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THE

WIRELESS ENGINEER

NUMBER 155 VOLUME XIII AUGUST 1936

A JOURNAL OF RADIO RESEARCH AND PROGRESS

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PUBLISHED BY
ILIFFE & SONS LTD.
DORSET HOUSE STAMFORD STREET LONDON S.E.1.

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The

WIRELESS ENGINEER

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

Technical Editor
Prof. G. W. O. HOWE, D.Sc. M.I.E.E

VOL. XIII. No. 155

AUGUST 1936

C O N T E N T S

Published Monthly on the first of each Month

SUBSCRIPTIONS Home and Abroad: One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

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Editorial

Cathode-Ray Oscillography

IT was in July, 1933, that we devoted the editorial article to a review of a book on "The cathode-ray oscillograph in radio research" which had recently appeared. It was written by three members of the staff of the Radio Research Board and we were pleased to be able to say that it was a book of which the authors could be justly proud and that we had rarely come across a book so free from typographical errors. Although that book dealt specially with one application of the cathode-ray oscillograph, it contained much information of a general character. In view of the growing importance of the subject, however, there was room for a book dealing with the principles and practice of cathode ray oscillography and a book with this title* has lately been published as one of a series of monographs on various branches of electrical engineering. The authors state that this book has been written to supply what was felt to be an urgent need for a reasonably concise source of information on the subject. They state that they have selected information from all the principal published papers on the subject and that no trouble has been spared to render the book international in its outlook. We feel bound to confess, however, that we cannot speak in the same terms of approval of this work, for although we opened the book with great expectations, and although a considerable portion of it fulfilled these expectations, we must admit that some of the sections which to a student are of great importance are far from satisfactory. The authors are on safe ground so long as they are giving descriptive accounts of constructional details and experimental apparatus, but in the theoretical and mathematical sections the treatment often suggests that the authors have not thoroughly digested the material which they are reproducing. To judge from the many typographical errors the proof-reading of some of these sections has either been dispensed with or has been very hurried and superficial.

The first chapter is introductory and historical. The following sentence on page 9 shows what a compositor can accomplish with three commas: "Another important modification is the introduction of the fluorescent screen, a mica plate D coated on the side, bombarded by the rays with a fine layer of mineral substance, chosen for its very intense fluorescence under cathode-ray bombardment." Chapter 2 deals with electron theory, and here the trouble commences, for the authors venture into relativity, a subject well worthy of the warning "drink deep or touch not." It is true that the mass of the moving electron varies in accordance with the formula

* "Cathode-Ray Oscillography," by J. T. MacGregor-Morris & J. A. Henley. 249 pp. + xiii. 151 Figs. Chapman & Hall, 21/-.

$m_v = m_0/\sqrt{1 - v^2/c^2}$, and that under a P.D. of E e.s. units the electron of charge e e.s. units acquires a velocity v and a kinetic energy Ee, but this kinetic energy is *not* equal to $\frac{1}{2}m_v v^2$ but to $(m_v - m_0)c^2$. The authors give the correct formula for the final velocity attained, but it cannot be deduced in the manner they adopt. Anyone who attempts to check their "hence" will find a non sequitur.

On page 20 a formula stated to give the sensitivity in cms per volt is really in cms per e.s. unit unless it be divided by 300. It is a pity that the authors did not adopt some convention as to the meaning of symbols and adhere to it throughout. On p. 17 e and E are e.s. units; on p. 21 E becomes volts and e e.m. units, with the result that on meeting them later one is never quite certain what they are. There should be a law prohibiting the use of J as a symbol for ampere-turns in a book intended for electrical engineers. The bald statement on p. 22 that for a circle the radius $\rho = x^2/2y$ approximately is only true over a very limited range and is not of general application. Equation (5) on page 23 is incorrect, giving a displacement ten thousand times too big.

Chapter 3 deals with electron beam concentration and electron optics. Magnetic and electric methods are considered and an interesting description given of the recent work which has been published, especially in Germany, on this important new subject. The statement on p. 25 that "the luminous intensity will depend upon the density of the electrons in the beam, that is upon the beam electric current" seems somewhat vague. The former refers to unit volume and does not include the velocity, whereas the latter applies to the whole beam and includes the velocity. At the foot of p. 27 $v \cos \alpha t$ should be $(v \cos \alpha)t$—a very different thing. This section would have been easier to follow if it had been more clearly emphasised that the divergence is so small—much smaller than in Fig. 10—that $v \cos \alpha$ is practically the same for all rays.

The mathematical treatment of electrostatic focusing on pages 39 and 40 appears to be very confused. On p. 39 the radius of the inner cylinder is r_1, a few lines further on it becomes r and r_1 is used for something else; V_L in equation (29) is presumably the same as V_2 in the following equation; the substitution $m\ddot{r} = m\frac{dv}{dr}$ is quite inadmissible, and the e of equation (29) appears to have vanished in the process of integration. The deduction from the equation is also presumably wrong, for if an electron passes approximately parallel to the axis along a radial field, it will be subjected to a radial force inversely proportional to its distance from the axis. If its axial velocity is constant, the time of passage, that is, the time during which it is subjected to this radial force, will also be constant, and the change of radial velocity due to the field will be proportional to the radial acceleration and therefore inversely proportional to the distance from the axis and not to the square of this distance as stated by the authors.

In equation (32) on p. 43 and in several other instances the limits of integration are given as from $-\infty$ to $+\infty$; it would have been preferable to have put t_1 and t_2 since the equation is only applicable between these limits. On pages 44, 45 and 46, d_z, d_t and $\delta\epsilon_r$ should be dz, dt and $\delta\epsilon_z$ respectively.

Chapter 4 is entitled "cold cathode high voltage oscillograph." Starting from the Braun tube the authors trace the development of the high voltage tube in this and other countries. The following chapter deals with the perhaps even more important hot cathode tube and its many-sided development. Various items of auxiliary apparatus such as pumps and photographic arrangements are described in Chapter 6, and important points in connection with the operation, performance, and limitations of the tube in Chapter 7. In reproducing descriptive articles from other sources the authors have sometimes omitted to change the Figure numbers in the text, *e.g.* on p. 91 Fig. 20 should be Fig. 48.

On p. 149, $y = 1/2g_0\frac{x^2}{v^2}$ is a dangerous way of writing $y = \frac{1}{2}g_0\frac{x^2}{v^2}$.

On p. 150 the authors again get into troubled waters. It is not at all clear whether x is the whole length of the deflecting plates or the distance which the electron has travelled between them up to the given moment; there is the same uncertainty about θ. Equation (53) is stated to be the terminal condition at the "farther boundary of the field," but it is then integrated: it appears that x and θ are playing a double role. The denominator in (54) should be $\omega \times v$ and not ω_v; this equation (54) is then referred to as (50) in finding a formula for A which should be A_ω. This formula is also wrong; $(\cos a - \cos b)$ is not equal to $2 \cos\left(\frac{a+b}{2}\right) \sin\left(\frac{b-a}{2}\right)$. At the foot of p. 152, 17 should be 117, and on p. 153, 10^{-5} cycles should be 10^5 cycles; similarly on p. 163, 10^{-4} should be 10^4.

A chapter is then devoted to the important subject of time sweeping and time bases. Chapters 9 and 10 deal with the more important applications of the cold and hot cathode tubes respectively.

On p. 170, the diagram which is alleged to represent the Marx impulse generator could not possibly function; the spark-gaps and condensers are in the wrong positions. This is Fig. 99 but is referred to in the text as Fig. 1. On p. 193 the mathematics of the elliptical trace needs a number of minor corrections, the first voltage is $E_1 \cos(\omega t + \phi)$, not $E_1 \cos(\omega t + \alpha)$, and the second $E_2 \cos \omega t$ not $E_2 \cos \omega$; $y = E_2 \sin \omega t$, not $E_1 \sin \omega t$.

In reproducing diagrams from different sources it is desirable to adopt a fixed convention with regard to the representation of batteries by thick and thin lines. In this country it is usual to represent the positive plates by thin lines and the negative by thick lines, but this is not universally adopted. In the volume under review sometimes the one and sometimes the other method is adopted.

A serious and surprising fundamental error occurs in the final chapter dealing with television, where it is stated that with an ideal photo electric cell having no time lag, if the picture consists of a chess board with black and white squares *of the same size as the spot of light* which scans the picture, the electrical wave form will be a rectangular; a diagram of the rectangular wave is given in Fig. 145(*b*). Such a wave would, of course, only be obtained with a point spot of light passing suddenly from black to white; with the square spot of the same size as the squares the transition would be gradual and the electrical wave would be triangular.

The book is well printed and beautifully illustrated, it contains a large amount of information concerning the development of cathode ray tubes in various countries and concludes with a very useful bibliography to which numerous references are given throughout the book.

G. W. O. H.

Radio Interference

I.E.E. Committee's Report

THE Institution of Electrical Engineers appointed a "preparatory Committee" in 1933 to consider the problem of electrical interference with broadcast reception. The findings of this Committee resulted in the appointment by the Council of the I.E.E. of a representative Committee with the following terms of reference :—

(a) To consider the report (drawn up by the preparatory Committee appointed by the Council) setting out the problems to be solved.

(b) To make recommendations as to the steps, if any, to be taken to secure the elimination or mitigation of electrical interference with radio reception.

(c) In connection with (b) above, the Committee are requested to consider, *inter alia*, the following specific matters :—

(i) The degree of immunity of each type of apparatus, and the degree of interference from each type of electrical plant and the best means for its elimination.

(ii) The desirability of embodying in specifications for new plant the requirements for interference suppression.

(iii) The desirability or otherwise of legislation.

The Report* of this Committee has now been published and is a comprehensive and constructive document containing positive recommendations which, if adopted, as we feel sure they will be, should pave the way to a real solution of this problem. It is recommended that the sale of interfering portable apparatus should be prohibited and that suppression of interference by existing apparatus should be carried out gradually; that the Electricity Commissioners should draw up the necessary regulations and that the Post Office should be given the requisite powers to enforce them. Imported as well as British made apparatus to be subject to these regulations.

The cost of preparing the Regulations and the expenses of the Post Office in connection with their enforcement to be met out of the Post Office share of the wireless licence revenues.

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* Obtainable from the Institution of Electrical Engineers, Savoy Place, London, W.C., price 6d.

Some General Relations of Vacuum Tube Electronics*

Illustrated by Current Distributions in Tubes with Plane Electrodes

By W. E. Benham

1. Introduction

VACUUM Tube Electronics is the term now favoured for the class of phenomena in Vacuum Tubes which come under the general heading "Transit Time Effects."

There are doubtless many cases, outside the field of vacuum tubes, where the finite time of travel of the electrons, or other charged particles, must be taken into account. Indeed, the writer's work on electron space charge in vacuum tubes[4,5] was originally prompted by the thought that in metals the carriers of electricity had been shown to possess inertia, and that this fact might mean a correction to the known theories of high frequency conduction by wires (skin-effect). This was in the year 1925, when the problem of metallic conduction was exciting a fair amount of attention owing to the failure of then existing theories to account for the observed specific heat of metals. While the inertial effects of the "electron gas" in metals have not been dealt with, it is quite possible that Vacuum Tube Electronics will prove to be valuable as supplementing existing theories where these do not fully cover the effects of electron inertia. As a case where electron inertia is of paramount importance, one may cite the passage of light through thin metallic films, the phenomena attending which are still in need of explanation. See also Ferris[16] (p. 91, footnote.)

The connection with other branches of Physics may best be seen as follows. In Vacuum Tubes the electrons, during their admittedly short time of stay in between the electrodes, may during that "split second" be regarded as "located" in space by the electrodes which limit their freedom of motion at the beginning and end of their passage. Because the electrons are thus inhibited from escaping into space (apart from the few whose tangential components of emission carry them laterally from the inter-electrode space into the bulb) the time average of the various quantities (current, velocity, electron density) at any selected equipotential surface between the electrodes is completely defined provided certain boundary conditions of the electrodes are specified in advance. It is true that this time average does *not* refer to a specified set of electrons, since these are always on the move, but it may be said that if we first consider the electrons which at some instant of time correspond to a certain current at a selected surface, then at that same surface, other electrons, $\frac{2\pi}{\omega}$ seconds later, where $\frac{\omega}{2\pi}$ is the frequency of the alternating potential applied between the electrodes, give rise to the same current as the first set. In this way, we may describe what goes on in vacuum tubes at high frequencies by means of diagrams, each drawn for a specific instant of time, and showing the space distribution of the various physical quantities at a given instant.

At intervals of time separated by, say, $\frac{1}{8}$ cycle we shall find changes of a periodic nature, which have been likened to waves of compression and rarefaction in organ pipes, and which also bear a close resemblance to the sequence of events occurring along a given section of a transmission line carrying alternating current. An example of such periodic changes is to be found in Fig. 2, to be explained later, which shows the instantaneous space distribution of the three important currents (important, that is, for the inter-electrode space). Returning now

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

to the point about the "location" of the space charge, we should expect to be able to deal with other physical problems where electrons are constrained to move in a limited region. In solid bodies, for example, the electrons are for the most part bound to the parent atoms by the restoring forces exerted by the positive nuclei of the atoms. The problem of the part played by such electrons in influencing the passage of electromagnetic waves is the dispersion problem, and has long been the subject of mathematical investigation by physicists. One and all, however, appear to have considered it possible to specify the refractive index at a given *place* in the medium by mathematics which in actual fact specifies the position of the electrons at a given *instant* only.* It may be that, since the excursions of the electrons is so minute, this difference was considered to be of no importance. Vacuum Tube Electronics rather suggests otherwise, but it is agreed that dispersion theory would become somewhat complicated by conversion of the formulae to apply at a given place. Reference 10, which deals with a problem similar in nature to dispersion, deals with some of the difficulties involved. In reference 10, the symbol ω was used for $\frac{e}{m}H$, where H is the magnetic field; in application to dispersion of electromagnetic waves $(eH/m)^2$ must be replaced by an "elastic constant," representing the quotient of the restoring force by the excursion distance of the electrons (the word "displacement" was avoided as we shall later be talking about displacement currents, and the "displacement" of the electrons from a mean position corresponds primarily to *convection* current).

Now in vacuum tubes (without applied magnetic field) restoring forces of the type indicated above do occur, but are by no means obvious. Consider, however, the mechanism by which a positive charge becomes induced on the electrodes by the electrons in the space. For simplicity we consider the effect of a single electron placed mid-way between a pair of earthed plates. This very simplification leads at once to a slight paradox. Clearly, the charge induced on each plate is exactly half an electronic charge, and a charge less than that of the electron has never been observed. Are we then to give up the old electrostatics when it comes to single electrons? The answer is "yes and no." The above paradox is removed as follows. What actually happens in cases of electrostatically induced charges is the formation of an "electrical double layer" on the surface of the body, brought about by the repulsion,† on the part of the inducing charge (assumed negative), of the more mobile (negative) electrons towards the interior of the body, the less (or not at all) mobile positive centres are then, on the whole, more effective at external points. The resultant field due to the combined action of the positives and negatives (constituting the double layer) is obviously much less than the field which would be created by either set of charges were the other removed, and, in the example of a single inducing electron mid-way between two earthed plates the double layers each produce, at points between the plates, a field corresponding to half an electronic charge (positive). This charge is distributed over the electrodes, in relation to the inducing electron, in the same way as given in text-books for the charge distributed over a single conducting plane as a result of induction by a point charge placed in front of the plane, with the difference that the charge density is halved due to the presence of the other plane. Thus, our "sub-electronic charge" is a myth, a charged layer of many discrete charges of either sign produces, at all points between

* It is not sufficient to obtain x, $\dot{x}$ in terms of t. In order to derive quantities having physical properties which are expressed as a function of space co-ordinates, it is desirable to express $\dot{x}$ in terms of x as a starting point. Other physical properties than $\dot{x}$ may then, in some cases, be derived from $\dot{x}$, as a function of x. In the above argument x is an abbreviation for x, y, z, the Cartesian co-ordinates of the particle (s) in question.

† This repulsion is resisted by the restoring forces exerted by the positive centres on the displaced electrons, but this resistance is overcome by the agent responsible for transferring the inducing charge to its position mid-way between the plates. In practical cases of valves, the work required to overcome such resistance is derived from the applied potentials, and it can be shown that the effective p.d., a.c. as well as d.c., is reduced as compared with the apparent value as recorded by a valve voltmeter. The formation of double layers thus involves a species of damping, in addition to the "electron loading loss" (q.v.). The effect is believed to be small compared with the electron damping, but may have appreciable influence on the rectification effect.[4, 5, 7, 8, 13]

the electrodes except those within atomic distances of the surface layers, an effect of an induced charge of sub-electronic value.

When we are considering large numbers of inducing electrons it is legitimate to ignore departures from a uniform distribution of induced charge on the electrode surfaces. In order to obtain the induced current, we differentiate with respect to time the expression for the induced charge, obtaining, with due allowance for sign, the same expression whichever charge (anode or cathode) is selected. In this expression, as might be expected, the quantity $\frac{dx}{dt}$ appears, being the velocity common to all inducing electrons present at the plane, or surface, specified by x, at the instant t. In order to arrive at the "number of electrons at the plane x," we take a "slice" of space charge, of thickness dx, the faces of which lie $\frac{dx}{2}$ on either side of the plane, and (ρdx) then specifies the number in question reckoned per unit area of a plane geometry, ρ being the space charge density.

In addition to the current induced in the electrodes by the motion of electrons between them, we also require the electron convection current, as it is this current which is particularly significant in the inter-electrode space, and which, in the example of a negative grid triode, is the only current which is continuous as electrons pass the grid. In D.C. working of the valve, the induced current is always the same as the electron convection current, owing to the absence of displacement current; for high frequency work the latter varies across the space in a complementary manner to the electron convection current, and the current induced in the electrodes is always intermediate in value between the values of electron convection current at cathode and anode respectively. In order that the significance of the various currents may be understood, the following table, which also gives symbols, may be considered in conjunction with Fig. 1, in which currents are plotted as ordinates, $x^{2/3}$ as abscissae, and A, B indicate the position of cathode, anode (or grid of triode),

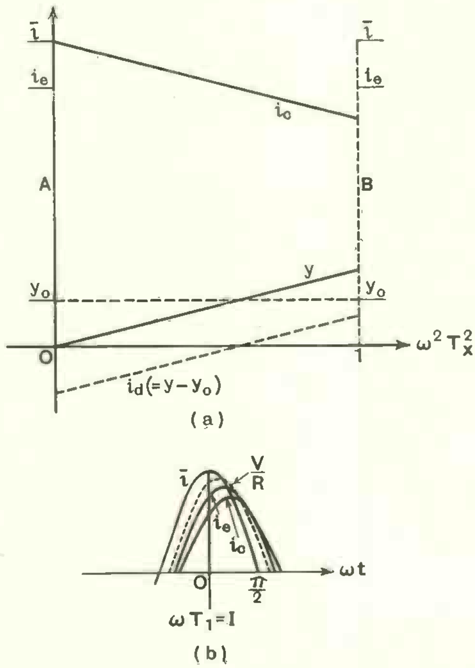

Fig. 1.

respectively. By plotting against $x^{2/3}$, rather than x, the curves are straightened into lines. The abscissae are actually shown as $(\omega T_x)^2$, which amounts to the same thing in view of the relation

$$x = \left(\frac{2}{3}\pi\frac{e}{m}I\right)T_x^{\,3},$$

TABLE I.

N.B.—Those currents which may be D.C. as well as A.C. are shown *

Currents having significance between the electrodes.	Currents having significance in the circuit immediately attached to the electrodes.
Maxwell's total current ($\bar{i}$)* Electron convection current (i_c)* Displacement current (y) Cold displacement current (y_0)	Maxwell's total current ($\bar{i}$)* Induced current (i_e)* "Cold" displacement current (y_0)

where T_x is the time taken to reach the plane x in the absence of alternating currents, and $I =$ D.C. current.

The use of y's for displacement currents is thought to be quite satisfactory. The "space current" is seen to be composite, for in addition to the electron convection current we have to consider the displacement current y. In future we shall talk only of those currents listed in the table, abbreviating by omitting the words "Maxwell's" and "Electron" in most cases. It must not be thought that the "total current" necessarily includes any D.C. component, in many cases it is convenient to deal with A.C. currents only, and this has been done in the case of Figs. 1, 2 and 3.

Fig. 1 refers to space charge limitation just sufficient to reduce the electric field to zero at the cathode. This condition corresponds to "infra-saturation" sufficiently closely for most purposes. If, however, B corresponds to the grid of a triode, biassed negatively, the effective lumped potential at the plane of the grid may only be a few volts positive, in which case the other important assumption, *e.g.*, that initial velocities are zero, may lead to inaccuracies. Ferris,[16] however, has obtained quite good agreement between theory and experiment under these conditions, so that it appears, as expected, that the main burden of error falls on the D.C. part of the solution.

we may regard the "cold" displacement current as existing superimposed on the induced current, even when the cathode is hot. Since the cold displacement current y_0 is always $\frac{\pi}{2}$ out of phase with the potential v we have not to consider it as introducing any damping. This is not true of the displacement current y, but as this current is relevant to the space rather than to the circuit, all damping effects may be obtained from a knowledge of i_e. It is true that in cases where the electrons are not collected (negative grid) it is necessary to subtract i_c, the convection current which passes through; this current is always known if i_e is known.

The fact that i_c happens to be equal to $\bar{i}$ at the cathode is due to the restricting assumption $\left.\frac{dv}{dx}\right|_0 = 0$ referred to above, and is not true in general. The important thing to note in Fig. 1 is that if we subtract y_0 from y we obtain the sloping dotted line. The negative value of $y - y_0$ at the cathode signifies that the loss of electrons by the cathode during the rising part of the cycle (Fig. 1*b*) is accompanied by the repulsion into the cathode of surface electrons as explained above. That this effect should show up as continuous with $(y - y_0)$ is due to the fact that mutual repulsions of electrons in the space are responsible for the difference

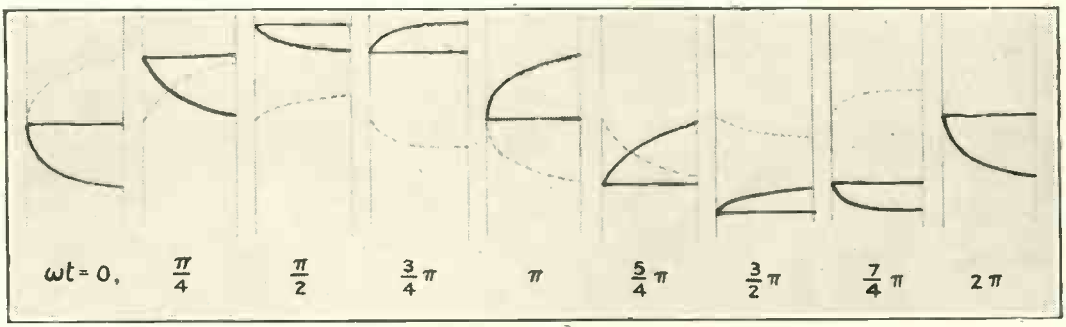

Fig. 2.—*A complete cycle of events is here represented for a space charge limited diode. The horizontal straight lines represent $\bar{i}$, the curves being i_c (full-line) and y (dotted). The abscissae in this case are proportional to x, not $x^{2/3}$; $\omega T_1 = 1$, as before. The instant $t = 0$ has here been chosen to correspond with $\bar{i} = 0$; the choice is purely arbitrary.*

It will be seen that i_c and y add up to $\bar{i}$ at all points of the space, but that in the external circuit it is i_e and y_0 which are relevant, and that these also add up to $\bar{i}$. Thus between the displacement current y and the cold displacement current y_0; thus any one electron in the space repels others, not only in the space, but also in the surface layers of the electrodes. The cold displacement current alone has no "electronic" explanation, and remains a somewhat mysterious quantity. It is not proposed, however, to attempt a physical explanation, but merely to point out the necessity of regarding y_0 as continuous in the space, as has been the case in electromagnetic theory ever since Maxwell.

In Fig. 1*b*, referred to above, it must further be explained that, in order to show

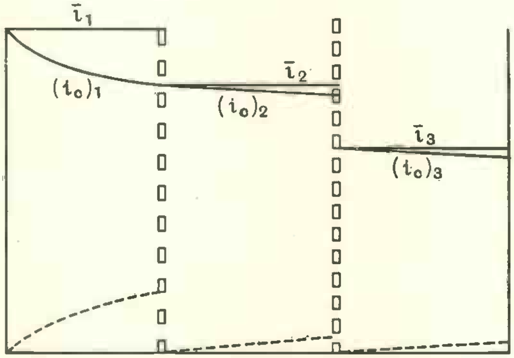

Fig. 3.—*Showing a typical alternating current distribution in a tetrode at instant* $t = \frac{\pi}{2\omega}$. *The control grid being negatively biased, all the electron convection current passes through into the grid-screen space. The screen is shown as capturing 25% of the electron convection current. The diagram is applicable without much error to the Pentode as the suppressor grid is usually of very open type. The screen, as well as the cathode, is, of course, at A.C. earth potential. The "cold" displacement current is sensibly zero, at the instant selected, in the spaces* (2) *and* (3).

the potential v in perspective, on this diagram, v is multiplied by R_0^{-1}. This enables one to see that all curves would coincide with that for $\bar{i}$, if we had taken $\omega = 0$. If, as in Figs. 1*a*, 1*b*, 2 and 3, the electrode separation, frequency and D.C. supply voltage stand in such relation that $\omega T_1 = 1$, where T_1 is the transit time of the electrons between A and B, then Fig. 1*b* gives the diminution in peak value, in comparison with $\bar{i}$, of the currents i_e, i_c, and of the potential v, as well as the relative phase differences. Above, R_0 is the slope resistance, reckoned at zero frequency, of the diode combination AB. In the event of AB being the cathode-grid space of a triode, or other multi-electrode valve, R_0 is (very nearly) the reciprocal of the mutual conductance; see pp. 117 and 119 of North's paper (Ref. 17).

2. An Impedance Theorem Applicable to Valves and Condensers

By reference to Figs. 1*a*, 1*b*, where all relevant alternating currents are displayed, it is thought that the following proof will be readily understood. We first explain that Z represents the impedance of any electrode pair (see Fig. 4), one of which is earthed and the other maintained at any D.C. potential whatever, the alternating potential having the value v. The electrodes, designated "0" and "1," may be immersed in any medium, dielectric or conductor. We further note that Z must refer to the "first order" impedance for the calculation to apply, that is, we must restrict ourselves to fundamental alternating components (a word of explanation may not be out of place to those followers of electric circuit theory who prefer to use the classical terminology: in valve theory the term "steady state" is so admirably descriptive of the valve in the "D.C." condition that the use of "steady state" as applied to the alternating current condition has been eschewed. It may be said that transients are supposed to have died down, and the condition then obtaining has been termed by Llewellyn the "Ultra-Dynamic" condition, which term may take precedence in all cases where we are concerned with the individual carriers of current, and not merely with the current as a whole).

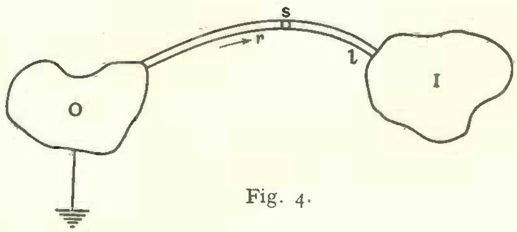

Fig. 4.

Coming now to the Impedance Theorem,† the key step is to multiply top and bottom by pC_0 (equation 2). Apart from this the theorem is fairly straightforward, though the

† The corresponding "Admittance Theorem" may be written:

$$A = \frac{\bar{i}}{v} = pC_0 + \frac{i_e}{v} = pC_0 + A\frac{i_e}{\bar{i}}\,;\ \therefore\ A = \frac{pC_0}{1 - \frac{i_e}{\bar{i}}}, \text{ etc.}$$

The elimination of v is to be especially noted, the impedance or admittance being expressible in terms of a ratio of two currents.

transition from (4) to (5) is later taken up more fully.

[C_0 = electrostatic capacity, p is the Heaviside operator, $\omega\sqrt{-1}$. $\omega = 2\pi \times$ frequency. In general, x is a measure of distance from the earthed electrode.]

$$Z = \frac{v}{\bar{i}} \quad \ldots \quad (1)$$

$$= \frac{1}{pC_0}\frac{pC_0 v}{\bar{i}} \quad \ldots \quad (2)$$

$$= \frac{1}{pC_0}\frac{y_0}{\bar{i}} \quad \ldots \quad (3)$$

$$= \frac{1}{pC_0}\left(1 - \frac{i_e}{\bar{i}}\right) \quad \ldots \quad (4)$$

$$= \frac{1}{pC_0}\left\{1 - \Sigma(\bar{i}x_1)^{-1}\int_0^{x_1} i_c dx\right\} \quad \ldots \quad (5)$$

The summation must be taken over all the tubes of force extending between the electrodes, and i_c is the (a.c.) convection current at any cross-section of a tube of force, including excursions of "free" and "bound" charges of either sign. Thus, in the case of material dielectrics, while i_c may possibly vanish at the boundaries of the dielectric, the currents induced in the electrodes due to intermediate values of i_c are by no means negligible. It has not been possible as yet to investigate fully the bearing of (5) on the Lorentz-Hartree formula[2, 6]. Equation (5) may be obtained either from (4), in view of image theory,[1] or as follows. Applying the equation of total currents to any tube of force extending between the electrodes we have, if s denote the area of the tube at any point, r being a co-ordinate following the tube of force (see Fig. 4):

$$\frac{\bar{i}}{s} = \frac{i_c}{s} + \frac{1}{4\pi}\frac{\partial E}{\partial t}$$

(where i_c includes any "polarisation" current $\frac{k-1}{4\pi}\frac{\partial E}{\partial t}$).

Since $\bar{i}$ is independent of r, we obtain by integration with respect to r, over the length l,

$$\bar{i}\int_0^l \frac{dr}{s} = \int_0^l \frac{i_c dr}{s} + \frac{pv}{4\pi}$$

in which we have written $p = \frac{\partial}{\partial t}$, and v denotes the alternating potential at l and is zero over the electrode (0). But $\frac{v}{\bar{i}}$ is the impedance Z_s so that we obtain

$$Z_s = \frac{4\pi}{p}\left[\int_0^l \frac{dr}{s} - (\bar{i})^{-1}\int_0^l \frac{i_c dr}{s}\right]$$

(*N.B.*—$\bar{i}$ and Z_s refer to a single tube of force.)

In case $i_c = 0$ for all values of r we must have $Z = (pC_0)^{-1}$. Thus we find

$$Z = (pC_0)^{-1}\left[1 - \Sigma(\bar{i}x_1)^{-1}\int_0^{x_1} i_c dx\right] \quad \ldots \quad (5a)$$

$$\text{where} \quad C_0 = \Sigma\left[4\pi\int_0^l \frac{dr}{s}\right]^{-1} \quad \ldots \quad (6)$$

$$dx = \frac{dr}{s} \quad \ldots \quad (7)$$

Equation (7) also defines x for equation (5), to which (5a) is now seen to be identical. We may interpret the result (7) as follows:—

$$\frac{\int_0^r \frac{dr}{s}}{\int_0^l \frac{dr}{s}} = \frac{\psi_r}{\psi_l} \quad \ldots \quad (8)$$

where ψ_r is the potential function for the tube of force, and vanishes for $r = 0$. We further note that the charges induced on the electrodes due to individual charges q are always given by

$$q_1 = -q\nu$$
$$q_0 = -q(1 - \nu)$$

where $\nu = \frac{\psi_r}{\psi_l}$. [We have used ψ rather than V since the latter represents the potential modified by space charge.]

