Experiments made with it gave good confirmation of the theory (Figs. 11–13). Measurements of reverberation times were made using a narrow band (Fig. 17) from the spectrum of the shot effect as a source of sound; the record obtained is shown in Fig. 16 and the results are compared with those otherwise obtained in Fig. 18. Statistical variations in the shot-effect source neutralised the advantages of its continuous spectrum.

2691. A Technique for Studying the Efficiency of Panel Damping Materials.—J. S. Parkinson and P. O. Young. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 281–286.)

2692. Method for Measuring Sound Isolation, in Particular of "Impact" Sound [but also of "Air-Borne" Sound: Hammer-Pounder with Cycle of 30 Increasing and 30 Decreasing Steps: Observer counts Number of Successive Blows heard].—F. M. Osswald. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 261–264.)

2693. The Acoustic Absorbing Power of Non-Porous Materials, Capable of Oscillation [*e.g.* Wood].—E. Meyer. (*E.N.T.*, March, 1936, Vol. 13, No. 3, pp. 95–102.)

For sound absorption, walls may be lined with a material such as wood, which is set into oscillation by the sound and thereby absorbs it. Free oscillation of the wood only takes place if there is an air-cushion between it and the wall (Fig. 1, with equivalent electrical circuit). The present work is concerned with a detailed investigation of the effect of the air cushion on the absorption coefficient of the wood. Maximum absorption may be expected to occur at the natural frequency of the wood/air combination (eqn. 1). The reverberation-time method was used for measuring the absorption coefficient; the procedure is described (*see* also 2006 of 1935).

The results are shown in Figs. 2–5 for various materials and air-cushion thicknesses; all show that the attenuation due to transversal oscillations increases the absorption considerably. Confirmation of eqn. 1 is found within the limits of experimental error (Table 1). This gives a means of producing selective absorption of chosen frequencies. Various explanations are offered for the difference in resonance frequency with and without attenuation. Multiple walls absorb over a wider frequency range (Fig. 6). The effect of the walls on transient phenomena was also investigated (Figs. 7, 8); Figs. 9, 10 give oscillograms of short sounds and their reflections from various types of wall. The transients produced by the wall are found to be very short, of the order of magnitude of two periods at most. The oscillating sound-absorbing materials absorb the lower frequencies much more than the higher ones.

2694. The Acoustical Insulating Power of Partitions calculated by the "Acoustic Quadripole" Method.—A. Gigli and G. Sacerdote. (*Alta Frequenza*, April/May, 1936, Vol. 5, No. 4/5, pp. 229–269.)

Further development of the work dealt with in 3110 of 1935. The general formulae obtained there are now applied to the derivation of practical formulae for the transmission of sound through porous materials, through air-proof materials, and through vibrating partitions. The calculated results agree with experimental findings. Formulae are then obtained for porous partitions which are also capable of vibration, and for double walls. Finally, the attenuation produced by acoustic filters and silencers is dealt with briefly: an appendix discusses the equivalent circuit for a porous material, starting from the classic Rayleigh theory.

2695. Portable Sound Measurements [Sound Reduction through Doors, Vehicle Bodies, etc., measured by Portable Equipment].—C. A. Anderson. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 26–27.)

2696. Johnson Noise [Explanation of "Kicks" with Harmonic Analyser].—D. A. Bell: Robin. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, p. 257.) *See* 1823 of May.

2697. A Magneto-Elastic Source of Noise in Steel Telephone Wires [Mechanical Vibration of Telephone Wire causes Noise in Receivers: traced to Changes in Circular Magnetisation accompanying Variations of Stress].—W. O. Pennell and H. P. Lawther. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 334–339.) A possible use of the effect in studying the vibrations and strains in steel structures such as bridges is mentioned.

2698. Blind Flying by Sound [using the "Binaural" Sense].—L. de Florez. (*Scient. American*, May, 1936, Vol. 154, No. 5, pp. 266–267.)

2699. The Transmission of Sound through Sea Water. Part II.—H. G. Dorsey. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 287–299.) For I *see* 1932 Abstracts, p. 466.

2700. The Domain of Velocities [of Waves in a Compressible Gas] almost Equal to the Local Velocity of Sound [General Principles].—D. Riabouchinsky. (*Comptes Rendus*, 27th April, 1936, Vol. 202, No. 17, pp. 1389–1391.)

2701. On a Fundamental Problem in Diffraction.—Green. (*See* 2530.)

2702. The Absorption of High-Frequency Sound in Oxygen containing Small Amounts of Water Vapour or Ammonia.—V. O. Knudsen and L. Obert. (*Journ. Acous. Soc. Am.*, April, 1936, Vol. 7, No. 4, pp. 249–253.)

2703. SUPERSONIC ABSORPTION IN LIQUIDS [measured by Radiation Pressure Method: Discrepancy between Measured and Calculated Values probably due to Hysteresis of Adiabatic Compressibility].—J. Claeys, J. Errera and H. Sack. (*Comptes Rendus*, 4th May, 1936, Vol. 202, No. 18, pp. 1493–1494.)

2704. VELOCITIES OF ULTRA-SONIC SOUNDS [Marked Decrease in Piezoelectric Modulus of Quartz between Temperatures of Liquid Air and Liquid Helium: Resulting Weak Oscillations of Crystal hinder Determinations of Supersonic Velocities at 4.2°K].—E. F. Burton, A. Pitt and D. W. R. McKinley. (*Nature*, 25th April, 1936, Vol. 137, p. 708.) *See* also 2706 of 1935.

2705. A UNI-DIRECTIONAL SUPERSONIC RADIATOR [with Greatly Increased Efficiency].—J. Gruetzmacher. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 17, 1936, pp. 166–167: preliminary communication.)

A hollow box is cemented to one surface of the oscillating crystal and the whole is submerged in oil. The air in the box has so small an acoustic resistance, compared with the oil touching the other surface of the crystal, that the device behaves as if there were no sound-carrying medium on the boxed side of the crystal: practically all the energy is radiated from the other side.

2706. "EINFÜHRUNG IN DIE ANGEWANDTE AKUSTIK" [especially the Newer Problems of Measurement, Transmission, and Recording: Book Review].—von Braunmühl and Weber. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, p. 310.)

2707. "THE NEW ACOUSTICS" [Book Review].—N. W. McLachlan. (*World-Radio*, 24th April, 1936, Vol. 22, p. 10.)

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2708. HIGH-DEFINITION TELEVISION IN HOLLAND [Demonstration of 405-Line System].—Philips Company. (*Wireless World*, 1st May, 1936, Vol. 38, pp. 451–452.) *See* also 1083 of March.

2709. TELEVISION: COMING DEVELOPMENTS IN GERMANY [and a Report on the Public Viewing-Rooms].—(*World-Radio*, 8th May, 1936, Vol. 22, p. 5: to be continued.)

2710. TELEVISION IN GERMANY.—H. Gibas. (*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 741–750.)

2711. THE PRESENT POSITION OF WIRELESS TELEVISION RECEPTION TECHNIQUE [with Brocken Field-Strength Diagram: Internal and External Noise Levels: etc.].—W. Scholz. (*Funktech. Monatshefte*, April, 1936, No. 4, Supp. pp. 25–28.)

2712. TECHNICAL CHARACTERISTICS OF THE EIFFEL TOWER TELEVISION STATION.—J. Le Duc and R. Barthélémy. (*Rev. Gén. de l'Élec.*, 2nd May, 1936, Vol. 39, No. 18, pp. 651–661.)

2713. THE PERMISSIBLE PHASE DISTORTION IN TELEVISION.—R. G. Shiffenbauer and N. N. Orlof. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 37–40.)

For a previous paper see 1079 of March. Proceeding with the investigation of the permissible phase distortion at low frequencies, experiments were made to determine how far this is affected by the characteristic of the neon lamp used. The static characteristics of 15 lamps were taken and checked with a cathode-ray oscillograph, and four lamps showing the greatest divergence selected. These lamps were used for tests with a number of separate observers, and the results indicate that the permissible phase displacement is substantially independent of the lamp characteristic. As a concrete case, the maximum phase displacement at the frame frequency, for transmission of a half-black and half-white rectangle, is about 1.5° to 2°.

2714. TRANSIENTS IN AMPLIFIERS WITH WIDE FREQUENCY RANGE: THE DISTORTIONS CAUSED BY AMPLIFIERS IN TELEVISION [and Their Compensation].—O. Lurje. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 229–248: in German.)

Correction at low frequencies is first treated: "from all these considerations it follows that the only way to suppress the distortion at low frequencies, in the amplifier examined [Fig. 1], without lengthening the time constants and thus increasing the distortion due to the building-up process, is to choose the correct value for the ratio of the two time constants, $K = T_2/T_1$. A simple increase of the time constants T_1 and T_2, or of the resistance R_1, does certainly decrease the distortion in stationary conditions, but it simultaneously increases the building-up time."

Correction at high frequencies is by neutralising the grid/cathode capacity by an inductance in series with the anode resistance (Fig. 11, derived from Fig. 10 by regarding the coupling condenser C as a short circuit for the high frequencies now being considered). "The best correction for an amplifier stage is when $K = L/R_a{}^2C_g = 0.35$. . . . The best phase characteristic occurs for $K = 0.332$, the best frequency characteristic for $K = 0.414$. The optimum working condition of a one-stage amplifier thus coincides neither with the best phase nor with the best frequency characteristic, but lies in between."

