51-65

2/6

THE

WIRELESS ENGINEER

The Journal of Radio Research & Progress

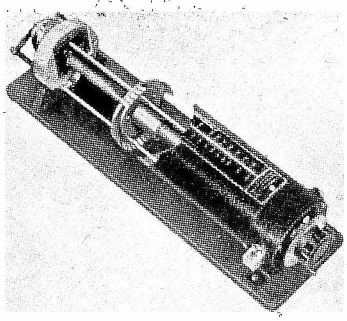
Vol. XIX FEBRUARY 1942 No. 221

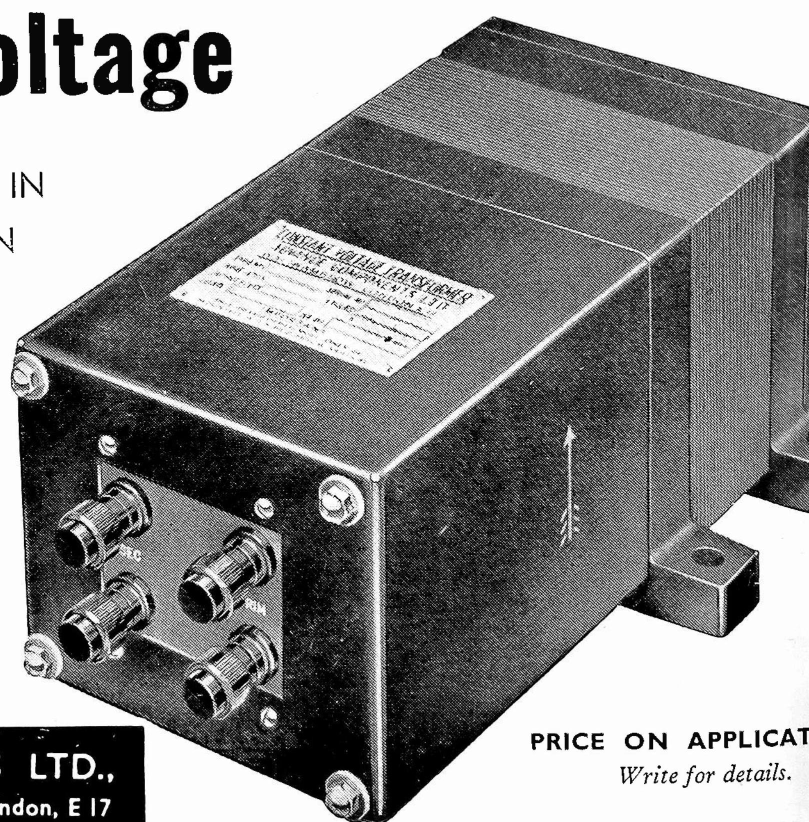
CONTENTS

Published on the first of each month.
SUBSCRIPTIONS (Home and Abroad):
One Year 32/-, 6 Months 16/-

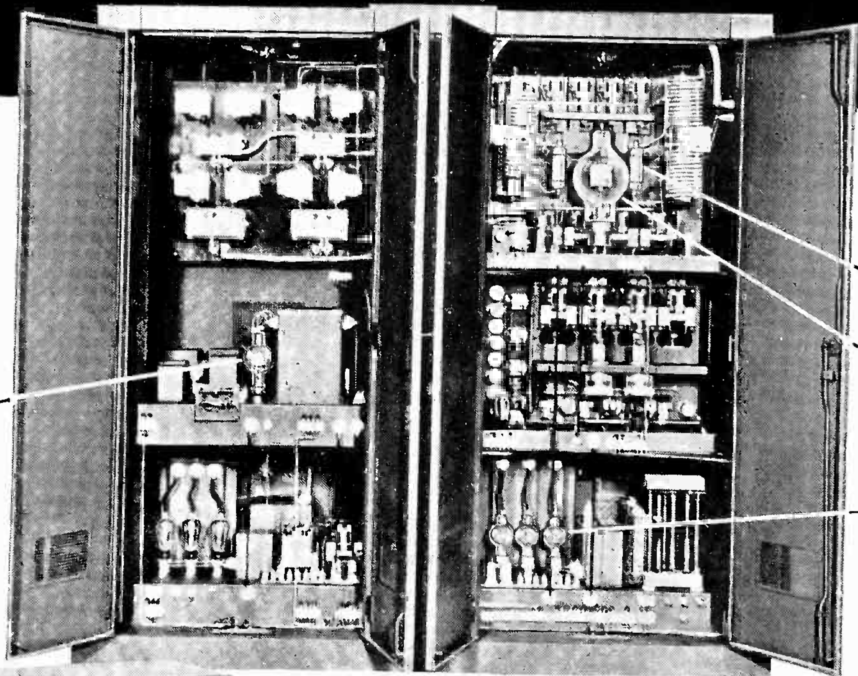
Telephone: Waterloo 3333 (35 lines)
Telegrams: Experiwyr Sedist London

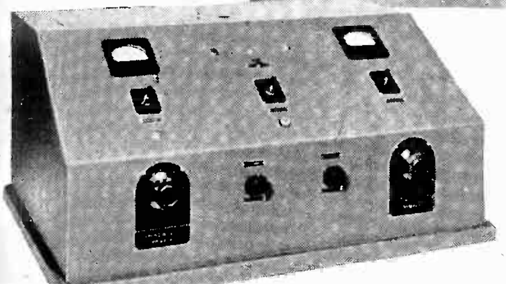
ILIFFE & SONS LTD. DORSET HOUSE STAMFORD ST. LONDON S.E.1

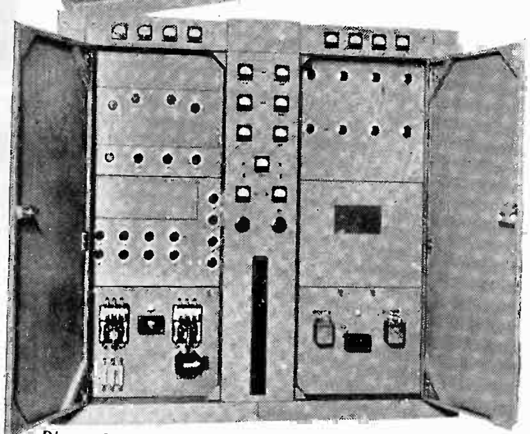




EIMAC EQUIPPED BRAZILIAN ARMY STATION







Photos from top to bottom show a rear view of transmitter, the remote control and a front view of the transmitter constructed by Maya Rebello & Comp. of Rio de Janeiro for the Brazilian army

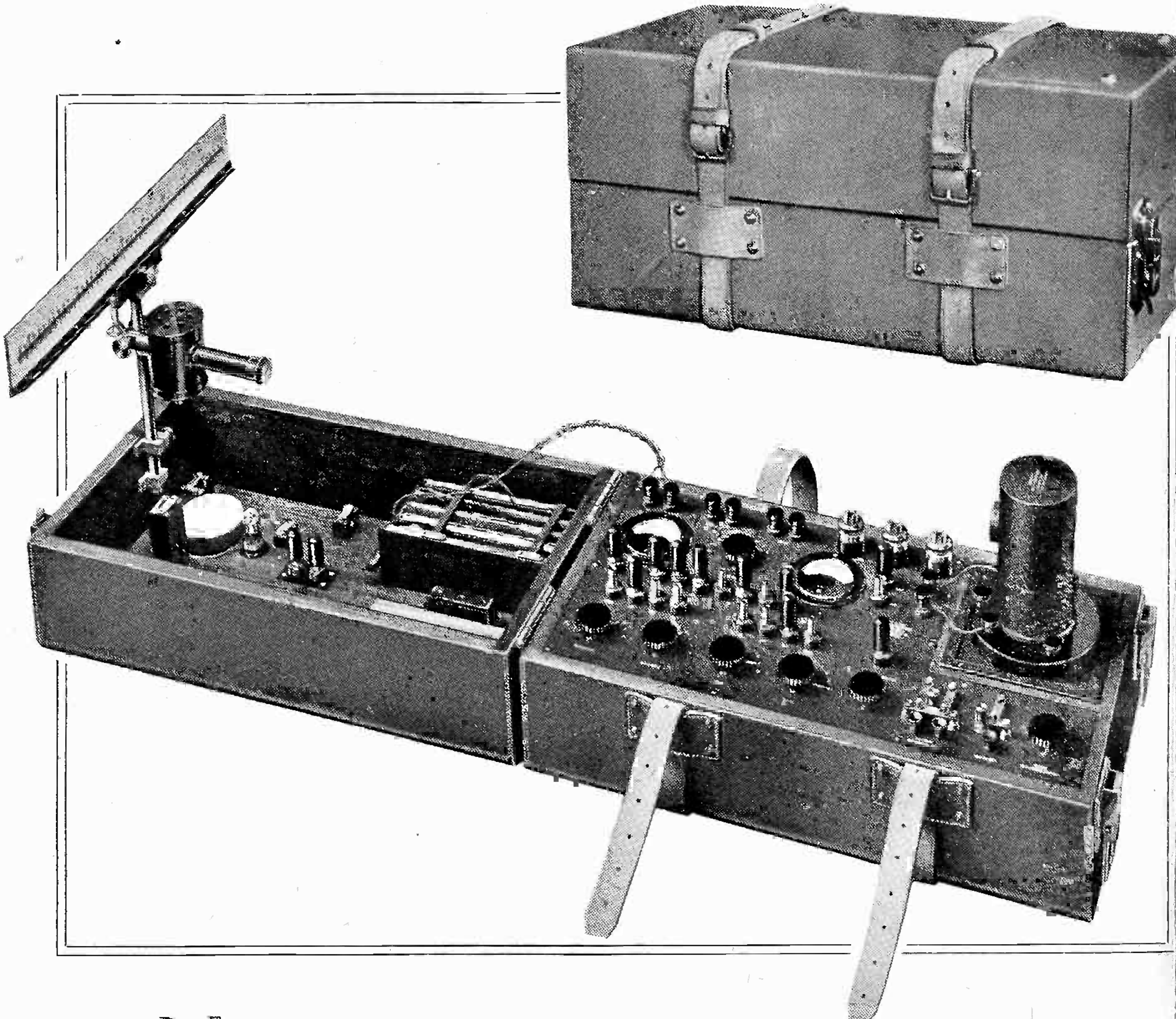
With a single 750T in the final stage and a pair of 250T's as modulators this station puts 1200 watts on the antenna. Operated by remote control on four frequencies using phone, CW and ICW.