The above result is thought to be of sufficient interest to justify fuller proof. Let $f(r)$ denote the function of r connecting the charge induced on electrode (1) with the inducing charge, *e.g.*, let us seek $f(r)$, where

$$q_1 = qf(r)$$

Let now q_1 vary with time due to the motion of the constant charge q (see Ref. 9):—

$$\frac{dq_1}{dt} = q\frac{dr}{dt}\cdot\frac{df}{dr}$$

Let us now replace q by the charge distribution $\rho s dr$. Since $\rho \frac{dr}{dt}$ is the convection current per unit area, the current induced in the electrode (1) due to motion of charges distributed in the field of force between (0) and (1) is

$$i_e = -\Sigma \int_0^l \rho s \frac{dr}{dt}\frac{df}{dr} dr$$

$$= -\Sigma \int_0^l i_c df$$

By comparison with equations (5) to (8) we see that

$$f = -\frac{x}{x_1} = -\frac{\psi_r}{\psi_l} = -\nu$$

which proves the proposition. The result may be seen to be consistent with known solutions (*c.f.* pp. 266, 7 of reference 1). The reader is referred to Bakker and de Vries' work[9, 12] for an excellent treatment of the problem from the standpoint of induced currents.

It may be remarked that equation (5) applies to condensers of any geometry, x being the potential function for that geometry and C_0 the capacity with vacuum dielectric. It has general application to condensers with non-conducting and with conducting dielectrics, and contains within itself the interpretation of "dielectric constant."

3. Application to Vacuum Tubes

In vacuum tube work it is generally the admittance that is sought, *e.g.*,

$$A = \frac{1}{Z} = \frac{pC_0}{1 - \frac{i_e}{i}} \quad \ldots \quad \ldots (4a)$$

Since $\frac{i_e}{i}$ is complex the selection of real and imaginary parts will involve rationalisation. Since $\left|\frac{i_e}{i}\right| < 1$ we may write

$$A = pC_0 \sum_{n=0}^{\infty} \left(\frac{i_e}{i}\right)^n \quad \ldots \quad \ldots (4b)$$

but this form has not so far been found useful. We should, however, note that the real part of Σ in (4*b*) gives the effective dielectric constant. In the case of the Langmuir diode, to which Figs. 1 and 2 refer, it happens that (4*a*) may be used as it stands. Thus in this case (*q.v.*),

$$i_c = \bar{\imath}\phi_3(a) \qquad i_e = \bar{\imath}\phi_4(a_1) \quad \ldots \quad (9)$$

$$A = \frac{2pC_0}{a_1\phi_6(a_1)} = \frac{2C_0}{T_1\phi_6(a_1)} = \frac{1}{R_0\phi_6(a_1)} \quad \ldots \quad (10)$$

where $a = pT_x \quad a_1 = pT_1$

(complex " transit angles ")

$$\phi_3 = \frac{2}{a^2}(1 - e^{-a} - ae^{-a})$$

$$\phi_4 = \frac{3}{a^3}\int_0^a a^2\phi_3 da \quad \ldots \quad \ldots (11)$$

$$\phi_6 = \frac{2}{a}(1 - \phi_4)$$

Equation (10), after rationalising ϕ_6, yields conductance and capacity values in agreement with the analysis of reference (7).

It may be noticed that the second of equations (9) follows from the first in view of image theory, which gives

$$i_e = x_1^{-1}\int_0^1 i_c dx \quad \ldots \quad \ldots (12)$$

Equation (12) is readily solved in view of equation (11), remembering that x varies as a^3 in this example. The first of equations (9) may be derived from the following relationship for convection currents, valid for *any* geometry

$$i_a = i_0 e^{-a} + I_0 e^{-a} \int_0^a e^a \left(\frac{u}{U}\right)_a da \quad \ldots (13)$$

in which

u = velocity " ripple " (superimposed on steady state velocity)

U, I_0 = velocity, current in steady state.

i_0 = current " ripple " where $a = 0$.

An interesting application of (13) occurs in the case of multi-electrode structures, for it can be shown that the integral term is of but small importance in the second (or grid-screen) space in the case where the grid is biassed negatively. Here a will refer to the second space and i_0 will be the convection current ripple at the plane of the control grid, and may be arrived at by the application of diode theory to the first (cathode-grid) space. For the admittance between grid and ground (the screen being at a.c. earth potential) we then have, with due regard to signs,

$$\left.\begin{aligned} A &= A_1 + A_2 \\ &= p(C_1 + C_2) + \frac{(i_e)_1}{v} + \frac{(-i_e)_2}{v} \\ &= p(C_1 + C_2) + \frac{A_1}{i_1}\left\{(i_e)_1 + (-i_e)_2\right\} \\ &= p(C_1+C_2) + \frac{A_1}{i_1}\left\{(i_e)_1 - \int_{x=0}^{x=x_2} (i_e)_2 \frac{dx}{x_2}\right\} \\ &\doteq p(C_1 + C_2) \\ &\quad + A_1\left\{(\phi_4)_1 - (\phi_3)_1 \frac{2}{a_2{}^2}\int_{a=0}^{a=a_2} ae^{-a}\,da\right\} \\ &= p(C_1+C_2) + \frac{g_1}{\phi_6}\{(\phi_4)_1 - (\phi_3)_1(\phi_3)_2\} \\ &= pC_2 + g_1\left\{\frac{1-(\phi_3)_1(\phi_3)_2}{(\phi_6)_1}\right\} \end{aligned}\right\} \quad (14)$$

Where g_1 is equal (nearly) to the slope conductance (see North's paper).[17] An approximation in the fifth line of the above analysis corresponds to the assumption that x varies as a^2 (not as a^3) in the second space, which corresponds to practical conditions very closely. *A's* real part agrees with the three major terms of North's and Llewellyn's[13] expressions for the grid to ground conductance, and it may be mentioned that Llewellyn's formula applies to any degree of space charge. Llewellyn, in a recent letter to the writer, states : "I was at first somewhat disturbed that the coefficients of equation (100) (Ref. 13) did not agree even better with North's equation (23) (ref. 17) because the effect of space charge between grid and plate must be quite small, but I found numerically that the results are quite indistinguishable in most cases." We now see more clearly why this is. In both cases, the only important term for the second space is derived from the term i_0e^{-a} of equation (13). The second term of (13) is small owing to the fact that the ratio $\frac{u}{U}$ is small at most points of the second space, and can be shown to involve the appearance of μ, the amplification factor of the control grid, in the denominator. Thus we should expect the more general expression of Llewellyn to be numerically indistinguishable from North's expression for negligible space charge in the second space.

The experiments of Ferris[16] on the electron loading loss arising from the real part of A show very fair agreement with theory using a series of R.C.A. triodes. North has shown that the electron damping arising from the second space is about as important as that due to the first space in a typical case, despite the reduced transit time.

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The Industry

MARCONI WIRELESS TELEGRAPH CO., LTD., and E. K. Cole, Ltd., have formed a jointly owned company to be known as Marconi-Ekco Instruments, Ltd. (Electra House, Victoria Embankment, London, W.C.2). The main object is to combine the activities of both companies in the fields of measuring instruments, diathermy and electro-medical apparatus.

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The National Radio Exhibition is to be held this year from August 26th to September 5th at Olympia, London, W.

Radio Atmospherics from a High-Tension Test Line*

By Harald Norinder

(Institute of High Tension Research, University of Upsala, Sweden)

Measuring Methods

IN earlier investigations into the variation forms of radio atmospherics horizontal antenna circuits were used, from which suitable measuring resistances were attached to cathode ray oscillographs. By visual observations in the cathode ray oscillographs[1]; or by photographic records [2 3] it has been possible to analyse the general variation structure of the atmospherics. The aerials used in Upsala when taking these measurements have been, generally, about a hundred metres in length and have been placed at a height of about 20 metres above the ground.

Widespread investigations have shown that the atmospherics were not always periodic but quasi-periodic and in a small number of cases aperiodic. The duration of the atmospherics observed varied from some few hundred micro-seconds up to several thousand micro-seconds. These wavelengths were considerably longer than the wavelengths of the aerial systems which were used in making the measurements.

Measuring methods employed hitherto have one great drawback which experience proved to be very troublesome. The root of this trouble was in the principle of measuring. If we express the field force E for the incoming atmospheric in volts per metre, the height of the aerial h in metres, the measuring and damping resistance R in ohms, the capacity C in farads and the voltage of the oscillograph above the deviation system with V we obtain the relation (1)

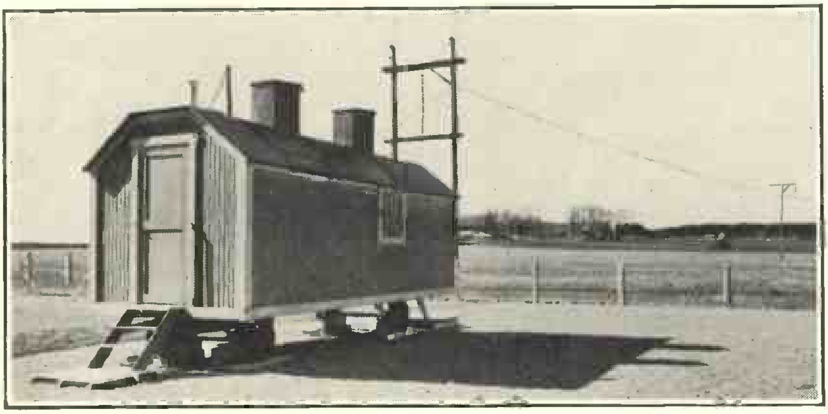

Fig. 1.—*A field station for recording atmospherics on a transmission line.*

$$\frac{dE}{dt} = \frac{1}{h}\left\{\frac{dV}{dt} + \frac{1}{RC}V\right\} \quad \ldots \quad \ldots \quad (1)$$

From which it follows that

$$\frac{dE}{dt} = \frac{1}{hRC}V\,;\; E = \frac{1}{hRC}\int V\,dt \quad (2)$$

$$\frac{dE}{dt} = \frac{1}{h}\frac{dV}{dt}\,;\; E = \frac{1}{h}V \quad \ldots \quad \ldots \quad (3)$$

For the approximation which holds good for relation (2) a small value of R is necessary.

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

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[2] E. V. Appleton, R. A. Watson Watt: Communications, p. 63; H. Norinder: Communication, p. 64. International Radio Union. General Assembly, London, 1934. Proceedings, Vol. IV. Bruxelles, 1935.

[3] H. Norinder: Cathode Ray Oscillographic Records on Atmospherics. *Proc. Amer. Inst. Radio Eng.*, Vol. 24, 2, p. 257. New York, 1936. This paper covers the Authors' communication at the London meeting 1934, mentioned in foregoing note.

The measuring method based on this approximation is called the $\frac{dE}{dt}$ method. To obtain the field variation curves which correspond to the recorded curves in the oscillograph with the $\frac{dE}{dt}$ method it is necessary, as can be seen from relation (2), to adopt an integration procedure. With extensive observation material this integration procedure can be attended with certain difficulties. With high values of R one can, on the other hand, use relation (3) as a permissible approximation. In such a case one obtains the variation curves of the field force in the form of so-called E curves. The general basis of the above methods and the difference between the $\frac{dE}{dt}$ and the E method was pointed out in the paper cited above by Appleton, Watson Watt and Herd.

In certain cases the experimental postulations may be such that one cannot work advantageously either with the low R values necessary for the $\frac{dE}{dt}$ method, or with the high ones required in the E method. So far experimental experience has shown that atmospherics of short duration may be advantageously recorded only by the $\frac{dE}{dt}$ method. It has, however, not been possible to use visual observations which, on account of the short variation periods, do not give reliable results. It has thus been necessary to measure the atmospherics with high velocity recording cathode ray oscillographs. For the taking of these measurements, the author has used exclusively a special cathode-ray oscillograph of his own construction[1].

Furthermore, it also proved to be impossible to record with certainty, atmospherics of long duration by the $\frac{dE}{dt}$ method. The difficulties here were both of principle and of a practical nature. For atmospherics of long duration, say for more than 2 000 μsec. one was absolutely obliged to work with the E method. Under certain conditions this showed slight errors in the results[2]. These errors arose in cases where the insulation of the antenna system was not sufficiently good, and one had at all times to use the greatest care when carrying out the measurements according to the E method.

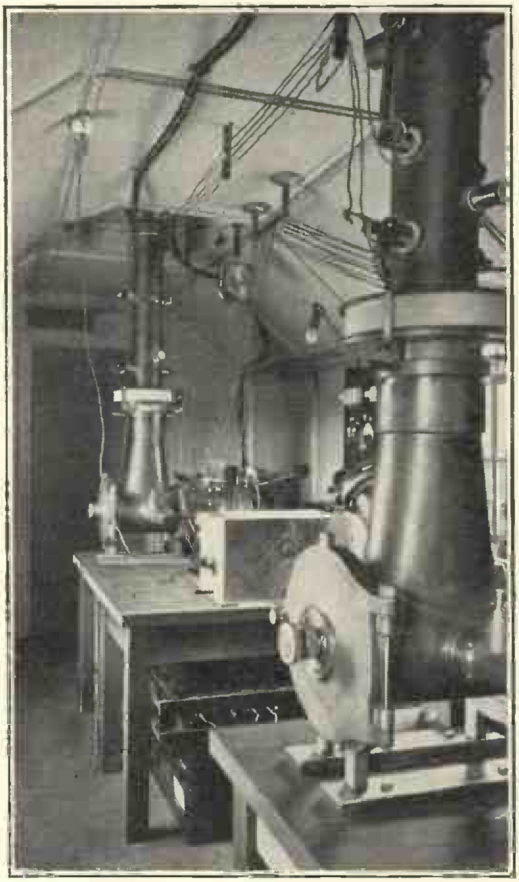

Fig. 2.—*Installation of cathode ray oscillographs and amplifier in a field station.*

From measurements carried out on a large scale it appeared that the atmospherics of short duration were considerably more common than those of long duration. Thus, as an example, atmospherics with a duration of 2 000 μsec. or still longer represented some few per cent. of the total number. Experience further showed that other atmospherics appeared which varied in duration

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between the types just mentioned. These special types of atmospherics were estimated to be about 10 per cent. of the total number. With this group of medium duration particularly strange difficulties arose when it was a question of adopting suitable observation methods. In the aerial circuits it is necessary, for the reliable measurements of these atmospherics, to apply resistance of such dimensions that the measurements cannot be characterised either as the $\frac{dE}{dt}$ or the E methods. Consequently the measurements constituted something between the two methods, and this resulted in troublesome and time-consuming corrections having to be made when estimating the oscillograms.

Having regard to these circumstances there was every reason to attempt a less unserviceable measuring method which, without troublesome corrections having to be made, allowed measurements to be taken of the whole scale with regard to the time variation of the atmospherics. The attempts made by the author in this connection form the subject matter of this paper.

The measurements have been carried out in such a way that, for the recording of the atmospherics, a very long high tension line with high insulation to earth has been used as an aerial.

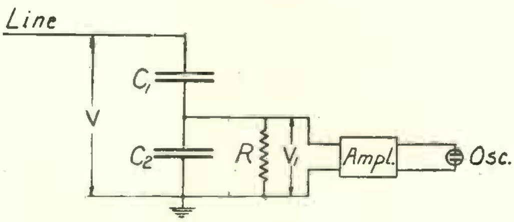


Fig. 3.—*Circuit diagram for connection to high tension line.*

To obtain as small a capacity to earth as possible for such an aerial a single phase high tension test line fixed on wooden poles, and which had been constructed at the Institute, was used. To avoid disturbances arising from neighbouring transmission lines the test line was, to a great extent, placed at a suitable distance away. The total length of the test line was 15 kilometres. With the measurements described in this work the investigations were limited to a horizontal and insulated part of this line which was 2.13 km. long. This part of the test line was entirely free from any perturbation which may possibly have arisen on account of the close proximity of the ordinary power line systems. The average height of that part of the line used was 7.75 metres. The cable which was made of aluminium was 1.2 cm. in diameter. Naturally this dimension of the cable had not been chosen on account of the measurements given here, but in connection with other investigations.

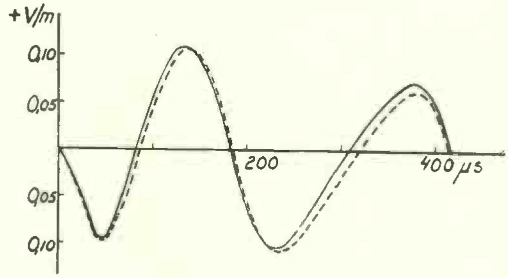


Fig. 4.—*Correction curve for potentiometer.*

The cable was insulated from the wooden poles with seven high tension insulators. The seven insulator units at each pole were well protected from rain, and consequently were suitable for the measuring of atmospherics. When taking such measurements it was, as we have already pointed out, necessary to keep the losses over the insulators as small as possible.

Both ends of the line were insulated and at the end of one of them a connection to the cathode-ray oscillographs was attached. Instruments necessary for the taking of the measurements together with operating units were placed in a field station of the movable type, an exterior view of which is given in Fig. 1.

The high tension line used when taking the measurements is partly seen in the same Fig. 1. The interior apparatus equipment of the field station is shown in Fig. 2.

All the oscillographic measurements were obtained by direct registration on a film which was placed under a vacuum in the cathode ray oscillographs.

The Electric Data of the Line and Measuring Possibilities

The self-induction of the line used for taking measurements was 0.0069 henry, and its capacitance was 0.00753 microfarad. The oscillographs were connected to the line by a potentiometer as shown in Fig. 3, in which V represents the voltage of the line. The incoming voltages from the line had such a low amplitude that it was necessary to increase them through a distortionless amplifier. The voltage on the first grid of this amplifier is represented by V_1. When making the measurements an amplification of 800 times was maintained. The capacitances C_1, C_2 with the potentiometer constituted variable air condensers, and by their variation it was easy to regulate the incoming voltage from the line. For the potentiometer

$$V = \frac{C_1 + C_2}{C_1} V_1 + \frac{1}{RC_1}\int V_1 dt \quad \ldots \quad (4)$$

In the potentiometer R was a non-inductive resistance of either 2 or 4 megohms. The capacitances C_1 and C_2 varied between 45 and 140 $\mu\mu$F. The ratios used most often for $\frac{C_1 + C_2}{C_1}$ were 1, 5, 2 or 3.

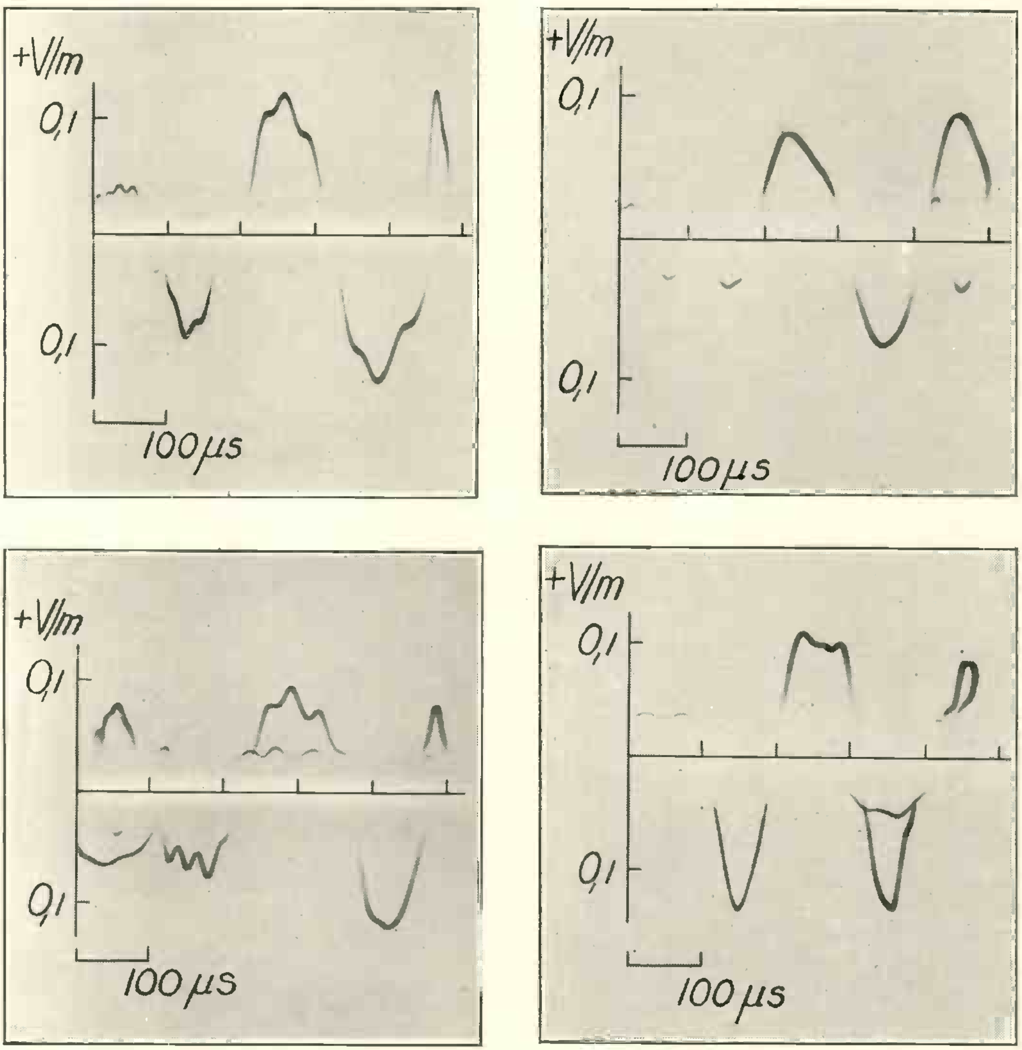


Fig. 5.—*Original oscillographic records of atmospherics of short duration type.*

According to relation (4) the second term in this equation is a typical factor of correction which, in our case, may be neglected on account of the large value of R. To exemplify this the correction terms have been estimated for an ordinary curve. The correction is given in Fig. 4, where a full line signifies the values observed, and a dotted

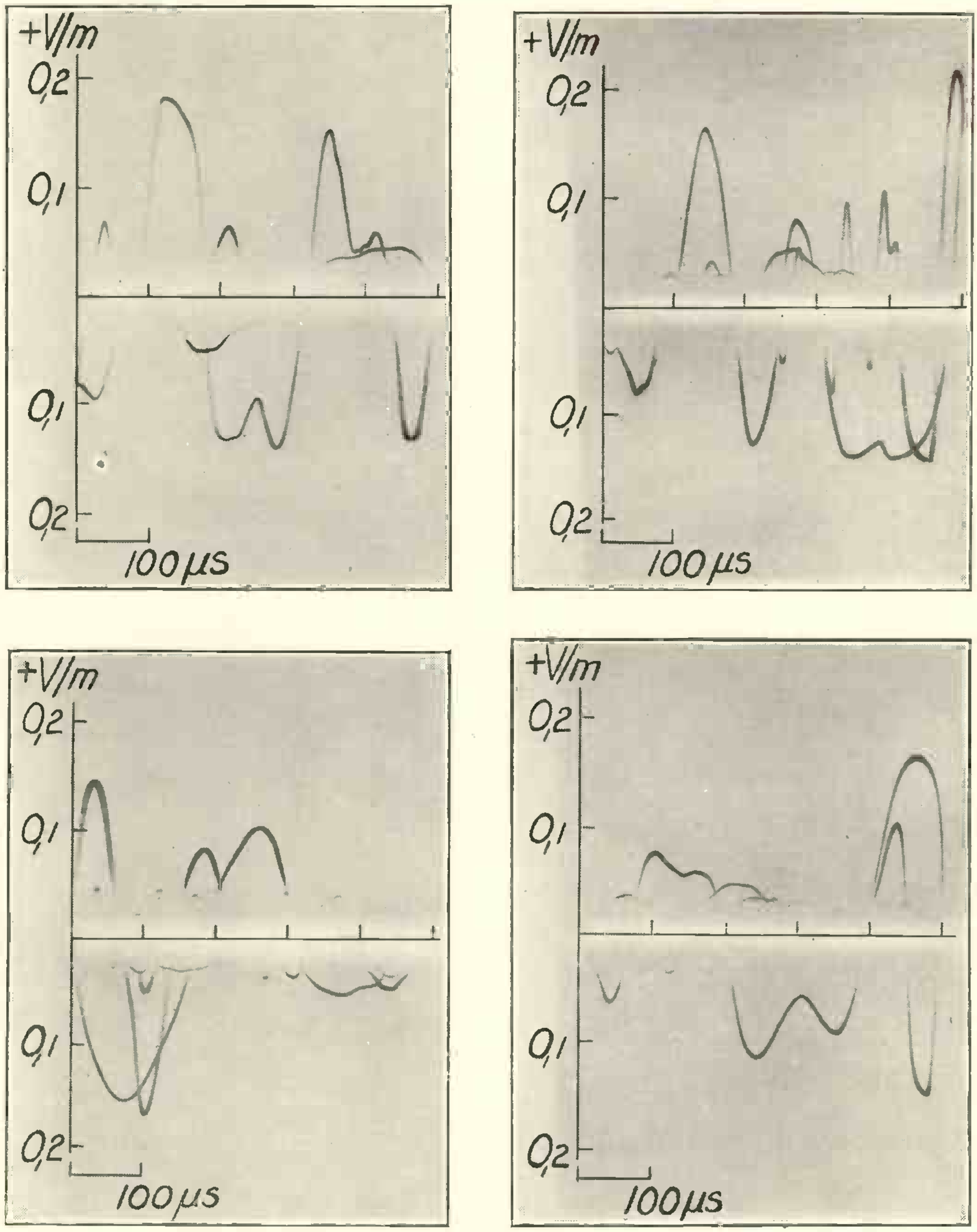


Fig. 6.—*Original oscillographic records of atmospherics of medium duration.*

line the values corrected. Neglecting the correction terms causes, as is seen in Fig. 4, a slight distortion of the curves. The correction terms do not, to any great extent, affect the determination of the maximum amplitude.

To make clear how the amplitudes have been estimated a typical case is given. The maximum voltage of an ordinary oscillogram is 600 volts after amplification in the oscillograph. Then, with an amplification of 800 the voltage V_1 on the first grid is $\frac{600}{800} = 0.75$ volt. The corresponding voltage on the line, according to relation (4) with a correction factor $\frac{C_1 + C_2}{C_1}$ of 2 gave a voltage amplitude for the line of 1.5 volt. With due consideration of the average height of the line, viz., 7.75 metres a maximum amplitude of 0.2 volt/metre was obtained for the atmospheric.

On account of its dimensions the potentiometer had one great advantage, viz., its capacitance could be neglected in relation to the capacitance of the line. The latter rose to 7 530 $\mu\mu$F, while the capacitance of the potentiometer was 70 $\mu\mu$F.

The Influence of the Self Oscillations of the Line

The line used when taking the measurements had no special damping resistances and consequently only its own damping. Thus, one could suppose that these self oscillations would act as a strong form of perturbation at the time of taking the measurements. In connection with these oscillations one must take into account two different kinds, viz., quasi-stationary, and non-quasi-stationary.

In quasi-stationary cases the whole line oscillates as a unit, and estimates showed that the oscillation period T for the line in this case was 45 μsec. One would have expected that oscillations with this period would easily be set up by incoming atmospherics with partial frequencies on the line near the above period. Judging from the investigations hitherto carried out, however, oscillations with this period occurred very seldom. In the following some cases will be exemplified.

This slight occurrence of self oscillation was partly explained by the fact that oscillations of perceptible amplitude were only produced when the atmospherics came from a particularly favourable angle of direction in relation to the principal angle of the line. The absence of partial frequencies sufficiently near the self oscillation period in the atmospherics has been of importance in this respect.

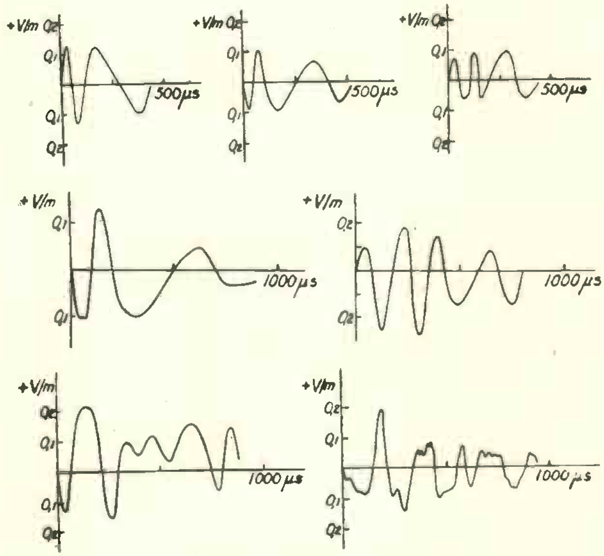


Fig. 7.—*Atmospherics of typical periodic variation.*

The oscillations with the period in question have, as appears in some oscillograms in the following, without exception, very small amplitude in relation to the amplitude of the atmospherics, and, therefore, have no disturbing influence upon the measurements.

Estimates of the non-quasi-stationary self oscillations of the line gave a period T of 14 μsec. Oscillations with this short period have not been discovered in the results.

The Results of the Investigations

Those investigations which have hitherto been carried out with the aforementioned method cover an observation period from September 1935 to February 1936. The total number of atmospherics which has been examined through recorded oscillograms is 960. It is worth mentioning that the observations were carried out at a time of the year when the atmospherics were neither very common nor showed a very large amplitude.

Hitherto, the object of the investigations has been to control the general validity of results obtained by antenna methods in connection with the variation forms of the atmospherics. In this respect interest has been particularly centred upon atmospherics of medium duration. As already pointed out, previous measurements, where linear horizontal aerials have been used, have met with difficulties as regards the obtaining of variation forms for atmospherics of medium duration. It was, therefore, considered necessary to direct the control measurements to this type of atmospheric.

Typical Original Oscillograms

In order to exemplify the possibilities of the method of registration a few original oscillograms are shown in Figs. 5 and 6. The zerobands, which appear in the oscillograms, are explained by the relay method used when taking the measurements. This relay method is characteristic of the construction of the cathode ray oscillograph used. This presupposes that the electron beam is blocked on those occasions when the deviation plates are free of tension. As a rule, there is no difficulty in making an interpolation for the transition of the variation to positions above zero.

On a number of oscillograms there appeared super-imposed periodic variations. These appeared particularly on the horizontal parts of the oscillograms and are most visible in the lower curves in Fig. 5. Even when the tension was increased these periodic variations sometimes showed weak bends in the ascending curves. These periodic variations are caused by the self oscillation of the line mentioned in the foregoing pages of this paper. As already pointed out in another connection, these self oscillations appear only under certain conditions.

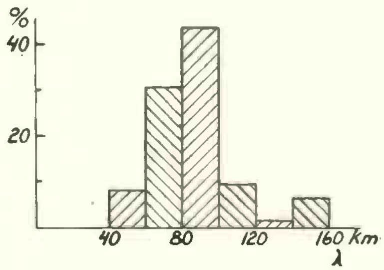
The atmospherics given in Fig. 5, belong to the short duration group, while those in Fig. 6 belong to the medium long duration group.