2715. THE MEASUREMENT OF AMPLIFICATION AND PHASE SHIFT IN AMPLIFIERS [for Frequencies up to about 2 Mc/s: Method, with Sources of Error and Their Correction].—E. E. Wright and G. E. G. Graham. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, pp. 259–261.)

2716. THE DESIGN OF HIGH-DEFINITION AMPLIFIERS. PART V—THE RESPONSE OF RESISTANCE-CAPACITY AMPLIFIERS TO SIGNALS OF A TRANSIENT NATURE.—Walker. (*Television*, May, 1936, Vol. 9, No. 99, pp. 305–307.) Conclusion of the series of articles referred to in 2299 of June.

2717. USING THE 37–56 MEGACYCLE SIGNAL GENERATOR [for Tests on High-Definition Receivers].—(*Television*, May, 1936, Vol. 9, No. 99, pp. 277–279.) Modulated with 8 frequencies along the frequency band of the new service.

2718. SCANNING SEQUENCE AND REPETITION RATE OF TELEVISION IMAGES.—Kell, Bedford and Trainer. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 559–576.)

Deductions, from experience with the experimental installation dealt with in 476 of 1935, regarding flicker, a.c.ripple, and other unsteadiness. An integer ratio between a.c.ripple frequency and frame frequency is "very desirable for progressive scanning and is almost imperative for interlaced scanning." Double interlaced scanning with a frame frequency of 30 c/s "is the optimum known condition at the present time for a.c. power supply sources of 60 c/s." Triple interlacing has objectionable features. The problems of odd- and even-line interlacing are discussed, and the odd-line method is found preferable.

2719. ELECTRON OPTICS AND ITS APPLICATIONS [Full Paper to Société des Radioélectricisms).—V. K. Zworykin. (*L'Onde Élec.*, May, 1936, Vol. 15, No. 173, pp. 265–298) *See* also 2270 of June.

2720. A NEW GLOW-DISCHARGE PHENOMENON AND ITS POSSIBLE APPLICATION TO LOW-VOLTAGE CATHODE-RAY TUBES.—Krug. (*See* 2772.)

2721. ON LIGHT STORING DEVICES.—V. I. Krasovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1936, pp. 24–34.)

A theoretical circuit is examined representing a mosaic of photocells which are acted on by light and discharged in turn by a wiper through a resistance *R* (Fig. 1). The operation of the circuit is considered in detail and the results obtained are applied to a study of practical systems in which the photocell mosaics are scanned by an electron ray. A theoretical interpretation of the various processes taking place in such a system is given and a number of factors pointed out on which the efficient operation of the system is dependent.

2722. LARGE PICTURES WITH THE CATHODE-RAY TUBE [Fluorescent Screen replaced by Mosaic of Optically Active Crystals affected by Ray Intensity].—L. S. Kaysie: Pulvermacher. (*Television*, May, 1936, Vol. 9, No. 99, pp. 273–274.)

2723. NEW ELECTRON MULTIPLIERS [Recent Advances in "Multipactor" Design: Kilowatts from Cold-Cathode Tube, up to 300 Mc/s: Applications to High-Efficiency Oscillators and R.F. Amplifiers].—Farnsworth. (*Wireless World*, 3rd April, 1936, Vol. 38, pp. 336–338.) Based on I.R.E. paper of 4th March.

2724. MOTOR SYNCHRONISES WITH ALL TELEVISION TRANSMISSIONS [Peck Multi-Speed Synchronous Motor with Speed governed entirely by Incoming Signal].—W. H. Peck. (*Scient. American*, May, 1936, Vol. 154, No. 5, p. 269.)

2725. THE PROPORTIONING OF SHIELDED CIRCUITS FOR MINIMUM HIGH-FREQUENCY ATTENUATION.—Green, Leibe and Curtis. (*See* 2605.)

2726. THE SCOPHONY LIGHT CONTROL [Scophony-Jeffree Light Relay making 50 to 100 Apertures progressively operative: Modulation of Quartz Crystal generating Supersonic Waves in Liquid].—J. H. Jeffree. (*Television*, May, 1936, Vol. 9, No. 99, pp. 260–264 and 310, 312, 314, 316.) *Cf.* Kharizomenov, 2302 of June.

2727. THE ELECTRO-OPTICAL KERR EFFECT IN METHANE, ETHYLENE AND ETHANE [Measurements].—W. M. Breazeale. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, pp. 625–626: abstract p. 643.)

2728. SULPHUR-CAESIUM AND SELENIUM-CAESIUM PHOTOCELLS.—P. V. Timofeev and V. V. Nalimov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 47–52.)

As is well known, the performance of a caesium cell is greatly affected by the nature of the cathode surface on which caesium is deposited. In the present paper an account is given of experiments with photocells in which caesium was deposited on layers of Ag_2S and Ag_2Se. The preparation of such cells is described and their spectral characteristics are given. It appears from these characteristics that although the integral sensitivity of the cells so prepared is below that of the cells in which caesium is deposited on Ag_2O, their sensitivity within the visible portion of spectrum greatly exceeds that of the Ag_2O type, and passes through a maximum between wavelengths of 4800 and 3500 Angström units. In order to account for this change in sensitivity, the effect of oxygen on caesium cathodes was investigated experimentally, and certain tentative explanations are put forward.

2729. VELOCITY DISTRIBUTION OF PHOTOELECTRONS AT COMPOSITE CAESIUM CATHODES [and Its Dependence on the Wavelength and on the Cathode Structure].—A. I. Pjatnitzski and P. W. Timofeev. (*Physik. Zeitschr. der Sowjetunion*, No. 2/3, Vol. 9, 1936, pp. 187–197: in German.) Confirming the view of de Boer & Teves that the effect is one of photo-ionisation of adsorbed alkali-metal vapour.

2730. THIN WINDOWS FOR PHOTOELECTRIC CELLS AND COUNTERS [Technique of Preparation].—G. P. Harnwell. (*Review Scient. Instr.*, May, 1936, Vol. 7, No. 5, p. 216.)

2731. THE THEORETICAL CONSTITUTION OF METALLIC POTASSIUM.—E. Gorin. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 328–344: in English.)

2732. HYPOTHESES FOR PHOTOELECTRIC EMISSION ANALYSIS.—W. B. Nottingham. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 649: abstract only.)

"A new hypothesis agreeing quite well with energy distribution data is that the number of electrons emitted per second per quanta absorbed per second is proportional to the number of electrons striking the surface per second, whose kinetic energy normal to the surface augmented by $h\nu$ is sufficient to overcome the potential step at the surface, multiplied by the time electrons of a given kinetic energy are 'bound' in a mirror-image potential barrier."

2733. Photoelectric Sensitivity of Palladium-Silver Alloys, Saturated with Hydrogen [Coincidence of Maxima of Sensitivity and Hydrogen Absorption: Sensitivity Maximum not caused by Shift of Limiting Frequency beyond 3130 Å].—F. Krüger and W. Kallenbach. (*Zeitschr. f. Physik*, No. 11/12, Vol. 99, 1936, pp. 743–750.)

2734. Influence of Electron Reflection on Photoelectric Emission [Incorporation of Results in Fowler's Theory: Correction and Negative Temperature Coefficient of Photoelectric Work Functions].—W. B. Nottingham. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 646: abstract only.)

2735. A Photoelectric Effect at Thin [Electrolytic] Films of Aluminium and Tantalum Oxide [Measurements].—G. Rosenthal. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 607–621.)

2736. Penning's "New Photo-Effect" in Pure Neon [Equilibrium between Metastable Atoms and Resonance Radiation in Gas Discharge: Comparative Insensitivity to Illumination of Pure Gas: Equations of Discharge].—E. W. Pike. (*Phys. Review*, 1st April, 1936, Series 2, Vol. 49, No. 7, pp. 515–518.) For Penning's work *see* 1931 Abstracts, p. 565.

2737. The Variation with Temperature of the Reverse Photoelectric Effect in Cuprite Crystals.—N. J. Barbaumov and R. G. Jensch. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 345–351: in German.)

2738. Crystal Photoelectric Effect with Coloured Rochelle Salt [Measurements of Secondary Effect].—F. Seidl with P. Petritsch. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 633–634.)

2739. On the Absorption of Light and the Trapping of Electrons and Positive Holes in Crystalline Dielectrics.—J. Frenkel. (*Physik. Zeitschr. der Sowjetunion*, No. 2/3, Vol. 9, 1936, pp. 158–186: in English.)

2740. Photoelectric Investigations with Semi-Conductors [Study of Internal Photoelectric Effect: Determination of Optical Absorption].—L. Bergmann and J. Hänsler. (*Zeitschr. f. Physik*, No. 1/2, Vol. 100, 1936, pp. 50–79.)

2741. On the Nature of the Blocking Layer in a Selenium Valve Photoelectric Cell: Preliminary Report.—Freiwert. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 266–267: in English.) *See* 2305 of June.

MEASUREMENTS AND STANDARDS

2742. Potential Measurement with a Lecher System.—N. N. Malov. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 405–406: in German.)