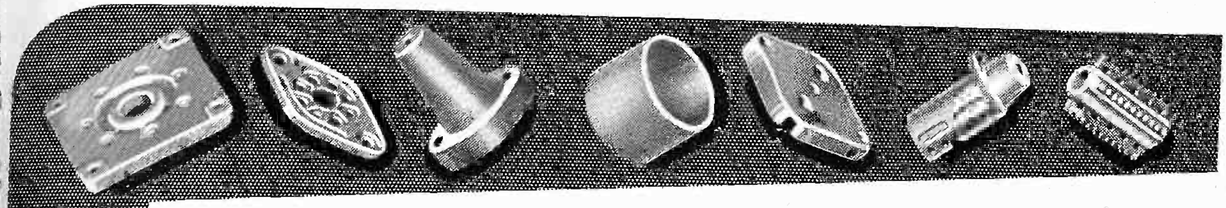
The transmitter was constructed by Maya Rebello & Comp. of Rio de Janeiro and employs Eimac RX 21 rectifier tubes as well as Eimac vacuum tank condensers in the final circuit. The design and construction does credit to its makers and the use of Eimac Tubes in the most important sockets is convincing evidence of their superiority and position in the world of radio.

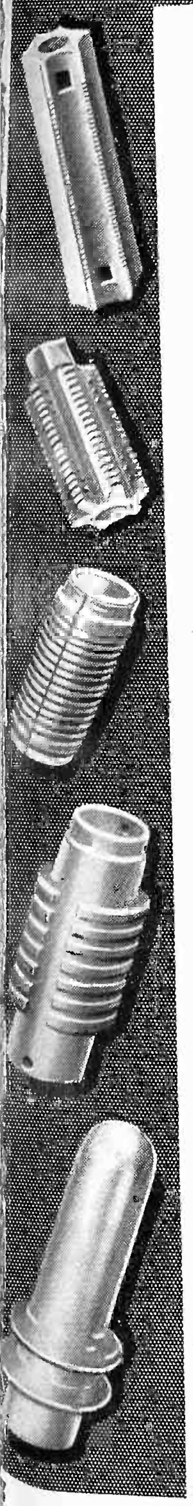
Follow the Leaders to **Eimac TUBES**

Export Agents:
FRAZAR & CO., LTD.
301 Clay St., San Francisco, California, U.S.A. • Cable "Frazar"

Export Agents: Frazar & Co., Ltd., 301 Clay Street, San Francisco, California, U. S. A.







Printed in England for the Publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.
by The Cornwall Press Ltd., Paris Garden, Stamford Street, London, S.E.1.

THE
WIRELESS ENGINEER

Editor HUGH S. POCOCK — Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XIX — FEBRUARY 1942 — No. 221

Editorial

Measurement of Cable Attenuation at 300 Megacycles per Second

ONE of the modern developments in radio-communication has been the low-loss coaxial cable for the transmission of waves at frequencies of the order of 300 Mc/s. The experimental investigation of such cables at these frequencies bristles with difficulties. In a recent number of the house journal of the General Electric Company of America* this problem is discussed by Dr. H. H. Race and Dr. C. V. Larrick and a description is given of the method developed for checking production samples of cable. The principal characteristic that has to be determined is the attenuation. If the cable is terminated by an impedance equal to its surge impedance the attenuation can be calculated directly from the ratio of the sending end voltage to the receiving end voltage. If the load has any other value, this is not strictly correct, but the longer the cable the less is the effect of the load on the measured attenuation. The oscillator employed had a frequency that could be varied between 305 and 325 Mc/s. The connections were as shown in Fig. 1, and the frequency was varied by means of the two variable capacitors. The tuned line connected to the filaments is set for optimum adjustment in the middle of the frequency band and is not changed. It was found desirable to keep the sending end voltage constant and determine the receiving end voltage over the frequency band and take the average. The sending end voltage was adjusted by a variable coupling between the oscillator and the cable feeding the cable under test. The voltages were measured by means of diode voltmeters connected to the cable as shown in Fig. 2. For greater sensitivity when measuring the receiving end voltage of long lengths of cable, the resistance in series with the microammeter can be reduced to 100,000 ohms, but the calibration

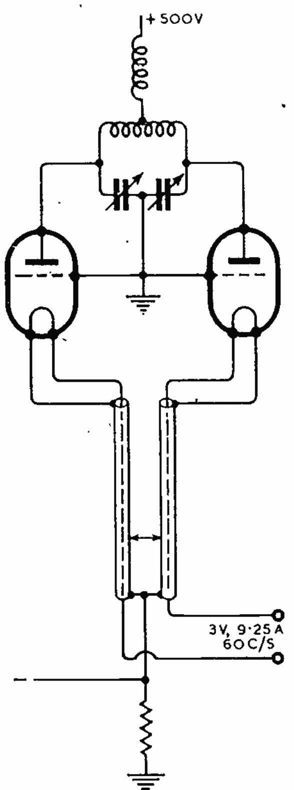


Fig. 1.

* *General Electric Review.* Sept. 1941, p. 507.

curve is then not so linear and the reading is considerably below the peak value of the voltage. The direct current path is completed through the coupling loop at the sending end of the feed-cable. The voltmeters were calibrated at 60 cycles per second, the capacitors being suitably increased from 50 $\mu\mu$F to 0.5 μF or even to 5 μF when using the 100,000 ohm resistance. The valves employed were of the acorn type.

The cable under test is terminated by a long length of similar cable with an attenuation of at least 10 decibels.¶ This avoids the difficulties involved in matching the impedance by means of resistors. If necessary the extension cable can be terminated by a resistor of the approximate value to obtain greater accuracy.

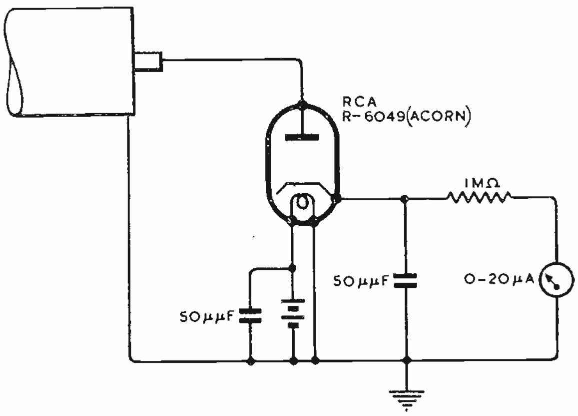


Fig. 2.

If the line were quite uniform and terminated accurately with the correct impedance the attenuation would not vary appreciably with the frequency, but if the termination is not accurate or the cable is not uniform, then the received voltage will be found to vary as the frequency is varied. The results of an actual test* are shown in Fig. 3; the length of the cable was 227ft.

* There is an obvious error in the original diagram (Fig. 8); either the ordinates should be divided by 10 or the sending end voltage was ten times as great as stated; as shown, the received voltage is much greater than the sending-end voltage.

and the attenuation is 9.9 decibels. This illustrates the importance of taking readings over a range of frequency; if one relied on a single observation it might be at one of the

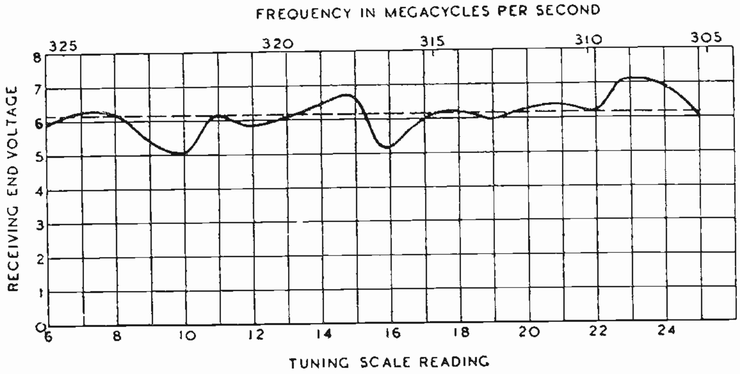


Fig. 3.

points considerably above or below the average value. With the apparatus described the range of attenuation over which reliable measurements could be made was from 5 to 40 decibels, and within this range the accuracy was of the order of $\pm$ 5 per cent.

G. W. O. H.

INDEX to ABSTRACTS

Available this Month

A DEPARTURE from the practice followed in past years has been made in the presentation of the Index to the Abstracts and References published month by month in *The Wireless Engineer* during 1941. An author index has been added and the subject index has been completely alphabetized irrespective of the sections into which the Abstracts and References are grouped.

The inclusion of this index as part of the December issue was discontinued last year, and instead it is to be published separately about the middle of this month.

If any reader has not already ordered a copy of the Index, application should be made at once to the Publishers, as otherwise it will not be possible to guarantee that copies will be available. The price of the Index, including postage, is 2s. 9d.

An Insulation Resistance Meter

Self-contained Instrument for Routine and Laboratory Work

By T. J. Rehfisch, B.Sc. (Eng.)

Introductory

THE conventional method of determining insulation resistance is to measure the leakage current in the unknown by means of a very sensitive mirror galvanometer; a source of voltage, a standard megohm and a multiplying shunt being additional components required. While it is possible to measure up to 10^{12} ohms with typical equipment, the arrangement is somewhat cumbersome for use in the laboratory, and hardly applicable in routine work, largely because of the delicacy of the galvanometer movement. In the special case of condenser testing, the time constant of the galvanometer prohibits reasonably fast checking of high insulation resistances.