Atmospherics of Medium Long Duration

As already pointed out, the method employed permitted the recording of atmospherics, of medium long duration, free of distortion. It was, therefore, of especial interest to make a thorough examination of this type of atmospherics. A remarkably regular periodic variation structure was often seen.

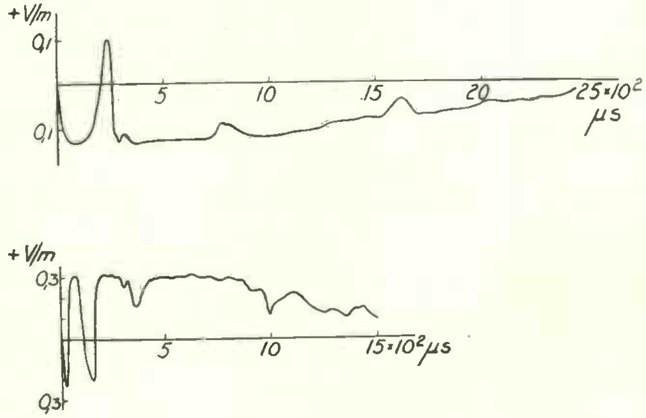
In Fig. 7 some typical atmospherics of the above type have been redrawn direct from the oscillograms. It is very noticeable that the periodic variation structures of these atmospherics are considerably more regular than other types of atmospherics. Particularly typical periodic variations appear in the upper curves in Fig. 7. It is remarkable that the period is increased towards the end of such atmospherics.

An investigation into the distribution of the periodic variations in such atmospherics, arranged according to wavelengths, is given



(*Above*) Fig. 8.—*Average percentage distribution of wave lengths in periodic atmospherics.*

(*Right*) Fig. 9.—*Atmospherics of long duration type.*



in Fig. 8. As is to be seen the most frequently occurring wavelengths appear either at 80–100 or at 80–60 kilometres. This typical accumulation on certain wavelengths must have a physical explanation ; but

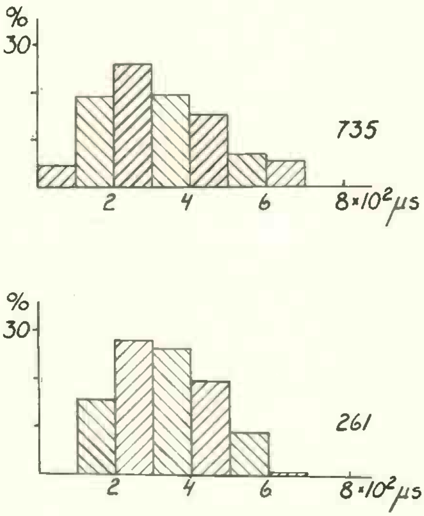


Fig. 10.—*Distribution of duration times of atmospherics of short type.*

whether one has here to deal with the influence of reflection from ionised layers is very difficult to say at this stage of the investigations.

To embark upon such a problem necessitates the knowledge of the physical conditions under which the atmospherics arise. In the first place it is necessary to know the discharge structure from which the atmospherics are emitted. And, furthermore, one must have a knowledge of how the discharge is localised in relation to both the ground surface and the reflecting ionised layers.

In Fig. 9 a few atmospherics of long duration are given for the sake of completeness. In general character these do not differ from atmospherics of this type published in another connection.[1]

Comparisons with Other Methods of Measuring Atmospherics

As already pointed out, linear horizontal antenna circuits have been used when investigations have been made into variation peculiarities of the atmospherics.

In connection with the writer's investigations in Upsala, during the years 1934–1935, about 22 000 atmospherics have been oscillographically examined. The principal results of these investigations have shown that the majority of atmospherics were of short duration with a total duration not exceeding 600 μ seconds. The most commonly occurring duration values in this group reached 200 to 300 μ seconds. There were also atmospherics with a remarkably long duration from 2 000 to 9 000 μ seconds, the average value lying between 3 000 to 4 000 μ seconds. Of the total number these atmospherics only represented a few per cent. There was also a small number of atmospherics of a medium long duration, the value of which was up to about 1 000 μ seconds.

The most important result in this paper is that the author's earlier statement concerning the distribution of atmospherics of so totally different duration groups has been completely confirmed. This is also supported by a detailed examination of the origin and peculiarities of the atmospherics

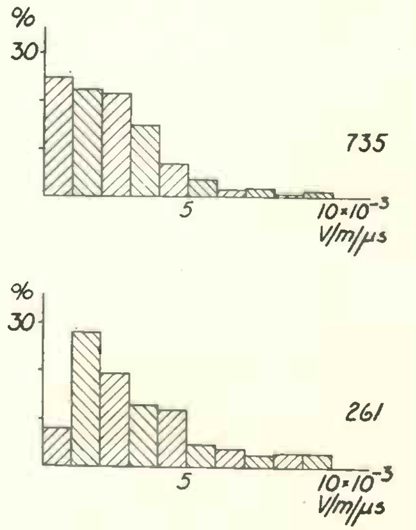


Fig. 11.—*Distribution of wave front slopes of atmospherics.*

during comparative periods of observation and where the number is sufficiently large in the groups compared.

For atmospherics of short duration there appear the approximately corresponding periods of observation where the measurements have been carried out partly with the

[1] loc. cit.

$\frac{dE}{dt}$ method—September 1934–February 1935 —and partly with the method mentioned in this paper—September 1935–February 1936.

A comparison between the general distribution of duration periods during the two

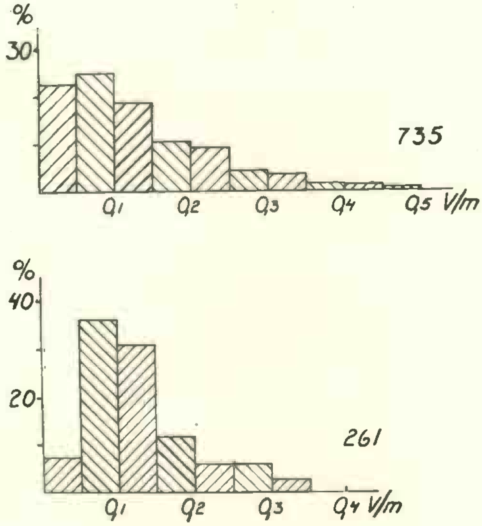


Fig. 12.—*Distribution of voltage amplitudes of atmospherics in volts/meter.*

periods in question is given in Fig. 10. In both cases the most commonly occurring duration values are between 200 to 300 μ seconds.

If one compares the observed steepness of wave front expressed in volts per metre per micro-second, one obtains the distribution shown in Fig. 11. Between the two periods no striking deviations are to be seen.

A comparison of the maximum amplitude values in volts per metre during the two observation periods is given in Fig. 12.

The general variation of atmospherics of short duration type did not differ from corresponding types taken during earlier observation periods. To illustrate such typical variation forms of atmospherics of short duration, some from a previous paper[1] are reproduced in Fig. 13.

Conclusions

The work of investigations carried out hitherto in connection with the variation of structure of the atmospherics has led to the following results :

The most commonly occurring group of atmospherics is the one of the short type where the most common duration is from 200 to 300 μ seconds. These atmospherics are sometimes aperiodic and often quasi-periodic. They sometimes show a one-sided polarity with more or less prominent periodical and deliberate variations. These periodic forms of variations with the short duration atmospherics are often only an effect of propagation.[2]

The opposite to these short atmospherics are the long duration atmospherics from 2 000 and up to 9 000 μ seconds. These atmospherics have previously been examined in detail in connection with the visual cathode - ray oscillographic observations carried out at Slough by Appleton, Herd and Watson Watt. These slow atmospherics are often aperiodic or quasi-periodic. Through photographic registration it has been possible to determine the periodic variations in these slow atmospherics with certainty.

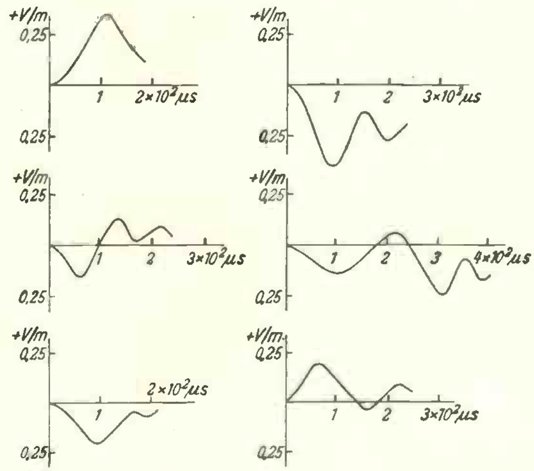


Fig. 13.—*Typical atmospherics of short duration.*

The measurements described in this paper have shown the existence of atmospherics of medium long duration from 300 to 1 000 μ secs. which are often characterised by well-developed periodic variation forms. These are more regular than the periodic variation forms which, in certain cases, appear in the two previously mentioned groups of atmospherics.

[1] loc. cit.

[2] Harald Norinder : Die Beziehungen zwischen Rundfunkstörungen und Blitzentladungen. *Elektrische Nachrichten Technik*, 13, 4, Berlin, 1936.

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

With Special Reference to the Voltage Output and Current Input

By N. H. Roberts

(*Lecturer at the University of Capetown*)

(7) Deductions from the Curves.

(*a*) *Efficiency.*

Values of the form-factor f_e may be substituted in (15a), in order to obtain the efficiency, but curves have not been plotted as the values are easily derived and, moreover, the efficiency is not of much importance.

For fixed n, the efficiency is a minimum for that value of m which corresponds to the hump in the f_e curve, i.e. there is a certain reservoir capacity which gives a minimum efficiency. Table (4) below will illustrate this point. For purposes of comparison, values of the efficiency calculated by Marique (Ref. 4 Fig. 9) from purely theoretical considerations for $n = 0.05$, are placed alongside values obtained by substituting values of f_e (from our Fig. 9) in equation (15a). It will be noted that the calculated efficiency at $m = 6.28$ is lower than the value derived from our curves, which means that the hump is not so pronounced in practice as one would expect from the theory.

TABLE 4.

Half-wave Case. $n = 0.05$.

m	Calc. η	Experimental f_e	Experimental η
628	83%	2.25	80%
62.8	82%	2.26	79.5%
6.28	75%	2.30	79%
1.0	—	1.80	86%

For fixed m, a decrease in n, that is, in ρ, causes a rise in the efficiency, as we would expect.

Although considerations of the efficiency alone would lead one to choose a low value of m, yet such a choice would be inadvisable from considerations of the magnitude of, and—more important—the ripple in, the rectified voltage v_m. The first point, that of the size of v_m, will be obvious after a study of Figs. 12, 13 and 14, while the second point, that of the ripple, is dealt with in the next section.

(*b*) *Magnitude of Ripple Voltage.*

It is of use to be able to predict the magnitude of the ripple in the rectified voltage, especially in the case of a comparatively high voltage equipment in which the expense of additional smoothing condensers is a considerable item. A knowledge of the ripple magnitude may influence a designer in his choice of the class of rectifier to be used. An approximate idea of the ripple may be obtained from the following treatment.

Examination of the oscillograms of Fig. 11, and others, shows that, provided one considers points only to the right of the top of the humps in the f_e curves (e.g. $m = 263$ and $m = 67$), the form of the current pulse is nearly sinoidal. The form-factor of such a pulse (in itself) may therefore be taken as approximately 1.11. The form-factor f_e of the current, considered over the period between successive pulses, is greater than 1.11 owing to the presence of the gaps.

Half and Full Wave.

If P be put equal to the ratio of the period between the beginnings of successive pulses, to the duration of one pulse, i.e. $P = \frac{k\pi}{\alpha_2 - \alpha_1}$, then the mean current averaged over the pulse only, will be PI_0. The peak of the pulse, assuming sinoidal form, will be $PI_0\frac{\pi}{2}$, and the mean square of the current averaged over the pulse only, $\frac{1}{2}\left(PI_0\frac{\pi}{2}\right)^2$, and averaged over the whole period between pulses, the R.M.S. current will be :—

$$I = \sqrt{\frac{\left(PI_0\frac{\pi}{2}\right)^2}{2P}} = \frac{\pi}{2\sqrt{2}}I_0\sqrt{P} = 1.11 I_0\sqrt{P}$$

$$\left.\begin{aligned} \text{whence } f_e &= \frac{I}{I_0} = 1.11\sqrt{P} \\ \text{and } \quad (a_2 - a_1) &= k\pi\left(\frac{1.11}{f_e}\right)^2 \end{aligned}\right\} \quad \ldots \quad \ldots \quad (38)$$

for the half- and full-wave cases.

Now the voltage across the reservoir condenser reaches its maximum shortly before the end of the pulse, and its minimum shortly after the beginning, and these values are (nearly) $E \sin a_2$ and $E \sin a_1$, respectively. Assuming that these values are really correct (the error is only of the second order, as will be seen from Fig. 17), we have the magnitude of the ripple, "trough to crest," $V_r \doteqdot E(\sin a_2 - \sin a_1)$. The output voltage is approximately

$$v_m \doteqdot \frac{E}{2}(\sin a_2 + \sin a_1)$$

if the value of m is fairly high.

$$\text{Therefore} \quad \frac{V_r}{v_m} = \frac{2(\sin a_2 - \sin a_1)}{\sin a_2 + \sin a_1} \quad \ldots \quad (38a)$$

Now, from (4),

$$\frac{\sin a_2}{\sin a_1} = \epsilon^{\frac{k\pi - (a_2 - a_1)}{m}} \doteqdot 1 + \frac{k\pi - (a_2 - a_1)}{m}.$$

Therefore $\frac{V_r}{v_m} \doteqdot \frac{1}{m}\{k\pi - (a_2 - a_1)\}$ if m is sufficiently large.

Substituting from (38) for $(a_2 - a_1)$ we get

$$\frac{V_r}{v_m}\% = \frac{k\pi}{m}\left\{1 - \left(\frac{1.11}{f_e}\right)^2\right\} 100 = \frac{k\pi}{m} \times \frac{f_e^2 - 1.232}{f_e^2} \times 100\,\% \quad \ldots \quad (39)$$

k being 2 for a half-wave, and 1 for a full-wave rectifier.

Voltage-Doubler.

P is put equal to the ratio of the time between successive pulses through the *same* diode, to the duration of one pulse, i.e. $P = \frac{2\pi}{a_2 - a_1}$. The quantity of electricity q which passes in one pulse is used mainly to charge *one* condenser (e.g. the quantity which passes during pulse 1, Fig. 5 goes mainly to charge the upper condenser of Fig. 4) and this charge q must be sufficient to maintain the load current I_0, passing through that condenser, for a *complete* period. This same load current is passed by the second condenser (which is in series with the first during the gaps) at the same time, and therefore the (equal) charge passed by the second diode in the next pulse must be sufficient to maintain the same load current for the same period. Herein lies the difference between the modes of operation of the voltage-doubler and of the full-wave rectifier. In both cases, there are two pulses per cycle, but in the latter case each pulse has to maintain the load current for half a period only. The charges passed during successive pulses are expended successively in the full-wave case, but concurrently in the voltage-doubler case.

Accordingly, in the case of the voltage-doubler, the mean current passed by one diode, averaged over the pulse only, will be PI_0, and the peak current of each pulse will be $PI_0\frac{\pi}{2}$, if we assume a pulse of sine form. The mean square of the current, through the first diode, averaged over the pulse only, will be $\frac{1}{2}\left(PI_0\frac{\pi}{2}\right)^2$, and averaged over a period, will be $\frac{1}{2P}\left(PI_0\frac{\pi}{2}\right)^2$. The second pulse demands from the source an equal contribution to the mean square, and hence we get, for the R.M.S. current drawn from the source

$$I = \sqrt{\frac{2}{2P}\left(PI_0\frac{\pi}{2}\right)^2} = I_0\frac{\pi}{2}\sqrt{P}.$$

$$\left.\begin{aligned} \text{Therefore} \quad f_e &= \frac{I}{I_0} = 1.57\sqrt{P} \\ \text{and} \quad (a_2 - a_1) &= 2\pi\left(\frac{1.57}{f_e}\right)^2 \end{aligned}\right\} \quad \ldots \quad (40)$$

for the voltage-doubler.

The voltage across the load reaches its maximum $v_{max.}$ at (nearly) $a = a_2$, and approximately

$$v_{max.} \doteqdot E\{\sin a_2 + (\sin a_2 - 2H)\} \doteqdot 2E(\sin a_2 - H).$$

The minimum occurs nearly at $a = a_1$, and

$$v_{min.} \doteqdot E\{\sin a_1 + (\sin a_1 + 2H)\} \doteqdot 2E(\sin a_1 + H).$$

The ripple voltage ("trough to crest")

$$V_r = v_{\max.} - v_{\min.}$$
$$\doteqdot 2E\{(\sin \alpha_2 - H) - (\sin \alpha_1 + H)\}.$$

Also we have $v_m \doteqdot \frac{1}{2}(v_{\max.} + v_{\min.})$

$$\doteqdot E\{(\sin \alpha_2 - H) + (\sin \alpha_1 + H)\}.$$

Therefore $\dfrac{V_r}{v_m} \doteqdot 2\,\dfrac{(\sin \alpha_2 - H) - (\sin \alpha_1 + H)}{(\sin \alpha_2 - H) + (\sin \alpha_1 + H)}$.

But, from (34) we have

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

$$\doteqdot 1 + \frac{2\pi}{m}\left(1 - \frac{2}{P}\right) \text{ if } m \text{ is large enough.}$$

$$\therefore \quad \frac{V_r}{v_m} \doteqdot 2\,\frac{\frac{2\pi}{m}\left(1 - \frac{2}{P}\right)}{2 + \frac{2\pi}{m}\left(1 - \frac{2}{P}\right)} \doteqdot \frac{2\pi}{m}\left(1 - \frac{2}{P}\right)$$

and, substituting from (40), we get :—

$$\frac{V_r}{v_m}\% = \frac{2\pi}{m}\frac{f_e^2 - 4.93}{f_e^2} \times 100\,\% \quad \ldots \quad (41)$$

for the voltage-doubler.

The magnitude of the ripple voltage may thus be deduced from values of f_e given by the curves of Figs. 8, 9 and 10, and curves of $\frac{V_r}{v_m}$ % plotted. Logarithmic scales should be used in order to cover a wide range. On account of the small variation of f_e over the working range (for a given value of n), the ripple is almost exactly inversely proportional to m, and therefore curves plotted

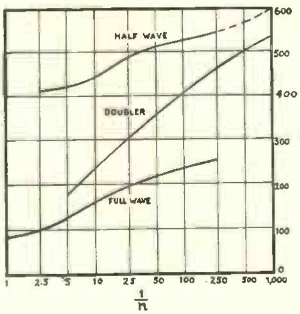


Fig. 15.—S VERSUS $\frac{1}{n}$.

logarithmically are practically straight for values of m down to the falling portion of the f_e curves to the left of the hump. Accordingly, equations (39) and (41) may be simplified, and become :—

$$\frac{V_r}{v_m}\% = \frac{S}{m} \quad \ldots \quad \ldots \quad \ldots \quad (42)$$

where S depends only on n and on the type of rectifier equipment used.

Table 5 below gives values of S and of the lower limit of $m = m_1$ below which (42) should not be applied. At this limit, the error due to using (42) instead of (39) or (41) is about 1 in 100. For lower values of m the latter equations should be used, but the results must then be accepted with

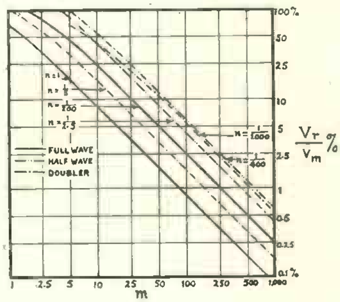


Fig. 16.—$\frac{V_r}{v_m}$ % VERSUS m.

reservation, as the wave-form of the pulse will be far from sinoidal. The error is, however, surprisingly small, as will be apparent from the tests described later. Fig. 15 shows S plotted versus $\frac{1}{n}$. The hybrid nature of the voltage-doubler arrangement is shown by the fact that its S curve approaches the half-wave curve for high values of $\frac{1}{n}$, and the full-wave curve for low values of $\frac{1}{n}$.

Fig. 16 shows some curves of $\frac{V_r}{v_m}$ % plotted versus m. These curves are given only to indicate the general way in which the ripple voltage varies with m, n and the type of rectifier. It will be seen that an increase of ρ causes a decrease in the ripple, but this decrease is usually small, unless the change in ρ is considerable. Nevertheless, it may be pointed out that the current-limiting resistance commonly inserted in one of the transformer secondary leads will help to reduce the ripple percentage.

From the point of view of reducing the ripple voltage, the half-wave, voltage-doubler and full-wave types are apparently in ascending order of merit. A true comparison, however, can only be made if other factors are taken into account, such as the required output voltage and the number of turns which can be coaxed into a given copper space. A further factor which should be borne in mind is that of the working voltage rating of the condensers, for the condensers in a doubler set are subjected to about one half of the output pressure, as against the full pressure in the other cases.

Note.—The value of S for $n = \frac{1}{800}$ (half-wave) is somewhat doubtful, as the meter readings necessary for the determination of the corresponding f_e curve were very low.

The predictions from Table 5 were checked against experimental tests on a half-wave rectifier. From oscillograms of the current pulse, a_1 and a_2 were found. The ripple voltage wave, even when the steady component was blocked out by a condenser.

Such an integrated curve is shown in

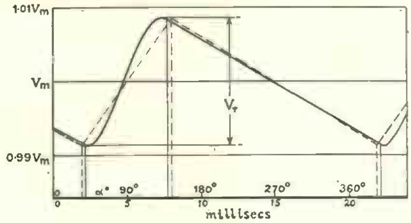


Fig. 17.—*Ripple voltage form.*

Fig. 17. The values of V_r so obtained differed by not more than one part in 100 from the values obtained from the first measurement.

TABLE 5.

Values of S. Equation (42).

Full Wave.			Half Wave.			Doubler.		
n	S	m_1	n	S	m_1	n	S	m_1
$\frac{1}{200}$	250	15	$\frac{1}{800}$	590 (?)	20	$\frac{1}{1000}$	533	60
$\frac{1}{100}$	234	14	$\frac{1}{400}$	560	15	$\frac{1}{500}$	500	50
$\frac{1}{50}$	216	11	$\frac{1}{200}$	545	12	$\frac{1}{250}$	458	30
$\frac{1}{20}$	190	8	$\frac{1}{100}$	527	10	$\frac{1}{100}$	406	25
$\frac{1}{10}$	160	6	$\frac{1}{50}$	510	8	$\frac{1}{50}$	360	15
$\frac{1}{5}$	128	5	$\frac{1}{20}$	478	6	$\frac{1}{20}$	290	10
$\frac{1}{2.5}$	100	4	$\frac{1}{10}$	445	4	$\frac{1}{10}$	236	6
1	84	3	$\frac{1}{5}$	423	3	$\frac{1}{5}$	175	5
—	—	—	$\frac{1}{2.5}$	412	2.5	—	—	—

voltage was then calculated from the relation

$$V_r = E(\sin a_2)\left\{1 - \epsilon^{-\frac{2\pi - (a_2 - a_1)}{m}}\right\}$$

and v_m was obtained from the product of the load current I_0 and the load resistance R. Hence $\frac{V_r}{v_m}\%$ was obtained.

With a view to checking the accuracy with which the oscillograms could be measured up, V_r was also obtained by graphical integration of oscillograms of the *condenser* current pulse. These pulses differ from the pulses previously considered in that, during the pulse, the load current is no longer included in the oscillogram. This integration yields curves of the wave-form of the output voltage. This indirect method was used, as there was no oscillograph loop available, sensitive enough for a direct tracing of the

Table 6 gives values of $\frac{V_r}{v_m}\%$ obtained from (42), (39) and from the above tests (columns 3, 4 and 5 respectively).

The agreement is satisfactory, even for low values of m, when the wave-form is far from the sine form. We may note that somewhat better agreement with the measured values is obtained from the approximate formula (42), than from (39), which is more correct theoretically!

The formulae for the voltage-doubler were also subjected to tests of the same nature, the results being given in the next table (Table 7).

A further deduction may be made. The ripple in the output voltage wave-form is roughly triangular—a fact which has been noted in previous papers (Ref. 5). As, with the help of (38) and (40), we may obtain a fair idea of the pulse length, it is possible to determine the approximate proportions of

TABLE 6. $\frac{V_r}{v_m}$ %

m	n	(42)	(39)	Expl.
261	$\frac{1}{10}$	1.71	1.67	1.71
,,	$\frac{1}{50}$	1.96	1.95	1.97
,,	$\frac{1}{100}$	2.03	2.04	2.00
,,	$\frac{1}{400}$	2.12	2.13	2.10
66	,,	8.40	8.48	8.24
31.4	,,	17.7	17.8	17.4
15.7	,,	35.4	35.2	35.7
7.95	,,	70.8	67.2	70.3
3.92	,,	141.6	123	131

the triangle, and thence, by application of Fourier analysis, to find the magnitudes of the various harmonics in the ripple. In the case of the half-wave rectifier, all harmonics, including the fundamental, may occur, whereas in the full-wave and voltage-doubler cases, only even harmonics can be present, provided that the arrangement is perfectly symmetrical, i.e. the diodes, for instance, must be identical. The phases of the harmonics may also be estimated from the foregoing results. Knowing the value of $\frac{V_r}{v_m}$, we can find values of α_1 and α_2, which differ by the pulse length, and which satisfy (38a), that is,

$$2\frac{\sin\alpha_2 - \sin\alpha_1}{\sin\alpha_2 + \sin\alpha_1} \text{ must equal } \frac{V_r}{v_m}$$

in the half- and full-wave cases. For the voltage-doubler, the relation to be used in place of (38a) is :—

$$\frac{V_r}{v_m} = \frac{2E(\sin\alpha_2 - \sin\alpha_1) - 4HE}{v_m}$$

$$= \frac{2E(\sin\alpha_2 - \sin\alpha_1) - \frac{2v_m\pi}{m}}{v_m} \text{ as } \frac{v_m}{E} = \frac{2mH}{\pi}$$

from (36)

$$= \frac{2(\sin\alpha_2 - \sin\alpha_1)}{\sin\alpha_2 + \sin\alpha_1} - \frac{2\pi}{m}.$$

Having found α_1 approximately, we can fix the vertices of the triangle with which we replace the actual ripple wave-form.

This extension of the theory has not been completely investigated yet, but the writer hopes to carry out this work shortly. Meanwhile it may be stated that, while the magnitudes of the higher harmonics are given somewhat inexactly by the above method, the magnitude of the lowest harmonic (the most important) is more accurate, as will be seen from the example worked out below. The rectifier is of the half-wave type, $m = 261$ and $n = 0.1$.

The actual form of the ripple is that shown in Fig. 17.

By extrapolation, we get, from the curves of Fig. 9, $f_e = 2.01$. Hence from (38), $P = \left(\frac{2.01}{1.11}\right)^2$ and $\alpha_2 - \alpha_1 = \frac{2\pi}{P} = 1.91$ radian $= 109.5°$ (say 110°). From (42), $\frac{V_r}{v_m}\% = 1.71\%$. Using (38a), and the pulse length of 110°, we get $\alpha_1 \doteqdot 34° \ 40'$ and $\alpha_2 \doteqdot 144° \ 40'$. These values fix the vertices of the assumed triangle, which is shown (broken lines) in Fig. 17. Analysis of this triangular wave yields the result :—

$$-0.670 \cos\alpha - 0.191 \sin 2\alpha + 0.024 \cos 3\alpha,$$

TABLE 7.

Values of $\frac{V_r}{V_m}$%. Doubler.

m	n	(42)	(41)	Expl.
1000	$\frac{1}{1000}$	0.53	0.53	0.54
500	,,	1.066	1.06	1.09
200	,,	2.67	2.66	2.68
100	,,	5.33	5.32	5.40
50	,,	10.66	10.42	10.6

the amplitudes being stated as percentages of the rectified voltage v_m.

Analysis of the actual curve of Fig. 17, using 36 ordinates, gives $-0.697\cos(\alpha + 4°) - 0.265\sin 2(\alpha + 6°) + 0.104\cos 3(\alpha + 5°)$

The explanation of the discrepancy lies in the fact that the pulse calculated from (38) is somewhat too long (110° instead of about 100°), and approaches 120°—a pulse-length which would eliminate all triple harmonics. The effect of the inaccuracy is therefore most marked in the case of the third harmonic, here.

The percentage amplitude of the lowest harmonic appears to be of the order of 40% of $\frac{V_r}{v_m}$, a conclusion which has been borne out by a few other tests. Nevertheless, further investigation is necessary.

The point of this analysis of the ripple into its components, is that the writer hopes to extend the theory of the diode to include the effect of smoothing stages. The effectiveness of the smoothing equipment obviously depends on the order of the ripple harmonics. From one or two simple tests already carried out, it appears that the addition of a smoothing stage does not greatly affect the conditions prevailing in the diode-reservoir-condenser portion of the circuit. If this should prove to be true, then the degree of smoothing attainable with a given equipment could be calculated from a knowledge of the nature of the ripple.

(c) *Voltage Regulation.*

Voltage Regulation curves may readily be obtained from Figs. 12, 13 and 14, if one bears in mind the fact that a change in load current, i.e. a change in load resistance, alters m as well as n.

(8) Example on the Use of the Curves.

The example worked out below illustrates the uses to which the foregoing results may be put.

It is required to design a rectifier equipment to supply 1mA at 4,000 volts D.C. The ripple voltage is not to exceed ½ per cent. of the mean rectified voltage. A protective resistance of 100,000 ohms is to be included in the high tension circuit of the transformer.

The supply pressure is 220 volts at 50 cycles per second.

We have :—

Load current $I_0 = 1$ mA.

Rectified voltage $v_m = 4{,}000$ volts.

Load resistance $R = \frac{4{,}000}{10^{-3}} = 4$ megohms.

We assume that m is large enough to bring us on to the flat parts of the f_e and v_m curves.

(a) *Full Wave.*

We may take it that the diode and transformer resistance will account for about 15,000 ohms in addition to the protective resistance. Therefore

$$\rho = 100{,}000 + 15{,}000 = 115{,}000 \text{ ohms}$$

and $n = \frac{115{,}000}{4{,}000{,}000} = \frac{1}{35}$.

By interpolation between the curves of Fig. 12, we get

$$v_m = 0.885E \text{ or } E = \frac{4{,}000}{0.885} = 4{,}520 \text{ volts.}$$

Hence R.M.S. voltage to be developed in each half of the H.T. secondary $\frac{4{,}520}{\sqrt{2}} = 3{,}200$ volts.

Fig. 8 gives us $f_e = 1.85$ ∴ R.M.S. current in each half winding $= \frac{f_e}{\sqrt{2}} I_0 = 1.31$ mA.

48 gauge wire would carry this easily, at a current density of 650 amps. per square inch, but we must remember the current rush which will occur if the transformer is switched in when the rectifier filaments are still hot and the condenser uncharged. The maximum possible current, in the lead from the centre-tap, is $\frac{3{,}200}{115} \doteqdot 28$ mA, but, as this is passed by the two sections alternately, we must calculate our conductor for an inrush current of $\frac{28}{\sqrt{2}} \doteqdot 20$ mA. It would be advisable to use heavier wire than 48 gauge, even 44 gauge.

Assume that a transformer core of the following dimensions is available : Nett iron cross-section 3 sq. in. Gross winding space 1.5 sq. in. Mean iron path 8 in. Nett iron volume 23 cub. inches.