In a previous paper (1534 of April) the writer discussed the measurement of potential by a telescopic Lecher-wire system with variable characteristic impedance. He now points out that similar measurements can be made with a system of fixed characteristic impedance, by sliding the ammeter along the two parallel wires, which must be of constant thickness. If y is the distance between the ammeter and the beginning of the Lecher system (where the potential to be measured is applied) and x is the length of the free ends beyond the ammeter, in the great majority of cases y coincides with the quarter wavelength. The relation between the potential V_0 to be measured and the current I_a in the ammeter is then given by $V_0 = I_a W \zeta$, where W is the characteristic impedance of the system (some 300–500 ohms, compared with the 0.1–1.0 ohm of the ammeter resistance), and ζ differs appreciably from unity only in a very narrow zone defined approximately by $0.245\lambda \leq x \leq 0.255\lambda$. Thus in all other cases the effect of the free ends can be neglected in practice.

2743. The Measurement of Currents in Circuits with Standing Waves [Magnetic Flux Method].—R. E. Albrandt. (*Izvestiya Elektroprom. Slab. Toka*, No. 2, 1936, pp. 53–55.)

At frequencies of the order of 10^7 cycles and higher, the current in a circuit varies considerably from point to point owing to the presence of standing waves. Under these conditions accurate current measurements cannot be obtained for any specific part of the circuit with an ordinary current measuring instrument, since this can only indicate the current flowing through the measuring element itself, which may be different from that at the point required. In order to obviate this difficulty the author proposes a method based on measuring the magnetic flux intensity in a conductor located near that part of the circuit in which the current is to be measured. It is shown that this method is sufficiently accurate for most measurements, since the magnetic field intensity is almost entirely determined by the current in the nearest element of the circuit. It is suggested that magnetrons could be used in these measurements.

2744. On the Theory of the Measurement of Dielectric Constants and Absorption Coefficients in the Region of [Ultra-] Short Electric Waves. I [Effect of the Measuring Apparatus on the Results in Drude's 2nd (Lecher Wire) Method].—W. I. Romanov. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 362–382: in German.)

2745. Addendum to the Paper: "On the Application of Broadcast Waves to the Measurement of Dielectric Constants of Insulating Liquids" [Note on Constancy of Broadcast Frequencies and Use of Modulated Waves].—D. Doborzyński. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, p. 91.) *See* 262 of January.

2746. New Measurements of the Dielectric Constant of Strong Electrolytes and the Debye-Falkenhagen Theory.—M. Jeżewski. (*Physik. Zeitschr.*, 15th Jan. 1936, Vol. 37, No. 2, pp. 52–55.)

2747. On the Determination of the Dielectric Constants of Organic Liquids at Radio Frequencies. Part II—Chlorobenzene and Ethylene Dichloride [with Description of Special Cylindrical and Parallel-Plate Condensers].—R. M. Davies. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 1008–1029.) For I *see* 1143 of March.

2748. A Logarithmic Cathode-Ray Resonance-Curve Indicator [Device handling 10 000/1 Range of Input Voltage, and giving Output directly proportional to Logarithm of Input Voltage, based on Use of 20-Metre Super-Regenerative Circuit].—S. Bagno and M. Posner. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, pp. 15–17.)

2749. The Measurement of Amplification and Phase Shift in Amplifiers.—Wright and Graham. (*See* 2715.)

2750. Automatic Potentiometer operates at High Speed [by use of Galvanometer-Controlled Photocells in Bridge Circuit].—Weston Company. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, p. 22.)

2751. The Works Testing of Broadcast Receiver Apparatus [Components and Finished Receivers].—Römer and Janschek. (*Zeitschr. V.D.I.*, 11th April, 1936, Vol. 80, No. 15, pp. 441–445.)

2752. Test Equipment for Measurements [of Inductance, Capacity and Decrement] at Radioelectric Frequencies.—E. Fromy. [*Rev. Gén. de l'Élec.*, 25th April, 1936, Vol. 39, No. 17, pp. 611–616.)

A calibrated generator is coupled by a very small variable capacity (a few electrostatic units) to a test circuit in which are connected a calibrated variable condenser, an inductance variable in steps, and the element to be measured. From measurements, with a valve voltmeter, of the voltages at the terminals of this test circuit for various values of the calibrated condenser in the neighbourhood of resonance, all the characteristic factors of the circuit can be calculated.

2753. High-Frequency Measurements with Mutual Inductances [Quick and Accurate Method for obtaining Power Factor of Capacities, using Variable Mutual Inductances and Air Condenser: Mutual Inductance as Source of Quadrature E.M.F: etc.].—A. A. Symonds. (*Abstracts of Dissertations approved for Ph.D., M.Sc. and M.Litt. Degrees in the University of Cambridge*, 1934–1935: published 1936: p. 49.)

2754. A Differential Method of Measuring Impedances.—K. Karandeev. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 249–254: in German). Making use of the writer's null method of frequency measurement (1889 of May).

2755. Loss Measurement, particularly on Power Condensers [and H.F. Apparatus] by a Static Thermal Method.—H. Gönningen. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, pp. 523–525.)

A simple process with an accuracy within about ±5%. A closed oil- or air-filled container is used, and the losses inside it are obtained from the curves of the average surface temperature, taken by thermometers affixed at various points on the outside of the container. The curves are plotted carefully and dealt with by Simpson's rule or by a planimeter. The thermal relations vary with the height of the container and the nature of the surface: allowance for these factors is made by calibrating the container beforehand.

2756. A Proposed Wattmeter using Multi-Electrode Tubes [Mixing Valves in Push-Pull, or Single Special Valve with Both Control Grid Characteristics sufficiently Linear].—J. R. Pierce. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 577–583.)

2757. The Effect of Stray Capacities to Ground in Substitution Measurements [Derivation of Formulae for Errors, enabling Best Conditions of Test to be Chosen].—M. Reed. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, pp. 248–257.)

2758. Magnetic Field and Inductance of a Cylindrical Coil [Calculations: Formulae for Numerical Work: Examples: Approximate Inductance Formulae].—K. Foelsch. (*Arch. f. Elektrot.*, 10th March, 1936, Vol. 30, No. 3, pp. 139–157.)

2759. The Alternating-Current Resistance of Tubular Conductors [Simple Formulae and Experimental Confirmation at Frequencies 25–600 c/s].—A. H. M. Arnold. (*Journ. I.E.E.*, May, 1936, Vol. 78, No. 473, pp. 580–593.)

2760. On a Valve Electrometer [with Positive Grid Valve].—B. A. Ostroumov. (*Journn. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 177–181.)

A description of an electrometer for measuring potentials of the order of 10^{-4} volt in which use is made of a "reversed" valve, *i.e.* a valve in which a negative voltage is applied to the anode and a positive voltage to the grid. More elaborate circuits with compensating devices are also described.

2761. Portable Electrostatic Voltmeter.—Anglo-Swiss Electrical Company. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, p. 169.)

2762. A New Method of Measuring [High] Voltages by Means of a Cathode-Ray Tube.—A. I. Romanov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 31–36.)

When a cathode ray passes through a uniform electric field, the deflection of the ray is inversely proportional to the square of the electron velocity.

It is therefore suggested that if the ray is passed between two elongated electrodes charged to a certain potential difference, the length of the path of the ray, before it strikes one of the electrodes, may serve as a measure of the voltage applied to the cathode-ray tube. Methods are indicated for calculating the constants of the system, and a description is given of a model which has actually been constructed. It is suggested that this method is suitable for measuring constant as well as alternating (low- and high-frequency) voltages. The accuracy of the method when the voltage is changed from 50 to 49 kv is stated to be within about 0.5%.

2763. A Broadcast Frequency Measuring Set.—W. M. Kellogg. (*Bell Lab. Record*, May, 1936, Vol. 14, No. 9, pp. 307–311.)

2764. A Simple Circuit for Oscillographic Frequency Comparison.—B. Kurrelmeyer. (*See* 2774.)

2765. The Application of Ricci-Calculus to the Solution of Vibration Equations of Piezoelectric Quartz.—B. van Dijl. (*Physica*, May, 1936, Vol. 3, No. 5, pp. 317–326: in English.)

Author's summary:—It is shown that the application of Ricci-calculus to the elastic vibration and piezoelectric equations yields results which can readily be interpreted. The wave equation is derived from the general equation of motion. The equations are worked out for Y-cut (30°-cut) plates and for Y_δ-cut plates. In particular the so-called AC-cut plate is examined [a Y_δ-cut plate where $\delta = -30° 55'$].

2766. Electrode Arrangement for Oscillating Quartz Crystals [adjustable to a Range of Frequencies by Variable Steps in One Electrode].—R. Bechmann, H. Elstermann and H. O. Roosenstein: Telefunken. (*Hochf: tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, p. 67: German Patent 606 360 of 27.1.33.)

2767. Marked Decrease in Piezoelectric Modulus of Quartz between Temperatures of Liquid Air and Liquid Helium.—Burton, Pitt and McKinley. (*See* 2704.)

2768. A New Form of Crystalline Quartz at −183.5° C [Cessation of Piezoelectric Oscillations and Changes in Rotatory Power at that Temperature].—H. Osterberg. (*Phys. Review*, 1st April, 1936, Series 2, Vol. 49, No. 7, pp. 552–553.)

2769. A New Method of Investigating Piezoelectric Substances in Powder Form [Powder mixed with Loss-Free Liquid used as Dielectric in H.F. Field: Temperature Changes as Function of Frequency show Resonance Phenomenon depending on Natural Frequencies of Powder Grains and Their Friction with the Liquid].—T. Engl and I. Leventer. (*Naturwiss.*, 3rd April, 1936, Vol. 24, No. 14, pp. 217–218.)