On the other hand, it has been found in the case of small mica or ceramic dielectric condensers, that it is desirable for each individual condenser to have an I.R. greater than $10^9\ \Omega$ say, and it is therefore necessary to check accordingly rather than rely on voltage breakdown tests. These considerations led to the development of an I.R. test set, covering the range 10^7 to $10^{12}\ \Omega$, and incorporating alternative test voltages of 500, 750, and 1,000 volts.

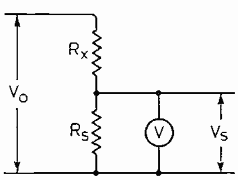


Fig. 1.

Principle of Valve Megohmmeter

The instrument is based on a well-known principle (Fig. 1). A supply voltage V_0 is applied across the unknown R_x in series with a standard resistance R_s. The voltage developed across R_s is then given by

$$V_s = V_0R_s/R_x + R_s = V_0R_s/R_x \quad \text{if } R_s << R_x,$$

and may be measured by applying it in the grid circuit of a valve and noting the change in anode current I. From a separate calibration of the measuring valve, and a knowledge of V_0 and R_s, $R_x = R_s \cdot \frac{V_0}{V_s}$ may be determined.

Instruments based on this principle have been described in the literature [1], [2], but it may be interesting to describe a design which offers an extended range and some additional features, although only standard radio components are used.

Design of the New Instrument

Fig. 2 is a circuit diagram of the complete instrument. On the upper right is shown the power supply for the 5 valves of the instrument, including a series reactance input filter for smoothing. Below is a conventional voltage doubler rectifying circuit, feeding a tapped resistance through a filter and limiting resistor, and supplying the test voltages.

The measuring circuit [3] consists of a degenerative D.C. amplifier, with a meter connected so as to back off the standing anode current. The sensitivity of the bridge is 2mA/V in the absence of the meter series resistance and the rectifier element H_1. The two latter are inserted to protect the meter against overload and adjusted so as to render the maximum meter current—which flows when V_1 is biased to cut-off—equal to 1mA, the full scale deflection of the meter.

Calibration stability and independence from valve replacement are obtained as a result of the degenerative self-bias resistor R_c. Part of the latter is made variable to allow of compensation for meter drift due to mains fluctuations, and it can be shown that this will automatically compensate against calibration error which might arise from that source, if the test voltage is also mains derived, as is the case here. The meter may be directly calibrated in thousands of megohms once the grid volts/meter current characteristic is known.

The sensitivity switch S_2 selects one out of four groups of grid resistors, the choice of one out of three resistors in the group depending on the voltage setting. This arrangement obviates the need for a multiplying factor when the test voltage is changed by means of the voltage selector switch S_1.

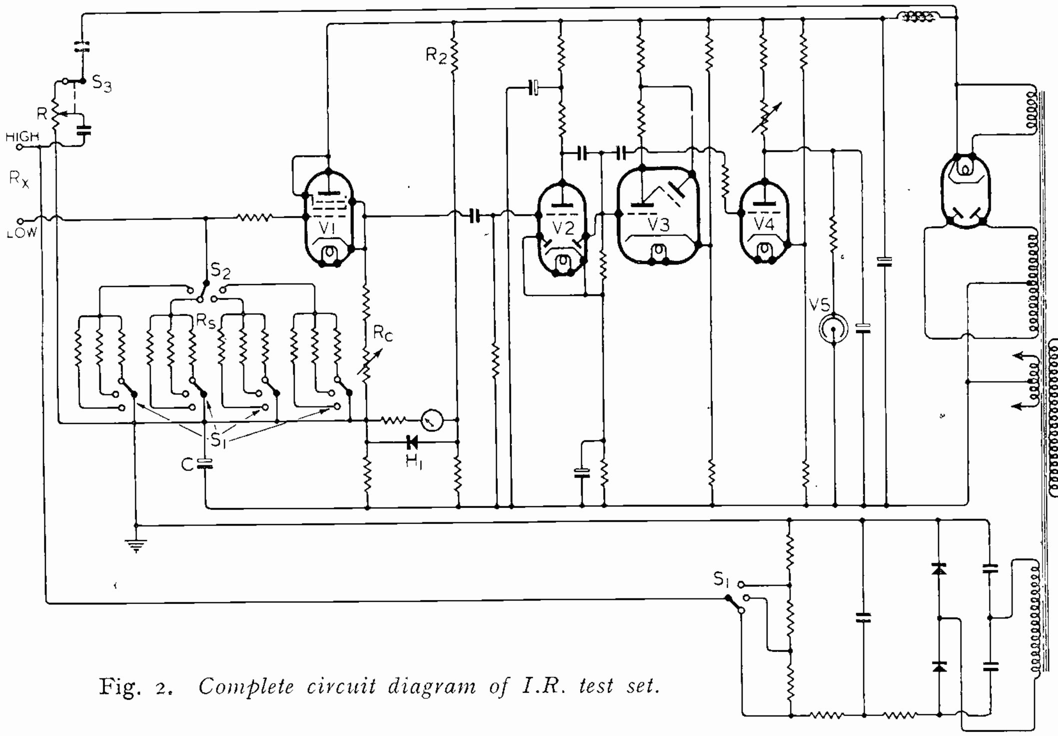


Fig. 2. *Complete circuit diagram of I.R. test set.*

As the live test terminal is negative with respect to earth, no valve damage will result in the event of a test object being shorted. Since all components, including the insulated test terminals, are mounted on a sheet metal chassis and panel, their insulation should be high only in comparison with the highest value of grid-resistor R_s (50 $M\Omega$)—but not necessarily in comparison with the highest value of R_x ($10^6 M\Omega$) likely to occur. This application of the guard principle makes for a simple construction. No difficulty is experienced in finding a valve with an adequately insulated grid, but some loss in negative grid potential when the instrument is allowed to warm up with R_s on the higher values was observed, presumably due to electron emission from the grid.[4]

As the meter is calibrated to read cathode current changes, the resultant drift may be compensated for by means of the variable part of R_c, although, as this will modify the sensitivity of the bridge slightly, it might be preferable to make variable a part of R_2, say, for this purpose.

Scale Shape

The characteristic of the shunting rectifier is superimposed on the incremental $I_A - V_g$ characteristic, consequently the scale shape differs from that of the usual ohmmeter in that the low resistance end is more compressed—it actually includes a zero marking. Owing to the large temperature coefficient of the shunting element, the meter calibration is somewhat affected by temperature at the low resistance portion of the scale, but the effect is negligible over the greater part; allowance may be made for this by calibrating the instrument after it has warmed up and the temperature become steady.

Another effect of the shunting rectifier is the by-passing of charging surges in condenser testing: the pointer "flicks" very slightly only when a condenser is applied across the test terminals.

Contact Indicators

Experience in mass production checking revealed the necessity for a positive contact and timing indicator [5]; this auxiliary circuit contains a thyratron and a small neon diode. The device is operated by the charging impulse of the test condenser, this impulse being amplified and phase inverted by V_1 and V_2, before applying it to the grid of the thyratron, the neon light being thereby extinguished, only to strike again after a predetermined time—3 sec. in an actual case—so indicating the end of the test period. However, even with this circuit, it was found that a condenser might become disconnected during test without obvious indication, hence a continuous contact indicator circuit was added. To achieve this, part of the A.C. ripple of the "raw" H.T. supply is fed to the "live" test terminal, and with the presence of a condenser between the test terminals, a trace of A.C. (100v. fundamental) is fed to the grid of the first valve, to be amplified and rectified in V_2. The resulting D.C. voltage is applied to the grid of the "magic eye" V_3, increasing its luminous area to a maximum. The amount of A.C. required at the grid of V_1 to operate the cathode-ray indicator does not affect the reading of the meter, because of the by-pass condenser C. As the voltage at the grid of V_1 is a function of the capacitance between the test terminals, it is necessary to allow of adjustment to the A.C. voltage supplied to the "live" terminal in order to cope with test-condensers of different size (down to $0.5\mu\mu F$).

The potential divider R provides for this requirement; in its minimum position switch S_3 is opened, and the A.C. ripple supply cut off entirely from the grid of V_1. This serves as a check, for an excessive amount of A.C. on the grid of V_1 would affect the meter reading.

Accuracy

The instrument was checked on all four voltage and three sensitivity ranges by means of 3 resistors (100, 1,000 and 10,000 $M\Omega$ respectively) of American manufacture and the readings obtained were found to be in agreement with the values arrived at by another method, within reading discrimination, i.e. better than plus or minus 5 per cent.

Conclusion

The instrument has been in use for a period of several months now and has served both for laboratory and production check measurements. It can be used by unskilled personnel without difficulty, once the controls are set.

The circuit lends itself to further development, containing as it does, all the essentials for automatic testing equipment.

Acknowledgment

The author wishes to express his thanks to the management of the United Insulator Co., Ltd. for permission to publish this article.

REFERENCES

[1] "Valve Megohmmeter," W. Schick, *Archiv für Techniches Messen*, No. 75, T.113, Sept. 1937.

[2] "A Portable Megohmmeter," W. N. Tuttle, *G.R. Experimenter*, Vol. XV., No. 2, July, 1940.

[3] "Type 726—A Vacuum-Tube Voltmeter," W. N. Tuttle, *G.R. Experimenter*, Vol. XI, No. 12, May, 1937.

[4] "The Electrometer Triode and its Applications," G. W. Warren, B.Sc., *G.E.C. Journal*, Vol. VI, No. 2, May, 1935.

[5] "A Contact and Timing Indicator for Insulation Measurements," T. J. Rehfisch, *Journ. Scient. Instr.*, April, 1941.

The Industry

A REVISED price list of insulated sleeving has been received from Hammans Industries, Ltd., 5, Regent Parade, Brighton Road, Sutton, Surrey. The types listed include varnished cotton, plastic and wrapped silk materials. An engineering bulletin (H101) comparing non-ferrous metals with laminated material for instrument cases, panels, etc., and a descriptive leaflet on engraved dials and nameplates have also been issued recently by this firm.

British Insulated Cables, Ltd., Prescot, Lancs., give information on B.I. Flux Solder in a leaflet (N.S.G.7) recently received. Standard sizes are 13 and 16 S.W.G. in 50/50 or 60/40 tin-lead alloy.