If we work at a maximum flux density of 9,300 lines per square cm, we require 2.5 turns per volt, i.e. 16,000 turns (centre-tapped) for the high-tension secondary. Of the winding space, probably only about one-third (0.5 sq. in.) will be available for this winding and the necessary interleaved insulation, when we have allowed for all other insulation and windings, including those for the heaters. This area is hardly enough for 44 gauge copper (d.s.c.), even without the interleaving. Enamelled wire of this gauge will go in, but is rather ticklish for a non-professional to handle.

A full-wave equipment is therefore not advisable, but we will nevertheless consider what size of condenser would be necessary in order to provide adequate smoothing.

If n is correctly taken as $\frac{1}{35}$, we find from Fig. 15 that $S = 207$.

$$\frac{V_r}{v_m}\% \doteqdot \frac{S}{m} \ngtr \frac{1}{2} \therefore m \nless 2S \text{ and } C = \frac{m}{pR}$$

$$\nless \frac{2S}{pR} \nless \frac{414}{100\pi \times 4}\mu\text{F} \nless 0.33\mu\text{F at}$$

4,000 volts wkg.

(*b*) *Half Wave.*

Assume the same value of n, viz., $\frac{1}{35}$.

From Fig. 13 we get

$v_m = 0.815 \; E \; \therefore$ transformer E.M.F.

$$= \frac{4{,}000}{0.815\sqrt{2}} = 3{,}480 \text{ volts R.M.S.}$$

From Fig. 9 we get $f_e = 2.45 \therefore I = 2.45$ mA.

Maximum current inrush $= \frac{3{,}480}{115}$ mA. $\doteqdot 30$ mA. 48 gauge will carry the final current, but 44 is advisable. Using the same transformer core, we require 8,700 turns for the secondary, 550 for the primary and 5 turns for a 2 volt rectifier heater winding.

The magnetising current is 175 mA and the iron loss 3.95 watt. The iron loss current is 18 mA and the heater current, referred to the primary, is 9.1 mA. I referred to the primary $= 2.45 \times \frac{8{,}700}{550} = 38.7$ mA.

The primary current is then

$$\sqrt{(9.1 + 18 + 38.7)^2 + 175^2} = 187 \text{ mA.}$$

This is actually lower than the real value, for we must remember that the current to the rectifier passes in brief pulses with a comparatively high peak value (about 120 mA in this case). On account of the high magnetising current, however, the effect of this distortion on the R.M.S. primary current is likely to be small, but the point should be borne in mind. If necessary, we can estimate the effect, for we can determine the length of the pulse from (38), and the peak from the paragraph immediately preceding that equation. Here $P = 4.88$ and the peak value is, in the secondary, 7.7 mA and, in the primary, 120 mA.

20 gauge will do for the primary winding. Its resistance (reckoning 9″ as the mean length of a turn) will be about 20 ohms, and, referred to the secondary, 5,000 ohms. The secondary winding, if the mean turn be taken as 11″, will have a resistance of about 8,200 ohms. A typical 2-volt rectifier suitable for this voltage (Loewe NG 3020) has a resistance of about 2,500 ohms at the current of this example. Hence $\rho = 100{,}000 + 5{,}000 + 8{,}200 + 2{,}500 = 115{,}700$ ohms which is fairly close to our assumed value.

From Fig. 15 $S = 505 \therefore m \nless 1{,}010$ or $C \nless 0.8 \mu$F at 4,000 volts working.

(*c*) *Voltage-Doubler.*

Assume $\rho = 112{,}000$ ohms. Hence $n = \frac{1}{35.7}$. From Fig. 14 we get $v_m = 1.46 \; E \therefore$ transformer secondary voltage $= 1{,}930$ volt. Also $f_e = 3.21 \therefore I = 3.21$ mA. The maximum inrush current $= \frac{1{,}930}{112} = 17.2$ mA. 44 gauge wire gives a maximum inrush current density of 2,150 amps per square inch, and there will be plenty of room for the winding. In fact, we could use a lower flux density or a smaller core, but, in order to make a comparison, we will keep to the same iron dimensions and maximum flux density as before. We therefore require 4,830 turns on the H.T. secondary, which will have a resistance of about 4,500 ohms. The primary resistance, referred to the secondary, will again be about 5,000 ohms. The rectifier resistance will again be about 2,500 ohms, as the peak current will be 6.6 mA.

Therefore $\rho = 100{,}000 + 4{,}500 + 5{,}000 + 2{,}500 = 112{,}000$ ohms and $n = \frac{1}{35.7}$.

From Fig. 15, $S = 335 \therefore m \nless \frac{335}{1/2} \nless 670$ and $C \nless 0.53 \mu$F. We therefore require two 0.5 μF condensers, for 2,000 volt working.

In all three cases, the values of m are such that our assumption of working on the flat portions of the f_e and v_m curves is justified.

Fig. 18 shows calculated curves of v_m versus I_0 (voltage regulation curves) and of the ripple magnitude versus I_0, for the last two examples. It is to be noted that the regulation of the half-wave rectifier is superior to that of the doubler, while the full-wave type would give better regulation still.

The above designs are capable of improvement. For instance, the required ripple magnitude could be obtained more economically by using considerably smaller reservoir condensers and adding a resistance capacity smoothing stage. It would then be easy to reduce the ripple. In the voltage-doubler, for instance, we might make $C = 0.1 \; \mu$F ($m = 126$) put a quarter megohm resistance in series with the load and a 0.1 μF condenser in parallel with the load. As far as the writer can say at present, the main effect of this addition, apart from the smoothing, would be to reduce the voltage across the load by the D.C. drop in the smoothing resistance, i.e. by about $\frac{0.25}{4}$ or $6\frac{1}{4}$ per cent. This drop may be compensated for by increasing the turns on the H.T. winding in the same proportion. The magnitude of the ripple in the voltage before the smoothing stage would then be $\frac{S}{m} = \frac{335}{126} = 2.66$ per cent. of the mean voltage there existing, i.e. 2.66 per cent. of 1.06 v_m or 2.82 per cent. of v_m. As the most important component of the ripple in the case of a voltage-doubling rectifier is of double frequency, the impedance of the smoothing condenser may be taken as 16,000 ohms. Accordingly, the lowest frequency component of the ripple would be reduced to $\frac{16{,}000}{250{,}000 - 16{,}000j} = 0.064$ of the value which it had before the smoothing stage. The higher frequencies would be reduced still further, and therefore we are safe in saying that the ripple magnitude at the load would not be greater than 0.064×2.82 per cent. or 0.18 per cent. of v_m. Owing to the lower frequency of the ripple in the half-wave case, such a smoothing stage would not be so effective there. The smoothing resistance would slightly impair the regulation.

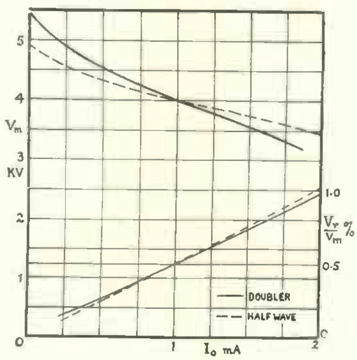


Fig. 18.—*Curves of regulation and ripple voltage for two designs.*

(9) Summary

The theory of the half- and full-wave diode power rectifier has been extended to include the effect of "back-voltage" V existing in the diode. Some of the expressions previously known have been reduced to simpler forms.

Similar expressions applying to the voltage-doubling arrangement have been developed, in the case when V is absent.

Experimentally obtained curves have been plotted for different ratios n of rectifier circuit resistance ρ to load resistance R, on a base of m, i.e., the product of the angular frequency of the supply and the time constant of the load resistance-reservoir condenser circuit. The curves are (1) of the ratio of the mean rectified voltage v_m to the peak value E of the A.C. supply voltage, and (2) of the ratio f_e of the R.M.S. current I carried by the secondary of the supply transformer, to the D.C. load current I_0. Note that the R.M.S. current flowingthrough either half of the centre-tapped winding used in a full-wave rectifier is $\frac{I}{\sqrt{2}}$. The effect of back-voltage V on v_m and f_e has been eliminated as far as possible. The effect is to lower the value of v_m by a fractional amount about equal to K, that is, to the ratio of the back-voltage to the peak value of the A.C. supply voltage. The effect on f_e is in the same direction but is half as large again.

It has been shown how the magnitude V_r of the ripple ("trough to crest" value) in the output voltage may be estimated from the curves.

Finally, the use of the results in the design of rectifier equipments intended for the supply of current to a high resistance load has been illustrated by the working out of an example.

(10) Acknowledgements

The author wishes to thank the Physics Department of the University of Capetown for the loan of the thermo-milliammeter used in the measurement of I, and also to thank Professor H. Bohle, of the Department of Electrical Engineering, for correcting the first draft of this Paper.

(11) References

(1) Colebrook, *W.E. & E.W.*, November 1930, p.595.
(2) Rocard, *L'Onde Electrique*, 1932, p. 23.
(3) Lewis, *W.E. & E.W.*, September 1932, p. 487.
(4) Marique, *W.E. & E.W.*, January 1935, p. 17.
(5) McDonald, *W.E. & E.W.*, October 1931, p. 522.

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

2898. MEASUREMENTS OF THE IONOSPHERE [Electron Densities in E Region: Apparatus and Results: "Sporadic" E Region: etc.], *and* MEASUREMENTS OF THE HEIGHTS OF THE KENNELLY-HEAVISIDE LAYER IN JAPAN —V.—Maeda, Konomi and Isagawa: Minohara and Ito. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, pp. 151–162: pp. L 51–L 92.)

The seasonal variations of the critical frequency, measured at noon (1934/1935), are compared with Appleton's results (1931/1932): all agree with the variations in solar activity, which was at its minimum towards the end of 1933. The ratio of the max. electron densities (at noon) in summer and winter (ignoring abnormally high summer values) is given by Appleton as 2.2; the writers find the value of 2.2–2.4. The diurnal variation of the critical frequency is also described; the critical frequency "pulsates," almost every night (over 14 months), so that a maximum is observed two or three times in the night. "It is evident that some other agents . . . besides the ultra-violet ray from the sun are at work" in causing E-region ionisation. Observations on the "sporadic E region" show that this state spreads itself over an area of diameter at least 100 km: it favours the propagation of medium-short (60–150 m) waves. Its origin is still obscure: there are indications that its ionisation is exponentially distributed and that its gradient is considerable. For various reasons (including the simultaneous occurrence of F echoes) the determination of its maximum electron density presents difficulty.

The second paper is based on Naval Research Department observations from April to September, 1935.

2899. CARNEGIE INSTITUTION OF WASHINGTON: ANNUAL REPORT OF THE DIRECTOR OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM. —(*Year Book* No. 34, 1934/35, pp. 223–267, issued December, 1935: also as separate Reprint.) Including ionospheric work.

2900. IONISATION CHANGES IN THE HIGHEST ATMOSPHERIC LAYERS DURING AURORAE AND MAGNETIC STORMS [Tromsö Observations: Great Increase of Ionisation in E Layer but Decrease in F Layer].—L. Harang. (*Gerlands Beiträge z. Geophys.*, No. 4, Vol. 46, 1936, pp. 438–454.)

2901. ON THE GEOMAGNETIC ANALYSIS OF COSMIC RADIATION [Mathematical Study of Trajectories of Charged Particles in Earth's Magnetic Field: North/South Asymmetry]. —G. Lemaitre and M. S. Vallarta. (*Phys. Review*, 15th May, 1936, Series 2, Vol. 49, No. 10, pp. 719–726.)

2902. POLARISATION OF RADIO WAVES FROM THE IONOSPHERE NEAR THE GEOMAGNETIC EQUATOR [at Huancayo Observatory: Electric Vector of Ordinary Ray found Polarised in Magnetic N–S Plane, of Extraordinary Ray in E–W Plane, as predicted by Theory: etc.].—H. W. Wells and L. V. Berkner. (*Sci. Abstracts*, Sec. B, 25th June, 1936, Vol. 39, No. 462, pp. 403–404.)

2903. A SOLAR ERUPTION AND SIMULTANEOUS DISTURBANCES AT HUANCAYO MAGNETIC OBSERVATORY [Magnetic, Earth-Current and Ionosphere Records all Disturbed at Time of Eruption].—Torreson, Scott and Stanton. (*Science*, 15th May, 1936, Vol. 83, pp. 463–464.)

No solar disturbance was noted 24–26 hours earlier which could account for the magnetic and earth-current disturbances and complete fade-out of the usual radio reflections, all of which coincided with the observed eruption. The results suggest that in addition to the recognised radiations from disturbed solar regions, acting on terrestrial elements, there may be some which travel with the speed of light. It is mentioned that this particular disturbance was centred approximately 10° west of the central meridian, and was therefore very near the 13° west position, given by Skellett as the most favourable for the production of terrestrial disturbances.

2904. HIGH-FREQUENCY RADIO FADE-OUTS CONTINUE [Descriptions of Complete "Dellinger Effects" on Feb. 14th and April 8th].—J. H. Dellinger. (*QST*, June, 1936, Vol. 20, No. 6, pp. 37–38.) Minor "general fade-outs" occurred on 6th and 8th February.

2905. SUNSPOTS AND WIRELESS FADE-OUTS [Coincidence on 8.4.1936: Possible Connection between Terrestrial Phenomena and Extreme Ultra-Violet Solar Activity].—Dellinger. (*Nature*, 23rd May, 1936, Vol. 137, p. 858: short note.)

2906. A SECOND LAW OF THE MOTIONS OF ERUPTIVE [Solar] PROMINENCES.—E. Pettit. (*Proc. Nat. Acad. Sci.*, 15th May, 1935, Vol. 22, No. 5, pp. 249–253.)

2907. A SOLAR PERIOD OF 100 YEARS [deduced from Shortness and Symmetry of Sunspot Cycle 1923/1933 and Its Similarity to Cycles 1823/1833 and 1723/1733].—H. Mémery. (*Comptes Rendus*, 11th May, 1936, Vol. 202, No. 19, pp. 1568–1569.)

2908. ENHANCEMENT OF RED LINES AND BANDS IN THE AURORAL SPECTRUM FROM A SUNLIT ATMOSPHERE.—L. Vegard and E. Tönsberg. (*Nature*, 9th May, 1936, Vol. 137, pp. 778–779.)

2909. NORTHERN LIGHTS [General Account of Upper Atmospheric Phenomena].—A. S. Eve. (*Nature*, 16th May, 1936, Vol. 137, pp. 813–820.)

2910. NEW RESULTS ON THE LIGHT OF THE NIGHT SKY [Variations in Intensity of Various Parts of the Spectrum].—H. Garrigue. (*Comptes Rendus*, 25th May, 1936, Vol. 202, No. 21, pp. 1807–1809.) For previous work *see* 1934 Abstracts, p. 317, and 883 of March.

2911. WIRELESS AND WEATHER [Correlation between Changes in Short-Wave Signal Strength and in Major Winds affecting New Zealand: *also* Shetland Observations on Short-Wave Telephony over Two Years show Definite Connection].—(*World-Radio*, 29th May, 1936, Vol. 22, p. 15: 12th June, 1936, Vol. 22, p. 14.)

2912. MICRO-RAY COMMUNICATION.—McPherson and Ullrich. (*See* 3208.)

2913. EXPERIMENTAL RESEARCHES ON THE ABSORPTION OF AN ELECTROMAGNETIC FIELD IN AN ELECTRONIC MEDIUM SUBJECTED TO THE ACTION OF A MAGNETIC FIELD, AND ON THE ANOMALOUS VARIATION OF THE DIELECTRIC CONSTANT OF THE MEDIUM (ANOMALOUS DISPERSION).—V. De Pace: Todesco. (*Alta Frequenza*, June, 1936, Vol. 5, No. 6, p. 356.) De Pace compares his own researches with the work of Todesco (1932 Abstracts, p. 633).

2914. EFFECT OF ELECTRON PRESSURE ON PLASMA ELECTRON OSCILLATIONS [General Equation for Electron Motion in Plasma: Series of Possible Frequencies of Free Vibration: Explanation of Variation of Resonance Frequency with Electron Gas Temperature].—E. G. Linder. (*Phys. Review*, 15th May, 1936, Series 2, Vol. 49, No. 10, pp. 753–754.) An abstract was referred to in 2520 of July.

2915. BEAT EFFECTS: AN INVESTIGATION IN "EXTRA RADIATIONS" AND "BACKGROUNDS" OBSERVED AT BRENTWOOD.—Hafekost. (*See* 2982.)

2916. INTERFERENCE CALCULATIONS AND WAVE GROUPS [Mathematical Principles].—D. G. Bourgin. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1033–1056.)

Relationships and implications of stationary phase method and saddle-point method: nature of group velocity for non-linear argument functions: each component energy travels with the group velocity of the sum: mathematical representation of finite group: criticism and generalisation of results of various writers on the subject.

2917. PROPAGATION OF ELECTROMAGNETIC WAVES IN NON-HOMOGENEOUS MEDIA [Two-Dimensional Case of Series of Finite Regions each enclosed in Preceding One, Electromagnetic Constants undergoing Discontinuous Change at Each Boundary].—V. Kupradze. (*Sci. Abstracts*, Sec. A, 25th May, 1936, Vol. 39, p. 560.)

2918. ABSORPTION IN THE EARTH IN THE CASE OF VERTICAL DIPOLES AT A GREAT HEIGHT ABOVE A PLANE EARTH.—Niessen. (*See* 3019.)

2919. FREQUENCY MODULATION PROPAGATION CHARACTERISTICS.—Crosby. (*See* 2962.)

2920. SCATTERING OF DAYLIGHT IN THE SEA.—Utterback and Jorgensen. (*Journ. Opt. Soc. Am.*, June, 1936, Vol. 26, No. 6, pp. 257–259.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2921. THE RELATION BETWEEN LIGHTNING DISCHARGES AND ATMOSPHERICS IN RADIO RECEPTION.—H. Norinder. (*Journ. Franklin Inst.*, May, 1936, Vol. 221, No. 5, pp. 585–611.)

For previous work *see* Abstracts, 1928, p. 516; 1930, pp. 450 and 581; 1932, pp. 401 and 518; 666, 2182 and 3331 of 1935; *also* 449 of February and 1715 of May. Here the methods of recording atmospherics and lightning discharges are briefly described. Audible atmospherics are classified into "clicks" of short duration and "grinders" of long duration; oscillograms of both types are given: "clicks" are considered to be due to field variations caused by local discharges, while "grinders" are thought to be caused by distant lightning discharges. Atmospherics of "ordinary type" are also classified into those of short and long duration, and oscillograms are shown. Typical variation forms of the short-duration type include a " unipolar one which is different from the others which are bipolar and have more or less typical superimposed variations of a periodic character." The " transformation of an initial lightning impulse with distance " is discussed on the basis of the variation with distance from a vertical lightning discharge of the " electric field force " produced by the discharge. The variation of the charge Q whose discharge causes the lightning flash can be deduced from the writer's oscillograms (*see* 3331 of 1935); the expression for the " electric field force " is applied to these experimental curves and the temporal variation of the force with distance from the discharge centre can thus be calculated. Illustrative curves for this are given; it is found that the " discharge variation form . . . will, after a short passage in the atmosphere . . . be transformed into forms of more or less superimposed periodic variations." Good correlation with observed forms of atmospherics is found. A form of the initial Q variation curve is found which can " result in transmission curves of unipolar character."

2922. THE RELATIONS BETWEEN BROADCAST DISTURBANCES AND LIGHTNING DISCHARGES.—H. Norinder. (*E.N.T.*, April, 1936, Vol. 13, No. 4, pp. 103–110.) Substantially the same paper as that dealt with above (2921).

2923. " STEP BY STEP " PROGRESS OF LIGHTNING STROKES PHOTOGRAPHED.—Beans, Snoddy and Workman. (*Science*, 8th May, 1936, Vol. 83, Supp. p. 10.) The first flash extended half way to earth, the second followed the path of the first and reached six-tenths of the way, the third seven-tenths, and the fourth struck the earth.

2924. THE INFLUENCE OF HIGH-FREQUENCY OSCILLATIONS ON THE POSITIVE POINT DISCHARGE [Experiments on Decrease of Sparking Voltage from Positive Point with Superposed H.F. Oscillations: Possible Explanation of Some Kinds of Lightning Discharges].—W. Deutsch. (*Ann. der Physik*, Series 5, No. 3, Vol. 26, 1936, pp. 193–218.)

2925. FIELDS CAUSED BY REMOTE THUNDERSTORMS [C-R-Oscillograph Investigations chiefly of Horizontal Electrical Component, using " Probes " (Ground Return Circuits) at Right Angles, on New Jersey Communication Circuits: Ratio of Max. Vertical to Max. Horizontal Intensity from Vertical Loop and Probe Measurements: etc.].—K. E. Gould. (*Elec. Engineering*, June, 1936, Vol. 55, No. 6, pp. 575–582.)

" By means of simultaneous directional measurements [of short-duration voltages appearing in the circuits] made in the frequency range below 40 kc at two points as much as 900 miles apart, thunderstorms at distances of several hundred miles from one or both of these points have been located with a degree of accuracy great enough to permit conclusive correlation of the storm locations indicated by the directional measurements with the locations of recorded thunderstorms."

2926. ON THE INSTABILITY AND RUPTURE OF DROPLETS AND BUBBLES IN STRONG ELECTRIC FIELDS [Theory: Oscillation of Bubbles and Difference in Behaviour of Positive and Negative Bubbles explained on Basis of Discharge of Electricity from Points: Relevance to Thunderstorm Theory].—L. Tonks. (*Journ. Franklin Inst.*, May, 1936, Vol. 221, No. 5, pp. 613–620.)

2927. HIGH-ALTITUDE STRATOSPHERE OBSERVATIONS [Radiometeorograph Balloon reaches 38.7 km].—Curtiss and Astin. (*Science*, 1st May, 1936, Vol. 83, pp. 411–412.)

2928. THE PRESSURE AND TEMPERATURE VARIATION OF THE RECOMBINATION COEFFICIENT AND THE IONISATION BY GAMMA RAYS IN AIR AND CARBON DIOXIDE [at Pressures up to 25 Atm.: Experimental Curves].—W. Mächler. (*Physik. Zeitschr.*, 15th March, 1936, Vol. 37, No. 6, pp. 211–213.)

2929. ON THE GEOMAGNETIC ANALYSIS OF COSMIC RADIATION.—Lemaitre and Vallarta. (*See* 2901.)

2930. RELATIONS BETWEEN THE ELECTRICAL CONDUCTIVITY OF THE ATMOSPHERE AND SOME METEOROLOGICAL FACTORS AT THE OBSERVATORY OF KSARA (LEBANON).—J. Chevrier. (*Comptes Rendus*, 11th May, 1936, Vol. 202, No. 19, pp. 1602–1604.)

PROPERTIES OF CIRCUITS

2931. NOTES ON THE THEORY OF THE SINGLE-STAGE AMPLIFIER [Existing Theory somewhat Generalised and Extended to Case where Electron Transit Time modifies Behaviour of Valve].—B. Salzberg. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 879–897.)

General expressions are derived for the increase in input admittance due to feed-back; for the conditions of stability; and for the amplifier gain. The results are then applied to special cases where certain simplifying assumptions can be made. Thus the calculated variation of the additional input conductance due to feed-back as a function of the tangent of the phase angle of the output circuit is shown in Fig. 4 for three cases:—usual conditions at medium frequencies, feed-back through capacitance only; the same with feed-back through equal parallel paths of conductance and capacitive susceptance—*e.g.* when leakage, intentional or otherwise, is present in valve or receiver; and conditions for high frequencies, feed-back through capacitance and 45° phase-angle retardation of transfer admittance. Regarding this last case, it is pointed out that in ordinary valves the effect of increasing the transit angles at high frequencies is, at least initially, more serious in its increase of the valve input conductance than in its reduction of the transfer admittance. The calculation of the portion of over-all gain which is due to feed-back is also described: " even this linear theory indicates that it is commercially impracticable to replace a stage of efficient, cascaded amplification by regeneration."

2932. INPUT ADMITTANCE OF A FEED-BACK NETWORK [Calculation by Hô-Thévenin and Reciprocity Theorems: Formula for Incremental Factor: etc.].—E. Takagisi. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 192–196: in English.) The analysis shows how the input impedance is modified by impedance variation in the lines, balancing networks, etc., and by amplifier gain.

2933. THE RESPONSE OF A NON-LINEAR ELECTRIC CIRCUIT TO AN IMPULSE [Anomalous Features in Oscillograms of Response confirmed by Solution of Circuit Equations using Differential Analyser: Study of Initial Response].—A. K. Nuttall, D. R. Hartree and A. Porter. (*Proc. Camb. Phil. Soc.*, May, 1936, Vol. 32, Part 2, pp. 304–320.)

2934. UNSYMMETRICAL SELF-EXCITED OSCILLATIONS IN CERTAIN SIMPLE NON-LINEAR SYSTEMS [Equation solved by Differential Analyser: Curves of Value in Theoretical Analysis and also in Design: Behaviour of System not operating on Inflection Point, thus giving Unsymmetrical Oscillations].—J. G. Brainerd and C. N. Weygandt. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 914–922.)

2935. TRANSIENTS ON ASYMMETRICAL CABLES [Oscillograms: Theory].—C. Flaam. (*Arch. f. Elektrot.*, 18th April, 1936, Vol. 30, No. 4, pp. 251–258.)

2936. THE EQUIVALENT CIRCUIT AND LOAD RESISTANCE OF PUSH-PULL AUDIO AMPLIFIERS [and the Incorrectness of the Accepted Equivalent Circuit].—L. Slepian. (*Tech. Phys. of USSR*, No. 4, Vol. 3, 1936, pp. 350–355: in English.)

Author's summary:—" The incorrectness of the equivalent circuit which is now everywhere used for class A and B push-pull audio amplifiers is pointed out. It is shown that the conception of ' plate-to-plate load ' is unsatisfactory. The two tubes of a push-pull amplifier operate into a load resistance not as if in series but as if connected in parallel. . . . The total load of the two tubes is equal to the real load in the secondary of the output transformer, assuming that the two halves of the primary and secondary are equal. The division of this output load between the two tubes under different operating conditions is discussed further." Thompson's graphical method of treatment (1933 Abstracts, p. 394) is correct, but his results do not agree with the accepted equivalent circuit, because of the unsuitability of the latter.

2937. ELECTRICAL " SHUNTING " CIRCUITS [Separating Filters for Separation and Distribution of Frequency Bands: Design on General Mathematical Principles].—W. Brandt. (*E.N.T.*, April, 1936, Vol. 13, No. 4, pp. 111–123.)

This paper treats the theory and design of electrical shunting circuits, which separate various frequency bands from a composite incoming signal and distribute them to more than one receiver, on the same lines as the theory already developed by Cauer for ordinary wave filters (*see* 1932 Abstracts, p. 537). The general mathematical theory of positive functions and matrices is applied to systems of coils and condensers; it is found that shunting circuits of any desired degree of efficiency can be constructed. All physically possible circuits are included in the theory. The theory is worked through for six-terminal shunting circuits; numerical examples are given at the end and circuits for simple high/low shunts are shown in Figs. 5–10.

2938. THE EXTENSION OF THE PROPERTIES OF THE QUADRIPOLE TO BALANCED POLYPHASE NETWORKS OF THE MOST GENERAL TYPE.—R. Julia and J. Fallou. (*Comptes Rendus*, 25th May, 1936, Vol. 202, No. 21, pp. 1767–1769.)

2939. GRAPHICAL STUDY OF CIRCUITS IN Π [and the Use of the Blondel Bipolar Diagram].—V. Genkin. (*Rev. Gén. de l'Élec.*, 13th June, 1936, Vol. 39, No. 24, pp. 851–860.)

2940. STUDY ON LATTICE NETWORK STRUCTURES [including the Transformation of Lattice Type into Ladder Type and a Comparison of Special Ladder Types (Zobel " Constant-K " and Matsumae " Double " Filters) with Corresponding Lattice Types].—Y. Watanabe and Z. Kamayachi. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 227–251: in English.) For the Matsumae " double filter " *see* 1934 Abstracts, p. 435.

2941. THE " BENDING " THEORY OF SYMMETRICAL ELECTRICAL NETWORKS.—E. W. Selach. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1936, pp. 14–24: to be continued.) The detailed analysis referred to on p. 200 of the English paper dealt with in 2956 of 1935.

2942. ON DIFFERENTIAL FILTERS.—V. I. Sizov and E. A. Vertyachkin. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1936, pp. 23–31.)

A theoretical discussion of the filter shown in Fig. 1, used in Siemens modulated telegraphy apparatus and consisting essentially of two parallel reactive legs connected across an output inductance. The input connections are brought to the common point of the two legs and to the middle of the output inductance. A theoretical analysis of the filter is presented for the first time and formulae are derived for designing the filter for a given load impedance and band width. Two numerical examples are included, and an attenuation curve is shown of a filter which was specially built to check the theoretical results obtained.

2943. THE THEORY OF BAND FILTERS IN BROADCAST RECEIVERS.—Feldtkeller and Tamm. (*See* 2992.)

2944. A METHOD FOR PRODUCING " FLAT-TOPPED " RESONANCE CHARACTERISTICS FROM SIMPLE TUNED CIRCUITS [by Shunting the Inductance or Capacitance by a Rectifier in series with Biasing Battery].—B. M. Hadfield. (*Journ. Scient. Instr.*, June, 1936, Vol. 13, No. 6, pp. 195–196.) The rectifier will not pass current if the applied voltage does not exceed the bias voltage, so that a flat response over any portion of the " peak " response can be obtained by adjusting the bias voltage with respect to the maximum response of the circuit.

2945. THE TUNING OF A THREE-CIRCUIT SYSTEM. —A. E. Suzant. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1936, pp. 17–21.)

In practice a main oscillating circuit I (see Fig. 1) is often coupled to the aerial III through an aperiodic tank circuit II, having constant parameters. In the present paper a discussion is given of the method of tuning the system by varying the reactive components of I and III and leaving circuit II unchanged. The conditions imposed are (a) maximum efficiency of the system; (b) maximum current in III; and (c) purely ohmic equivalent impedance of I. The necessary relationships between the components of I and III, to satisfy these conditions, are established, and a procedure to be followed in tuning the system is indicated.

2946. ON VALVE OSCILLATING CIRCUITS COMPRISING *R* AND *C*.—V. I. Siforov. (*Izvestiya Elektroprom. Slab. Toka*, Nos. 4 & 5, 1936, pp. 1–6 and 1–11.)

Having presented a theoretical investigation of the above circuits the author sums up his conclusions as follows:—

1. The presence of self inductance in valve circuits is not always necessary for the generation of sinusoidal oscillations. In a number of circuits comprising *R* and *C* only, such as the 3-valve circuit proposed by van der Pol (Fig. 1) or the one-valve circuit proposed by the author (Fig. 2), sinusoidal oscillations can be generated. 2. The main difference between the circuits examined and the well-known multivibrator of Abraham and Bloch is that in the former circuits oscillations can take place even if the valve characteristics are strictly linear. The curvature of the valve characteristic in this case only limits the amplitude of the oscillations which have already appeared, while in the multivibrator it is the necessary condition for the appearance of the oscillations.