2770. Note on the Three Absolute Systems of Electrical Measurements [with Appendices on Practical Absolute and International Systems, the Giorgi System, the M.K.S. System], *and* The Fourth Unit of the Giorgi System of Electrical Units.—R. T. Glazebrook. (*Proc. Phys. Soc.*, 1st May, 1936, Vol. 48, Part 3, No. 266, pp. 444–451: 452–455.)

SUBSIDIARY APPARATUS AND MATERIALS

2771. A Cathode-Ray Oscillograph with High-Speed Drum Camera rotating in Vacuo.—Whipple. (*Journ. I.E.E.*, May, 1936, Vol. 78, No. 473, pp. 497–506: Discussions pp. 506–515.) Record lengths of 50 metres or more can be obtained, although the drum circumference is only 2 metres, by the use of zero-shifting plates moving the beam across the drum step by step at every revolution.

2772. A New Glow-Discharge Phenomenon and the Possibilities of Application to Braun [Cathode-Ray] Tubes with Low Cathode Voltages.—Krug. (*Arch. f. Elektrot.*, 10th March, 1936, Vol. 30, No. 3, pp. 157–183.)

For a preliminary report *see* 3552 of 1935. The new phenomenon is found when hollow cathodes (*e.g.* Fig. 15) are used in place of plane ones in the cold-cathode oscillograph. These give, under certain working conditions, a fine, concentrated beam of cathode rays. Experiments on the use of this cathode as a source of high intensity with small cathode voltages in a small metallic cathode-ray tube are described; examples are given of its concentration and the records obtainable with it. General phenomena and properties of the plane cathode are also reviewed (§ II); pressure/voltage and current/voltage characteristics for the hollow cathode are shown (Figs. 13, 14) and the behaviour of the metal tube including the cathode is fully discussed. § V describes a four-position metal tube for low cathode voltages (of the order of 2 kv).

2773. The Electrostatic Repulsion of Electrons in a Beam.—V. S. Lukoshkov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 26–30.)

When electrons are moving in a beam the electrostatic forces of repulsion tend to cause spreading, while the electromagnetic forces exercise an opposite effect. In this paper, starting from certain simplifying assumptions, a theoretical study is presented of the action of these forces. The movement of an electron on the surface of a cylindrical beam is examined and its deviation due to the action of the electrostatic forces is determined. The magnitude of the electromagnetic force of attraction acting on this electron is also calculated and is found to be only 4% of that of the electrostatic repulsion. Finally, the movement of electrons in a converging beam is examined and the minimum radius of the beam determined. The position of the real focus with regard to the geometrical focus is also indicated.

2774. A SIMPLE CIRCUIT FOR OSCILLOGRAPHIC FREQUENCY COMPARISON [Circular Time Base with Radial Modulation: Loops counted (if Pattern is slowly Rotating) through Reversing Rotating Prism].—Kurrelmeyer. (*Review Scient. Instr.*, May, 1936, Vol. 7, No. 5, pp. 200–201). The methods of Watson Watt and his collaborators are referred to (*e.g.* 1932 Abstracts, pp. 535–536): the present circuit "has the advantage of extreme simplicity and flexibility."

2775. THE ELECTRON SWITCH—AN ACCESSORY FOR THE CATHODE-RAY OSCILLOGRAPH [for Simultaneous Observation of Two Phenomena: Use of Multivibrator Circuit].—Dumont. (*Rad. Engineering*, January, 1936, Vol. 16, No. 1, p. 18.) *See* also 2041 of 1935 and 1163 of March.

2776. A PHOTOKYMOGRAPHIC METHOD WITH CONTINUOUS CATHODE-RAY OSCILLOGRAMS [giving Simultaneous Record of Oscillograph Movements in Black, and Other Signals in White, on Gray Background].—McCullock and Wendt. (*Science*, 10th April, 1936, Vol. 83, pp. 354–355.)

2777. THE VACUUM CELL LUMINESCENCE MICROSCOPE AND ITS USE IN THE STUDY OF LUMINESCENT MATERIALS.—Gallup. (*Journ. Opt. Soc. Am.*, May, 1936, Vol. 26, No. 5, pp. 213–215.)

"In the study of manganese-activated calcium silicates, this microscope has facilitated the determination of many of the relationships which exist between colour of luminescence, intensity of luminescence, and crystal form. The low-temperature form of calcium metasilicate luminesces more brightly than any other calcium silicate studied. A thorough wet mixing of raw materials is necessary to obtain a product of uniform luminescence."

2778. PIEZOELECTRIC OSCILLOSCOPES.—Brush Company. (*Rad. Engineering*, April, 1936, Vol. 16, No. 4, p. 19.)

2779. POLAROID GLASS USED TO DETECT STRAINS AND FLAWS IN GLASS ENVELOPES AND STEMS.—(*Electronics*, April, 1936, Vol. 9, No. 4, p. 40.) For this special glass *see* also 1605 of April.

2780. NOTES ON THE DESIGN OF VACUUM JOINTS IN METAL APPARATUS.—Archer. (*Journ. Scient. Inst.*, May, 1936, Vol. 13, No. 5, pp. 161–165.)

2781. NEW MATERIALS FOR GLASS-METAL SEALS [Iron-Nickel Alloys: New Glass].—Hull, Burger and Navias. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 647: abstract only.) *See* also 1184 of 1935.

2782. ADVANCES IN METAL/GLASS SEALS [the Use of Kovar], *and* BRAZED SEALS FOR ALL-METAL TUBES. (*See* 2647 and 2648.)

2783. MOLYBDENUM FOIL SEALED INTO QUARTZ, A NEW DEVELOPMENT IN QUARTZ LAMP MANUFACTURE.—Lauster. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, pp. 517–519.) An important point is the choice of the correct relation between surface of foil and its thickness.

2784. THE IMPULSE VACUUM METER [Ionisation Manometer connected as Resistance governing the Pulse Frequency of Gas-Filled Triode Circuit].—Butschinsky. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 223–228: in German.)

2785. NEW TYPE OF PRESSURE CONTROL AND INDICATOR [Concentric Glass Cylinders coated with Electrically Conducting Material, Variable Impedance and Grid-Controlled Tube: the Barotron].—Killian. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 647: abstract only.)

2786. A UNIVERSAL ION SOURCE [Electron Beam focused electrostatically on Cup-Shaped Target vapourises Material in Cup which forms Ion Stream in Direction opposite to Beam].—Smith and Carlock. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 646: abstract only.)

2787. DETERMINATION OF THE VELOCITY DISTRIBUTION OF ELECTRONS IN A LOW-PRESSURE [Neon] DISCHARGE TUBE [from Second Derivative of Current/Voltage Characteristic of a Probe in the Discharge].—Van Gorcum. (*Physica*, April, 1936, Vol. 3, No. 4, pp. 207–218: in English.) The curves show how, approaching the positive column from the cathode side, the velocity distribution changes into a Maxwellian one.

2788. TEMPERATURE OF ELECTRONS IN A POSITIVE COLUMN DISCHARGE IN A NE/NA MIXTURE [Maximum Positive Ion Current at about Same Temperature as Maximum Potential Gradient].—Uyterhoeven and Verburg. (*Comptes Rendus*, 4th May, 1936, Vol. 202, No. 18, pp. 1498–1500.)

2789. ON THE MEAN LIFETIME OF METASTABLE NEON ATOMS [Contribution to Explanation of Mechanism of Gas Discharges], *and* PENNING'S "NEW PHOTO-EFFECT" IN PURE NEON.—Pike. (*Phys. Review*, 1st April, 1936, Series 2, Vol. 49, No. 7, pp. 513–515: 515–518.)

2790. INVESTIGATIONS OF THE VARIATION OF THE MAINTENANCE VOLTAGE OF A GLOW DISCHARGE WITH THE LENGTH OF ITS POSITIVE COLUMN [Curves showing Anomalous Values for Very Short Discharges].—Holtz and Kömmnick. (*Zeitschr. f. Physik*, No. 3/4, Vol. 99, 1936, pp. 252–253.)

2791. THE INERTIA IN VARIOUS REGIONS OF THE VOLT/AMPERE CHARACTERISTIC OF A GAS DISCHARGE.—Kvartshava. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 3–18.)

2792. Spectroscopic Investigation of Discharges at High Gas Pressure.—Watson and Hull. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, pp. 592–596: abstract p. 648.)

2793. Effect of Intense Illumination on Time Lag in Static Spark Breakdown [Time Lag observed with Electro-Optical Shutter: Decreases of Illumination Intensity and Overvoltage increase Time Lag: Explanation on Basis of Space-Charge Effects].—White. (*Phys. Review*, 1st April, 1936, Series 2, Vol. 49, No. 7, pp. 507–512.)

2794. Concentration of Arc Current in a Thyratron [Discharge consists of Concentrated Current Streamer in Rapid Motion around Outer Portions of Electrodes].—Kingdon and Lawton. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 646: abstract only.)

2795. Applications of the Hot-Cathode Grid-Controlled Rectifier, or Thyratron.—Whiteley. (*Journ. I.E.E.*, May, 1936, Vol. 78, No. 473, pp. 516–528: Discussions pp. 528–539, and June issue, pp. 722–723.)