Current Induced in an External Circuit by Electrons Moving Between Two Plane Electrodes*

By Rudolf Kompfner

SUMMARY.—Starting from the equation for the velocity of an electron in motion through the space of a planar diode, an expression is obtained for the current induced in an external circuit connected to the diode. A uniform entering current of low density has been assumed. A simple graphical representation of the induced current is given and various cases are shown where the induced current has been found graphically.

In a previous paper [1], means have been described by which the current induced in an external circuit by electrons in transit between two plane electrodes can be found. The method followed in that paper holds quite generally, though it is somewhat laborious, especially if the induced current is required for one particular set of parameters only.

In the present paper a graphical method of determining the induced current will be described which is far simpler to apply and which is much clearer at the same time.

The method indicated in the paper [1] is as follows:—

The current induced in an external circuit by an electron moving with a velocity v cm/sec in the space between two planar electrodes of a diode, d cm apart is given by

$$i = \frac{ev}{d} \quad \ldots \quad (1)$$

Hence, if we know the number and velocities of all electrons in the diode space at any particular instant t, we obtain the total induced current I_{ind} by summation over d. That is to say we have to multiply the charge density with the velocity at any point and integrate between $z = 0$ and $z = d$, keeping the time t constant. Both charge density and charge velocity have to be found before the integration can be carried out. A very tedious process, to say the least.

There is another way, however, and its description forms the subject of this paper.

We start by finding the velocity of an electron at the time t which had started at the instant t_1, by integrating the equation of motion

$$\ddot{z} = \frac{dv}{dt} = \frac{e}{m}\frac{1}{d}(P + E_0 \sin \omega t) \quad \ldots \quad (2)$$

which gives

$$v = \frac{Pe}{md}(t - t_1) + \frac{E_0 e}{m\omega d}(\cos \omega t_1 - \cos \omega t) + V_0 \quad \ldots \quad (3)$$

where P is the D.C. difference of potential across the diode, E_0 the peak voltage of the A.C. component, and V_0 the initial velocity,

$$\left(V_0 = \sqrt{\frac{2e}{m}U_0}\right)$$

Putting

$$\left.\begin{aligned} &\frac{P}{E_0} = Q\,;\quad \sqrt{\frac{2e}{m}}E_0 = v_0\,;\quad \frac{\omega d}{v_0} = \theta\,; \\ &\frac{E_0}{U_0} = \left(\frac{v_0}{V_0}\right)^2 = M\,;\ \omega t = y \text{ and } \omega t_1 = x_1 \end{aligned}\right\} \quad (4)$$

we can write (3)

$$v = \frac{v_0 Q}{2\theta}(y - x_1) + \frac{v_0}{2\theta}(\cos x_1 - \cos y) + V_0 \quad \ldots \quad (5)$$

At first we will treat only the case of a diode, where electrons are entering without interruption throughout and where there is no turning back of electrons, and we wish to point out an important fact, however self-evident it may seem to be:

If t_0 is the time of entry into the space of an electron which leaves the space at the instant t, then there will be present in the space at the time t all the electrons which entered between $t_1 = t_0$ and $t_1 = t$.

Hence, with the assumption of a uniform entering current, the induced current I_{ind} at the instant given by the time-angle y will

* MS. accepted by the Editor, December, 1941.

[1] Transit-time Phenomena in Electronic Tubes. R. Kompfner, *Wireless Engineer*, January 1942, Vol. XIX, No. 219, p. 2.

be found by summing v over all the electrons in the space at that instant (and multiplying with $\frac{e}{d} \cdot \frac{\xi_0}{\omega}$) ; that is to say, by integrating (5) with respect to x_1 between the limits x_0 and y, where x_0 is the time-angle of entry of the electron which leaves the space at y. ξ_0 is the number of electrons entering per second.

Thus $I_{ind} = \frac{e}{d} \cdot \frac{\xi_0}{w} \int_{x_0}^{y} v dx$

and

$$\int_{x_0}^{y} v dx = \frac{v_0 Q}{2\theta} \frac{(y - x_0)^2}{2}$$

$$+ (V_0 - \frac{v_0}{2\theta} \cos y)(y - x_0) + \frac{v_0}{2\theta} (\sin y - \sin x_0) \quad \ldots \quad \ldots \quad (6)$$

Writing $\xi_0 = \frac{I_0}{e}$, where I_0 is the steady current assumed to be emitted by the cathode, or entering the space, we have

$$\frac{I_{ind}}{I_0} 2\theta^2 = \frac{Q}{2}\left(y - x_0\right)^2$$

$$+ \left(\frac{2\theta^2}{\sqrt{M}} - \cos y\right)(y - x_0) + \sin y - \sin x_0 \quad \ldots \quad \ldots \quad (7)$$

In this form, the equation is very reminiscent of equation [5a] [2] of the previously published paper [1] for the distance z covered at the time y by an electron which entered at x, namely :

$$\frac{z}{d} 2\theta^2 = \frac{Q}{2}\left(y - x\right)^2$$

$$+ \left(\frac{2\theta}{\sqrt{M}} + \cos x\right)(y - x) - \sin y + \sin x \quad \ldots \quad \ldots \quad [5a]$$

inviting one to look for a graphical construction analogous to the one given in that paper. Such a construction does indeed exist, as will be shown presently.

Apart from some different signs, the main difference lies in the second term on the right-hand side, where we have now $(-\cos y)$ instead of $(+\cos x)$; but otherwise the similarity of (7) with [5a] is striking.

[5a] becomes the correct relation between x_0 and y when $z = d$. Hence it is quite in order to drop the suffix of x in (7), provided [5a], (or its equivalent graphical representation) is used to obtain y. From now on we will use y and x as denoting "complete transit-time" angles only, i.e. y is the arrival-time angle at the anode of an

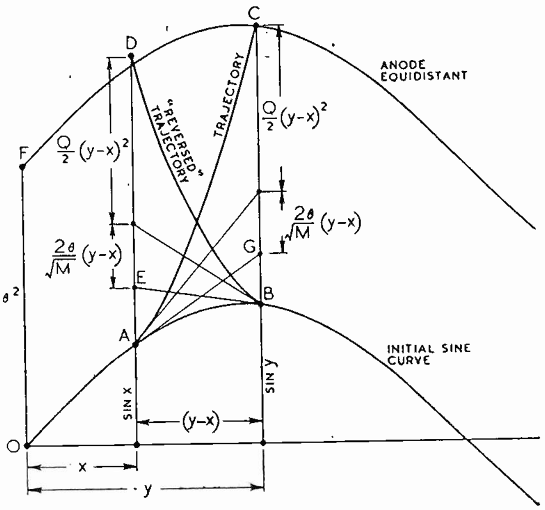


Fig. 1.

electron which started at the cathode at x, and x is the starting-time angle of an electron which left the space at y.

In Fig. 1 we show the graphical representation of [5a], where the arrival-time angle y has been found for an arbitrary time-angle of entry x by drawing the appropriate "trajectory."

Using the same figure, it can be shown that the induced current I_{ind} is given by a very similar construction indeed. It merely involves drawing a "trajectory" from the right to the left instead of from the left to the right, a so-called "reversed trajectory." Starting from the point B, we first draw a tangent to the initial sine-curve which intersects the ordinate through A in E. This corresponds to the term $(-\cos y)$ $(y - x)$. Next we draw a line corresponding to the term $\frac{2\theta}{\sqrt{M}}(y - x)$ which gives us the point E ; that is, we add the slope $\frac{2\theta}{\sqrt{M}}$ to the slope $(-\cos y)$. Actually, $BG = AE$. Finally we draw a parabola based on the line BE corresponding to the term $\frac{Q}{2}(y - x)^2$

[2] Square brackets indicate equations taken from the previous paper [1].

which gives us the point D. As $GC = ED$, it is only necessary, after having found E, to plot a distance equal to GC along the ordinate

$$\frac{AD}{OF} = \frac{I_{ind}}{I_0}$$

When the point D lies above the anode

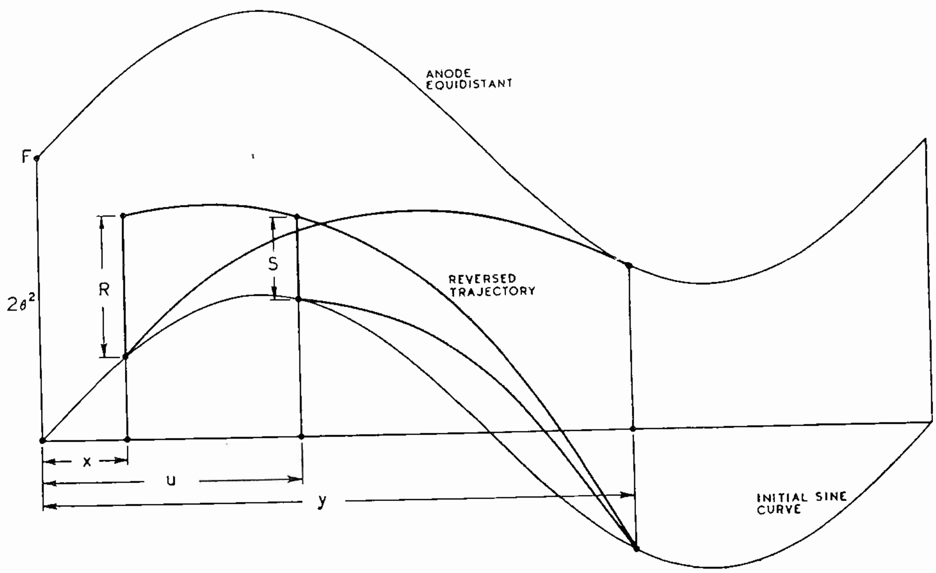


Fig. 2.

through A to find D, but it may help in understanding the complete process to have the intermediate steps indicated.