3. The period of the oscillations generated in the van der Pol circuit is proportional to the capacity of the coupling condensers and the resistance of the grid leaks (eqn. 24). For self-excitation the condition (22) must be fulfilled. 4. In addition to the fundamental oscillations, h.f. parasitic oscillations must appear in the van der Pol circuit. When the circuit is completely symmetrical, the condition for the appearance of these oscillations is the same as that for the appearance of the fundamental. Their frequency is determined by eqn. 50. 5. The asymmetry of the circuit renders more difficult the appearance of both fundamental and parasitic oscillations. To prevent the generation of high-frequency oscillations the circuit must be made asymmetrical with regard to high frequencies by connecting, for example, a condenser between the filament and grid of one of the valves. 6. The oscillations do not appear if the insulation resistance of the coupling condensers is low. The region within which the oscillations can appear is shown in Fig. 7.

7. The one-valve oscillator (Fig. 2) will generate approximately sinusoidal oscillations. The period of the oscillations and the condition for their excitation are determined by eqns. 33 and 31 respectively. 8 When the oscillating circuits comprising *R* and *C* are under-excited, resonance phenomena will be observed when they are acted upon by an external e.m.f. The above methods of generation of sinusoidal oscillations are of great importance. They permit the generation of approximately sinusoidal oscillations within a very wide frequency range, including very low frequencies, of the order of a few cycles per second. These methods thus widen the field of application of valve oscillators.

2947. RETROACTION CIRCUITS WITHOUT RESONANT CIRCUITS.—Lattmann and Salinger. (*See* 2972.)

2948. ELECTRICAL CIRCUITS CONTAINING RECTIFIERS [Correction].—Ghiron and Pernier. (*Alta Frequenza*, June, 1936, Vol. 5, No. 6, p. 355.) *See* 1728 of May.

2949. THEORY OF THE GREINACHER CIRCUIT [for Voltage Doubling: Solution of Differential Equation].—H. Piesch. (*Arch. f. Elektrot.*, 18th April, 1936, Vol. 30, No. 4, pp. 259–266.)

TRANSMISSION

2950. HIGH-POWER HABANN GENERATORS [Split-Anode Magnetrons] FOR MICRO-WAVES.—O. Pfetscher and W. Puhlmann. (*Hochf: tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, pp. 105–115.)

This investigation aims at discovering the amount of useful power obtainable from split-anode magnetrons. In § II a preliminary investigation of the various types of magnetron oscillations is described; the statical characteristics (Fig. 2), the oscillation region (Figs. 3–5) for two- and four-section anodes, and the influence of the length of the Lecher wire system on frequency, magnetic field and intensity of the oscillations (Fig. 6) are discussed. B-K oscillations are also found to occur in the magnetron (Fig. 7) and there is an additional reaction heating effect due to electron motion which depends on the oscillation amplitude (Fig. 8). General considerations on the theory of oscillation generation are discussed in connection with the electron paths (Fig. 9) and the question of two or four anode sections.

The general principles on which the construction of high-power magnetrons depends are dealt with in § III. Intensive anode cooling and a rich electron source must be provided, while the oscillation frequency must be as high as possible. Water-cooled electrodes are adopted (designs for direct and indirect cooling Fig. 11; photographs Fig. 12); the cooling system is itself an oscillatory circuit. Cathodes are in the form of cylindrical spirals (§ III 1b) and the screening is good (§ III 1c). Capacitative coupling is used to lead off the energy (§ III 1d). The power is measured by a calorimetric method (§ III 2). The valves as finally designed with two-section anodes are described in § III 3 (Fig. 12); their working data are tabulated. The influence of voltage on efficiency and power with the optimum magnetic field is shown in Fig. 13. The additional reaction heating effect is illustrated by the curves of Fig. 14. Methods of modulation are shortly referred to in § III 5 (*see* also Lindenblad, 3834 of 1935). Outputs of 850 and 80 watts were obtained for wavelengths of 100 and 19 cm respectively.

2951. ELECTRON PATHS AND MECHANISM OF EXCITATION OF OSCILLATIONS IN THE SPLIT-ANODE MAGNETRON.—H. G. Möller. (*Hochf: tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, pp. 115–117.)

The potential distribution in the magnetron is first calculated from Laplace's equation, which is solved by a method of successive approximation. The space-charge density (§ III), the flow of magnetic force of the circulating electrons (§ IV), and the electron paths (§ V) are calculated. The paths in a magnetron with a two-piece (§ VI) and a four-piece (§ VII) anode are separately considered; the latter is found to give more favourable conditions for oscillation excitation. In § VIII a numerical example is given for a valve giving a wavelength of about 20 cm.

2952. MAGNETRON OSCILLATIONS [Mathematical Theory of Single-Anode Magnetron].—F. B. Pidduck. (*Nature*, 6th June, 1936, Vol. 137, pp. 945–946: short note only.) "The stream of electrons must be interrupted and oscillations can then be maintained by any emission, however small, provided the resistance of the circuit is small."

2953. OTHER PAPERS ON MAGNETRONS.—(*See* 3029/3031, under "Valves and Thermionics.")

2954. LUMINOUS DISCHARGES OBSERVED IN A MAGNETIC FIELD AT PRESSURES BELOW 10^{-4} MM HG [Description of Appearance of Discharge under Various Conditions: Possibility of Occurrence of Powerful Oscillations].—T. V. Jonescu. (*Comptes Rendus*, 2nd June, 1936, Vol. 202, No. 22, pp. 1842–1843.)

2955. SOME NOTES ON A PENTODE OSCILLATION CIRCUIT OF ULTRA-HIGH FREQUENCY [Two Pentodes in Push-Pull each with Plate and Screen Grid Shorted, External Oscillation Circuit connected to these Composite Electrodes: Oscillation controlled by Suppressor Grids].—H. Uchida. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 27.) Two oscillation regions are given, separated by a non-oscillatory region. One application is to a new super-regenerative u.s.w. receiver, where the quenching voltage is applied to the suppressor grids.

2956. MICRO-WAVE TRANSMITTERS AND RECEIVERS USING MULTI-GRID VALVES.—D. Giliberti. (*Alta Frequenza*, June, 1936, Vol. 5, No. 6, pp. 364–365: summary only.) *See* also Hamburger, 1934 Abstracts, p. 150.

2957. MICRO-WAVE GENERATOR OF CONSTANT AMPLITUDE AND FREQUENCY FOR MEASUREMENTS ON VISCOUS FLUIDS.—Dahms. (*See* 3124.)

2958. THE 6L6 BEAM POWER TUBE AS A HIGH-OUTPUT CRYSTAL OSCILLATOR [particularly suitable for Portable Transmitters or as Compact Exciter for Larger Transmitters].—F. W. Edmonds. (*QST*, June, 1936, Vol. 20, No. 6, pp. 20–21.) The valve "is more stable and gives more power output if the shield is left ungrounded." For previous papers on this valve *see* 2636 of July; *also* Grammer, 3067, below (under "Acoustics and Audio-Frequencies").

2959. A METHOD OF STABILISING THE FREQUENCY OF A RADIO TRANSMITTER BY MEANS OF AN AUTOMATIC MONITOR [to 5–10 Parts in a Million for Slow Changes of Circuit Parameters and 30 Parts for Changes at rate of 25 per Second, on 100 m Wave].—H. A. Thomas. (*Journ. I.E.E.*, June, 1936, Vol. 78, No. 474, pp. 717–722.) An appendix describes a suggested mode of reception to avoid "key chirps" (the footnote reference to Reed's paper should read *Wireless Engineer*).

2960. HIGH POWER FREQUENCY MODULATION [Licence for 40 kW Transmitter on 40 Mc/s applied for: Tests on 350 W 2.5 m Signals show Noise-Voltage Reduction of 20–50 Times].—Armstrong. (*Electronics*, May, 1936, Vol. 9, No. 5, p. 25.)

2961. FREQUENCY MODULATION BY MEANS OF VARIATION OF RESISTANCE IN THE OSCILLATING CIRCUIT, AND ITS APPLICATION TO RADIOTELEPHONY [without Amplitude Variation if Proper Ratios are chosen].—K. Awaya. (*Nippon Elec. Comm. Eng.*, May, 1936. No. 3, pp. 268–269: in English.)

2962. FREQUENCY MODULATION PROPAGATION CHARACTERISTICS [California/New-York Short-Wave Circuit Tests].—M. G. Crosby. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 898–913.)

T. L. Eckersley's prediction (1930 Abstracts, p. 627), of "appalling distortion" wherever appreciable echo delays (around 2–3 ms) are present, is completely confirmed: the distortion is most severe on the lower modulation frequencies and on the lower radiation frequencies: it is equally severe with or without limiting. Even on ultra-short waves, where the only multi-path transmission is that due to the direct ray and the ray reflected from the ground and near-by objects, distortion will be appreciable for modulating frequencies of the order used in television, and will be specially severe where transmitter and receiver are both at rather high elevations: directivity, to discriminate against one of the rays, might be effective. Diversity-reception tests on the short waves showed that the higher modulation frequencies and the lower radiation frequencies displayed the most random phase characteristics. A theoretical analysis of the two-path case gives the conditions for least and for most destructive distortion.

2963. METHOD OF DEMONSTRATING THE AMPLITUDE AND FREQUENCY MODULATION OF MODULATED OSCILLATIONS.—H. J. Zetzmann. (*Hochf:tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, pp. 138–139: German Patent 622 694 of 29.8.34.)

Frequency reduction and double application of a stroboscopic method to a reed frequency meter are used to determine whether the side-band frequencies oscillate co- or anti-phasally, and thus whether frequency or amplitude modulation is being used.

2964. APPLYING PRE-DISTORTION TO BROADCASTING [Improvement of Signal/Noise Ratio by Over-Emphasis of High Frequencies: WCAU Tests show Improvement of about 8 db: Too Much Adjacent Channel Interference except on Ultra-High Frequencies].—L. F. Jones. (*Communication & Broadcast Engineering*, May, 1936, Vol. 3, No. 5, pp. 5–6 and 13.)

2965. A NEW HIGH-EFFICIENCY POWER AMPLIFIER FOR MODULATED WAVES [about 65% Efficiency: One Valve supplying Power up to Carrier Power, Second furnishing Additional Power when Modulation demands It].—W. H. Doherty. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, p. 7: summary of I.R.E. Convention paper.) For fuller details see *Communication & Broadcast Engineering*, May, 1936, Vol. 3, No. 5, pp. 7–9 and 20; *also* 2966, below.

2966. A NEW POWER AMPLIFIER OF HIGH EFFICIENCY [60% Over-All for Unmodulated Carrier, Higher with Complete Modulation].—W. H. Doherty. (*Bell Lab. Record*, June, 1936, Vol. 14, No. 10, pp. 333–338.) *See* 2965, above. "By the application of . . . the feed-back principle of H. S. Black, to reduce the effects of non-linearity in the amplifier characteristics, the new high-efficiency equipment has been made to perform with a quality of transmission which satisfies the most rigorous requirements of high-fidelity broadcasting."

2967. APPLICATION OF THE MULTIPLE-MODULATION SYSTEM TO A MODERN BROADCASTING STATION.—Fayard. (*See* 3212.)

2968. THE MARCONI TYPE R.C.56 TELEPHONE PRIVACY EQUIPMENT [" Inversion " System, by Single Process of Modulation].—S. T. Cope. (*Marconi Review*, March/April, 1936, No. 59, pp. 1–6.) An inexpensive system compared with the " first grade " equipment which employs the inversion system by the method of modulation and demodulation.

2969. ON THE HIGH-SPEED KEYING METHOD WITH THE WIRELESS TELEGRAPH TRANSMITTER [Simple Arrangement giving 1300 w.p.m. or more].—T. Ishida and E. Maeda. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 261–262: from *J.I.T.T.E.*, July, 1935.)

2970. MODULATED HIGH-FREQUENCY POWER AMPLIFIER [Class B Operation: Choice of Valves and Operating Conditions for a Given Purpose].—T. C. Macnamara. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 294–298.)

2971. DISTORTION IN H.F. CLASS B AMPLIFIERS.—Rubin. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 362–379.)

Conclusion of the paper dealt with in 2560 of July. After treating the upper curves of the dynamic characteristics, the influence of grid current, and the non-linear distortion introduced by the filters in the supply circuits, the writer deals with the over-all distortion and methods of correction, particularly by counter-retroaction. Results at the Lyon-Tramoyes station are quoted.

2972. RETROACTION CIRCUITS [for Production of Stable Sinusoidal Oscillations] WITHOUT RESONANT CIRCUITS.—M. Lattmann and H. Salinger. (*E.N.T.*, April, 1936, Vol. 13, No. 4, pp. 133–142.)

This paper describes the design of retroaction quadripoles for the production of stable sinusoidal oscillations without the use of resonant circuits. The voltage led back on to the grid for building up the oscillations must have sufficient amplitude and the correct phase for one frequency only. The retroaction quadripole must thus be a phase-shifter or bridge network for which the input impedance is real at all frequencies. § 2. *Single-valve circuits.* A simple circuit is shown in Fig. 1: it is essentially the same as one already given (715 of 1935) for the production of two frequencies in one valve. The retroaction quadripole is a two-member bridge network. Its action is explained. This circuit does not however permit of easy variation of frequency. The latter may be obtained by using the bridge network shown in Fig. 2; or better by the simple circuit of Fig. 3, in which two phase-shifters are connected through a transformer, the second having a much higher impedance than the first. Fig. 4 shows the phase as a function of frequency, for various values of the principal frequency. Fig. 5 gives measured and calculated values of the variable condenser C_2 (Fig. 3) for varying frequency.

§ 3. *Two-valve circuits.* Here two similar phase-shifters may be used (Fig. 6). Fig. 7 gives the vector diagram for the self-excited frequency (eqn. 8), for which measured and calculated values are shown in Fig. 8. The transformer may be eliminated by using two valves in a push-pull circuit, or pentodes as shown in Fig. 9. A simpler circuit (Fig. 10, scheme Fig. 11) is obtained by taking off the output voltage from the terminals of a bridge condenser or resistance. This is no longer a pure phase-shifter; its theory is given. Figs. 12 and 12a show the measured values of the frequencies and of the anode alternating voltage for various condenser positions, also the " klirr " factor for the medium frequency band. Fig. 13 gives oscillograms showing the form of the oscillations. The optimum adjustments of the circuit are described.

The building-up of oscillations is discussed in § 4. It is shown that the sinusoidal nature of the oscillations depends on the existence of definite relations between the variation of the retroaction phase with frequency and the non-linearity of the amplifier characteristic. These relations are investigated in detail for the circuit of Fig. 10. The frequency band which can be covered with a phase-shifter circuit is discussed in § 5; in circuits without inductance (*e.g.* Fig. 10) it is determined by the input impedances of the valves and is very wide. The effect of the apparent grid capacity of the valves is deleterious at high frequencies (10^6 c/s) and that of the real input impedance of the valves at low frequencies. The optimum orders of magnitude for the circuit elements are deduced. Possible applications of the circuits are referred to in § 6; their efficiency and power output are not large, so that they are suitable mainly for small laboratory emitters, particularly at low frequencies.

2973. ON VALVE OSCILLATING CIRCUITS COMPRISING R AND C [and Their Importance for Generating approximately Sinusoidal Oscillations over Very Wide Frequency Range, down to a Few Cycles per Second].—Siforov. (*See* 2946.) "These methods thus widen the field of application of valve oscillators."

RECEPTION

2974. A NEW METHOD OF TUNING USING MAGNETIC BIAS [applicable to All Wave-Bands including Ultra-Short].—G. Leithäuser and H. Boucke. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 167–171.)

In the course of investigations on the influence of magnetic bias on the permeability of core materials and thus on the self-inductance of coils wound on such cores, the question arose how far this effect could be utilised for tuning purposes by the employment of high magnetic field strengths. The common method of producing the magnetic bias by a direct current through the coil fails for this purpose because the modern h.f. irons have such low permeabilities that with suitable current values only a few gauss can be obtained, and even if the current is pushed up to the heating limit of the coil the resulting permeability variation is insignificant.

On the other hand it was found that if a broadcast-band coil with a suitable core was placed in an electro-magnet field of about 1000 gauss, the oscillatory-circuit frequency changed by about 100 kc/s. Tests showed that this change was due not to eddy-current action but exclusively to the magnetic bias; also, that the relation between magnetic field strength and variation of inductance was sufficiently linear to make the principle suitable for tuning purposes. Figs 1a and 1b show the experimental arrangement, 2 representing the h.f. winding wound in two parts round the two branches of the low-permeability h.f. iron core 1, so that the h.f. leakage fields neutralise each other in the high-permeability laminated pole-pieces 3, 3 of the "tuning" electro-magnet, thus avoiding the production of undesirably large eddy currents. With such an arrangement the tuning curves of Figs. 3–5 were obtained, for broadcast, short and ultra-short waves respectively, the maximum d.c. power used being 4.5 watts. The design is susceptible of improvement in the direction of decreasing the air-gap and thus increasing the efficiency. The slight curvature of the characteristics is not due to approaching saturation but to the nature of the relation between frequency and inductance: tests showed that the curves were approximately linear up to about 10 000 gauss, whereas the fields actually used were only about 1000.

It is possible that to get the best results on these lines a special h.f. iron will be developed. Tests on various commercial types of h.f. iron have shown that those having least initial permeability and subjected, in manufacture, to the least amount of pressure are the most suitable; this rather unexpected result requires further investigation. The writers then deal with the question of remanence effects, distortions, and the production of harmonics; and with practical points such as the necessity for keeping the biasing current steady. Finally, various receivers embodying the new principle are described and illustrated, Figs. 7b and c showing a particularly small ultra-short-wave adaptor unit, complete with dipole aerial. The advantages, for various purposes, of the facility for distant control offered by this tuning method are discussed at the beginning of p. 171.

2975. METHOD OF TUNING A MICRO-WAVE RECEIVER USING VALVES IN A RETARDING-FIELD CIRCUIT, BY VARYING THE ELECTRON TRANSIT TIME.—H. E. Hollmann: Telefunken. (*Hochf:tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, p. 139: German Patent 622 514 of 24.4.1934.)

The accelerating voltage on the grid G_2 (Fig. 6) and the emission current are simultaneously varied; the current alone is observed on a meter which can be calibrated in wavelengths. The current is altered either by means of the filament current or the bias of the grid G_1; the accelerating voltage is varied by an impedance in the G_2-circuit.

2976. A UNICONTROL RADIO RECEIVER FOR ULTRA-HIGH FREQUENCIES USING CONCENTRIC LINES AS INTERSTAGE COUPLERS.—Dunmore. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 837–849.) *See* 1403 of April.

2977. MICRO-WAVE TRANSMITTERS AND RECEIVERS USING MULTI-GRID VALVES.—Giliberti. (*See* 2956.)

2978. A NEW PENTODE ULTRA-SHORT-WAVE OSCILLATION CIRCUIT AND ITS APPLICATION TO A SUPER-REGENERATIVE RECEIVER OF ULTRA-SHORT WAVES.—Uchida. (*See* 2955.)

2979. POINTS FOR THE DESIGN OF AN ULTRA-SHORT-WAVE RECEIVER [Single-Valve Super-Regenerative Stage (Fromy-Flewelling Circuit) followed by One A. F. Amplifier].—(*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 380–385.) Suggested for the combined investigation of u.s.w. reception organised by the Société des Radioélectriciens.

2980. NEW POLICE [Ultra-Short-Wave] SUPERHETERODYNE USES SUPER-REGENERATIVE SECOND DETECTOR.—General Electric Company. (*Electronics*, May, 1936, Vol. 9, No. 5, p. 42.)

2981. THE MUTUAL MODULATION EFFECT OF ELECTRICAL WAVES [Luxembourg Effect: Systematic Investigations on German Broadcasting Network (1934/5) and Conclusions reached].—W. Pfitzer. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 161–164.)

2982. BEAT EFFECTS: AN INVESTIGATION IN "EXTRA RADIATIONS" AND "BACKGROUNDS" OBSERVED AT BRENTWOOD.—Wm. L. Hafekost. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 298–301.)

Measurements of what are described as "extra radiations" have been made on the emissions of various English and foreign 14–50 m stations: they are found to differ from the fundamental frequency of the station observed by either 2026 or 272 kc/s, or by multiples of one or other of these frequencies. The two frequencies 2026 and 272 kc/s being the sum and difference frequencies, respectively, of the London National and Regional stations, it is thus suggested that the " extra radiations " are due to beats between the carriers of any two stations; interaction between the two fundamentals producing " primary beats," and between the second harmonic of one station and the fundamental of the other producing " secondary beats," and so on. For the London pair of transmitters, 8 " secondary beats " can be calculated, two of which coincide with others. Similarly, beats may be produced between either of the London transmissions and that of a foreign broadcasting station, and certain examples of this are claimed to have been observed.

The " extra radiations " are observed at distances up to 20 or 30 miles from the London station aerials. Marked fading effects have been observed, and it is claimed that some correlation has been obtained between field strength and barometric height, and also that the results observed are greatly affected by thunderstorms.

2983. THEORETICAL FOUNDATIONS OF BROADCAST DISTURBANCE ELIMINATION AND THE TECHNIQUE OF ITS MEASUREMENT.—W. Oehlerking. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, pp. 69–79.)

The purpose of this paper is to systematise the various cases of reception disturbance, so that each cause of disturbance may be characterised by definite values of certain parameters and the circuit required to eliminate the disturbance may be determined on logical principles instead of by trial and error in each separate case. The causes of reception disturbance are discussed. A machine need not *spark* to cause a disturbance; any change in the circuit is, in principle, sufficient for this. The propagation of disturbances is considered from the point of view of the pertinent question : " What is propagated, the power or the voltage from the disturbance source ? " The voltage is found to be the important factor; it may be propagated either (a) by symmetrical propagation along the wires feeding the receiver, or (b) by unsymmetrical propagation between a feeder wire and the earth. These modes may be interchanged at any point of discontinuity of the feeder. The equivalent circuits producing the voltages corresponding to (a) and (b) are shown in Fig. 3. The " transmission condition " (eqn. 4) is defined as the ratio of the disturbing voltage produced in the receiving aerial to that at the terminals where the disturbance is produced; it measures the loss occurring between the interference source and the receiving aerial. The voltage in the aerial is then given by eqn. 6 [with misprint of U_A for $\dot{U}_A$ on right-hand side]. Three methods of influencing the interference are found from this equation: (1) reduction of the interference when building the interfering machine itself; (2) reduction of the " transmission condition " by altering the position of the receiving aerial or fitting the lead with " tramway " condensers; (3) adjustment of the h.f. matching of the feeder lines to the disturbing machine by means of the connection to the machine terminals.

The determination of the suitable value for this connection forms the subject of the rest of the paper; the reception is considered to be free from interference when the disturbing voltage is one-hundredth of the desired signal. The conditions for maximum matching are dealt with theoretically and a value for the matching condenser to be put across the machine terminals derived (eqn. 9, Fig. 5), for the case when the mains impedance is to be increased; if the internal impedance of the interfering machine is to be increased, the circuit of Fig. 6 is used and eqn. 10 gives the value of the required choke. The matching is further discussed, with classification (Table 2) of the various possible cases which may occur. Table 3 and Fig. 10 apply to the case when both choke and condenser are required. The proper place for connecting the condensers is also deduced for various cases of which the equivalent circuits are shown (Figs. 11–15). An illustrative practical case is described. The entrance of interference into the receiver *via* the mains connection is similarly discussed. The theory of the measurement of the matching coefficient is given; the writer proposes a bridge circuit (Fig. 18) and describes, with diagrams, a practical case of the application of his methods. The position of the resonance frequency of a choke is the determining factor in its applicability. The optimum form is found to be the one-layer cylindrical coil. Many practical hints are given throughout the paper. A list of literature references is appended.

2984. ELECTRIC OSCILLATIONS IN THE IGNITION SYSTEM.—Mochizuki, Miyoshi and Horiuchi. (*Journ. I.E.E. Japan*, February, 1936, Vol. 56 [No. 2], No. 571, p. 189: Japanese only.)

2985. RMA–SAE STUDY NOISE [Combined Investigation on Car Ignition Interference].—Horle. (*Electronics*, May, 1936, Vol. 9, No. 5, p. 41.)

2986. A STUDY OF NOISE CHARACTERISTICS.—Landon. (*Communication & Broadcast Engineering*, May, 1936, Vol. 3, No. 5, pp. 16–17 and 23: long summary.) *Cf.* 2583 of July.

2987. INVESTIGATIONS ON OVERHEAD-LINE INSULATORS AND THEIR BEHAVIOUR IN CAUSING BROADCAST INTERFERENCE [1933 Investigations on St. Pölten/Mariazell Line: Necessity of Testing in Position on Line, not only as Individual Insulators: and Short Survey of Present Research and Development].—B. Mengele. (*Elektrot. u. Masch:bau*, 19th April, 1936, Vol. 54, No. 16, pp. 181–184.)

2988. 287 kV BOULDER DAM DISCONNECTING SWITCHES [and the Precautions to avoid Radio Interference].—Bowie and Garman. (*Elec. Engineering*, June, 1936, Vol. 55, No. 6, pp. 582–589.)

2989. SUGGESTION THAT RADIO WAVELENGTH BE ASSIGNED TO PHYSICIANS FOR DIATHERMY, ETC.—(*Sci. News Letter*, 16th May, 1936, Vol. 29, p. 317.)

2990. " RADIO INTERFERENCE AND ITS SUPPRESSION " [Book Review].—J. H. Reyner. (*World-Radio*, 12th June, 1936, Vol. 22, p. 13.)

2991. RADIO INTERFERENCE: SUPPRESSION ON PRIVATE HOUSE LIGHTING PLANTS [from " Radio Interference Bulletin No. 17 "].—Belling & Lee Company. (*Electrician*, 1st May, 1936, Vol. 116, p. 579.)

2992. THE THEORY OF BAND FILTERS IN BROADCAST RECEIVERS.—R. Feldtkeller and R. Tamm. (*E.N.T.*, April, 1936, Vol. 13, No. 4, pp. 123–133.)

The theory given here is based on the properties which should be possessed by the amplification of the ideal band filter, namely, that its numerical magnitude should be constant in the pass band while its phase angle should vary linearly with frequency. Its ideal path in the complex plane (Argand diagram) is thus a circle described with constant velocity, and the same is true for its reciprocal (a constant factor being neglected) the " transmission measure " *S*. An analytic approximation to the circular form is sought in a series in ascending powers of the frequency; the first approximation which gives the character of a band filter (flattening or depression of the resonance curve) is the quadratic form which represents a parabola (Fig. 3b). Band filters with two coupled oscillating circuits are represented by this form, and the rest of the paper discusses its properties and use in the design of actual filters. Eqn. 2 gives the parabolic equation to the " transmission measure "; in § III the relations of the parameters of the parabola to the practical working quantities of the filter are discussed. § IV gives these parameters and the equations connecting them with the magnitudes of the actual circuit elements. Practical circuits based on the parabolic parameters are given in § V; § VI works through the example of the band filter shown in Fig. 12. A perfect filter is calculated in § VII; § VIII discusses the effect of inaccuracies in the circuit elements.

2993. VARIABLE SELECTIVITY [and the Evolution of the Small Coupling Coil, switched In or Out to vary Transformer Coupling].—H. J. Benner. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, pp. 12–14.)

2994. AUTOMATIC TUNING—SIMPLIFIED CIRCUITS AND DESIGN PRACTICE [and a New " Discriminator "].—D. E. Foster and S. W. Seeley. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, pp. 6–7: long summary of I.R.E. Convention paper.) *See* also 2148 of June.

2995. DISTORTIONLESS AVC SYSTEMS [Two Systems free from the Distortion recently shown to be Introduced by Incorrect Application of AVC].—W. T. Cocking. (*Wireless World*, 12th June, 1936, Vol. 38, pp. 574–577.)

2996. CRITICISM OF A CIRCUIT FREQUENTLY RECOMMENDED FOR HIGH-FIDELITY RECEPTION [Bad Quality of Push-Pull Output fed by " Cathodyne " Triode Stage traced to " Violent Dissymmetry," at Frequencies above 1000 c/s, of Voltage to Push-Pull Grids].—L. Chrétien. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 386–395.)

" Numerous circuits published in journals for amateurs might be subjected to similar criticisms."

2997. BIASING THE OUTPUT STAGE [Loss of Amplification due to Incorrect Bias particularly Serious in Output Stage: Use of High-Capacity Electrolytic Shunt Condensers].—T. H. Bridgewater. (*Wireless World*, 5th June, 1936, Vol. 38, pp. 558–559.)

2998. GANGING A SUPERHET [and the Drift of the Third Tracking Point when Trimming-Up the Calculated Circuits: Analysis leading to Design Method avoiding This].—C. P. Singer. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 307–310.)

2999. " L'ART DU DÉPANNAGE ET DE LA MISE AU POINT DES POSTES DE T.S.F." [Broadcast Receiver Servicing: Book Review].—L. Chrétien. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, p. 34 A.)

3000. CATHODE-RAY OSCILLOGRAPH EQUIPMENT FOR TRACING THE SELECTIVITY CURVES OF RECEIVERS [with Special Method of Frequency Sweep giving Constant Band Width at All Parts of Scale, aiding Comparison of Different Curves].—Baudet. (*Génie Civil*, 13th June, 1936, Vol. 108, No. 24, p. 56: summary only.)

3001. ANALYSIS OF BRIDGE CIRCUIT FOR PIEZOELECTRIC QUARTZ RESONATORS [as used in Stenode Radiostat: with Experimental Confirmation: Effect of Changes in Balancing Condenser].—O. E. Keall. (*Marconi Review*, March/April, 1936, No. 59, pp. 19–29.)

3002. STANDARD RADIO RECEIVERS: OPPOSITION TO A RECOMMENDATION [Participation would hamper B.B.C. in Development of Transmission Technique].—(*Wireless Engineer*, June, 1936, Vol. 13, No. 153, p. 310.)

3003. ALL-WAVE AERIAL CIRCUIT [without Switching].—(*World-Radio*, 5th June, 1936, Vol. 22, p. 13: summary of an Austrian article.) Only recommended for superhets with i.f. about 128 kc/s.

3004. ALL-WAVE SUPERHET FOR A.C. MAINS, WAVELENGTHS 6–90 AND 200–2000 m.—Faust. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 191–194.) Extension of the " single-span " receiver referred to in 1405 of April.

3005. SHORT-WAVE BATTERY FOUR [7–77 Metres].—H. B. Dent. (*Wireless World*, 26th June, 1936, Vol. 38, pp. 618–622.)

3006. Five-Metre Superheterodyne [Six-Valve Battery-Operated].—H. B. Dent. (*Wireless World*, 19th June, 1936, Vol. 38, pp. 596–598.)

3007. The "Wireless World" Holiday Portable [4-Valve, with Headphones: "Straight" Circuit with Aperiodic R.F. Stage].—W. T. Cocking. (*Wireless World*, 5th June, 1936, Vol. 38, pp. 550–553.)

3008. The Technique of the German Portable ["Suit-Case"] Receivers with "Straight" Circuits.—E. Schwandt. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 175–180.) Of the seven current types of German suit-case receivers, five are straight sets and two superhets. A later paper will deal with the latter.

3009. Modifications to the Imperial Short-Wave Six.—(*Wireless World*, 19th June, 1936, Vol. 38, pp. 604–606.) *See* 991 of March.

3010. Combined Superhet-Super-Regenerative Circuit [for Combined Selectivity and Sensitivity].—(*World-Radio*, 5th June, 1936, Vol. 22, p. 13: summary of *Radio Welt* article). A crystal-controlled oscillator provides the supersonic quench frequency, and a harmonic from this oscillator is used for heterodyning.

3011. An Original "Straight" Receiver [about 10–625 m: Separate Oscillator Valve replacing Ordinary Retroaction: other Special Features].—(*World-Radio*, 5th June, 1936, p. 13: summary of *Radio World* article.)