2796. The Gas-Discharge Tube [Widening Sphere of Usefulness of Mercury-Vapour Rectifiers for feeding Class B Amplifiers, etc., where High Voltage Drop of Ordinary Hard Rectifiers is Serious Drawback: Advantages of Voltage-Doubling Circuit].—Pollock. (*Wireless World*, 24th April, 1936, Vol. 38, pp. 416–417.)

2797. Power-Tube Manufacturing Problems: Discussing Ways and Means to produce More Efficient Transmitter and Rectifier Tubes at Lower Cost [Use of Svea Metal].—McMaster. (*Rad. Engineering*, March, 1936, Vol. 16, No. 3, pp. 11–12.) *See* also 1895 of 1935.

2798. The Discharge in an Ionic Converter with Magnetic Control.—Romanof. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 19–25.)

2799. On the Question of the Temperature-Dependence of Cathode Disintegration [Critical Potential independent of Temperature].—Morgulis, Bernadiner and Patiocha. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 9, 1936, pp. 302–316: in German.)

2800. Impact of Corpuscular Rays on Solid Bodies [Pulverising Effect: Secondary Electron Emission].—Sommermeyer. (*Ann. der Physik*, Series 5, No. 6, Vol. 25, 1936, pp. 481–511.)

2801. The Influence of Mechanical Deformation on the Properties of Copper-Oxide Rectifiers [Important Factor in Deterioration].—Dunaev and Nasledov. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 268–278: in English.)

2802. The Nature of the Surface Conductivity of Cuprous Oxide [High Values previously obtained are due to Contamination by Adsorption and Formation of Superficial Layer of Distinct Properties].—Dubar. (*Comptes Rendus*, 15th April, 1936, Vol. 202, No. 15, pp. 1330–1332.) For previous Notes *see* 2847 of 1935 and 1213 of March.

2803. The Effects of Heat and Ultra-Violet Light on the Rectifying Action of Some Crystals.—Sen. (*Indian Journ. of Phys.*, March, 1936, Vol. 10, Part 2, pp. 91–102.) For work by Khastgir and Gupta *see* 2407 of 1935.

2804. The Rectification of Alternating Current by a Thin Vibrating Wire.—Backman and Theodorchik. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 298–301.) For previous work *see* 923 of March.

2805. Condenser Stability: Nature and Causes of Undesired Changes in Capacitance and Power Factor [and Methods of obtaining Greater Constancy].—Thomas. (*Electrician*, 15th May, 1936, Vol. 116, p. 631.) Summary of I.E.E. paper.

2806. Condensers for Broadcast Reception Technique, with Special Reference to Electrolytic Condensers.—Linder. (*Hochf:tech. u. Elek:akus.*, February, 1936, Vol. 47, No. 2, pp. 64–67: Industry Review.)

A broadcast receiver with built-in electrolytic condensers, in which the dielectric is an aluminium oxide layer, is shown in Fig. 1; Fig. 2 gives curves illustrating the space saved by using them. The properties of barrier layers are described; their constitution is illustrated by Fig. 3. The variations in capacity and loss angle are discussed on the basis of an equivalent circuit (Fig. 4); the curves of Figs. 5–7 show the variations with temperature and frequency. Points in connection with the practical use of these condensers are mentioned. *See* also 1600 of April.

2807. The Growth and Constitution of Electrolytically-Produced Aluminium Oxide Films [Methods for producing Highly Insulating Films, Free from Corrosion: Dielectric Properties depend on Water bound in Film: Working Model of Film].—Rummel. (*Zeitschr. f. Physik*, No. 7/8, Vol. 99, 1936, pp. 518–551.)

2808. Electrical Properties of Different Micas of the USSR [Measurements chiefly on 180 m].—Jakiméz. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1936, pp. 43–51.)

2809. The Dielectric Characteristic Curves of the Two-Layer Condenser, especially with Mica Insulation at 50 c/s.—Schaudinn. (*Berlin Thesis*, 1935: at Patent Office Library, London: Cat. No. 75 935: in German.)

2810. THE MANUFACTURE OF ELECTRO-PORCELAIN [from Kaolin, Quartz and Felspar], *and* THE USE OF PORCELAIN AND OTHER CERAMIC INSULATING MATERIALS IN ELECTRICAL ENGINEERING.—Steger. (*E.T.Z.*, 23rd April, 1936, Vol. 57, No. 17, pp. 469–470 : 471–476.)

2811. "IMPREGNATED PAPER INSULATION. THE INHERENT ELECTRICAL PROPERTIES" [Book Review].—Whitehead. (*Review Scient. Instr.*, April, 1936, Vol. 7, No. 4, p. 168.)

2812. THE CHOICE OF THE PERMISSIBLE STRAIN FOR THE PAPER INSULATION OF STATIC CONDENSERS.—Walther and Inge. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 234–243.)

2813. THE ELECTRICAL CONDUCTIVITY OF SOLID DIELECTRICS IN STRONG ELECTRIC FIELDS.—Walther and Inge. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 141–150.)

2814. PHYSICAL STRUCTURE AND DIELECTRIC LOSS OF SOLID INSULATING MATERIALS [Loss Angle as Function of Voltage, Temperature and Frequency : Decisive Effect of Amount and Condition of Enclosed Air on Shape of Curves].—Junius. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, pp. 519–522.)

2815. CURRENT CONDUCTION [in Dielectric Media] BY MEANS OF CONVECTION AND DIFFUSION. I [Theory].—Borgnis. (*Zeitschr. f. Physik*, No. 1/2, Vol. 100, 1936, pp. 117–140.)

2816. ON THE MEASUREMENT OF THERMAL CONDUCTIVITY ON SOME INSULATORS.—Shimizu. (*Journ. I.E.E. Japan*, January, 1936, Vol. 56 [No. 1], No. 570, p. 86 : letter, Japanese only.)

2817. ELECTRICAL CONDUCTIVITY OF THIN FILMS OF RUBIDIUM ON GLASS SURFACES.—Lovell. (*Nature*, 21st March, 1936, Vol. 137, pp. 493–494.)

2818. IRON CORES FOR RADIO COILS [High Resistivity probably More Important than High Permeability when Space Factors are low : Need for Very Low Temperature Coefficient of Permeability : "Sirufer" and "Draloperm" : etc.].—G. W. O. H. (*Wireless Engineer*, May, 1936, Vol. 13, No. 152, pp. 235–236 : Editorial.)

2819. TOROIDAL TRANSFORMERS [and Their Advantages as Mains Transformers for Compact High-Gain Amplifiers].—Salford Elec. Instruments, Ltd. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, pp. 167–168.)

2820. TRANSFORMERS WITH MAGNETIC SHUNTS [and Regulable Leakage].—Wirz. (*Bull. Assoc. suisse des Élec.*, No. 4, Vol. 27, 1936, pp. 98–109 : in German.)

2821. THE PROPERTIES OF HEUSLER'S ALLOY [Cu/Al/Mn : Strongly Magnetic Substance], AND THE TRUE SPECIFIC HEAT OF MANGANESE AND ITS DISCONTINUITY.—Ashworth. (*Proc. Phys. Soc.*, 1st May, 1936, Vol. 48, Part 3, No. 266, pp. 456–467 : Discussion p. 468.)

2822. MAGNETIC ATOMIC MOMENTS OF ALLOYS OF MANGANESE WITH COPPER, SILVER AND GOLD [with Method of measuring Susceptibility of Wires].—Gustafsson. (*Ann. der Physik*, Series 5, No. 6, Vol. 25, 1936, pp. 545–560.)

2823. "NIPERMAG," A NEW ALLOY FOR PERMANENT MAGNETS. (*See* 2661.)

2824. ALNICO—A NEW MAGNET MATERIAL.—(*Rad. Engineering*, February, 1936, Vol. 16, No. 2, pp. 20 and 21.)

2825. RESTORATION [after Heating] OF [Magnetic Properties of] NICKEL/BERYLLIUM ALLOYS.—Gerlach. (*Naturwiss.*, 3rd April, 1936, Vol. 24, No. 14, p. 218.)

2826. THE FERROMAGNETISM OF NICKEL [is the Stable State : Calculations of Saturation Magnetic Moment and Curie Point].—Slater. (*Phys. Review*, 1st April, 1936, Series 2, Vol. 49, No. 7, pp. 537–545.)

2827. THE CHANGE OF MAGNETISATION OF NICKEL, PERMALLOY AND SINGLE CRYSTALS OF NICKEL IN STRONG FIELDS [Decrease of Susceptibility to Constant Value at 4 000 Gauss].—Gerloff. (*Zeitschr. f. Physik*, No. 9/10, Vol. 99, 1936, pp. 585–594.)

2828. MAGNETIC INVERSION POINTS BY THE DIFFUSION OF H_2 THROUGH NICKEL AND IRON AND THROUGH IRON-NICKEL AND PALLADIUM-NICKEL ALLOYS.—Ham and Sauter. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 195 : abstract only.)

2829. INVESTIGATION OF THE VARIATION IN IMPEDANCE [at Low Frequencies] OF NICKEL IN A LONGITUDINAL MAGNETIC FIELD [No Remanence : Absence of Irregularities : Variation with Magnetic Field Strength].—Sen Gupta, Mohanti and Sharan. (*Zeitschr. f. Physik*, No. 3/4, Vol. 98, 1935, pp. 262–266.)