By comparing equation (7) with Fig. 1 it will now easily be seen that the ratio

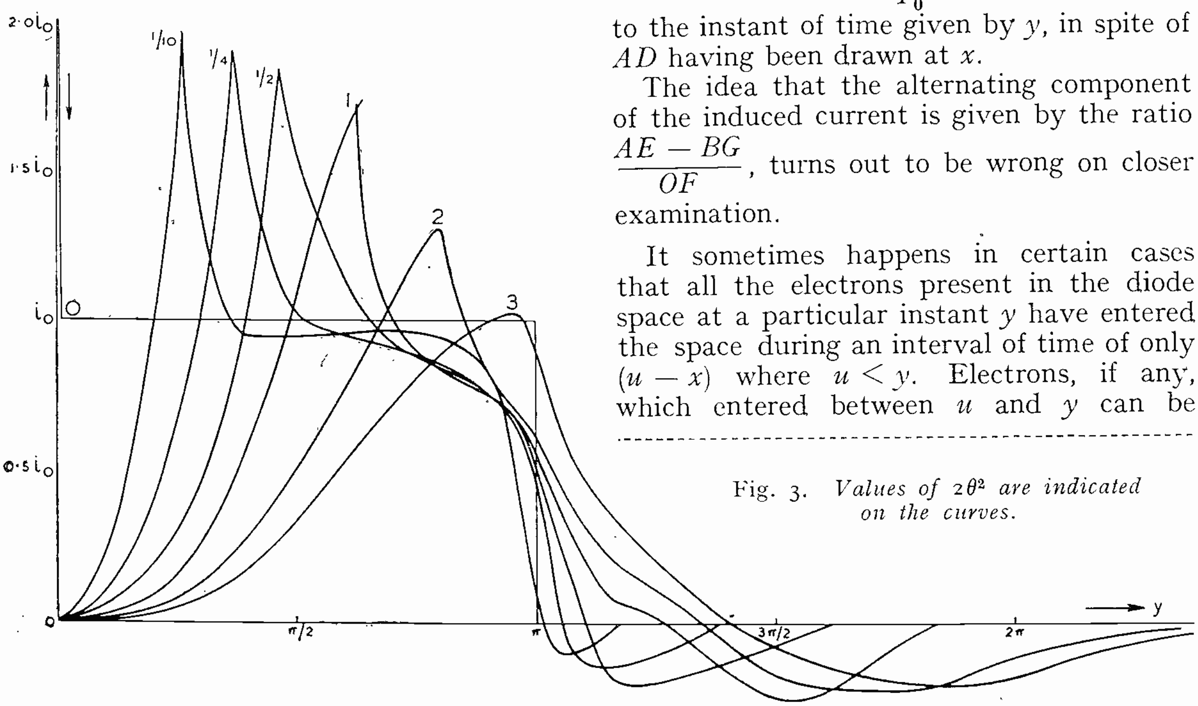


Fig. 3. *Values of $2\theta^2$ are indicated on the curves.*

equidistant, the induced current is larger than the initial steady current; when it lies below the anode equidistant, the induced current is less than I_0. It must not be overlooked that the ratio $\frac{I_{ind}}{I_0}$ thus obtained refers to the instant of time given by y, in spite of AD having been drawn at x.

The idea that the alternating component of the induced current is given by the ratio $\frac{AE - BG}{OF}$, turns out to be wrong on closer examination.

It sometimes happens in certain cases that all the electrons present in the diode space at a particular instant y have entered the space during an interval of time of only $(u - x)$ where $u < y$. Electrons, if any, which entered between u and y can be supposed to have left the space before the instant y by returning to the cathode for instance.

In such a case, the simple construction shown in Fig. 1 will obviously be of no immediate use. But it can be shown that

$$\frac{2\theta}{v_0}\int_x^u v_y dx, \text{ where } u < y_1 \text{ is given by}$$

$$\Big[\tfrac{1}{2}Q(y-x)^2 + \Big(\frac{2\theta}{\sqrt{M}} - \cos y\Big)(y-x) + \sin y - \sin x\Big]$$
$$-\Big[\tfrac{1}{2}Q(y-u)^2 + \Big(\frac{2\theta}{\sqrt{M}} - \cos y\Big)(y-u) + \sin y - \sin u\Big] = R - S \qquad \ldots \quad \ldots \quad (8)$$

Thus we find that the induced current at the instant y due to electrons which started between x_0 and u involves the difference between R and S, where R stands for the induced current due to all electrons starting between x_0 and y, and S stands for a hypothetical current due to all electrons starting between u and y. The graphical representation is very simple and is shown in Fig. 2.

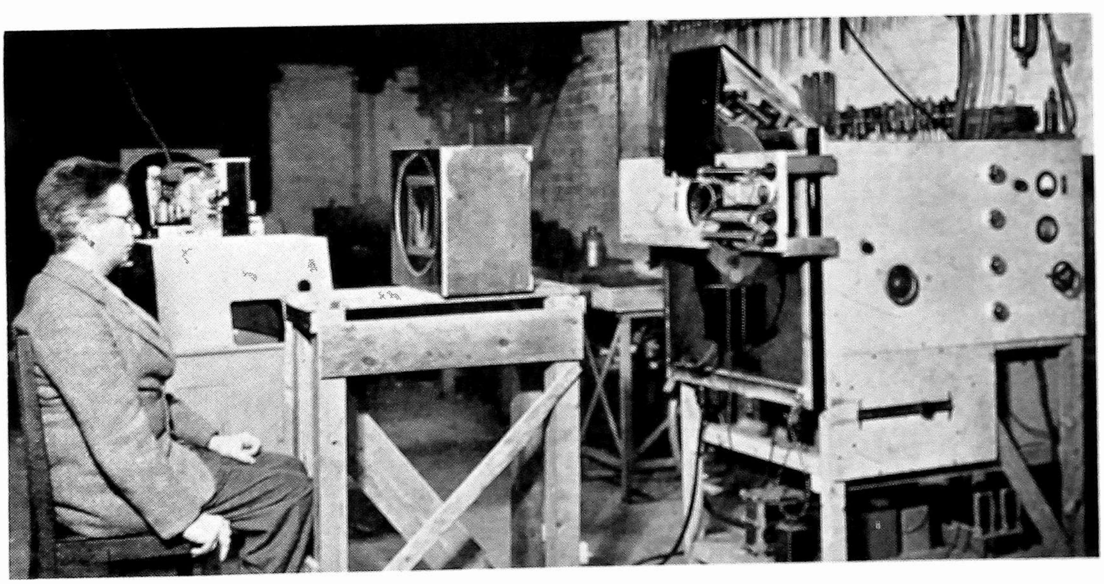
It can be shown that, quite generally, the contribution to the induced current at y by electrons starting between two arbitrarily chosen points r and s, will be determined by the difference between the distances marked out on the ordinates through r and s by the reversed trajectory originating at y and the initial sine-curve.

The simplest case to treat by this method is that of the unbiased diode. It is, incidentally, also very instructive. Mr. W. E. Benham has kindly given permission to include a set of curves showing the induced current in the unbiased diode for several values of the parameter $2\theta^2$ which he has constructed (see Fig. 3). Note the positions and magnitudes of the peaks occurring at the beginning of every induced current curve.

Physicists' Planning Committee

A PLANNING Committee with the following terms of reference has been appointed by the Board of the Institute of Physics: "To watch and advise the Board on matters affecting Physics and Physicists, including their education and training, and on post-war planning."

The constitution of the Committee, which has power to co-opt, is as follows: Prof. Sir Lawrence Bragg, Prof. J. A. Crowther, Mr. E. R. Davies, Dr. H. Lowery, Major C. E. S. Phillips, Dr. C. Sykes, and Dr. F. C. Toy.



STEREOSCOPIC COLOUR TELEVISION.—*Mr. J. L. Baird gave a successful demonstration of three-dimensional image transmission in colour to representatives of the Press on December 18th, 1941. The object was scanned alternately by beams spaced by a distance equal to the average spacing of the eyes and the corresponding images were reformed with a similar displacement at the receiver in a field lens which at present can be seen by only one viewer at a time.*

Recent Improvements in Air-Cored Inductances

By W. H. F. Griffiths, F.Inst.P., M.I.E.E., M.I.R.E.

(Concluded from page 19 of the January issue)

HAVING devised a commercial standard of large inductance with a sensibly temperature-coefficientless value of *true* inductance and with a value of *effective* inductance sensibly unaffected by change of temperature or humidity it seems natural to endeavour to provide such a coil with a means for eliminating the effect of frequency itself. This is necessary only when the coil is used as a sub-standard of reference or is incorporated as such in a bridge network in which balance depends upon effective rather than upon true values of inductance. If the effective inductance of a coil at any given frequency is sensibly unaffected by the effects of temperature and humidity, the difference between the effective and true values may be compensated at that frequency, but such compensation is possible only by the reproduction of a calibration adjustment appropriate to such frequency. Such compensation is, of course, unnecessary in a coil to be used as a component of a resonant circuit of a wavemeter or oscillator because it is the *effective* value of the inductance which, in these cases, determines the frequency calibration, and it is only necessary, therefore, that the effective value at any given frequency (within the range being used), under varying conditions of temperature and humidity, shall be as stable as the true value.

The author has recently devised a coil in which the *effective* inductance may be adjusted to be sensibly constant and equal to the *true* inductance throughout a considerable range of frequency. The coil, the diagram of which is given in Fig. 15, is adjusted to have at the terminals HP, LP, a *true* inductance sensibly equal to a nominal value L. This adjustment is effected at any frequency lower than the frequency f_0 which gives the expression :—

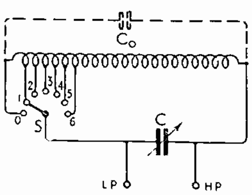


Fig. 15.

$$4\pi^2 f^2 L_0(c_0 + C_{min}) \quad \ldots \quad (10)$$

a value comparable with the adjustment accuracy of the coil, say, 0.0002. The *effective* inductance of the coil with the switch S at position O is sensibly constant and equal to the true inductance L_0 at all frequencies up to f_0. The expression (10) is that for the frequency correction of the coil due to its self-capacitance c_0 when the latter is augmented by the residual capacitance of the small variable condenser C which is connected in parallel with the portion of the coil in use as shown in Fig. 15.