3012. A Local-Station Receiver for Highest Fidelity: Some Quantitative Considerations [particularly on the Audio-Frequency Side].—Hertel. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 172–174.) For this receiver see 2164 of June.

3013. Current-Economising Circuit for Battery Receivers [Independent of Anode Load and therefore of Frequency Characteristic of Loudspeaker, unlike (and simpler than) Usual Quiescent Circuit: Use of Metal Rectifier in place of Grid-Lead Resistance].—J. Frommer. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 314–315.)

3014. A New Current Limiter for Wireless Telegraph Receivers [using the "Jumping" Properties of Neon Tube: operates with 0.3–0.5 Volt on Grid of Final Detector: Improved Wave Form].—E. Kido. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 262–263.) Abstract from *J.I.T.T.E.*, July, 1935.

3015. Circuit Technique of Current Stabilisers in "Universal" Receivers ["Urdox" and "Iron-Urdox" Barretter Tubes and Their Application: including the Effect of Stray Magnetic Fields and Sound Waves on the Iron Filaments].—H. Sutaner. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 188–190.) The new Osram and Phillips "pin-less" types are particularly dealt with.

3016. British Standard Specification for Inlet and Outlet Connectors for Radio Circuits.—(*British Standards Institution*, Specification No. 666–1936, March, 1936, 13 pp.)

3017. Frequency Recorder used in Radio Listener Survey [Metering Clock combined with Pencil Recorder geared to Tuning Dial].—Elder and Woodruff. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, p. 19: *Electronics*, May, 1936, Vol. 9, No. 5, p. 50.)

AERIALS AND AERIAL SYSTEMS

3018. The Directive Properties of Paraboloidal Reflectors as used on Ultra-Short Waves.—K. Morita. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 25.) English summary of the Japanese paper referred to in 998 of March. The calculation is also given in the paper dealt with in 2866 of July.

3019. Absorption in the Earth in the Case of Vertical Dipoles at a Great Height above a Plane Earth.—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 8, Vol. 25, 1936, pp. 673–687.)

A formula previously found (1731 of 1935 and 19 of January) for the proportion absorbed in the earth of the total energy emitted by a vertical dipole is evaluated mathematically for the case when the dipole is at a great height above a plane earth. Numerical calculations are made for some cases of practical importance. For wavelengths between 15 and 40 m and an earth with electromagnetic constants as measured by Smith-Rose (3764 of 1935) it is found that the optimum height for the dipole is an uneven number of quarter-wavelengths; ranges of dipole height giving good and bad results are also given. A height of three or four wavelengths above the earth's surface is found to be sufficient to give a value of the absorption in the earth which is practically equal to that given by a dipole at an infinite height.

3020. Radio Field-Intensity and Distance Characteristics of a High, Vertical Broadcast Antenna [Tower Aerial: including Tests with Top Capacity increased by Wires from Top to Waist or nearly to Ground].—Kirby. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 859–871: *Journ. of Res. of Nat. Bur. of Stds.*, April, 1936, Vol. 16, No. 4, pp. 289–300.) The full paper, a summary of which was referred to in 3032 of 1935.

3021. Feeder Lines for High-Power Broadcast Antenna [Concentric Tube Type preferable, but Steep Voltage Gradient in Air Film between Insulator and Inner Conductor].—S. Makabe. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 269–270: in English.) Abstract from *J.I.T.T.E.*, August, 1935.

3022. On the Theory of Receiving Aerials.—V. I. Kovalenkov and L. S. Vysoki. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1936, pp. 6–17.)

A theoretical investigation of the current and voltage distribution in a single-wire receiving aerial. The aerial is regarded as a transmission network which also includes a source of e.m.f. Using the theory of networks, equations are derived in which the resistance and leakage losses are taken into account and also the phase variation of the incoming field along the aerial conductor. Aerials open at one end and loaded at both ends are examined separately, and the effect of the direction and angle of incidence of the incoming signal on vertical, horizontal and sloping aerials is studied in detail. It is shown that with certain simplifications the formulae derived are reduced to those which are normally used in practice.

3023. Enormous Improvement in Long-Distance Short-Wave Reception on replacing Horizontal 50′ Aerial by Same Wire sloping down (45°) to Far End.—(*World-Radio*, 22nd May, 1936, Vol. 22, p. 15.) *See* also *ibid.*, 5th June, 1936, p. 14: *also* Ashbridge, 1934 Abstracts, p. 268.

VALVES AND THERMIONICS

3024. "Les Tubes à Vide et leurs Applications : Vol. I—Principes généraux" [Book Review].—H. Barkhausen. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 33–34 A.) The classic German work translated into French.

3025. "Critical Distance" Tubes.—J. H. O. Harries. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 33–35.) For Editorial Note *see* p. 9, and for previous papers 3450 of 1935 and 2182 of June. *See* also below.

3026. Secondary Emission in Valves [Investigation of Pentode with Suppressor Grid brought out to Separate Pin: Suggested Detailed Mechanism of Harries ("Critical Distance") Valve].—D. A. Bell: Harries. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 311–313.)

It is shown that so far as d.c. characteristics are concerned the suppressor grid (G_3) need not be connected to the cathode; it may be left free. Even when it is joined to the anode there is no sign of secondary emission in the anode circuit, only in the G_3 circuit. It seems therefore that secondary emission from the anode can be checked by producing approximately zero field at its surface. It is suggested that in the Harries valve the wider spacing of the anode from the other electrodes reduces secondary emission (since it decreases the field at the anode) to so small a value that it merely serves to counteract the natural convexity of a secondary-free characteristic, thus producing the straight characteristic following the steep initial rise. For papers, etc., on the Harries valve *see* 2182 of June; also above and below.

3027. "The Anode to Accelerating Electrode Space in Thermionic Valves" [Correspondence].—S. Rodda: J. H. O. Harries. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 315–316.)

Referring to the paper dealt with in 2182 of June, Rodda suggests that angular deflection of electrons is responsible for the shape of the anode characteristic at the knee (Schulze, 398 of 1935), and that space charge would, at a sufficiently high negative bias, be inadequate to prevent the retrograde passage of secondary electrons. The author replies.

3028. Papers on the 6L6 Beam Power Tetrode.—Grammer: Edmonds. (*See* 3067 and 2958.)

3029. On the Design Calculations of a Magnetron from Energy Considerations.—L. A. Dudnik. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 11–18.)

The usual methods for designing a split-anode magnetron are based on the static characteristics and power balance of the magnetron. In the present paper a method is proposed in which instead of the power balance, use is made of equations determining the oscillating energy in terms of the operating constants and circuit parameters. The paper begins with a theoretical analysis of the static characteristics, and the calculated curves are compared with those obtained experimentally. On the basis of this analysis, and from the equations referred to above, formulae are derived for determining the load impedance, power and efficiency of the magnetron. A numerical example is included.

3030. Magnetron Valves for Ultra-Short Wavelengths [Survey: including the Use of a Special Form of Grid to prevent Filament Bombardment: Effect of Variable Loads (Local Heating of Anode Supports, etc.): the Production of Linear Modulation and Avoidance of Frequency Modulation: Data of G.E.C. Magnetrons: etc.].—E. C. S. Megaw. (*G.E.C. Journal*, May, 1936, Vol. 7, No. 2, pp. 94–107.)

3031. The Magnetron.—G. W. O. H. (*Wireless Engineer*, July, 1936, Vol. 13, No. 154, pp. 347–350.) Editorial on the papers dealt with in 2952, above; 2129 of June; 2950, above; 2951, above; 3378 of 1935; 1736 of May; 2555 of July; and 3030, above.

3032. Other Papers on Magnetrons.—(*See* 2950/2952, under "Transmission.")

3033. Fluctuation Noises in Thermionic Valves [particularly at Ultra-High Frequencies].—N. I. Chistyakov. (*Izvestiya Elektroprom. Slab. Toka*, No. 3, 1936, pp. 1–12.)

A theoretical investigation is presented of the following causes of fluctuation noises: (a) fluctuation of the emission current; (b) fluctuation of the secondary emission; (c) thermal agitation of the electrons, and (d) presence of positive ions in the valve. Formulae are deduced determining the noise level due to each of the above causes, and it appears that (a) produces the strongest effect.

It is, therefore, examined in greater detail, with special attention to the operation of the valves on ultra-short waves. An account is also given of an experimental investigation confirming the theoretical results obtained, and a number of curves are shown.

3034. EFFECT OF ELECTRON PRESSURE ON PLASMA ELECTRON OSCILLATIONS.—Linder. (*See* 2914.)

3035. CAESIUM-OXYGEN FILMS ON TUNGSTEN [Mode of Formation of Oxygen Layer under Various Conditions].—J. H. Lees. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1131–1139.)

Observational material is presented dealing with the mode of formation of the oxygen layer under variation of (a) the pressure of the oxygen forming the film, (b) the temperature of activation of the filament, (c) the time allowed for oxygen adsorption, and (d) the time of activation.

3036. ON MEASURING THE INTER-ELECTRODE CAPACITIES OF THERMIONIC VALVES.—A. A. Kuz'menko. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 23–28.)

When it is desired to measure the inter-electrode capacities of a multi-electrode valve it is customary to interconnect some of the electrodes and regard the valve as a diode or triode. In this way the individual and "grouped" capacities can be measured. In the present paper a brief survey is given of the various methods used, and these are classified into the following two groups :—Group 1, when "grouped" capacities only are measured, and capacities to ground are also included (beat method, crystal-controlled oscillator method, resonance method, etc.) ; and Group 2, where both individual and "grouped" capacities are measured but capacities to ground are not taken into account (compensation method, bridge method, etc.). A discussion is given of the difference in the results for the same valve when methods belonging to different groups are used, and the conclusions reached are verified experimentally.

3037. VARIATION OF THE SECONDARY ELECTRON EMISSION FROM INSULATORS AND SEMICONDUCTORS BY ELECTRON IRRADIATION.—M. Knoll. (*Naturwiss.*, 29th May, 1936, Vol. 24, No. 22, p. 345.)

For reference to the experimental method used *see* 1157 of March. Here an example is shown of the secondary emission from an oxidised aluminium plate with an irradiated spot. The latter shows a decrease of the secondary emission factor. This also occurred in several other cases but increases were found in some cases. Disturbances of the space charge or lattice structure of the plate (*see* also Suhrmann & Haiduk, 1218 of March), or variation of the equilibrium potential at the surface, are suggested as explanations.

3038. THEORY OF THE WORK FUNCTION. II. THE SURFACE DOUBLE LAYER [Calculation of Electronic-Charge Density at Metal Surface : Surface Barrier due to Exchange and Polarisation Forces : Each Electron has Its Own Barrier].—J. Bardeen. (*Phys. Review*, 1st May, 1936, Series 2, Vol. 49, No. 9, pp. 653–663.) For I *see* 3072 of 1935.

3039. ON THE CONSTANT *A* IN RICHARDSON'S EQUATION [Calculation of Its High-Temperature Value in terms of Thermodynamic Quantities].—E. Wigner. (*Phys. Review*, 1st May, 1936, Series 2, Vol. 49, No. 9, pp. 696–700.)

3040. THE NORMAL CATHODE DROP AT THE MELTING-POINT OF BISMUTH [Measurements showing Decrease in Work Function].—H. Kurzke. (*Ann. der Physik*, Series 5, No. 8, Vol. 25, 1936, pp. 688–696.) For previous work *see* 149 of 1935.

3041. METHODS FOR MEASUREMENT OF THE VOLTA EFFECT [Critical Account : Ionisation, Condenser, Photoelectric, Thermionic Methods].—H. Gericke. (*Physik. Zeitschr.*, 1st May, 1936, Vol. 37, No. 9, pp. 327–338.)

3042. PAPERS ON HIGH-FREQUENCY POWER AMPLIFIERS, CLASS B.—Macnamara : Rubin. (*See* 2970 and 2971.)

3043. "WERKSTOFFKUNDE DER HOCHVAKUUMTECHNIK" [Book Review].—Espe and Knoll. (*Electrician*, 29th May, 1936, Vol. 116, p. 697.) "Deals exhaustively with the materials used in the manufacture of all kinds of high vacuum devices and can be strongly recommended to those engaged in the field of thermionics and allied subjects."

3044. BRITISH STANDARD SPECIFICATION FOR DIMENSIONS OF RADIO VALVE-BASES AND VALVE-HOLDERS.—(*British Standards Institution*, Specification No. 448–1936, March, 1936, 21 pp.)

DIRECTIONAL WIRELESS

3045. "FEELERS" FOR SHIPS [Micro-Wave Obstruction Detector on s.s. "Normandie"].—(*Wireless World*, 26th June, 1936, Vol. 38, pp. 623–624.) *See* also 2651 of July.

3046. RADIOGONIOMETER WITHOUT NIGHT ERROR.—Société Française Radioélectrique. (*Hochf: tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, p. 140 : French Patent 793 957 of 14.11.34.)

Short regular pulses from the emitter are received by an ordinary goniometer and led on to the control electrode of a thyratron whose anode voltage is an alternating one of the same frequency as that of pulse emission. The phase of the anode voltage is adjusted so that an anode current only flows while the pulse current is rising, so that the echoes do not influence the circuit at all. *Cf.* 1031 of March.

3047. DEMONSTRATION OF THE LORENZ BLIND LANDING SYSTEM.—(*Wireless World*, 26th June, 1936, Vol. 38, p. 627.) *See* also 1905 of 1935.

3048. A RESEARCH OF DIRECT-READING ALTIMETER FOR AERONAUTICAL USE BY RADIO WAVE REFLECTION.—S. Matsuo. (*Journ. I.E.E. Japan*, February, 1936, Vol. 56 [No. 2], No. 571, pp. 89–93 : Japanese only.)

3049. ELECTRICALLY INDICATING MEASURING APPARATUS FOR RAPID PRESSURE CHANGES.—Hasse: Schnauffer. (*Zeitschr. V.D.I.*, 9th May, 1936, Vol. 80, No. 19, pp. 563–564.) Applicable to aircraft height indication. Schnauffer's "half resonance curve" principle is used (1930 Abstracts, p. 647).

3050. BEACON MARKER TRANSMITTER [at WBNS].—L. H. Nafzger. (*Electronics*, May, 1936, Vol. 9, No. 5, p. 29.) *Cf.* 1033 of March. The marker here described has a single-wire aerial 30′ high and 250′ long, and the transmitter (with 15 w in the aerial) has "consistently been checked to the borders of the state."

3051. TRAINING THE AIRCRAFT OPERATOR.—(*Wireless World*, 29th May, 1936, Vol. 38, pp. 532–534.)

3052. SPECIAL TYPES OF INDUCTOR COMPASS AND THEIR APPLICATIONS [to Aircraft, etc.].—G. Giulietti. (*L'Elettrotec.*, 25th April, 1936, Vol. 23, No. 8, pp. 231–236.)

ACOUSTICS AND AUDIO-FREQUENCIES

3053. TRANSIENT OSCILLATIONS IN A LOUDSPEAKER HORN [Differential Equation: Operational, Steady State, Transient Solutions: Numerical Calculation of Form of Transient Oscillation: Mathematical Appendix].—N. W. McLachlan and A. T. McKay. (*Proc. Camb. Phil. Soc.*, May, 1936, Vol. 32, Part 2, pp. 265–275.)

3054. CHARACTERISTICS OF THE CONE-TYPE MOVING-COIL LOUDSPEAKER, AND ITS DESIGN—PART I [Complex Modes of Vibration of Cone: Possible Improvements to give Same Characteristics as Horn Type, apart from Efficiency].—H. Wada. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 35.) For the writer's paper on the efficiency of these loudspeakers *see* 1934 Abstracts, p. 386.

3055. MEASURING LOUDSPEAKER PERFORMANCE [N.P.L. Methods].—(*Electronics*, May, 1936, Vol. 9, No. 5, p. 42.)

3056. LOUDSPEAKER WITH TWO DIAPHRAGMS EACH WITH SEPARATE DRIVE, CONNECTED IN OPPOSITION TO USE BOTH ALTERNATIONS OF CURRENT: SURROUNDING FLUID UNDER ADJUSTABLE PRESSURE.—C. Boutelleau. (French Pat. 795 811, pub. 23.3.1936: *Rev. Gén. de l'Élec.*, 30th May, 1936, Vol. 39, No. 22, p. 176 D.)

3057. A SOUND-RECORDING APPARATUS FOR TALKING-PICTURE FILMS.—A. F. Shorin. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 47–58.)

A special feature of the design is the light modulator, in the form of a micro-oscillograph giving a "shaded" oscillogram; the resulting characteristic has a deviation of only $\pm$ 2 db up to 25 000 c/s. Special methods ensuring uniformity of film transport and stability of position are used. Automatic elimination of recording noise, and the correction of certain distortions, are provided.

3058. A DEVICE FOR COPYING SINGLE SOUNDS [down to less than 0.39 Second] FROM A PHONOGRAPH RECORD OF SPEECH OR MUSIC.—G. Fairbanks. (*Science*, 8th May, 1936, Vol. 83, pp. 445–446.)

3059. A "MASS-LESS" PICK-UP [Audak Design using "Relayed Frequency" Principle, widening Frequency Range, lengthening Record Life, etc.: Maximum-Amplitude Low Frequencies followed with only 1.25 Ounces on Needle].—W. N. Weeden. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 36–38.) *See* also *Communication & Broadcast Engineering*, May, 1936, Vol. 3, No. 5, pp. 22–23 (Paneyko).

3060. METHOD OF TESTING THE FREQUENCY CHARACTERISTIC OF MICROPHONES [by converting Diaphragm into One Plate of Electrostatic Loudspeaker: Practical Technique].—M. H. Alker. (*Funktech. Monatshefte*, May, 1936, No. 5, p. 180.)

3061. ELECTRONIC MUSIC INSTRUMENTS [First Year's Sales Results: etc.].—Miessner. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, p. 19: from I.R.E. paper.)

3062. THE "MAGNETON" TONE-WHEEL ORGAN WITH MANY TONE-COLOURS.—(*Funktech. Monatshefte*, May, 1936, No. 5, pp. 195–196.)

3063. "DAS ELEKTROAKUSTISCHE KLAVIER" [Piano: Book Review].—O. Vierling. (*Génie Civil*, 16th May, 1936, Vol. 108, No. 20, p. 480.)

3064. THE "FORMANT" IDEA [Band of Audio Frequencies characterising a Particular Vowel Sound].—O. Vierling. (*Ann. der Physik*, Series 5, No. 3, Vol. 26, 1936, pp. 219–232.)

The "formant" is the frequency band of a sound emphasised by the resonance cavities of the throat and mouth in the production of a particular vowel sound. Properties of frequency and attenuation are here ascribed to it; its frequency is defined as the resonance frequency of the resonance curve which is the envelope of the group of frequencies comprised in it, and its attenuation is defined as that of this resonance curve. "Its intensity depends not only on the properties of the resonance cavities but on the number and strength of the partial tones of the original sound which fall within the resonance band." The artificial production of sounds with "formants" is investigated in § 3, where an example of the use of resonant circuits for this purpose is given. Experiments on the dependence of the "formant" on the original sound are described in § 4, with illustrative oscillograms.

3065. DETERMINATIONS OF THE AUDIBILITY THRESHOLD WITH THE THERMOPHONE AND MEASUREMENTS ON THE EAR-DRUM [Frequency/Threshold and Frequency/Ear-Drum Absorption Coefficient Curves for Left and Right Ears of One Subject].—E. Waetzmann and L. Keibs. (*Ann. der Physik*, Series 5, No. 2, Vol. 26, 1936, pp. 141–144.) *See* also von Békésy, 1830 of May.

3066. THE EQUIVALENT CIRCUIT AND LOAD RESISTANCE OF PUSH-PULL AUDIO AMPLIFIERS [and the Incorrectness of the Accepted Equivalent Circuit].—Slepian. (*See* 2936.)

3067. A 50-WATT AUDIO AMPLIFIER-MODULATOR WITH BEAM TUBE OUTPUT: THEORY AND PRACTICAL OPERATION OF THE NEW 6L6 [Four-Stage Amplifier with about 50 Watts of Practically Undistorted Output from Two 6L6 Valves: Gain sufficient for Diaphragm-Type Crystal Microphone, and Other Purposes].—G. Grammer. (*QST*, June, 1936, Vol. 20, No. 6, pp. 11–15.) Using only 400 volts on the plates. *See* also 2636 of July.

3068. THE TELEPHONE TRANSFORMER: PART I.—C. Calosi. (*Alta Frequenza*, June, 1936, Vol. 5, No. 6, pp. 347–354.)

The working of a telephone transformer is examined as regards the attenuation produced, in the case where the terminal impedances are equal. The conclusion is reached that the customary method of matching the terminal impedances to the characteristic impedance of the transformer is correct.

3069. ELECTROACOUSTIC RESONANCE AND ITS RECENT APPLICATIONS [particularly the Adjustment of the Acoustical Colour of a Broadcasting Studio by the Gamzon, Sollima and Sarnette Method of Resonance Chamber and Potentiometers].—M. Adam. (*Génie Civil*, 20th June, 1936, Vol. 108, No. 25, pp. 580–583.)

3070. AN ACOUSTIC RESISTANCE METER [measuring Resistance to Steady Flow of Air—*i.e.* Sound at Zero Frequency].—T. J. Pope. (*Bell Lab. Record*, June, 1936, Vol. 14, No. 10, pp. 343–346.)

3071. PRECISION APPARATUS FOR MEASURING THE VELOCITY OF SOUND IN SOLID RODS [allowing Specimen to be subjected to Various Physical Conditions].—J. I. Swigart. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 252–254.)

3072. AUDIO-FREQUENCY GENERATORS FOR MEASURING PURPOSES [General Account].—R. Tamm and U. Hennecke. (*Hochf:tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, pp. 133–138: Industry Review.)

A summarising account of the various types of audio-frequency generators and their applicability for various needs, with special reference to those developed by Siemens & Halske AG.

3073. FILTER-COUPLED GLOW-DISCHARGE OSCILLATORS [Frequency Stability increased by Second Tuned Circuit].—W. E. Kock. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, p. 17.) *See* also 1383 of April.

3074. A SINGLE-VALVE BEAT-FREQUENCY OSCILLATOR AS AN APPLICATION OF THE THIRD-GRID DYNATRON OF A TRIPLE-GRID PENTODE.—S. Takamura. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts pp. 33–34.)

3075. A NEW PHOTOELECTRIC AUDIO-FREQUENCY GENERATOR.—T. Sone and M. Saito. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 252–259: in English.) Thanks to the magnetic clutch and eddy-current brake, the disc rotations can be varied reliably between 3 and 3000 r.p.m.

3076. AN A.C.-OPERATED BEAT OSCILLATOR [giving 500 mW Audio Power over Wide Range with Less than 2% Harmonic Distortion: Electron Coupling].—S. J. Haefner and E. W. Hamlin. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 20–21.)

3077. HIGH Q AUDIO REACTORS [Values around 35 by Suitable Design: Use with Resonant Transformer Circuits].—P. F. Bechberger. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 22–24.)

3078. COMPUTING REACTANCE ATTENUATION [with Chart].—(*Electronics*, May, 1936, Vol. 9, No. 5, pp. 40 and 39.)

3079. A POINTER FREQUENCY METER FOR SOUND-WAVE FREQUENCIES.—K. B. Karandeev. (*Tech. Phys. of USSR*, No. 4, Vol. 3, 1936, pp. 361–365: in English.)

Further development of the work dealt with in 1889 of May, from which a pointer meter for frequencies up to 500 c/s was evolved by Ivanova (639 of February). The present instrument, still using the crossed-coil ratio meter (logohmmeter), is of higher quality and extends up to 15 or 20 kc/s.

3080. THE NEW STROBOSCOPIC METHOD FOR AUDIO-FREQUENCY MEASUREMENTS [200–10 000 c/s with Error of Some Hundredths of 1%].—I. A. Gorodinsky and I. F. Possabilova. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1936, pp. 42–48.)

Two gas-discharge tubes are used, one controlled by the current whose frequency is under measurement and the other by impulses from a standard oscillator. Each tube illuminates a disc, the two discs being geared together and driven synchronously. The speed of the system is varied until the picture seems motionless upon one disc, and the operator then takes the reading of the apparent rotation of the figures on the second disc. A nomogram is given to help in calculating the required frequency, and the description of the equipment includes the thyratron "flashing circuit" necessary to produce bright illumination.

3081. LOCATING UNDERGROUND ROCK BY SOUND WAVES [by Measurement of Travel Speed of Explosion Impulse].—(*Nature*, 6th June, 1936, Vol. 137, p. 955: note on paper in *Roads and Streets*, April, 1936.)

3082. EXPERIMENTS ON THE THEORY OF RAMAN AND NAGENDRA NATH OF THE DIFFRACTION OF LIGHT AT SUPERSONIC WAVES.—R. Bär. (*Helvetica Phys. Acta*, Fasc. 4, Vol. 9, 1936, pp. 265–284: in German.)

The theory is found to hold accurately for frequencies between 1000 and 2000 kc/s, and thus represents "a very great step in advance, likely to have many applications." At 7500 kc/s it is only qualitatively valid. *Cf.* 3083. For the work of Raman & Nath see *Sci. Abstracts*, Sec. A, 25th May, 1936, p. 531: also *cf.* 2252 of June.

3083. MATHEMATICAL THEORY OF THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—G. Wannier and R. Extermann. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 9, 1936, pp. 337–339.)
The writers conclude that the theory of Raman and Nath (*see* also 3082) will give nearly accurate results only if the layer of supersonic waves traversed by the light is less than 3.5 mm thick, so that under ordinary experimental conditions the method is not employable.

3084. ABSORPTION, VELOCITY AND DEGASSING MEASUREMENTS IN THE SUPERSONIC RANGE [200–1000 kc/s: Various Liquids: Emulsification Effects].—G. Sörensen. (*Ann. der Physik*, Series 5, No. 2, Vol. 26, 1936, pp. 121–137.)

3085. EMULSIFICATION BY ULTRASONIC WAVES.—Boudy and Solluer. (*Current Science*, Bangalore, May, 1936, Vol. 4, No. 11, pp. 821–822: summary of three papers.)

3086. CAVITATION HOLES IN LIQUIDS, PRODUCED BY INTENSE 1–9 KC/S SOUND WAVES, EMIT VISIBLE LIGHT.—L. A. Chambers. (*Science*, 8th May, 1936, Vol. 83, Supp. pp. 12–13.)

3087. METHODS AND RESULTS OF SUPERSONIC RESEARCH [Survey].—E. Hiedemann. (*Zeitschr. V.D.I.*, 16th May, 1936, Vol. 80, No. 20, pp. 581–586.)

3088. CHLADNI FIGURES ON SQUARE PLATES [High Harmonics: Figures with Rectangular and Triangular Symmetry].—R. C. Colwell. (*Journ. Franklin Inst.*, May, 1936, Vol. 221, No. 5, pp. 635–652.)

3089. A MECHANICAL SLIDE ILLUSTRATING WAVE MOTION.—E. J. Irons. (*Journ. Scient. Instr.*, June, 1936, Vol. 13, pp. 184–189.)

3090. "GLOSSARY OF ACOUSTICAL TERMS AND DEFINITIONS, No. 661–1936" [Book Review].—British Standards Institution. (*Electrician*, 1st May, 1936, Vol. 116, pp. 581–582.)

PHOTOTELEGRAPHY AND TELEVISION

3091. THE TECHNICAL AND INDUSTRIAL CONDITIONS FOR THE POPULAR DEVELOPMENT OF TELEVISION [and the Writer's Simple and Cheap Receiver with Small Oscillograph Tube working on 1000 Volts: the Advantage of Barthélémy's Synchronising Method].—M. Chauvierre. (*Génie Civil*, 23rd May, 1936, Vol. 108, No. 21, p. 499: summary of lecture.)

3092. MECHANICAL FILM TRANSMISSION: THE MIHALY-TRAUB SYSTEM.—L. M. Myers. (*Television*, June, 1936, Vol. 9, No. 100, pp. 369–373.)

3093. SOME NEW IDEAS IN MECHANICAL SYNCHRONISING [General Requirements and Necessary Design Principles].—W. R. Frank. (*Television*, June, 1936, Vol. 9, No. 100, pp. 333–335.) "For some purposes, such as scanning large cinema screens, mechanical methods of scanning appear to be the only ones possible."

3094. THE STANDARDS OF THE TWO LONDON TELEVISION SYSTEMS [Numerical Data of Baird and Marconi-E.M.I. Systems for London Television Scheme].—(*E.N.T.*, April, 1936, Vol. 13, No. 4, pp. 142–144.)

3095. THE COMPARATIVE PROPERTIES OF SOFT AND HARD CATHODE-RAY TUBES ["Each fulfilling Certain Specific Fields of Application": Space-Charge Theory of Beam: Electron-Optical Aspect (and the "Contracted" Focal Length): Contrast in Details of Deflection Conditions: etc.].—L. H. Bedford. (*Journ. Scient. Instr.*, June, 1936, Vol. 13, No. 6, pp. 177–184.)

3096. A CATHODE-RAY TIME AXIS FOR HIGH FREQUENCY [capable of tracing out One Cycle of a 30 Mc/s Wave].—L. M. Leeds. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 872–878.)

The limitations of the condenser-charge method, when applied to very high frequencies, led to an investigation to discover other methods, independent of condenser charging, of obtaining a linear variation of voltage with respect to time. In the method here described the wave form of a conventional h.f. oscillator is altered by means of a high-vacuum rectifier circuit to obtain the required sweep-voltage wave. The return trace is removed by biasing the control grid of the c-r tube. The theoretical non-linearity is less than 1%.

3097. ELECTRON-OPTICAL SYSTEMS AND THEIR APPLICATION.—Zworykin. (*See* 3144.)

3098. ELECTRICAL "SHUNTING" CIRCUITS [Separating Filters for Separation and Distribution of Frequency Bands].—Brandt. (*See* 2937.)

3099. POLARISING CHARACTERISTICS OF POLAROID PLATES FOR WAVELENGTHS 4000 A to 20 000 A.—Ingersoll, Winans and Krause. (*Journ. Opt. Soc. Am.*, June, 1936, Vol. 26, No. 6, pp. 233–234.)

For a reference to the new glass *see* 2779 of July. "The probable increase in the use of the recently developed polarising films or plates makes it desirable to determine their characteristics over a wide wavelength range. It is generally understood that these films are made by embedding minute dichroic crystals, such as those of herapathite, in a cellulose acetate film, aligning them by a stretching process and mounting between glass plates." The polarising property is found to be limited almost entirely to the visible spectrum, dropping off very rapidly in the infra-red and violet regions.

3100. THE TEMPERATURE VARIATION OF THE KERR EFFECT IN NITROBENZOL.—F. Gabler and P. Sokob. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 17, 1936, pp. 197–201.)

For previous work *see* 1533 of April. The present work is concerned with an exact determination of the temperature coefficient of the parameter *B* there measured in the neighbourhood of 20°C. Some alterations in the apparatus are described (§ 2) and the results of the measurements are given (§ 3, Fig. 2) for the range 12 to 111° C; they are found to be represented by an interpolation formula (eqn. 1). They are also compared with the molecular orientation theory of Langevin & Born (§ 4); the agreement is however not good.

3101. PAPERS ON THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—Bär: Wannier and Extermann. (*See* 3082 and 3083.)