2830. ON THE EFFECT OF A MAGNETOMOTIVE FORCE APPLIED FOR A SHORT TIME TO A STEEL CYLINDER [Theoretical and Practical Determination of Flux Penetration].—Warren and Friend. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 980–990.)

2831. APPLICATION OF ARKADIEW'S METHOD OF SKIN-EFFECT ELIMINATION TO THE INVESTIGATION OF THE DYNAMIC MAGNETISATION CURVES [at Audio and Radio Frequencies: Connection between Skin Effect and Magnetic Viscosity].—Veletzkaia. (*Zeitschr. f. Physik*, No. 7/8, Vol. 99, 1936, pp. 569–575.)

2832. ON ANOMALOUS MAGNETIC VISCOSITY.—Mitkevitch. (*Journ. de Phys. et le Radium*, March, 1936, Vol. 7, No. 3, pp. 133–137.)

2833. MAGNETIC VISCOSITY [Occurrence of Magnetisation Jumps after Magnetising Force has become Constant : Possible Explanations].—Heaps. (*Phys. Review*, 1st March, 1936, Series 2, Vol. 49, No. 5, p. 409 : abstract only.)

2834. A New Experiment in Magnetostriction.—J. L. Snoek: Perrier. (*Physica*, April, 1936, Vol. 3, No. 4, pp. 205–206: in French.) Explanation of one of Perrier's results (4054 of 1935.)

2835. Magnetic Susceptibility of Single Crystals of Lead, Thallium and Tin.—Rao and Subramaniam. (*Phil. Mag.*, March, 1936, Series 7, Vol. 21, No. 141, pp. 609–624.)

2836. The So-called Temperature Variation of Spontaneous Magnetisation [of Single Iron Crystals: Induced, Not Real Magnetisation].—Honda and Nishina. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 657–665.)

2837. Nonorthogonality and Ferromagnetism [Theoretical Error due to Nonorthogonality of Wave Functions is not Infinite with Large Number of Atoms: Critical Conditions for Ferromagnetism cannot however be exactly Deduced].—van Vleck. (*Phys. Review*, 1st Feb. 1936, Series 2, Vol. 49, No. 3, pp. 232–240.)

2838. The Alternating Field in Saturated Massive Iron [Rigid Theoretical Solution: Magnetic Impedance: Power Loss: Influence of Hysteresis in decreasing Power Loss].—Haberland. (*Arch. f. Elektrot.*, 18th Feb. 1936, Vol. 30, No. 2, pp. 126–133.)

2839. A Flux Balance for the Measurement of Magnetic Susceptibilities in Alternating Fields of Low Intensity.—Hector and Eckstein. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 643: abstract only.)

2840. Contemporary Advances in Physics, XXX—The Theory of Magnetism.—Darrow. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 224–247.)

2841. Some Investigations on the Axial Spin of a Magnet and on the Laws of Electromagnetic Induction [and Some Practical Applications].—Cramp and Norgrove. (*Journ. I.E.E.*, April, 1936, Vol. 78, No. 472, pp. 481–491.)

2842. Contact Phenomena in Carborundum Resistances.—Kostina and Rusinow. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 217–233.) For a previous paper *see* 2409 of 1935.

2843. Spontaneous Resistance Fluctuations in Carbon Microphones and Other Granular Resistances [Commercial Grid Leaks, Sputtered Metal Films, etc.]—Christensen and Pearson. (*See* 2674.)

2844. A General Purpose Electric Coil-Winding Machine.—Bloxam. (*Journ. Scient. Instr.*, December, 1935, Vol. 12, No. 12, pp. 377–379.)

2845. Electrostatic High-Tension Generators for D.C. Potentials.—Walter and Sinelnikov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 6, 1936, pp. 151–162.)

2846. Improvement in D.C. Machines by Suppression of Short-Circuit Current: Increased Brush Resistance by Use of Insulating Layers.—Juditzki. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, pp. 529–530.)

2847. The High-Voltage Laboratory Equipment at Queen Mary College [late East London College], University of London.—Beetlestone and Smee. (*Metropolitan-Vickers Gazette*, April, 1936, pp. 98–103.)

2848. A Cyclotron Electromagnet [Numerical Design Data].—Henderson and White. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, p. 641: abstract only.)

2849. Voltage Sources and Amplifiers for Geiger Counters [Stabilised Sources of 1000–2000 v: Use of "Strobotron" Cold-Cathode Neon Two-Grid Tube as Amplifier: etc.].—Gingrich. (*Review Scient. Instr.*, May, 1936, Vol. 7, No. 5, pp. 207–210.)

2850. A Magnetic Mains-Voltage Regulator [Saturated-Iron Auto-Transformer, with Parallel Condenser, combined with Series Air-Gap Choke with Compensation Winding: Models for 10 to 250 VA: $\pm$ 1% Constancy between 175 v and 250 v].—Greiner: Siemens & Halske. (*E.T.Z.*, 30th April, 1936, Vol. 57, No. 18, pp. 489–491.)

2851. A Harmonic Analyser [using a Triode Circuit].—Neri. (*L'Elettrotec.*, 10th Feb. 1936, Vol. 23, No. 3, pp. 66–70.)

2852. A New Method of obtaining Perfectly Polished Metal Surfaces [Electrolysis in Phosphoric Acid].—Jacquet. (*Génie Civil*, 25th Jan. 1936, Vol. 108, pp. 92–93.)

2853. "Stabol," a New Material for the Sheaths of Cables and Lines [in place of Lead].—(*E.T.Z.*, 30th April, 1936, Vol. 57, No. 18, p. 502.)

2854. A New Receiver of Radiant Energy [Light or Heat Impulses], *and* A New Method of Measurement of Radiant Energy.—Hayes: Hall. (*Review Scient. Instr.*, May, 1936, Vol. 7, No. 5, pp. 202–204: 205–206.) The energy acts on a finely divided gas-occluding "fluff" in a hermetically sealed chamber, one side of which is a thin diaphragm forming one electrode of a condenser microphone.

2855. Thermoelements for the Reception of Radiant Energy [Survey].—Selzer. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 6, 1936, pp. 195–216.)

2856. Photographic Process for engraving Scales, etc., on Curved Surfaces.—Burmistrov. (*Tech. Phys. of USSR*, No. 3, Vol. 3, 1936, pp. 258–265.) French version of the Russian paper dealt with in 1601 of April.

2857. How Shall We Solder the Radio Chassis? *and* Fluxes and Solders.—Barber: Wagner. (*Rad. Engineering*, February, 1936, Vol. 16, No. 2, pp. 19 and 21: April, No. 4, pp. 8–9: May, No. 5, pp. 10–11 and 14.)

2858. A Thermionic Time-Delay Relay [for Intervals of from 1/20 Sec. to a Minute or more: utilising Negligible Leakage of Paper Condensers].—Mucher. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 38 and 40.)

2859. Review of Literature on Electrical Contacts.—Windred. (*World Power*, May, 1936, Vol. 25, pp. 262–264.)

2860. An Improved Thermo-Regulator [Increased Precision of Toluene Regulator by Rapidly Conducting Metal Foil (*e.g.* Copper) in Bulb].—Stiehler. (*Science*, 10th Jan. 1936, Vol. 83, p. 40.)

STATIONS, DESIGN AND OPERATION

2861. Indian Broadcasting: Mr. Kirke's Recommendations.—(*Electrician*, 15th May, 1936, Vol. 116, p. 635.)

2862. How the B.B.C. relays America [Methods and Equipment at Tatsfield Receiving Station].—(*Wireless World*, 1st May, 1936, Vol. 38, pp. 422–424.)

2863. The Law of 20th March, 1936, on Private Broadcasting Stations.—de Fabel. (*Génie Civil*, 18th April, 1936, Vol. 108, pp. 378–379.)

2864. "Radio-Distribution" [Wired Broadcasting] in European Countries: Survey.—(*Alta Frequenza*, April/May, 1936, Vol. 5, No. 4/5, pp. 325–328.)

2865. Experiments in Germany on Micro-Waves.—Telefunken. (*L'Onde Élec.*, May, 1936, Vol. 15, No. 173, pp. 332–341.) *See* also 3475 of 1935.

2866. Radio Telephony over a Distance of 80 km by means of 68-cm Waves with Parabolic Reflectors [with 2.5 m Opening: Sharpness of Directivity improved by Four Half-Wave Rods at Half Wavelength from Doublet: 3 Watts Output from Transmitter].—Morita. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, pp. 137–150.)
Modulation is by speech voltages impressed on grid and plate separately, in such a way that there is no accompanying frequency change.

2867. The Reliability of Short-Wave Radio-Telephone Circuits [Relation between "Percentage Lost Circuit Time" and "Transmission Improvement," deduced from Routine Service Data: Comparison of 1930, 1932 and 1934.]—Potter and Peterson. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 181–196.)

2868. New Empire Flying Boats [and Their Wireless Equipment].—(*Wireless World*, 24th April, 1936, Vol. 38, pp. 409–410.)

2869. Coastguard Radio [Methods and Equipment of American Patrol Aircraft].—(*Wireless World*, 22nd May, 1936, Vol. 38, pp. 505–506.)