This correction factor is taken from the expression for the effective inductance of a coil

$$L_{eff} = \frac{L_0}{1 - \omega^2 L_0 c_0}$$

which is, for frequencies well below the natural frequency of the coil, an accurate simplification of the exact formula :—

$$L_{eff} = \frac{L_0(1 - \omega^2 L_0 c_0) - c_0 R^2}{(1 - \omega^2 L_0 c_0)^2 + \omega^2 c_0{}^2 R^2}$$

The coil is now tapped at the point 1 in order to reduce the true inductance by an amount equal arithmetically to the amount of the increase of inductance at frequency f_0 due to $c_0 + C_{max}$ where C_{max} is the maximum capacitance of the variable condenser. If the *true* inductance of this tap is L_1 then

$$L = L_0 \div L_1 + 4\pi^2 f_0{}^2 L_0(c_0 + C_{max})$$

Strictly, of course, L_0 and c_0 of the correction term should be replaced by L_1 and the self-capacitance (c_1) of L_1 respectively, but the effects of the actual differences between L_0 and L_1 and between c_0 and c_1 are negligible and within the accuracy of adjustment of the tap.

If now the variable condenser C is reduced in value the frequency at which the effective inductance of L_1 is equal to the nominal value L is raised until it reaches a maximum f_1 at the minimum capacitance $C_{\min}$ when

$$L = L_0 \doteqdot L_1 + 4\pi^2 f_1^2 L_1(c_1 + C_{\min})$$

The scale of the variable condenser is graduated in terms of frequency such that the approximate frequency correction term

$$4\pi^2 f^2 L_1(c_1 + C) \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

is constant throughout the whole scale.

The tap 2 is now made and so adjusted that the true inductance of the coil is reduced to a value L_2 such that the following expression is satisfied :—

$$L = L_0 \doteqdot L_2 + 4\pi^2 f_1^2 L_2(c_2 + C_{\max})$$

c_2 being the new self-capacitance of the coil thus tapped.

Thus with the switch S set to position 2 another range of the variable condenser C is produced and may be calibrated in terms of ascending frequency until, at the minimum capacitance setting,

$$L = L_0 \doteqdot L_2 + 4\pi^2 f_2^2 L_2(c_2 + C_{\min})$$

The same procedure is employed in adjusting the other taps. Associated with each tap is a frequency scale, the six scales giving continuity of frequency from f_0.

The uncertainty as to the frequency at which the coil shall be adjusted is removed since for all frequencies the true and effective inductance remains sensibly constant.

If σ = the accuracy to which the coil is required to be adjusted, then

$$4\pi^2 f_0^2 L_0(C_{\min} + c_0) = \sigma \quad \ldots \quad \ldots \quad (12)$$

at the frequency below which frequency compensation is unnecessary, and this frequency is

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{\sigma}{L_0(C_{\min} + c_0)}} \quad \ldots \quad \ldots \quad (13)$$

and for the nth tapping (switch position n) the tapped value L_n of the coil is given by :—

$$L_n \doteqdot L - 4\pi^2 f_n^2 L_0(C_{\min} + c_0) \quad \ldots \quad (14)$$

where f_n is the highest frequency which can be compensated for a given coil tapping.

The amount by which the coil must be adjusted low in making this tap is determined purely by the accuracy σ of making the taps and the range of the variable condenser as augmented by the coil self-capacitance, so :—

$$L - L_n = \sigma r^n \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

where $r = \dfrac{C_{\max} + c_0}{C_{\min} + c_0}$

From (14) and (15)

$$L - L_n \doteqdot 4\pi^2 f_n^2 L_0(C_{\min} + c_0) \doteqdot \sigma r^n$$

Therefore $f_n^2 \doteqdot \dfrac{\sigma r^n}{4\pi^2 L_0(C_{\min} + c_0)}$

and $$f_n \doteqdot \frac{1}{2\pi}\sqrt{\frac{\sigma r^n}{L_0(C_{\min} + c_0)}} \quad \ldots \quad (16)$$

which gives the maximum frequency compensated for any given range, n, corresponding to the lowest capacitance setting of the nth tapping ; the frequency compensated at any other capacitance setting C is given by :—

$$f \doteqdot \frac{1}{2\pi}\sqrt{\frac{\sigma r^n}{L_0(C + c_0)}} \quad \ldots \quad \ldots \quad (17)$$

The above expressions for frequency are approximations on the assumptions that $L_n = L_0$ and that the coil self-capacitance c_0 remains unchanged by tapping. The frequency errors due to these assumptions are negligible on all but the highest frequencies of compensation and even then are only of the same order as the scale accuracy. But, in any case, the variable condenser scale is finally calibrated in terms of the actual frequency required to maintain the effective inductance constant and equal to L and the errors removed completely.

There is a limit to the number of ranges of frequency compensation which may be employed on any given coil with any given capacitance range of condenser. This limit is imposed by the approach of the compensated frequency f_n to the natural frequency of the tapped coil. If the previous assumption that a standard should not be used at frequencies higher than one-third of its natural frequency is made, then the maximum value for f_n would be :—

$$f_{n(\max)} \doteqdot \frac{1}{2\pi}\sqrt{\frac{\sigma r^{n(\max)}}{L_0(C_{\min} + c_0)}}$$

$$= \frac{1}{6\pi\sqrt{L_0(C_{\min} + c_0)}}$$

from which $r^{n(\max)} = \dfrac{1}{9\sigma}$

and $$n_{(\max)} = -\frac{\log 9\sigma}{\log r} \quad \ldots \quad \ldots \quad (18)$$

and the maximum permissible number of tappings is therefore the nearest integer lower than this value. There is however another factor which may govern the maximum frequency which may be compensated—the increase of resistance due to the augmented self-capacitance of the coil. Away from resonance this resistance augmentation is given by :—

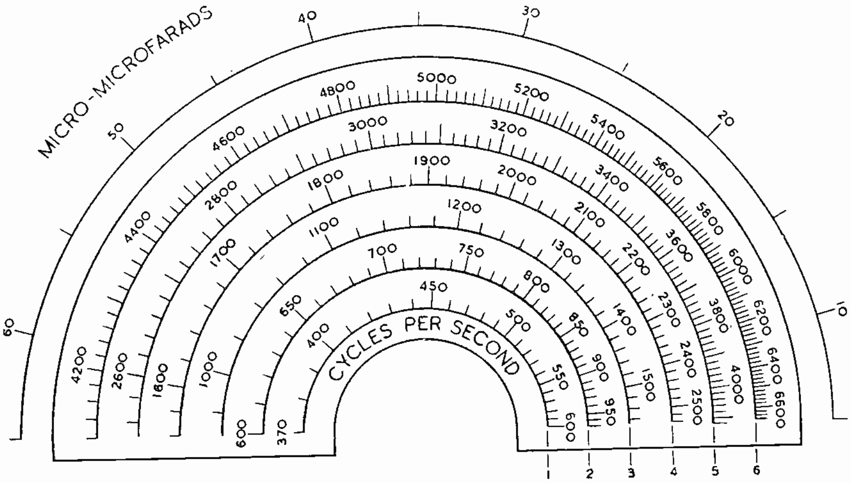


Fig. 16.

$$R_{eff} = \frac{R_0}{\{1 - \omega^2 L_0(C_{\min} + c_0)\}^2}$$

If ϕ is the maximum permissible fractional increase in resistance

$$\{1 - \omega^2 L_0(C_{\min} + c_0)\}^2 = \frac{1}{1 + \phi}$$

$$\omega^2 = \frac{1 - \dfrac{1}{\sqrt{1 + \phi}}}{L_0(C_{\min} + c_0)}$$

and $$f = \frac{1}{2\pi}\sqrt{\frac{1 - \dfrac{1}{\sqrt{1 + \phi}}}{L_0(C_{\min} + c_0)}},$$

the frequency limit of compensation imposed by this condition.

If, therefore, ϕ is not to be exceeded n must be determined as follows, for then

$$\frac{1}{2\pi}\frac{\sqrt{\sigma r^{n(\max)}}}{\sqrt{L_0(C_{\min} + c_0)}}$$

must equal

$$\frac{1}{2\pi}\sqrt{\frac{1 - \dfrac{1}{\sqrt{1 + \phi}}}{L_0(C_{\min} + c_0)}}$$

Therefore

$$\sqrt{\sigma r^{n(\max)}} = \sqrt{1 - \frac{1}{\sqrt{1 + \phi}}}$$

from which

$$n_{(\max)} = \frac{\log\left(1 - \dfrac{1}{\sqrt{1 + \phi}}\right) - \log \sigma}{\log r} \quad \ldots \quad \ldots \quad (19)$$

and the maximum number of tappings permissible must be the nearest integer below the lower of the values found from expressions (18) and (19).

The drawing of Fig. 16 is of the frequency scales associated with the six taps of a coil adjusted at 50 c/s to within 0.02 per cent. of 1 henry. The taps were adjusted to the *true* values tabulated below.

A variable condenser of 60 $\mu\mu$F capacitance change was necessary for interpolation between adjacent tappings.

The upper curve of Fig. 17 shows the error due to the frequency which would be ordinarily experienced in this coil and the

$\sigma = 0.0002$
$c_0 = 32 \times 10^{-12}$
$C_{\max} = 65 \times 10^{-12}$
$C_{\min} = 5 \times 10^{-12}$
$r = 2.62$
$n_{\max} = 6.6$
$f_{nat}/3 = 8700$

Switch Position (n)	$L - L_n = \sigma r^n$ (H)	Range of Frequency Compensation c/s
		No compensation necessary up to $f_0 = 370$ c/s
0	1.0000 (L_0)	
1	0.9995 ($L - L_1$)	370 (f_0) to 600 (f_1)
2	0.9986 ($L - L_2$)	600 (f_1) to 970 (f_2)
3	0.9964 ($L - L_3$)	970 (f_2) to 1570 (f_3)
4	0.9905 ($L - L_4$)	1570 (f_3) to 2550 (f_4)
5	0.9750 ($L - L_5$)	2550 (f_4) to 4120 (f_5)
6	0.9350 ($L - L_6$)	4120 (f_5) to 6670 (f_6)

lower curve is of the possible inaccuracy of compensation due chiefly to the capacitance uncertainty of the variable condenser which must of necessity be of small dimensions for incorporation in the structure of the coil. The inaccuracy caused by a given error in the capacitance setting is proportional to the square of the frequency.