3102. THE EFFECT OF LENGTH OF EXPOSURE OF THE TEST OBJECT ON VISUAL ACUITY: A CORRECTION.—Ferree and Rand: Conner and Ganoung. (*Journ. Opt. Soc. Am.*, June, 1936, Vol. 26, No. 6, p. 272.) *See* 3960 of 1935.

3103. PHOTOELECTRIC PROPERTIES OF SODIUM FILMS ON ALUMINIUM [Differences from Properties of Cs, Rb, K Films on Ag].—J. J. Brady and V. P. Jacobsmeyer. (*Phys. Review*, 1st May, 1936, Series 2, Vol. 49, No. 9, pp. 670–675.)

3104. CAESIUM-OXYGEN FILMS ON TUNGSTEN.—Lees. (*See* 3035.)

3105. THE OPTICAL CONSTANTS OF POTASSIUM [including in the Ultra-Violet], *and* CALCULATED AND EXPERIMENTAL PHOTOELECTRIC EMISSION FROM THIN FILMS OF POTASSIUM.—H. E. Ives and H. B. Briggs. (*Journ. Opt. Soc. Am.*, June, 1936, Vol. 26, No. 6, pp. 238–246: pp. 247–250.)

"No optical constants for the alkali metals have been available except in the visible region. In this region, a very satisfactory combination of the theory [Ive's vectorial theory—1932 Abstracts, p. 102] was obtained . . . One of the most characteristic phenomena of photoelectric emission from thin films, namely the occurrence of a pronounced maximum of emission in the spectrum, could not be compared with the predictions of this theory because these maxima in the case of the alkali metals lie in the ultra-violet." The measurements of the first paper are, in the second paper, applied to this theory and the results compared with experiment.

3106. THE VARIATION WITH WAVELENGTH OF THE NUCLEAR PHOTOELECTRIC EFFECT IN BERYLLIUM.—R. Fleischmann and W. Gentner. (*Zeitschr. f. Physik*, No. 7/8, Vol. 100, 1936, pp. 440–444.)

3107. CONTINUOUS ABSORPTION AND THE PHOTOELECTRIC EFFECT [Analogy of Atom with Absorbing Radio Antenna cannot explain Observed Photoelectric Energy Relations and Rapid Onset of Photoelectric Emission].—H. Rakshit: Fleming. (*Zeitschr. f. Physik*, No. 5/6, Vol. 100, 1936, pp. 396–400.) For reference to the analogy *see* Fleming, 1933 Abstracts, p. 54.

3108. THEORY OF THE WORK FUNCTION. II.—Bardeen. (*See* 3038.)

3109. TALBOT'S LAW IN PHOTOELECTRIC PHOTOMETRY [Results for Vacuum and Gas-Filled Cells: Variation in Transmission Factors for the Same Rotating Disc].—G. A. Boutry. (*Comptes Rendus*, 11th May, 1936, Vol. 202, No. 19, pp. 1580–1582.)

3110. THE YIELD OF PHOTOELECTRONS IN [Geiger-Müller] COUNTERS [Dependence on Field Strength: All Electrons emitted from Cathode are not Counted].—W. Christoph. (*Physik. Zeitschr.*, 15th April, 1936, Vol. 37, No. 8, pp. 265–269.)

MEASUREMENTS AND STANDARDS

3111. THE FREQUENCY STABILITY OF TUNED CIRCUITS [and particularly the Reduction of the Temperature Coefficient of Frequency from 25–40 Parts in 10^6 to 1 Part in 10^6 by Compensation of Product *L.C.* as a Whole].—J. H. Piddington. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, pp. 302–306.) Either by making the t.c. of the condenser negative, to counteract the positive t.c. of the shielded coil, or by a corresponding treatment of the inductance.

3112. ANALYSIS OF BRIDGE CIRCUIT FOR PIEZO-ELECTRIC QUARTZ RESONATORS.—Keall. (*See* 3001.)

3113. VARIATIONS IN THE LENGTH OF THE ASTRONOMICAL DAY AND IN THE ASTRONOMICAL DETERMINATION OF TIME WITH THE QUARTZ CLOCKS OF THE P.-T. REICHSANSTALT. EXPERIMENTAL RESULTS II.—A. Scheibe and U. Adelsberger. (*Physik. Zeitschr.*, 15th March, 1936, Vol. 37, No. 6, pp. 185–203.) For I *see* 1934 Abstracts, p. 105, and for other papers *see* Abstracts, 1933, p. 109 (two) and 633; 1934, p. 278; 2369 of 1935 and 1560 of April.

3114. ON THE CALCULATION OF THE FREQUENCY SCALE OF A WAVEMETER WITH INVERTED LINEAR CONDENSER.—G. A. Kiandsky. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 18–23.)

In order to obtain a rise of the frequency curve with the angle of rotation (Fig. 2) a linear condenser with inverted scale may be used. The paper gives formulae for capacity (eqn. 3), frequency (eqn. 11) and linear interpolation (eqn. 13) for such a condenser. The question of the accuracy of interpolation for both types of linear condenser is examined.

3115. A THEORY OF THE ULTRA-SHORT-WAVE WAVEMETER WITH AN AUXILIARY COIL.—Ataka. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 32.) English summary of the paper in Japanese referred to in 2328 of June.

3116. A POINTER FREQUENCY METER FOR SOUND-WAVE FREQUENCIES.—Karandeev. (*See* 3079.)

3117. A Method for the Measurement of the Equivalent Resistance of Oscillatory Circuits.—G. Latmiral. (*Alta Frequenza*, June, 1936, Vol. 5, No. 6, pp. 331–346.)

Author's summary :—" A method is described [based on a suggestion of Vecchiacchi] which presents two substantial variations on the classic method of neutralisation. The first departure consists in avoiding the measurement of the neutralising negative resistance ; by means of this resistance the equivalent resistance of the h.f. oscillatory circuit under examination is compared with the equivalent resistance of an audio-frequency resonator calibrated by the bridge method. The second departure consists in carrying out this comparison not by reference to the condition of oscillation onset but by reference to a condition of oscillation of finite amplitude [of arbitrary value provided it is equal in both cases and not too great]. This second departure has the property of allowing, within certain limits which can be pre-determined, the influence of harmonics on the amplitude of the oscillations to be neglected. An apparatus [Figs. 10 and 11] is described which allows measurements to be made with the method proposed, and some of the principal applications are specified."

The author claims that the measuring process can be carried out more accurately and more quickly than with the classic method. A suitable indicator of amplitude is provided by a triode voltmeter working on the anode bend with strong negative grid potential. The negative resistance may be obtained by the dynatron method : the simpler method of the negative-transconductance pentode (Herold, 77 of January) is discussed on pp. 341–342, but has the objection of requiring a grid-circuit resistance which must remain constant at radio and acoustic frequencies. Moreover, the dynatron method has the advantage of allowing operation on anode currents near to zero.

3118. A Method of Measuring Very Small Changes in Resistance by means of Frequency-Unstable Oscillating Circuits.—S. Fahrentholz. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 17, 1936, pp. 187–190.)

The purpose of this investigation is to determine to what degree of frequency instability the production of oscillations by valve generators can be driven, and whether it is possible to develop a sensitive beat-method for measuring small changes in resistance, analogous to that used for measuring dielectric constants. Particular attention is paid to the variation of frequency with filament heating and with retroaction, different valves being used. Fig. 1 shows the diagram of the two circuits whose oscillations are superposed. The filament resistance of the valve in the first circuit was varied and the resulting frequency variation compensated and measured by a variable condenser. The results are given in the form of curves (Figs. 2–6) for various degrees of retroaction and different valves. The application of the results to the construction of a sensitive, rapid valve bolometer (Fig. 7) is described and the theory of bolometer measurements is given. A paper on the measurement of small variations of large resistances (photocells) by a similar method is promised.

3119. On the Calibration of High-Frequency Attenuators [for Medium or Short Waves : Simple but Accurate Methods].—E. Kido. (*Nippon Elec. Comm. Eng.*, May, 1936, No. 3, pp. 266–267 : in English.) From *J.I.T.T.E.*, August, 1935 : summary only.

3120. Photoelectric Voltage Compensation and Resistance Measurement.—Wulff. (*Physik. Zeitschr.*, 15th April, 1936, Vol. 37, No. 8, pp. 269–271.)

Two examples are given of the use of photocells in the place of mechanical-electrical compensating devices. Fig. 1 shows the circuit of an arrangement for measuring e.m.fs, thermo-voltages and other potentials up to about 300 mv. The illumination falling on the photocell is regulated by a moving-coil instrument. The theory of the circuit is explained. Fig. 2 gives the circuit of a bridge arrangement for resistance comparison, in which two arms are occupied by photo-elements which replace the customary current source in the second diagonal arm ; the latter is here eliminated.

3121. A Method for Measuring Alternating Voltages of All Frequencies by means of a Photocell and Electrometer (Photo-cell-Voltmeter).—F. Schuhfried. (*Hochf: tech. u. Elek:akus.*, April, 1936, Vol. 47, No. 4, pp. 117–119.)

The circuit investigated is shown in Fig. 1 (*see* also Behnken, *Verh. dtsch. physik. Ges.*, 1914, Vol. 16). The voltage to be measured is put across a photocell, which charges up a string electrometer. This does not charge up to its maximum voltage, as might be expected ; discharge may occur owing to bad insulation (§ II) or incomplete rectification in the photocell (§ III), which can be understood from its current/voltage characteristics in the region of negative anode voltage (Fig. 2). Fig. 3 shows how the electrometer deflection depends on the illumination ; the curve has a broad maximum, showing a region of optimum illumination. The practical method of measurement is described in § IV ; the electrometer string is brought to its centre position by an auxiliary potentiometer and battery before the voltage to be measured is switched in. A compensation voltage (Fig. 4) is again used to bring the string back to the centre after the alternating voltage is switched in ; this compensation voltage measures the maximum value of the alternating voltage. The calibration (Fig. 5) and experimental tests with a valve voltmeter (§ V ; Fig. 6) are described.

3122. Methods for Measurement of the Volta Effect [Critical Account : Ionisation, Condenser, Photoelectric, and Thermionic Methods].—Gericke. (*Physik. Zeitschr.*, 1st May, 1936, Vol. 37, No. 9, pp. 327–338.)

3123. A Variation of the Method developed by H. König for the Measurement of High Voltage [Use of Valve Rectifier Method : Condenser in Place of König's Additional Battery].—J. L. Jakubowski. (*Arch. f. Elektrot.*, 18th April, 1936, Vol. 30, No. 4, pp. 276—280.). For König's paper *see* 1930 Abstracts, p. 345.

3124. Dispersion and Absorption of Viscous Fluids at High Frequencies [Micro-Wavelengths: Construction of Emitter giving Constant Amplitude and Frequency: Measurements with Various Organic Liquids: Comparison with Debye Theory].—W. Dahms. (*Ann. der Physik*, Series 5, No. 2, Vol. 26, 1936, pp. 177–192.)

3125. Electrostatic Capacity Measurements [Revival of Boltzmann's Electrostatic Method: Application to measurement of Capacity and Capacity Changes, and particularly to a Precision Method of measuring Dielectric Constants of Gases].—B. Kurrelmeyer and Lucy Hayner. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 233–237.)

3126. On Measuring the Inter-Electrode Capacities of [Multi-Electrode] Valves.—Kuz'menko. (*See* 3036.)

3127. An A.C. "Detector Bridge" [for Production Testing of Capacities].—K. B. Karandeev. (*Tech. Phys. of USSR*, No. 4, Vol. 3, 1936, pp. 356–360: in German.) *See* 1140 of March.

3128. "Messbrücken und Kompensatoren" [Book Review].—J. Krönert. (*Zeitschr. V.D.I.*, 16th May, 1936, Vol. 80, No. 20, p. 611.)

3129. A Vacuum Tube Alternating-Current Bridge Detector [Visual Balance-Indicator provided by 6E5 Electron-Ray Tube].—W. M. Breazeale. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 250–251.) Independent development of the plan suggested by Ulrey (2184 of June).

3130. New High-Frequency Measuring Instruments of the Leybold and von Ardenne Oscillograph Company, Ltd., Cologne [Valve "Trip" Oscillation Apparatus: Oscillograph Amplifier: Small Portable Cathode-Ray Oscillograph: Sensitive Mains-Driven Valve Voltmeter with Two Ranges: Single-Stage Mains-Driven Valve Voltmeter with Four Ranges].—Leybold & von Ardenne Company. (*Hochf:tech. u. Elek: akus.*, March, 1936, Vol. 47, No. 3, pp. 98–99: Industry Review.)

3131. The Use of Quartz Resonators [with Resonance Point shown by Neon Tube] as Vibration Electrometers for Measurements with a Wheatstone Bridge, in particular the Measurement of the Skin Effect in Iron and Mumetal Wires [with Generator Circuit: Frequency/Skin-Effect Curves for Range 35–1000 kc/s].—F. Krüger. (*Ann. der Physik*, Series 5, No. 2, Vol. 26, 1936, pp. 167–176.)

3132. Charge Sensitivity of Compton Electrometer [and Its Adjustment to Maximum].—L. T. Pockman. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 238–243.) The advantages of the new electrometer due to Hansen (2336 of June) are pointed out at the end of the paper.

3133. Measuring the Torque of a Sealed Electrostatic Voltmeter.—E. H. W. Banner. (*Journ. Scient. Instr.*, June, 1936, Vol. 13, No. 6, pp. 191–194.)

3134. On the Development of the Insulation Meter.—E. Blamberg. (*E.T.Z.*, 28th May, 1936, Vol. 57, No. 22, pp. 643–645.)

3135. High-Frequency Errors of Thermo-Ammeters.—J. S. Averbukh. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 28–35.)

Author's summary:—"Possible h.f. errors of thermo-ammeters are considered and data of their experimental investigation are given. It is pointed out that the errors of high-sensitivity milliammeters are chiefly provided by internal capacity, and those of high-current ammeters by skin effect. The errors of ammeters with flat and round heaters are given, and the optimum range of application of either of these heaters is determined." *Cf.* Kruse & Zinke, 1541 of April.

3136. Notes on Two-Dimensional Electric Field Problems [Formulae for Calculation of Capacity of Condenser of Section a Square within a Square, Diamond-wise].—F. Bowman. (*Proc. Lond. Math. Soc.*, 30th May, 1936, Series 2, Vol. 41, Part 4, pp. 271–277.)

3137. Calculation with Complete Elliptic Integrals [Tables eliminating Difficulties of Difference Building and Interpolation at Singular Points: Formulae: with Application to Calculation of Coil Constants].—F. Emde. (*Arch. f. Elektrot.*, 18th April, 1936, Vol. 30, No. 4, pp. 243–250.)

SUBSIDIARY APPARATUS AND MATERIALS

3138. Cathode-Ray Oscillograph Time-Base Deflection by Sinusoidal Alternating Current of Constant Frequency [*e.g.* from "Time-Controlled" Mains: for the von Ardenne Portable Oscillograph, for All Frequencies between 250 and 20 000 c/s.].—Leonhardt. (*Funktech. Monatshefte*, May, 1936, No. 5, pp. 181–184.)

The great advantages of a time deflection worked off the standard 50 c/s mains supply are theoretically countered by the fact that truly stationary images can only be obtained for frequencies which are whole multiples of 50 c/s. However, this condition can be fulfilled in a large number of cases, and the investigations here described show that even when it is not fulfilled the rate of movement of the image is not rapid enough to upset the eye. The rate is greatest when the frequency under investigation differs by 9–10 c/s from a multiple of 50 c/s: if the deflection amplitude is adjusted so that 5 complete periods appear on the screen, the image of a single wave form moves at a rate of about 0.72 km/hour, and even at close range such a movement can easily be followed by the eye. This is the worst condition; longer wave-trains move more slowly, and these are the ones which require most careful watching. An incidental advantage of the system is that on time-controlled mains it provides a means of checking the frequencies of note generators, etc.

The magnetic method of deflection is chosen for the sake of simplicity and shortening of the tube, avoidance of zero error in gas-concentrated tubes, and other advantages. The slope of the sine-wave current is only sufficiently linear for deflecting purposes over 40% of its full amplitude (on the assumption that at the edges of the screen the time scale can be 20% less extended than at the centre, where the steepest part of the curve is utilised). This involves a deflection amplitude at least 2.5 times the diameter of the screen, which means that the spot is visible on the screen for at most 1/5th of the total time: for it must be extinguished on the return stroke. This extinction is accomplished by applying a sinusoidal voltage to the Wehnelt cylinder, combined with a d.c. potential in such a way that it not only darkens the return stroke but also keeps the ray current below the limit at which the concentration begins to fail. Switching arrangements are provided by which the time deflection and return-stroke darkening can be cut out for photographic recording. The only external adjustments are for spot-focusing and deflection amplitude.

3139. A Cathode-Ray Time Axis for High Frequency.—Leeds. (*See* 3096.)

3140. Discussion on "A Cathode-Ray Oscillograph for the Direct Measurement of High-Voltage Transients." — Nuttall. (*Journ. I.E.E.*, June, 1936, Vol. 78, No. 474, pp. 714–716.) *See* 1574 of April.

3141. The Comparative Properties of Soft and Hard Cathode-Ray Tubes.—Bedford. (*See* 3095.)

3142. Cathode-Ray Oscillograph Apparatus.—Leybold & von Ardenne Company. (*See* 3130.)

3143. The Corona Rotation Effect [in Cathode-Ray Tubes] in Different Gases at Various Temperatures [Measurements].—Güntherschulze and Betz. (*Zeitschr. f. Physik*, No. 3/4, Vol. 100, 1936, pp. 269–272.) For previous work *see* 2880 of July.

3144. Electron-Optical Systems and Their Application [General Account].—Zworykin. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 17, 1936, pp. 170–183.)

The subjects dealt with in this survey of electron optics are: § 1. *The electron optics of picture reproduction;* electron-optical telescope (Fig. 1) and microscope (Fig. 3); electron lenses in the form of coaxial cylinders (Fig. 4), the potential distribution and electron paths therein (Fig. 5), the connection between magnification and tube dimensions (Fig. 6); distortions and their correction, in particular by the use of curved cathode surfaces and a potentiometer with concentrating rings inside the tube (Figs. 8, 9); arrangements of stops (Fig. 10); tube with variable magnification (Fig. 11); infra-red microscopy and photography (Figs. 14–17). § 2. *Electron optics of the secondary-emission multiplier;* scheme of statical-type multiplier (Fig. 18); fundamental principles of secondary emission, efficiency of multiplier, disturbance threshold of multiplier output, frequency variation; magnetic multipliers (Fig. 22), their general theory and practical construction (Fig. 24); electrostatic multipliers, *L*- and *T*-types of electrode arrangement (Figs. 27–30); use of multipliers as photoelectric amplifiers.

3145. Remarks on the Production of Rapid Charge Carriers [Electrons or Positive Particles] in Alternating Fields.—Brüche and Recknagel. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 17, 1936, pp. 184–187.)

This paper extends the writers' work on motion of electrons in electric and magnetic fields (2352 of June); eight different types of multiple accelerators may be expected from the three properties which characterise them: (1) the electron paths, (1a) linear or (1b) circular; (2) the potential field, corresponding to (2a) a stationary or (2b) a progressive wave; (3) the type of acceleration, (3a) discontinuous or (3b) continuous. The last division is not always clear-cut. The acceleration in linear paths is discussed (§ 1); the electrons move through cylinders at different potentials, which may be adjusted to give a variation comparable with that of a stationary wave or a progressive wave (Fig. 2). The acceleration in circular paths is dealt with in § 2; the magnetic-field accelerator of Lawrence & Livingston belongs to this type. Their duants may be replaced by condenser plates to obtain continuous acceleration, or by several sectors driven with multiphase voltage (*see* also Moon & Harkins, 2003 of May). The possible types are tabulated in the summary; some have not yet been investigated experimentally.

3146. Extinction of Fluorescence in Methylene Blue by Iron Salts.—Weber. (*Naturwiss.*, 15th May, 1936, Vol. 24, No. 20, p. 318.)

3147. The Characteristic Curve of the Photographic Plate [Equation for].—Houstoun. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1113–1119.)

3148. Observations on Vapour-Stream Vacuum Pumps [Use of Long Conical Funnels].—Klumb. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 17, 1936, pp. 201–202.)

3149. The Substitution of Mercury by Oil in Diffusion Vacuum Pumps.—Levinson. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1936, pp. 32–41.)

3150. A Method for the Mechanical Magnification of Small Movements. Application to the L.F. Oscillograph [Theory and Use of Plane Hinged Quadrilateral].—Bay. (*Zeitschr. f. Physik*, No. 3/4, Vol. 100, 1936, pp. 253–262.)

3151. Determination of the Electron Velocity [in Gas Discharges] by Probe Measurements.—Denecke and Lübcke. (*Physik. Zeitschr.*, 1st May, 1936, Vol. 37, No. 9, pp. 347–350.)

3152. Increase of Sparking Voltage [in Gas Discharges] by Ultra-Violet Irradiation.—Seitz and Fucks. (*Naturwiss.*, 29th May, 1936, Vol. 24, No. 22, p. 346.)

3153. A New Polarisation Effect in Discharge-Tubes [Variation of Sparking Potential with Nature of Previous Discharge].—Thomson. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1057–1066.)

3154. On the Functioning of a Controlled Rectifier on a Load of the Nature of a Constant Counter-Electromotive Force.—Babat and Rumjanzev. (*Izvestiya Elektroprom. Slab. Toka*, Nos. 5 and 6, 1936, pp. 40–47 and 52–65.)

3155. Transformers for Mercury-Vapour Rectifiers [and Their Special Requirements].—Buinier. (*Rev. Gén. de l'Élec.*, 6th June, 1936, Vol. 39, No. 23, pp. 845–846.)

3156. Theory of the Greinacher Circuit [for Voltage Doubling: Solution of Differential Equation].—Piesch. (*See* 2949.)

3157. The Destruction of an Adsorbed Barrier Layer by Pressure [of 4000 kg/cm² on PbS: Disappearance of Rectifying Properties.].—Trey. (*Physik. Zeitschr.*, 15th March, 1936, Vol. 37, No. 6, pp. 213–214.)

3158. Peltier Heat Effect in the Element $Cu/Cu_2O/Cu$ [Measurements of Thermo-voltage: Variation with Temperature].—G. Mönch. (*Zeitschr. f. Physik*, No. 5/6, Vol. 100, 1936, pp. 321–325.) For reference to preliminary communication *see* 795 of February.

3159. Ageing in Copper-Oxide Rectifiers [and the Need for Allowance in Design for any Particular Purpose].—Harty. (*Gen. Elec. Review*, May, 1936, Vol. 39, No. 5, pp. 244–245.) With resistance and efficiency curves.

3160. A Method for Producing "Flat-Topped" Resonance Characteristics from Simple Tuned Circuits.—Hadfield. (*See* 2944.)

3161. Coil Forms [Advantages of Laminated Bakelite: etc.].—Place. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, pp. 9 and 20.)

3162. Ceramic Materials [for Condenser Construction] of Increased Dielectric Constant.—E. Albers-Schönberg and A. Ungewiss. (*Hochf:tech. u. Elek:akus.*, March, 1936, Vol. 47, No. 3, pp. 95–98: Industry Review.)

An account of the dielectric properties of titanium dioxide, their variation with temperature, and the treatment required to evolve a useful insulating ceramic material from it. Curves of the loss factor as a function of frequency (Fig. 1) and temperature (Fig. 2) are given for an older and a modern material. Photographs of various types of condenser are shown in Figs. 3–5, and a table of ceramic materials correct to January, 1936, is given.

3163. The Structure of Glass [Summarising Account of Modern Theories: Experimental Curves.].—Büssem and Weyl. (*Naturwiss.*, 22nd May, 1936, Vol. 24, No. 21, pp. 324–331.)

3164. Direct Voltage Measurements [of Dielectric Properties] on Electrolytically-Produced Aluminium Oxide [Surface and Volume Conductivity: Breakdown Voltage: After-Effects].—Franckenstein. (*Ann. der Physik*, Series 5, No. 1, Vol. 26, 1936, pp. 17–54.)

3165. Investigation of Aluminium Oxides by the Electron Interference Method [including Crystalline Structure of Electrolytic Oxide Films].—Belwe. (*Zeitschr. f. Physik*, No. 3/4, Vol. 100, 1936, pp. 192–196.)

3166. Investigations on Low-Melting-Point Insulating Materials [Paraffin and Other Waxes: Special Technique: Loss Factor and Dielectric Constant measured as Functions of Temperature].—Vieweg and Pfestorf. (*E.T.Z.*, 28th May, 1936, Vol. 57, No. 22, pp. 632–636.) No instability was observed at the passage from liquid to solid stage.

3167. The Use of Halowax for the Impregnation of D.C. Low-Voltage Condensers [Replacement of Paraffin Wax in Paper Condensers increases Capacity by 15–20%: Breakdown Voltage unchanged: Insulation Resistance slightly decreased].—Bogoroditzky and others. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1936, pp. 65–72.)

3168. Tests on Oil-Impregnated Paper.—Race. (*Elec. Engineering*, June, 1936, Vol. 55, No. 6, pp. 590–599.)

3169. An Electrical Investigation of the Polymerising Oxidation Processes in Liquid Dielectrics [Drying Oils].—Lazarev and Raschektaev. (*Tech. Phys. of USSR*, No. 4, Vol. 3, 1936, pp. 366–388: in English.)

3170. Materials used in Radio Manufacture [with Particular Attention to Insulating Materials].—V. O. Stokes. (*Marconi Review*, March/April, 1936, No. 59, p. 7–18.)

3171. Conduction of Electric Current by means of Convection and Diffusion. II [Theory of Two-Dimensional Current Flow in Dielectric Liquids and Gases including Effect of Diffusion: Numerical Solutions].—Borgnis. (*Zeitschr. f. Physik*, No. 7/8, Vol. 100, pp. 478–512.) For I *see* 2815 of July.

3172. Elementary Theory of the Critical Field of a Dielectric.—Cernuschi. (*Proc. Camb. Phil. Soc.*, May, 1936, Vol. 32, Part 2, pp. 276–280.)

3173. Variation of the Secondary Electron Emission from Insulators and Semi-conductors by Electron Irradiation.—Knoll. (*See* 3037.)

3174. Litz Wire and its Use in the Construction of Coils [Correction of Possible Misapprehension].—Saic. (*Funktech. Monatshefte*, May, 1936, No. 5, p. 196.) *See* 731 of February.

3175. THE DESIGN OF RADIO-FREQUENCY CHOKE COILS [to avoid "Kinks" in Curve of Apparent Capacitance, representing Overtones for which the Coil has Maximum Values of Excess Shunt Conductance].—Wheeler. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 850–858.)

3176. MAGNETITE-CORE I.F. COILS [of Variable Inductance by Adjustable Moulded Core of Magnetite Powder].—Carlson: RCA Victor. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, p. 18.)

3177. DEMAGNETISATION CONDITIONS FOR RHOMBOHEDRIC IRON SESQUIOXIDE [Effect of Temperature Variation].—Michel. (*Comptes Rendus*, 25th May, 1936, Vol. 202, No. 21, pp. 1769–1771.)

3178. THE QUANTUM THEORY OF THE TEMPERATURE DEPENDENCE OF THE MAGNETISATION CURVE [Derivation of Expression for Anisotropic Constant: Calculation of Magnetisation Curve for Any Temperature near the Curie Point].—Akulov. (*Zeitschr. f. Physik*, No. 3/4, Vol. 100, 1936, pp. 197–202.)

3179. REMARKS ON THE HIGH-FREQUENCY IRON "SIRUFER" AND ITS FURTHER DEVELOPMENT [Material "Sirufer 4"; Quality of H.F. Iron-Cored Coils: Measurement of Losses in Coils: Quality of Core Material: Adjustment of Self-Inductance: New Core Forms: Example of Input Band Filter with Sirufer Cores].—Nottebrock and Weis. (*Hochf:tech. u. Elek:akus.*, March, 1936; Vol. 47, No. 3, pp. 100–103.) The paper referred to in 2818 of July.

3180. THE MAGNETO-DYNAMIC RELATION BETWEEN VISCOUS LOSSES AND PERMEABILITY IN VERY WEAK FIELDS [at Audio Frequencies: Remarks on and Comparison of Results of Previous Papers].—Arkadiew. (*Comptes Rendus*, 2nd June, 1936, Vol. 202, No. 22, pp. 1840–1841.) *See* Goldschmidt, Abstracts, 1933, p. 112, and 2417 of June; Arkadiew, 1984 of May; and Veletzkaia, 2831 of July.

3181. THE ACTION OF CONDUCTING SCREENS ROUND HIGH-FREQUENCY COILS.—Bachstroem. (*Arch. f. Elektrot.*, 18th April, 1936, Vol. 30, No. 4, pp. 267–275.) "Curves are calculated from which the optimum amount of screening for a given coil can be obtained immediately for any given time constant, effective impedance or inductance."

3182. ELECTROMAGNETIC SHIELDING EFFECT OF AN INFINITE PLANE CONDUCTING SHEET PLACED BETWEEN CIRCULAR COAXIAL COILS [Analysis leading to Highly Accurate and also Approximate and Convenient Formulae].—Levy. (*Proc. Inst. Rad. Eng.*, June, 1936, Vol. 24, No. 6, pp. 923–941.)

"It will be shown, among other things, that placing a plane conducting sheet of thickness T cm and percentage conductivity γ between and perpendicular to the common axis of two circular coils of radius A cm will cause a drop in the cross-talk between them of $10 \log[(AT\gamma f/78.8)^2+1]$ db at a frequency of f cycles/sec."

3183. MAGNETIC SCREENING OF APPARATUS [by Nickel/Iron Alloys].—(*Nature*, 9th May, 1936, Vol. 137, p. 787: note on paper in *Nickel Bulletin*.)

3184. THE NEW PERMANENT MAGNET ALLOYS [with Patent References and Other Data].—(*Electronics*, May, 1936, Vol. 9, No. 5, pp. 30–32 and 35.)

3185. MAGNETIC CIRCUIT CALCULATIONS [and Their Use in connection with the New Permanent-Magnet Alloys].—Friend. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, pp. 15–16.)

3186. THE APPEARANCE OF FERROMAGNETISM IN SOME PARAMAGNETIC SALTS [Ammoniacal Iron Alum] AT VERY LOW TEMPERATURES.—Kürti and others. (*Comptes Rendus*, 11th May, 1936, Vol. 202, No. 19, pp. 1576–1578.)

3187. THE VARIATION OF YOUNG'S MODULUS WITH MAGNETISATION AND TEMPERATURE IN NICKEL [Measurement with Composite Piezoelectric Oscillator: Comparison with Akulov's Theory].—Siegel and Quimby. (*Phys. Review*, 1st May, 1936, Series 2, Vol. 49, No. 9, pp. 663–670.)

3188. LUMINOUS DISCHARGES OBSERVED IN A MAGNETIC FIELD AT PRESSURES BELOW 10^{-4} MM HG.—Jonescu. (*See* 2954.)

3189. THE INFLUENCE OF A SHORT-CIRCUITED TURN UPON THE ACTION OF AN A.C. ELECTROMAGNETIC RELAY.—Potapov. (*Izvestiya Elektroprom. Slab. Toka*, No. 6, 1936, pp. 36–42: to be continued.) For such a relay *see* 2406 of June.

3190. AN IMPROVEMENT IN RELAY CONTROL CIRCUITS [closing by Slow Progressive Motion: Chattering avoided by using Three Contact Points and a Single Resistance].—Chapin. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, p. 258.)