GENERAL PHYSICAL ARTICLES

2870. The Structure of Light Waves [Axially Symmetrical Systems of Electromagnetic Waves].—Japolsky. (*Nature*, 18th April, 1936, Vol. 137, p. 663.) *See* back reference in 2449 of June, and 810 of February.

2871. Deviations from the Maxwell Equations resulting from the Theory of the Positron [Addition to Lagrangian].—Kemmer and Weisskopf. (*Nature*, 18th April, 1936, Vol. 137, p. 659.)

2872. A New Relativity. Paper II. Transformation of the Electromagnetic Field between Accelerated Systems and the Force Equation.—Leigh Page and Adams. (*Phys. Review*, 15th March, 1936, Series 2, Vol. 49, No. 6, pp. 466–469.)

2873. A Method of Investigating the Hall Effect [Primary Current generated by Inductive Action of Rotating Magnetic Field on Cylindrical Metal Sheet set Coaxially with Axis of Field Rotation].—Hatfield. (*Proc. Phys. Soc.*, 1st March, 1936, Vol. 48, Part 2, No. 265, pp. 267–276.)

2874. On the Measurement of *e/m* with a Triode Valve [by Effect of Magnetic Field on Grid Current].—Sant Ram. (*Indian Journ. of Phys.*, March, 1936, Vol. 10, Part 2, pp. 127–132.)

2875. The Energy Levels of the Electron in a One-Dimensional Crystal Model, Non-Compact in Places (with Application to the Theory of Electrical Breakdown).—Sokolow and Machalowa. (*Zeitschr. f. Physik*, No. 7/8, Vol. 99, 1936, pp. 503–517.)

2876. On Tonk's Theory of Liquid Surface Rupture by a Uniform Electric Field [Sparking Potential 20 Times Smaller than with Solid Cathode].—Frenkel: Tonks. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 8, 1935, pp. 675–679: in English.) *See* 1324 of March.

2877. "What is Electricity?" [Fifth Joseph Henry Lecture].—Heyl. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 4–11.)

2878. Contribution to the Study of the Molecular Diffusion of Light: Cabannes-Daure Effect, Critical Opalescence of Binary Mixtures.—Rousset. (*Ann. de Physique*, January, 1936, Series 11, Vol. 5, pp. 5–135.)

2879. Magnetic Behaviour in the Chromium/Sulphur System [Ferromagnetic Behaviour of Susceptibility at Certain Concentration: Analogy with Dielectric Constant of Rochelle Salt].—Haraldsen and Neuber. (*Naturwiss.*, 1st May, 1936, Vol. 24, No. 18, p. 280.)

2880. FURTHER INVESTIGATIONS OF THE CORONA ROTATION EFFECT [Experience on Variation of Velocity of Rotating Wire with Corona Current Density and Wire Temperature].—Güntherschulze and Hesse. (*Zeitschr. f. Physik*, No. 7/8, Vol. 98, 1936, pp. 476–489.) *See* 820 of February.

MISCELLANEOUS

2881. AN EXTENSION OF OPERATIONAL CALCULUS [to cover Arbitrary Initial Conditions, for System of Finite Number of Degrees of Freedom: Application to Transmission Line Equations].—Carson: van der Pol. (*Bell S. Tech. Journ.*, April, 1936, Vol. 15, No. 2, pp. 340–342.)

2882. CONJUGATE POTENTIAL FUNCTIONS AND THE PROBLEM OF THE FINITE GRID [of Coplanar Equidistant Filaments of Infinite Length: Conformal Transformations: Effect of Parallel Infinite Plane].—Barkas. (*Phys. Review*, 15th April, 1936, Series 2, Vol. 49, No. 8, pp. 627–630.)

2883. AN OPERATIONAL PROOF OF THE WAVE-POTENTIAL THEOREM, WITH APPLICATIONS TO ELECTROMAGNETIC AND ACOUSTIC SYSTEMS.—Ballantine. (*See* 2656.)

2884. ON LAMÉ'S EQUATION [Expansion of Arbitrary Function in Terms of Lamé Functions].—Sharma. (*Phil. Mag.*, May, 1936, Series 7, Vol. 21, No. 143, pp. 991–994.)

2885. THE MAGNETIC VECTOR POTENTIAL [and Its Use in Electric Circuit Analysis, including at High Frequencies].—McRae. (*Elec. Engineering*, May, 1936, Vol. 55, No. 5, pp. 534–542.)

2886. ELECTROSTATIC FIELDS AND SPACE CHARGES ABOUT A CONDUCTOR AT HIGH ALTERNATING AND CONTINUOUS POTENTIALS.—W. G. Hoover. (*Elec. Engineering*, May, 1936, Vol. 55, No. 5, pp. 448–454.)

2887. NOMOGRAMS [Alignment Charts] IN ELECTRICAL ENGINEERING.—Kapp. (*Journ. I.E.E.*, May, 1936, Vol. 78, No. 473, pp. 567–576.)

2888. RECENT AUSTRALIAN WORK IN RADIO RESEARCH.—(*Australian Radio Research Board*, Report No. 9, 1936, 71 pp.) Containing papers dealt with in past Abstracts:—Bailey, 1934, p. 606 (2nd abstract); Martyn, 938 of 1935; Piddington, 1813 of 1935, Builder, 716, 2955 and 3192 of 1935. Also a hitherto unpublished paper by Piddington—*see* 2688, under "Acoustics and Audio-Frequencies."

2889. ON THE POSSIBILITY OF OBSERVING A SELECTIVE EFFECT OF THE [Ultra-] HIGH-FREQUENCY FIELD IN FLAMES.—Malinowski. (*Physik. Zeitschr. der Sowjetunion*, No. 2/3, Vol. 9, 1936, pp. 264–267: in German.)

For a supplementary paper *see* pp. 268–270. The natural frequency of an "electron plasma" is calculated to be about 72 Mc/s, which is of the same order as the field frequency (34 Mc/s) previously found to produce a 20% increase of flame velocity—*see* 1934 Abstracts, p. 633: *also* 2534 of 1935.

2890. ON THE POSSIBILITY OF "POINT WARMTH" FORMATION IN HIGH-FREQUENCY CONDENSER FIELDS [with Reference to Ultra-Short-Wave Action on Bacteria, Drosophila, etc.].—Malov: Krasny-Ergen. (*Physik. Zeitschr. der Sowjetunion*, No. 2/3, Vol. 9, 1936, pp. 271–272: in German.)

Krasny-Ergen's formula for the temperature rise in a semi-conducting sphere in a condenser field has led him to conclude that the bactericidal action of ultra-short waves cannot be due to "point warmth" (3732 of 1935: *see* also 382 of January). Malov here points out that this conclusion applies only to spheres of very small radius (around 10^{-5} cm); it would, therefore, hold good for bacteria, but not for the Drosophila of his own investigations; while even bacteria might in many cases form colonies large enough to undergo a marked temperature rise.

2891. THE ACTUAL FACTS ON THE BEHAVIOUR OF ORGANISMS ELECTRICALLY CONNECTED TO, OR INSULATED FROM, THE EARTH [Biological and Physico-Chemical Processes].—Vlès. (*Rev. Gén. de l'Élec.*, 4th April, 1936, Vol. 39, No. 14, pp. 519–520.) For previous work on this subject *see* 1934 Abstracts, p. 110 (Vlès & Gex) and back reference.

2892. "LA VIE ET LES ONDES" [The Work of Georges Lakhovsky: Book Review].—Adam and Givelet: Lakhovsky. (*Rev. Gén. de l'Élec.*, 25th April, 1936, Vol. 39, No. 17, p. 610.)

2893. THE TRIPLE HETERODYNE AND ITS POSSIBLE APPLICATION TO ULTRA-MICROMETRIC MEASUREMENTS.—Blake. (In the paper referred to in 2683.)

2894. ELECTRICAL [Ultra-] MICROMETER.—Reisch. (*E.T.Z.*, 7th May, 1936, Vol. 57, No. 19, p. 532.) The apparatus used by Fieber as high-speed motor indicator (1679 of April).

2895. NEW ELECTRIC DEVICE DETECTS DISTANCES LESS THAN ATOMIC SIZE [Ultra-Micrometer (with Quartz Resonator) measures Displacements of 10^{-9} cm within a Few per Cent].—Hubbard. (*Sci. News Letter*, 9th May, 1936, Vol. 29, p. 305.)

See also *Science*, 15th May, 1936, p. 472. Using a quartz plate of 600 kc/s resonant frequency, a frequency change of one-sixtieth of a cycle per second (about 3 parts in 100 million) can be detected. By taking precautions against mechanical disturbances it is expected that displacements of 10^{-10} cm may be measured: "the attainment of a sensitivity of this order should open a new avenue of approach to a number of important problems."

2896. A PROPOSED NEW METHOD OF STUDYING THE VIBRATIONS IN STEEL STRUCTURES SUCH AS BRIDGES.—Pennell and Lawther. (*See* 2697.)

2897. BODY-IMPEDANCE ["Q"-Value] MEASUREMENTS AID IN MEDICAL DIAGNOSIS.—(*Electronics*, April, 1936, Vol. 9, No. 4, pp. 36–37.)

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

442 003.—Radio beacon transmitter which maintains constant directivity in spite of variations in the aerial characteristics due to weather conditions.

British Thomson Houston Co., Ltd. Convention date (U.S.A.), 29th April, 1933.