The curves of Fig. 18 show the increase of effective resistance due to the effective capacitance c_0, $C_{min} + c_0$ and $C_{max} + c_0$ for the various tappings and shows clearly why the number (n) of tappings is limited to 6 by formula 19.

In conclusion, the curves of Fig. 19 indicate the manner in which definite frequency bands should be associated with a standard of inductance. They should prove interesting since they are plotted for actual coils of the author's compensated design.

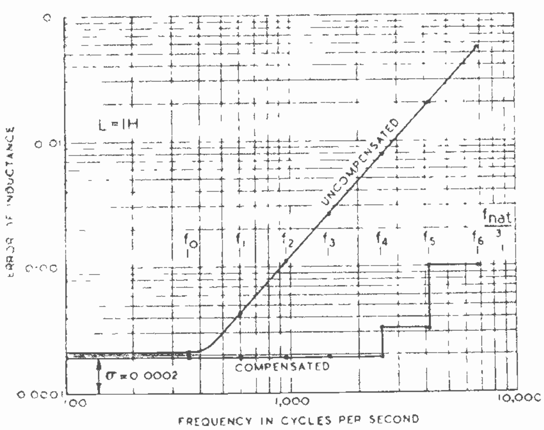


Fig. 17.

The curve of f_0 gives the frequency above which the self-capacitance of the coil exercises an appreciable effect upon the value of the inductance. At frequencies below f_0 the *effective* inductance is sensibly equal to the *true* inductance.

The curve of f_s shows the frequency which may not be exceeded if, under conditions of excessive or greatly varying temperature and humidity, the stability of *effective* inductance is required to be equal to that of *true* inductance. This frequency may however be exceeded in the case of coils used as standards on a bridge in which double balance is provided for the elimination of the residual capacitance of coils so that their *true* inductances only are measured. Higher frequencies may also be employed if the standards are mounted in sealed shielding cases prior to calibration or when unsealed coils are used under reasonably good ambient

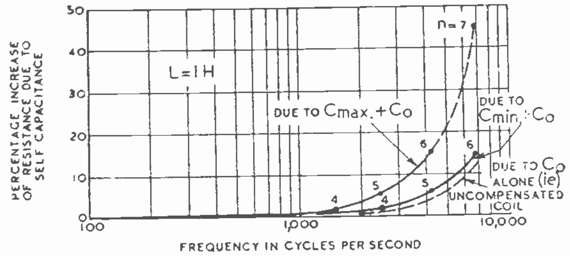


Fig. 18.

conditions. The shields of coils, however, may be responsible for much instability with changes of temperature if they are not constructed in a very rigid manner. Moreover, it is not easy to ensure the permanence of the relative positions of coil and shield under all conditions. This fact, together with the increase of effective resistance of "open field" coils due to the proximity of complete shields, leads to large shields or to the abandonment of solid shields altogether and to the substitution where possible

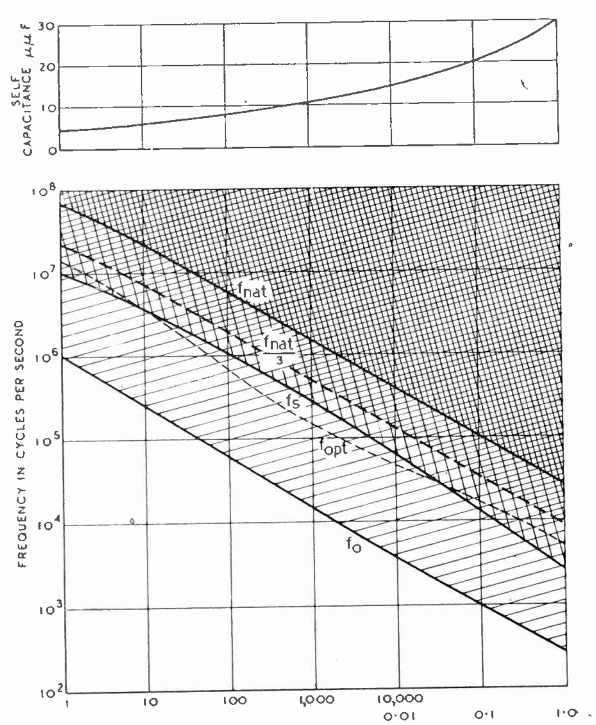


Fig. 19.

of an electrostatic "cage" shield in which all possibility of closed circuit loops is avoided by the provision of insulated junctions.

The curve $f_{max}/3$ gives the frequency above which coils are seldom used as standards owing to the approach to their natural resonance frequencies. The curve f_{max} gives the natural frequency of any coil, the frequency at which the coil ceases to behave as an inductance.

It is seen therefore that the limitations of the uses to which the coils may be put are indicated at a glance by the shading intensity of the areas between the curves. The most heavily shaded area is that in which coils cannot be used at all and the most lightly shaded that in which no limitations whatever need be imposed upon their use.

The *effective* self-capacitances which govern the heights of all the frequency curves of Fig. 19 are also given in the same figure. It must be understood, however, that the heights of the curves f_0 and f_s are governed also by the geometrical perfection of the coils since these curves are based upon the maintenance of accuracy and stability of *effective* inductance of the same order as is associated with the *true* inductance. The curves f_0 and f_s would therefore be raised for coils of lesser quality and lowered for coils of greater self-capacitance.

When used as reference standards coils of medium and high inductance may be frequency-compensated as shown in Fig. 17 to an extent which, in effect, might raise the curve f_0 to the level of f_s or even to that of $f_{max}/3$.

Finally the curve f_{op} indicates the mean frequency of a band throughout which the optimum efficiency ($\omega L/R$) is obtained. The frequency band throughout which $\omega L/R$ is not seriously reduced is of the order $\pm$ 30 per cent. of f_{op} — in some cases more and in others less. It is extremely interesting to see how the curve f_{op} closely follows the curve f_s; this, of course, means that the coils may be used in resonant circuits of wavemeters and stable generators at their most efficient (lowest decrement) frequencies without loss of frequency stability.

While discussing the significance of the various frequencies associated with a coil there is another frequency or band of frequencies which may prove important in a coil of which great stability is demanded at high frequencies.

The frequencies referred to are those at which the current redistribution within the cross section of the conductor of a coil (the "skin effect") becomes appreciable.

The change of inductance consequent upon such current redistribution with increasing frequency is well known; the inductance of a straight conductor or of a coil formed by that conductor decreases with frequency above a certain value until a limit is reached when the current is confined to a peripheral strip of the conductor of negligible thickness. A further increase of frequency beyond this limiting value produces no corresponding further reduction of inductance although, of course, the conductor resistance continues to rise with frequency and has no limit.

The effect of this current redistribution upon the temperature coefficient of inductance is not so well known however. The extent of the redistribution within a conductor (assuming unity permeability) depends not only upon frequency but also upon the specific resistance of that conductor. Therefore, as the specific resistance of the conductor changes with temperature it is seen that the inductance of a coil wound with that conductor varies with temperature to an extent which depends upon frequency. The "skin depth" t of the conductor of circular cross section to which the current is in effect confined at any given frequency f, is given by

$$t = \frac{1}{2\pi}\sqrt{\frac{10^9\rho}{\mu f}}$$

and, since this skin depth is proportional to the root of the specific resistance ρ of the conductor, it follows that the temperature coefficient of inductance due to current redistribution will always be positive.

At frequencies below that at which the skin depth is sensibly equal to the radius of the conductor, it is obvious that there will be no such temperature coefficient augmentation. And at frequencies higher than that at which the skin depth is reduced to a negligible dimension compared with the conductor radius the augmentation also will be reduced to a negligible amount.

It is important to know the frequency band between these two frequencies and especially to know the frequency at which the augmentation is a maximum.

In a circular conductor of radius R the increase ΔA of the cross sectional area A of " skin " with an increase of temperature is

$$\Delta A = 2\pi(R - t) \times \delta t \quad \ldots \quad \ldots \quad (20)$$

The temperature coefficient of copper is 0.004 per 1 deg. C. and, as

$$t \propto \sqrt{\rho}$$

the temperature coefficient of t is half that of the specific resistance ρ.

For a 1 deg. C. temperature rise in a copper conductor therefore,

$$\Delta A = 2\pi(R - t) \times 0.002t$$
$$= 0.004\,\pi t(R - t)$$

When ΔA is a maximum the largest number of imaginary elemental filaments, each carrying its correct proportion of the total current, is included within the inward extension of magnetic field. The maximum augmentation of temperature coefficient of inductance does not occur when ΔA is a maximum, however, because the magnetic flux density diminishes towards the centre of the conductor even when the current is uniformly distributed throughout the entire section of that conductor. Owing to the higher flux densities towards the periphery of the conductor section it is obvious that the maximum augmentation of temperature coefficient occurs when the skin depth is somewhat less than that which makes ΔA a maximum.

The flux density B at any point (at radius $R - t$) within the conductor when a total current I is distributed uniformly throughout the section is given by :—

$$B_{(R-t)} = 0.2I\,\frac{(R - t)^2}{R^2} \cdot \frac{1}{R - t}$$
$$= \frac{0.2I}{R^2} \cdot (R - t)$$

The flux density therefore must diminish towards the centre of the conductor at least proportionately to $R - t$ and

$$\Delta A(R - t)$$

therefore more nearly gives the augmentation of linkages for a 1 deg. C. rise.

It is not correct, of course, because, not only does the current density itself diminish towards the centre of the conductor, but it causes also a further diminution of magnetic flux density in this direction.

Thus the non-uniformity of current density within the skin and, of course, the indefinite boundary of the skin are both contrary to the assumptions upon which the following expression (21) is based.