3191. CIRCUIT TECHNIQUE OF CURRENT STABILISERS ["Urdox" and "Iron-Urdox"] IN "UNIVERSAL" RECEIVERS.—Sutaner. (*See* 3015.)

3192. A NEW FRICTION SPEED REGULATOR COMPENSATED BY A CENTRIFUGAL GOVERNOR [Less than 1.4 per 1000 Speed Variation for Load Variation of 40%].—Doignon. (*Rev. Gén. de l'Élec.*, 6th June, 1936, Vol. 39, No. 23, pp. 819–821.)

3193. A NEW [Valve] METHOD OF SYNCHRONISATION OF D.C. MOTOR SPEED OF ROTATION AT A GIVEN FREQUENCY.—L. D. Brithgev. (*Izvestiya Elektroprom. Slab. Toka*, No. 5, 1936, pp. 35–39.)

Author's summary:—"A new method . . . proposed and developed by the author is described . . . It gives a more reliable synchronisation than the commonly used Lacour wheel. The change of motor load to double, or an 8% variation of the voltage feeding the rotor, still do not bring the motor out of synchronisation. The arrangement is very simple and requires no auxiliary supply sources. When used for the synchronisation of a tuning-fork generator, the speed variations are of the order of 0.001%. The equipment is used for the rotation of a commutator in the Maxwell-Thomson method of measuring capacity."

The difference between the new method and that of Voorhoeve & de Jong (1933 Abstracts, p. 112) is seen from the diagrams (6–7 and 1, respectively). In the new method the frequency f, of an alternator rigidly coupled to the motor, and the standard frequency f_0, are fed through separate transformers to two coils in series, in the grid circuit of a triode whose anode circuit is in series with the motor field-winding.

3194. A Stabilised Mains Unit for Counter Tubes [D.C. Volts around 1500, with Single Knob Adjustment: Variation only 4‰ for 10% Mains Voltage Change].—Baldinger. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 9, 1936, pp. 327–328: in German.)

3195. Note on Disc-Type Electrostatic Generators [and Their Practicality for producing Currents up to 10 Milliamperes at Voltages up to 200 Kilovolts].—Dahl. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 254–256.)

3196. A Direct-Current Voltage Multiplier [Number of Condensers permanently in Series and Charged Rapidly in Succession by Rotating Brushes: for Bias for Kerr Cells and Counters, and other High-Voltage D.C. Devices.].—Anderson. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 243–245.) A step-up of 46 : 1 has been obtained with an efficiency exceeding 75%. The output voltage is quite steady under normal operating conditions.

3197. A Portable High-Frequency High-Voltage Test Oscillator [20–100 kc/s, up to 50 kV].—Ford and Leonard. (*Gen. Elec. Review*, May, 1936, Vol. 39, No. 5, pp. 246–248.)

3198. The Design, Operation and Performance of the Round Hill Electrostatic Generator.—van Atta, Northrup, van Atta and van de Graaff. (*Phys. Review*, 15th May, 1936, Series 2, Vol. 49, No. 10, pp. 761–776.)

3199. The [Crystal] Structure of Thin Metallic Films vaporised on Rock-Salt [determined by Electron Diffraction].—Brück. (*Ann. der Physik*, Series 5, No. 3, Vol. 26, 1936, pp. 233–257.)

3200. The Diffusion of Gases through Metals. III.—The Degassing of Nickel and the Diffusion of Carbon Monoxide through Nickel.—Smithells and Ransley. (*Proc. Roy. Soc.*, Series A, 18th May, 1936, Vol. 155, No. 884, pp. 195–212.)

3201. The Electrical Resistance of Bismuth Alloys [No Negative Temperature Coefficient].—Thompson. (*Proc. Roy. Soc.*, Series A, 18th May, 1936, Vol. 155. No. 884, pp. 111–123.)

3202. Self-Supporting Multi-Core Overhead Cable.—Thiel. (*Zeitschr. V.D.I.*, 9th May, 1936, Vol. 80, No. 19, pp. 573–574.)

3203. Impulse Counter for Rapid Successions of Impulses [Simple, Reliable Circuit counting up to 3000 Impulses per Sec.].—Barnóthy and Forró. (*Physik. Zeitschr.*, 15th March, 1936, Vol. 37, No. 6, pp. 208–211.)

3204. The Residual Effect in [Geiger-Müller] Counters [Effects of Constructional Asymmetry, Electrode Gas, etc.].—Christoph. (*Ann. der Physik*, Series 5, No. 2, Vol. 26, 1936, pp. 145–166.)

3205. Polarising Characteristics of Polaroid Plates.—Ingersoll & others. (*See* 3099.)

3206. "Lens-Disc" High-Speed Cinematography [5000 Pictures per Second].—Rassweiler and Withrow. (*Science*, 24th April, 1936, Vol. 83, Supp. p. 9.)

3207. X-Ray Diagnosis for Telephone Apparatus [including Valves].—Abbott. (*Bell Lab. Record*, June, 1936, Vol. 14, No. 10, pp. 339–342.)

STATIONS, DESIGN AND OPERATION

3208. Micro-Ray Communication.—McPherson and Ullrich. (*Journ. I.E.E.*, June, 1936, Vol. 78, No. 474, pp. 629–657: Discussion pp. 658–667.) The full paper, summaries of which were referred to in 1341 of April and 2069 of June.

3209. Application of Ultra-Short-Wave Telephony to Shunting Locomotives.—(*Rev. Gén. de l'Élec.*, 6th June, 1936, Vol. 39, No. 23, p. 183 D: summary only.)

3210. Carrier-Frequency Broadcasting along Overhead Lines.—Werrmann. (*E.T.Z.*, 18th June, 1936, Vol. 57, No. 25, pp. 707–710.)

In Section I the requirements of a broadcasting system are enumerated and discussed: it is concluded that a high-quality system involves a frequency range of 30–8000 c/s and a contrast range of 100 : 1. Section II shows that these requirements can be completely fulfilled by transmission along overhead lines, provided that a h.f. carrier method is used.

The advantages of single side-band working, with suppressed carrier, are explained: the suggestion that the carrier, instead of being suppressed entirely, should merely be reduced so as to consume little power compared with the side-band, is examined, and its objections pointed out. Finally, the great advantage of the multiple utilisation of the overhead line by various types of telephony and telegraphy, while only the upper region of the spectrum is taken up by the carrier-current broadcasting programme, is illustrated by Fig. 8. The paper will be concluded in another issue, when the practical solution of the three main problems formulated in the present part will be described—namely the practically complete suppression of the carrier, by the "ring" modulator; the suppression of one side-band, by a crystal filter; and the restoration, at the receiving end, of the missing carrier.

3211. HIGH-FIDELITY RADIO BROADCASTING [an Account of Station WOR of the Bamberger Broadcasting Service].—Owens. (*Bell Lab. Record*, June, 1936, Vol. 14, No. 10, pp. 325–329.)

3212. APPLICATION OF THE MULTIPLE MODULATION SYSTEM TO A MODERN BROADCASTING STATION [Nice, Côte d'Azur].—Fayard. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 348–361.)

The elementary theory of this modulation system was dealt with in 1933 Abstracts, p. 621. Applied to the Nice 60 kw Station, the system has fulfilled its theoretical promise. The carrier wave is modulated 5 times: more powerful carriers might well be modulated 8 times. In the present transmitter there are two linear modulations on the grids, in the low and medium power stages; one non-linear modulation on the penultimate stage or the exciting stage of the output stage (actually occurring over only about 15° of the modulation cycle, in the part corresponding to the smallest h.f. amplitudes, to correct distortion due to the bottom bends of the valve characteristics); one linear grid modulation of the exciting stage, increasing the percentage of modulation produced by the preceding stages; and one non-linear (absorption-type) modulation on the grid circuit of the output power stage (during about 100° of the cycle in the region of h.f. amplitudes superior to the carrier amplitude). This last modulation has two objects, the correction of distortion due to the impedance variation in the grid circuit, and the increase of the efficiency.

The writer concludes: "A station equipped with a system of constant energy from the mains barely exceeds an efficiency of 22–24%; with the multiple-modulation system the overall efficiency may easily reach 30%; the economy of consumption which it thus allows to be obtained is about 20%."

3213. BROADCAST COVERAGE [N.B.C. Survey: Methods of Measurement: Influence of Soil: etc.].—Guy. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 16–19.)

3214. SITE-TESTING [B.B.C. Methods in Selecting a Station Site].—Baily. (*Wireless World*, 12th June, 1936, Vol. 38, pp. 578–580.) The site for the proposed new transmitter for the South Coast area is taken as an example.

3215. BROADCASTS FROM THE "QUEEN MARY" [Technical Arrangements].—(*World-Radio*, 22nd May, 1936, Vol. 22, pp. 10–11.)

3216. THE QUEEN MARY'S WIRELESS.—(*Wireless World*, 29th May, 1936, Vol. 38, pp. 526–528.)

3217. SHORT-WAVE WIRELESS EQUIPMENT ON MOTOR BOATS OF BERLIN RIVER POLICE.—(*E.T.Z.*, 18th June, 1936, Vol. 57, No. 25, p. 706.)

3218. RADIOTELEPHONIC INSTALLATIONS IN TRAINS [French Railways].—(*Génie Civil*, 13th June, 1936, Vol. 108, pp. 564–565.)

3219. PRESENT STATUS OF RADIO COMMUNICATION SYSTEMS OF THE JAPANESE GOVERNMENT RAILWAYS.—Abe. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 37.) Including u.s.w. telephone equipment for snow ploughs.

GENERAL PHYSICAL ARTICLES

3220. THE NATURE OF LIGHT [Reply to Criticisms].—J. J. Thomson. (*Nature*, 16th May, 1936, Vol. 137, pp. 823–824.) *See* 2870 of July and back reference.

3221. ON MAGNETIC AND ELECTRIC ENERGY [Formulae independent of Magnetic-Field/Induction and Electric-Field/Displacement Relationships], *and* THE THERMODYNAMICS OF MAGNETISATION [Formulae: Magnetic Equation of State: Adiabatic Changes: Systems maintained at Constant Pressure].—Guggenheim. (*Proc. Roy. Soc.*, Series A, 18th May, 1936, Vol. 155, No. 884, pp. 49–70: pp. 70–101.)

3222. COLLECTIVE ELECTRON SPECIFIC HEAT AND SPIN PARAMAGNETISM IN METALS [Theory: General Condition for Ferromagnetism].—Stoner. (*Proc. Roy. Soc.*, Series A, 1st May, 1936, Vol. 154, No. 883, pp. 656–678.)

3223. AN EXPERIMENTAL EXAMINATION OF THE ELECTROSTATIC BEHAVIOUR OF SUPRACONDUCTORS [with A.C. Bridge Circuit measuring Large Capacity Change by Low Measuring Voltage: No Electrostatic Fields exist in Pure Supraconductor].—London. (*Proc. Roy. Soc.*, Series A, 18th May, 1936, Vol. 155, No. 884, pp. 102–110.)

3224. RECENT WORK ON THE COMPTON EFFECT [and the Inadequacy of Photon Theory suggested by Shankland's Experiment indicating Non-Simultaneity of Scattered Photon and Recoil Electron].—Hill. (*Review Scient. Instr.*, June, 1936, Vol. 7, No. 6, pp. 225–228.)

3225. THE PHYSICAL SIGNIFICANCE OF ACTIVITY COEFFICIENTS IN REVERSIBLE ELECTRODE EQUILIBRIA [with Corresponding Adsorption Potentials].—Belton. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1140–1144.)

3226. THE POSSIBILITY OF IONISATION BY COLLISION IN LIQUIDS [negatived by Experimental Photocurrent/Field-Strength Curves].—Reiss. (*Naturwiss.*, 15th May, 1936, Vol. 24, No. 20, pp. 317–318.)

3227. THE CORONA ROTATION EFFECT [in Cathode-Ray Tubes].—Güntherschulze and Betz. (*See* 3143.)

3228. THE ELECTRICAL RESISTANCE OF DILUTE SOLID SOLUTIONS [of One Metal in Another: Theory].—Mott. (*Proc. Camb. Phil. Soc.*, May, 1936, Vol. 32, Part 2, pp. 281–290.)

3229. Recent Questions and Views on Dimensions, Units and Measuring Systems of the Electromagnetic Quantities [Number of Fundamental Units and Dimensions: Absolute and Practical Systems: Possibility of Calculation without Measuring System].—Fischer. (*Zeitschr. f. Physik*, No. 5/6, Vol. 100, 1936, pp. 360–373.)

MISCELLANEOUS

3230. Application of Electrical Circuits to the Graphical Integration of Differential Equations [New Apparatus at Massachusetts Institute].—Minorsky. (*Rev. Gén. de l'Élec.*, 30th May, 1936, Vol. 39, No. 22, pp. 787–794.)

3231. A Machine for solving Systems of Linear Equations [Principles of Construction].—Vidal. (*Comptes Rendus*, 25th May, 1936, Vol. 202, No. 21, pp. 1748–1751.)

3232. A Numerical Method for Two-Dimensional Fourier Synthesis [Use of Sets of Card Strips].—Beevers and Lipson. (*Nature*, 16th May, 1936, Vol. 137, pp. 825–826.)

3233. Calculation with Complete Elliptic Integrals.—Emde. (*See* 3137.)

3234. On Operational Representations of Confluent Hypergeometric Functions and Their Integrals.—Dhar. (*Phil. Mag.*, June, 1936, Series 7, Vol. 21, No. 144, pp. 1082–1096.)

3235. "Calcul des Probabilités" [Book Review].—Pomey. (*Génie Civil*, 16th May, 1936, Vol. 108, No. 20, p. 480.)

3236. Radio, Ether, Audible and Photoelectric Spectra [Chart].—(*Electronics*, May, 1936, Vol. 9, No. 5, inset between pp. 44 and 45.)

3237. The Effect of Ultra-Short Waves on Various Bacteria.—Sasada, Nakamura and Wakabayashi. (*Journ. I.E.E. Japan*, February, 1936, Vol. 56 [No. 2], No. 571, pp. 94–97: English summary p. 11.) For previous work *see* 1275 of 1935. Among various results, typhoid bacilli suspended in salt solution and heated by short waves were destroyed more rapidly than when heated in a water bath to the same temperature.

3238. The Production of Electricity by Bacteriological Phenomena [*e.g.* Fermentation].—Génin: Potter. (*Rev. Gén. de l'Élec.*, 6th June, 1936, Vol. 39, No. 23, pp. 821–824.)

3239. Lethal Effects of Ultra-Short Waves [and the Pathological and Bacteriological Section of the Radio Society of Great Britain].—(*Electrician*, 12th June, 1936, Vol. 116, p. 748.)

3240. The Scientific Value of "Radiesthesia" [Water Divining, Disease Diagnosis, etc: Adverse Criticism].—Lumière. (*Génie Civil*, 30th May, 1936, Vol. 108, No. 22, pp. 517–518: summary only.)

3241. On the So-Called "Radioactive Phenomena of Second Order and of Artificial Origin" reported by Reboul.—Eichenberger: Reboul. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 9, 1936, pp. 334–336.)

3242. The Cause of Deaths by Low-Voltage Electric Shocks [Sensitivity of Heart varies with Point in Heart-Cycle when Shock occurs: "Counter-Shock" as Antidote to Fibrillation], *and* The Effect of Electric Shock on the Heart.—Williams and others: Ferris and others. (*Science*, 15th May, 1936, Vol. 83, Supp. p. 9: *Elec. Engineering*, May, 1936, Vol. 55, No. 5, pp. 498–515.)

3243. Valve Relay, controlled by Relaxation Oscillations, as Timing Device for Seam Welding.—Duinker. (*Philips Tech. Review*, January, 1936, Vol. 1, No. 1, pp. 11–15.)

3244. Electronic Welding Timers.—Weiller. (*Electronics*, May, 1936, Vol. 9, No. 5, pp. 26–28 and 38.)

3245. Electron Devices used in Spark Plug Industry.—Frost. (*Electronics*, May, 1936, Vol. 9, No. 5, p. 44.)

3246. British Highway Safety studied with Electronic Instruments.—(*Electronics*, May, 1936, Vol. 9, No. 5, pp. 46 and 48.)

3247. Fault Detection in Metals by Magnetic Methods [including Magnetic Powder Methods].—Metropolitan-Vickers Company. (*Engineering*, 8th May, 1936, Vol. 141, pp. 504–505.)

3248. Cathode-Ray Oscillograph [with Carbon-Pile Pressure Element] for Oil-Engine Injection Research.—(*Engineer*, 1st May, 1936, Vol. 161, pp. 456–458.) The carbon pile method was chosen in preference to piezoelectric, photoelectric and capacity-variation methods.

3249. Electrically Indicating Measuring Apparatus for Rapid Pressure Changes.—Hasse: Schnauffer. (*See* 3049.)

3250. "The Measurement of Rapid Changes of Form with the Help of a Condenser Micrometer."—Löffler. (*Stuttgart Thesis*: in German. At Patent Office Library, London: Cat. No. 76 179.)

3251. The Plane Hinged Quadrilateral as a Means of Mechanical Magnification of Small Movements.—Bay. (*See* 3150.)

3252. The Influence of H.F. Oscillations on the Positive Point Discharge.—Deutsch. (*See* 2924.)

3253. Radio-Controlled Lighthouse Functions entirely without Keeper.—(*Electronics*, May, 1936, Vol. 9, No. 5, p. 50.)

3254. A New Type of Photocell "Watchdog" [requiring One Point only: can cover Large Areas from a Distance: spots Aeroplanes: operates Nature Camera: etc.]—R. L. Ashmore. (*Television*, June, 1936, Vol. 9, No. 100, pp. 325–327.) An American device. Identical images of the scene are thrown on two reversed "chess board" screens each feeding its own photocell. *Cf.* 1639 of April.

3255. Application of Conventional Vacuum Tubes in Unconventional Circuits [including Simple Two-Stage Photocell Amplifier Relay for A.C. Mains (using Only Two Resistances and Three Condensers) and a Valve Multiplier for Small D.C. Currents from High-Impedance Sources].—Shepard. (*Rad. Engineering*, May, 1936, Vol. 16, No. 5, pp. 8 and 20: *Electronics*, June, 1936, Vol. 9, No. 6, pp. 34, 36, and 38: summaries of I.R.E. Convention paper.)

3256. Flickering of Incandescent Lamps with Alternating Current [with Circuit for Measurement using Photocell and Cathode-Ray Tube].—van Liempt and de Vriend. (*Zeitschr. f. Physik*, No. 3/4, Vol. 100, 1936, pp. 263–266.)

3257. Talbot's Law in Photoelectric Photometry.—Boutry. (*See* 3109.)

3258. A Portable Blocking-Layer Photocell Pyrometer [Small and Easily Operated].—Hubing. (*Journ. Opt. Soc. Am.*, June, 1936, Vol. 26, No. 6, pp. 260–261.)

3259. Use of Photocells in Measuring Technique.—Wulff: Schuhfried. (*See* 3120 and 3121.)

3260. Tube Control of A.C. Motors [Cheap and Effective Methods, for Small Motors, using Broadcast Receiver Valves].—Ryder. (*Electronics*, April, 1936, Vol. 9, No. 4, pp. 31–33.)

3261. Modern Adaptations of Electron Tubes in Industry [2° Discrimination in 1650°F by Photocell, in Car Valve-Stem Hardening: Automatic Paint-Sprays controlled by Capacity-Sensitive Device].—Powers. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, pp. 549–550: summary only.)

3262. Applications of Photoelectric Cells [to Problems of Daylight Illumination, etc.].—Walker: McDermott: Hall. (*Nature*, 2nd May, 1936, Vol. 137, pp. 734–735: notes on recent papers to the Illuminating Engineering Society.)

3263. An Automatic Potentiometer for Thermal Analysis [with Photocell Control].—Payne. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, pp. 158–161.) *Cf.* 2750 of July.

3264. Applications of the Photoelectric Recorder.—Carson. (*Gen. Elec. Review*, April, 1936, Vol. 39, No. 4, pp. 189–193.)

3265. G.P.O. Clock announces Time over Telephone.—(*Electronics*, April, 1936, Vol. 9, No. 4, p. 36.)

3266. Recent Progress in Radio Technique: Third Exhibition-Demonstration of Wireless Components, Accessories and Valves (Paris, Feb. 1936).—Adam. (*Rev. Gén. de l'Élec.*, 9th May, 1936, Vol. 39, No. 19, pp. 689–699.) *See* also 2501 of June.

3267. The National Physical Laboratory: Report for 1935 [Review].—(*Electrician*, 8th May, 1936, Vol. 116, p. 604.)

3268. Paris Meeting of the U.I.R., February, 1936.—(*Alta Frequenza*, April/May, 1936, Vol. 5, No. 4/5, pp. 320–325.) Including table of television data for European countries.

3269. Eleventh I.R.E. Annual Convention: Summaries of Papers to be read.—(*Proc. Inst. Rad. Eng.*, May, 1936, Vol. 24, No. 5, pp. 681–687.) *See* also *Electronics*, May, 1936, pp. 11–15, and *Rad. Engineering*, May, 1936, pp. 5–8 and 20.

3270. The Stand of the Ministry of Posts, Telegraphs and Telephones at the First Colonial French Salon.—Labrousse and Villeneuve. (*Ann. des Postes T. et T.*, March, 1936, Vol. 25, No. 3, pp. 275–288.)

3271. Radio at the Leipzig Spring Fair, 1936.—Gross. (*Radio, B., F. für Alle*, April, 1936, pp. 71–74.)

3272. Works and Researches of the Laboratoire National de Radioélectricité in the Year 1935.—C. Gutton. (*Ann. des Postes T. et T.*, March, 1936, Vol. 25, No. 3, pp. 213–221.)

3273. Outline of the Electrotechnical Laboratory, Ministry of Communications, Japan.—(pub. by Gotanda, Shinagawa-ku, Tokyo: 47 pp, in English.) With list of publications from 1931 to 1935.

3274. Latest Trend of Developments in Telecommunication Engineering.—Kajii. (*Rep. of Rad. Res. in Japan*, December, 1935, Vol. 5, No. 3, Abstracts p. 23.) Including the development of super-permalloy and Furukawa magnetic alloy.

3275. Organisation of Radio Research in India [Note on Development of Radio Research Boards in the British Empire: Desirability of Inauguration of One in India].—(*Nature*, 23rd May, 1936, Vol. 137, pp. 841–842.) *See* also *Science & Culture*, Calcutta, June, 1936, Vol. 1, No. 13, pp. 755–758.

3276. The U.I.R. Reunions in Warsaw (1935) and Paris (1936).—(*Journ. des Télécommunications*, July, 1935, Vol. 2, pp. 185–193: March, 1936, Vol. 3, pp. 75–81.) For summaries see *Rev. Gén. de l'Élec.*, 30th May, 1936, pp. 810–812.

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

443 018.—Coupling arrangement between the feed line and the aerials in a short-wave directional system.
W. S. Persival. Application date 19th July, 1934.

2 008 931.—Transmitting aerial of the half-wave self-supporting type in which a plate-condenser carried by the piers serves to minimise ground losses.
C. E. Schuler (assignor to International-Stacey Corporation).

2 018 324.—Balancing a high-frequency transmission line with respect to ground, and eliminating the " antenna " effect.
O. Schmidt (assignor to Telefunken Co.).

TRANSMISSION CIRCUITS AND APPARATUS

443 150.—Lecher-wire circuit for rejecting harmonic frequencies in a wireless transmitter.
Marconi's W.T. Co. and D. E. O'Donovan. Application date 21st July, 1934.

444 050.—Transmitting-circuit in which anode voltage and grid-bias are independently and simultaneously regulated according to the amplitude of the applied modulation signals.
C. Lorenz Akt. Convention dates (Germany) 2nd May and 20th July, 1934.

2 026 005.—To reduce side-band " spread " television signals are modulated first on a low-powered high-frequency carrier-wave which is, in turn, superposed on a high-powered low-frequency carrier.
G. Wald.

2 027 527.—Radio navigation system in which a facsimile of the aerodrome, on which the moving aeroplane is superposed, is transmitted by television to the pilot in the air, as he prepares to land.
J. H. Hammond, Junr.

RECEPTION CIRCUITS AND APPARATUS

442 897.—Wireless receiver in which a rough or searching movement of the tuning controls is followed by an automatic readjustment to a desired station.
E. K. Cole and G. Bradfield. Application date 14th September, 1934.

442 903.—Broadcast receiver in which a knob controlling the degree of noise suppression also serves to modify the circuits to ensure optimum reproduction.
E. K. Cole and E. J. Wyborn. Application date 28th September, 1934.

443 046.—Superhet receiver for television designed to simplify the separation of the carrier-wave from the demodulated picture signals.
Radio Akt. D. S. Loewe. Convention date (Germany) 4th November, 1933.

443 172.—Tuning dial and system in which the various stations are grouped together according to their nationality.
Ideal Werke Akt. fur drahtlose Telephonie. Convention date (Germany) 9th December, 1933.

443 270.—Selective receiver designed to receive the carrier wave and one only of its associated side-bands, and provided with automatic gain-control.
Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 3rd October, 1933.

443 363.—Automatic tuning system involving the use of a magnetic brake which is released until the circuits are in resonance and then operated to hold them there.
E. K. Cole and G. Bradfield. Application date 26th July, 1934.

443 423.—Automatically correcting for an initial mistuning of the circuits of a superhet set.
Murphy Radio ; G. B. Baker ; and G. F. Hawkins. Application dates 25th July and 4th December, 1934.

443 505.—Automatically correcting the initial mistuning of a superhet receiver.
E. K. Cole ; A. W. Martin ; and F. A. Inskip. Application date 20th September, 1934.

443 637.—Remote control of a superhet receiver by varying the frequency of the local oscillator valve through a reactance located at a distance from that valve
Marconi's W. T. Co. ; N. M. Rust ; and J. D. Brailsford. Application date 3rd August, 1934.

444 391.—Muting circuit with a delay action which is designed to silence any strong stations that would otherwise be heard in changing over from one programme to another.
F. T. Lett. Application date, 17th July, 1934.

444 881.—Combined television and sound receiver on which both signals are heterodyned by a common local oscillator having a frequency lying between the two signal frequencies.
Radio Akt. D. S. Loewe. Convention date (Germany), 1st July, 1933.

2 010 014.—Preventing distortion due to valve curvature by the application of A.V.C.
H. F. Elliott.

2 010 252.—Muting arrangement for a wireless receiver depending upon a high-frequency pentode valve having a resistance in the anode circuit designed to produce a " falling " characteristic.
L. E. Barton (assignor to Radio Corporation of America).

2 020 656.—Motor-car provided with a number of separate aerials and a common aerial tuning inductance to give remote-control wave-band switching.
C. W. Renz.

VALVES AND THERMIONICS

442 519.—Construction of cathode ray tube designed to minimise the risk of *implosion.*
Radio Akt. D. S. Loewe. Convention date (Germany), 10th July, 1933.

442 776.—Magnetron type of valve in which the magnetic field and anode potential are so chosen as to increase the transit time of the electrons beyond the normal half-cycle period.
Marconi's W. T. Co. and W. E. Benham. Application date, 14th June, 1934.

DIRECTIONAL WIRELESS

443 426.—Quasi-optical reflectors, comprising a number of low-pressure discharge tubes, for ultra-short waves.
Marconi's W. T. Co. (assignees of V. K. Zworykin). Convention date (U.S.A.)31st August, 1933.

2 023 891.—Direction-finder fitted with automatic means for correcting the so-called quadrantal error.
L. L. Kaess.

2 026 254.—Direction-finding system in which two differently-orientated frame aerials are used, the voltage pick-up on one being applied to regulate the amplification factor of the other.
M. Sandfort (assignor to H. N. Wolff).

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

2 008 704.—Low-frequency amplifier in which grid-bias derived from the signal input is applied to two control valves so that amplification is intensified with increasing volume so as to expand the dynamic range.
J. H. Hammond.

TELEVISION AND PHOTOTELEGRAPHY

442 531.—Transverse-current carbon microphone comprising a number of cells connected by their flexible metal-foil.
H. J. Round. Application date, 8th August, 1934.

442 666.—Television transmitter in which a mosaic cell surface is associated with a photo-sensitive electrode in a cathode-ray tube.
H. G. Lubszynski and S. Rodda. Application date, 12th May, 1934.

442 682.—Cathode-ray tube in which the anode voltage is kept constantly related to the scanning or deflecting voltages.
Marconi's W. T. Co. and A. J. Young. Application date, 29th September, 1934.

442 740.—Scanning oscillation-generators wherein the curvature of discharge is at least equal to the duration of an image point in the picture.
Radio Akt. D. S. Loewe. Convention dates (Germany) 14th and 21st August, 1933.

442 963.—Viewing screen for a cathode-ray tube in which the effect of the electron stream is assisted by the application of a direct heating-current.
J. L. Baird and Baird Television. Application date, 19th December, 1934.

443 012.—Scanning system in which the lines are held continuously in synchronism even during intervals in the framing impulses.
J. Hardwick and F. Blythen. Application date, 18th May, 1934.

443 031.—Synchronising the saw-toothed oscillation-generators in a cathode-ray television receiver.
T. M. C. Lance ; D. W. Pugh ; and Baird Television. Application date, 24th August, 1934.

443 286.—Portable television outfit suitable for military and police service.
Radio Akt. D. S. Loewe. Convention date (Germany) 21st July, 1933.

443 393.—Method of scanning by projecting the ray of light completely through a closed ring of lenses.
Scophony and J. H. Jeffree. Application date, 28th December, 1934.

443 484.—Protective casing for the cathode-ray tube of a television receiver.
Radio Akt. D. S. Loewe. Convention date (Germany) 27th May, 1933.

443 844.—Electron optical system for focussing the electron stream in a cathode-ray tube.
C. Lorenz Akt and M. von Ardenne. Convention date (Germany) 8th September, 1933.

444 173.—Cathode-ray tube in which the electron stream received by a " target " electrode is utilised to increase the deflection of the stream.
R. A. Watson Watt and L. H. Bainbridge Bell. Application date, 12th July, 1934.

2 017 901.—Television system in which a film is scanned through a screen having alternate lenses and opaque sections, with the object of restricting the frequency spread of the radiated signals.
C. E. Huffman.

2 029 488.—Piezo-crystal oscillator energised directly by a dynatron valve and without the interposition of any tuning inductance or capacity.
E. L. Koch (assignor to E. L. Koch Holding Corporation).

SUBSIDIARY APPARATUS AND MATERIALS

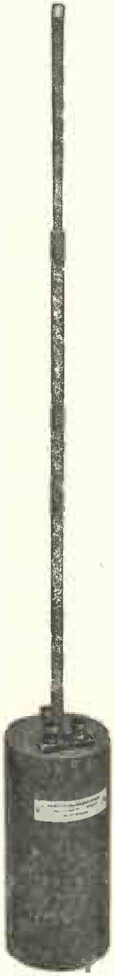
2 010 016.—Mirror oscillograph vibrated by two piezo-electric crystals cemented together to form a reed.
R. W. French.

2 029 358.—Piezo-electric crystal oscillator supported at nodal points by pads of cork.
J. K. Clapp (assignor to General Radio Co.).

443 001.—Ignition noise-suppressor for motor cars fitted with a wireless receiver.
Philadelphia Storage Battery Co. Convention date (U.S.A.) 20th September, 1934.

MISCELLANEOUS

443 366.—Feed-line terminal impedances for preventing reflection effects in carrier-wave wired-wireless systems.
P. P. Eckersley and R. E. H. Carpenter. Application date, 26th July, 1934.



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