442 164.—Radio beacon transmitter of the Adcock aerial type radiating two overlapping beams with interlocked signals.

Marconi's W. T. Co. and S. B. Smith. Application date, 3rd August, 1934.

2 007 640.—Dipole aerial designed to minimise high-angle radiation by virtue of a logarithmic variation in diameter from each end to the centre.

P. S. Carter (assignor to Radio Corporation of America).

2 008 266.—Removing deposits of sleet, snow, etc., from a short-wave directive aerial system by low-frequency drying-currents, which are supplied, in parallel with the H.F. carrier currents, through tuned Lecher-wire circuits which isolate the H.F. currents from the L.F. supply.

E. J. Sterba (assignor to Bell Telephone Laboratories).

TRANSMISSION CIRCUITS AND APPARATUS

442 384.—Wired wireless or rediffusion system on which impedance step-down transformers are used to couple the feeder lines with the subscribers apparatus.

Standard Radio Relay Services, Ltd. and P. Adorjan. *Application date, 10th October, 1934.*

2 007 875.—Means for preventing an ultra-short wave generator from ceasing to oscillate when modulating signals are applied to it.

H. O. Roosenstein (assignor to Telefunken Co.).

2 008 082.—Method of maintaining the overall level of modulating voltage constant in a broadcast transmitter fed simultaneously from a number of different microphones.

W. A. Mueller (assignor to United Research Corp.).

2 008 286.—Ultra-short-wave oscillator utilising a "discontinuous" coupling or transmission line formed of short capacity strips arranged in staggered formation.

A. Leib (assignor to Telefunken Co.).

2 011 299.—Ultra-short-wave generator in which two condensers, shunted in parallel across the plate and grid, serve to reduce the circuit inductance to a low value.

H. S. Polin (assignor to Polin, Inc.).

2 018 356.—Heterodyne method of generating two or more frequencies to be radiated with a constant frequency-difference for multiplexing or for distant control of apparatus.

J. H. Hammond, Junr.

RECEPTION CIRCUITS AND APPARATUS

441 591.—Receiving circuit in which frequency-modulated signals are converted into an equivalent amplitude-modulated form.

Marconi's W. T. Co. (assignees of J. W. Conklin). Convention date (U.S.A.), 23rd. March, 1934.

441 691.—Automatic or self-tuning circuit for a superhet receiver.

E. K. Cole and A. W. Martin. Application date, 20th July, 1934.

442 158.—Tuning indicator in which an illuminated resonance lamp or tube also acts as a wavelenth pointer.

R. H. Hacker and A. G. Hacker. Application date, 3rd August, 1934.

442 477. Superhet receiver with means for varying the effective width of the I.F. modulation sideband, and for shifting the local-oscillation frequency relative to that of the signals.

Hazeltine Corporation (assignees of J. K. Johnson). Convention date (U.S.A.), 22nd May. 1934.

442 626.—Eliminating static interference by utilising a dynatron valve to reduce the amplification of the receiving circuits when the static voltage exceeds the signal voltage.

Ideal Werke Akt. Convention date (Germany), 14th February, 1934.

443 121.—Tuning scale provided with a spiral scanning-device to facilitate accurate tuning to a given station.

R. J. Pickard. Application date, 11th October, 1934.

443 900.—Wave-change switch based on the step-by-step movement of the iron core of a variable-permeability inductance coil.

L. L. de Kramolin. Convention date (Germany), 22nd May, 1934.

444 329.—Tuning indicator in which a cursor mounted on an endless band is moved across, and up and down, a panel bearing the names of the stations.

L. H. Brown. Application date, 18th October, 1934.

2 007 764.—Eliminating the A.C. "hum" from a mains-driven set by arranging certain of the circuit elements in the form of a balanced Wheatstone bridge.

E. L. Koch (assignor to Kellogg Switchboard and Supply Co.).

2 008 108.—Clock-controlled device for automatically switching-in or tuning a wireless receiver to a predetermined selection of items broadcast from the same or different transmitters.

C. Petersen.

VALVES AND THERMIONICS

441 740.—Magnetron oscillation-generator in which the magnetic "control" field is regulated by varying the reluctance of a permanent magnet.

Telefunken Co. Convention dates (Germany), 23rd February, and 5th July, 1934.

442 285.—Magnetron valve with auxiliary electrodes to screen the cathode electrostatically from the anode.

S. Rodda. Application date, 5th July, 1934.

442 465.—Magnetron oscillator in which an auxiliary electrostatic control of the electron stream is utilised to increase the power-output.

Marconi's W. T. Co. (assignees of E. G. Linder), Convention date (U.S.A.), 21st December, 1933.

DIRECTIONAL WIRELESS

441 770.—Making a graphical record of the critical signals received by a wireless direction-finder.

R. H. L. Bevan, C. Crampton, and S. E. Triglee. Application date, 24th June, 1934.

441 964.—Radio direction-finder having a characteristic in which a minimum or zero zone of reception occurs within a small solid angle which is otherwise filled with signals of substantial strength.

Telefunken Co. Convention date (Germany), 27th January, 1934.

2 008 401.—"Blind" landing and navigational system for aircraft based on the use of two rotating-frame beacons and a non-directive aerial installed on the aerodrome.

V. R. Philpott (assignor to Westinghouse Co.).

2 028 510.—Radio navigation beacons in which a keyed reflector system is used to produce overlapping beams with an equi-signal line for guiding aeroplanes over a predetermined course.

E. Kramer (assignor to C. Lorenz Akt.).

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

444 261.—Tone-correction circuit comprising a series capacity and two shunt circuits of different and variable reactance.

Pye Radio and C. J. Carter. Application date, 24th September, 1934.

TELEVISION AND PHOTOTELEGRAPHY

441 761.—Synchronising system for television in which the level of a positive bias applied to the modulator at the transmitting end is lowered to a constant and definite value by the synchronising impulse.

Radio Akt. D. S. Loewe. Convention date (Germany), 19th May, 1933.

441 847.—Circuit for separating the synchronising impulses used in television.

M. Bowman-Manifold. Application date, 25th June, 1934.

441 896.—Television system in which a series of image points are transmitted simultaneously on carrier waves of different lengths for each series.

L. Gabrilovitch, V. Isnard, and R. Berthon. Convention date (France), 25th October, 1933.

442 103.—Electron optical systems for cathode-ray tubes.

F. H. Nicoll and L. F. Broadway. Application date, 7th December, 1934.

442 323.—Method of mounting the cathode-ray tube in the casing of a television receiver.

General Electric Co. and L. C. Jesty. Application date, 1st February, 1935.

442 408.—Tripping circuit for the frame and line synchronising frequencies used in television.

C. Lorenz Akt. Convention date (Germany), 1st. August, 1934.

442 513.—Preventing the so-called "origin" distortion or "white cross" effect in cathode-ray tubes.

A. C. Cossor (assignees of M. von Ardenne). Convention date (Germany), 22nd July, 1933.

442 668.—Mirror screw system of scanning for television.

C. O. Browne. Application date, 12th June, 1934.

442 686.—Saw-toothed oscillation-generators for use in television and designed to give a rectilinear "rising" curve with a small "fly-back" period.

L. R. Merdler and Baird Television. Application date, 13th October, 1934.

443 032.—Controlling the form and duration of the synchronising impulses applied to a television receiver.

T. M. C. Lance, D. W. Pugh, and Baird Television. Application date, 24th August, 1934.

2 018 873.—Television scanning system in which a number of light-points in different lines of the picture are made simultaneously visible.

G. Ramsey.

SUBSIDIARY APPARATUS AND MATERIALS

441 813.—Fluorescent screen comprising layer of tungsten or molybdenum for cathode-ray work.

N. V. Philips. Convention date (Germany), 4th May, 1934.

441 898.—Fluorescent screen formed on a carrier coated with a white insoluble pigment.

F. F. Renwick and F. J. Shepherd. Application date, 31st October, 1934.

442 099.—Suppressor unit to be fitted to electrical motors and other apparatus for preventing interference with broadcast reception.

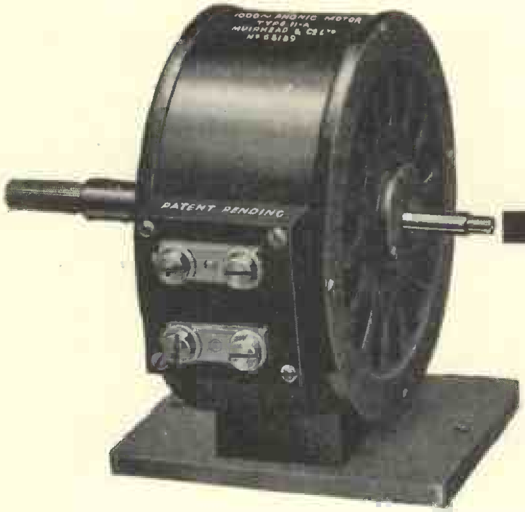
Belling and Lee and E. M. Lee. Application date, 6th November, 1934.

442 165.—Moving-coil loud-speaker fitted with a cone which has an elliptical cross-section at the larger end and a circular cross-section at the smaller end, in order to give a wide frequency-response without any focusing effect.

G. F. Dutton. Application date, 3rd August, 1934.

442 361.—Electric pick-up for use with a cylindrical or Edison-cut sound record.

A. F. Sykes. Application date, 2nd May, 1934.


PATENT PENDING

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