The augmentation of temperature coefficient of inductance is however sufficiently proportional to

$$\tau = \Delta A(R - t)$$

to give the band of frequencies to be avoided for any given diameter of conductor if the augmentation is not to be serious. The expression is sufficiently accurate also to give the skin depth (and therefore the frequency) at which the augmentation is a maximum. The chief object in presenting this method is to give a clear elementary physical picture of the effect.

$$\tau = \Delta A(R - t)$$
$$= 0.004\,\pi t(R - t)^2 \quad \ldots \quad \ldots \quad (21)$$

τ is plotted against $R - t$ (for a particular case of a 0.01 cm radius conductor) in Fig. 20 and it is obvious that the temperature

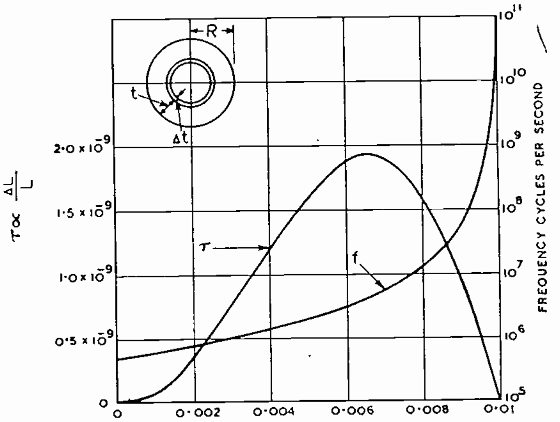


Fig. 20.

coefficient augmentation is a maximum when $\frac{d\tau}{dt}$ is zero.

From (21) $\tau = 0.004\,\pi t(R^2 - 2Rt + t^2)$

$$= 0.004\,\pi(R^2t - 2Rt^2 + t^3)$$

Differentiating :—

$$\frac{d\tau}{dt} = 0.004\,\pi(R^2 - 4Rt + 3t^2)$$

and the temperature coefficient augmentation is a maximum when

$$3t^2 - 4Rt + R^2 = 0$$

$$t^2 - \frac{4}{3}Rt + \frac{4}{9}R^2 = -\frac{1}{3}R^2 + \frac{4}{9}R^2$$

$$t - \frac{2}{3}R = \sqrt{\frac{R^2}{9}}$$

$$\therefore \quad t = R \text{ or } R/3$$

The first of these solutions gives an indication of the unimportance of the centre of the conductor owing to the small areas and weak fields involved, and the second gives the skin depth which produces the maximum augmentation of temperature coefficient.

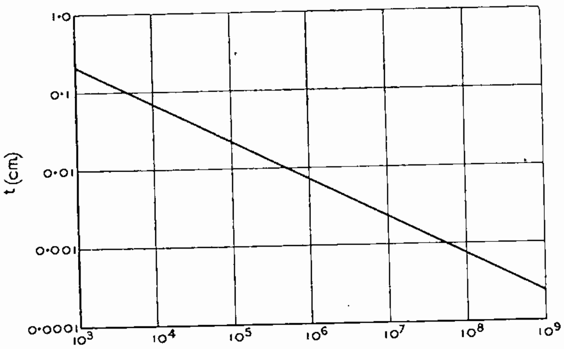


Fig. 21.

Skin depths for copper are plotted against frequency in Fig. 21 and from this curve therefore may be read directly the order of radius of the conductor to be avoided for any given frequency. The frequency band throughout which there is an appreciable augmentation of temperature coefficient of inductance for any given section of conductor is very wide—the lower limiting frequency being sensibly that at which the "skin depth" is equal to the radius and the upper limit being the frequency at which the skin depth is such as to reduce τ to, say, 10 per cent. or less of its maximum value—this skin depth is of the order $R/100$ as is seen from the curve of Fig. 20. In this figure are shown for a circular conductor of 0.01 cm radius (about 36 S.W.G.) the increase τ of linkage between current and flux due to varying skin depth t and the frequency f which corresponds to t. For this particular conductor it is seen that an appreciable increase of temperature coefficient of inductance will be present within the frequency band 4×10^5 to 2×10^9 c/s.

In Fig. 22 is shown the frequency band which must be avoided for wires of any radius if the temperature coefficient augmentation due to skin effect is to be less than 2 or 3 parts in one million per deg. C. The band extends from $t = R/100$ to $t = R$ and the frequency at which the augmentation is greatest ($t = R/3$) is also indicated.

Thomas[4] has calculated the temperature coefficient augmentation of circular wires using a method based upon the formula of Rosa and Grover[5]. He has shown that for long wires (300 cms) of from 0.001 cm to 0.1 cm radius the maximum augmentation varies from 25 to 40 parts in one million respectively. The augmentation increases with the shortening of the wire until it is 50 per cent. or so greater for very short wires of the order 10 cms. A slight increase of augmentation is also to be expected upon forming the straight wires into coils.

It is seen that wires of large radius may be used at frequencies lower and higher than the "skin effect band" but that wires of small radius can be usefully employed only at frequencies below this band.

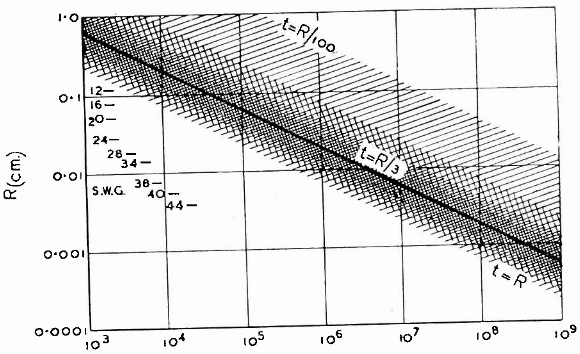


Fig. 22.

Thus the precautions usually taken in the design of coils to prevent an undue rise of high frequency resistance due to skin effect serve also to minimise the augmentation of temperature coefficient of inductance.

For coils of medium and high values there is, indeed, no alternative to such precautions, but coils of low values if intended for use at

[4] "Theory and Design of Valve Oscillators," by H. A. Thomas, D.Sc., M.I.E.E., pp. 129–136.

[5] "Formulae and Tables for the Calculation of Mutual- and Self-Inductance." *Bulletin of the Bureau of Standards*, 1912, Vol. 8, p. 1.

very high frequencies may be constructed from a conductor of such ample section that the increase of resistance due to "skin effect" is enormous while the augmentation of temperature coefficient of inductance is negligible.

Although the shaded frequency band of Fig. 22 must be avoided with fair precision at its lower frequency boundary, more tolerance is permissible at its upper boundary since the temperature coefficient change with frequency is very gradual in the vicinity of this boundary as is indicated by the intensity of the shading. In Fig. 23 is shown the

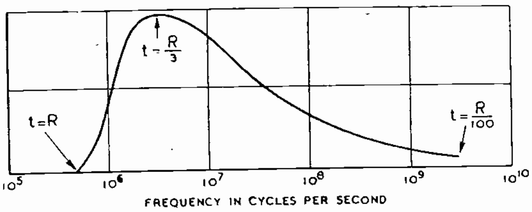


Fig. 23.

shape of the temperature coefficient augmentation curve for a circular wire of 0.01 cm. radius. The shape, which is typical of wires of any radius with displacement to the left or right occurring with radii greater or lesser respectively, is the obvious combination of the two curves of Fig. 20—the frequencies which produce the skin depths for various values of τ being plotted against those values. The shape of this curve and that of Fig. 20 needs some slight correction owing to the invalidity of the assumptions already explained.

In the author's coils the "skin effect band" is avoided in all coils above 30 μH by the use of finely stranded Litzendraht wire—this ensures freedom from temperature coefficient augmentation at frequencies up to the useful limit of $f_{nat}/3$ of Fig. 19.

Coils of 25 μH and less are wound with thin copper ribbon of considerable width and these also exhibit no augmentation of temperature coefficient throughout the useful ranges of frequency associated with them.

In conclusion, the author wishes to express his indebtedness to Messrs. H. W. Sullivan, Ltd., for permission to publish the constructional details of the coils shown in Figs. 4 and 6 and the results of experiments on the coils.

Books Received

The Story of Electromagnetism.—By Sir William Bragg, O.M., K.B.E., F.R.S. In this book is reproduced, with modifications appropriate to book form, a lecture given by Sir William Bragg on three occasions at the Royal Institution to Cadets of the Air Training Corps. It is intended as a sketch of the gradual realisation of the fundamental principles of electromagnetism, and the successive contributions of the principal discoverers are briefly described. Many of the illustrations are reproduced from drawings in the original papers. Those illustrating Faraday's work are from the margin of his diary. Pp. 64, Figs. 18. G. Bell & Sons, Ltd., Portugal Street, London, W.C.2. Price 1s. 6d.

Thermionic Valves in Modern Radio Receivers.—By A. T. Witts. In this, the second edition of this book, which outlines the theoretical and practical applications of thermionic valves to modern receivers, notes have been added on a number of subjects, such as push-pull phase splitters, negative feedback and output tetrodes. It is not confined to broadcast receiver technique and should, therefore, be of interest to those engaged in other wireless fields. Pp. 218, Figs. 135. Sir Isaac Pitman & Sons, Ltd., Parker Street, London, W.C.2. Price 10s. 6d.

Radio Navigation.—By W. J. D. Allan. As would be expected in a short treatise occupying less than 100 pages, the subject of radio navigation for wireless operator-observers is dealt with very briefly. It is intended as a logical companion volume to those in the series on astro-navigation, dead-reckoning and map reading. Pp. 101, Figs. 32. George Allen & Unwin, Ltd., 40, Museum Street, London, W.C.1. Price 2s. 6d.

Engineers and Salvage

OF all professional men the engineer is, perhaps, the most prone to the habit of hoarding papers, periodicals and technical literature generally, in anticipation that they might be needed in the future to solve some problem or elucidate some difficulty in design. Engineers' libraries, however small, invariably contain some literature which is good for neither use nor ornament. Whilst it is not suggested that the majority of this material is useless, or that it is kept for purely sentimental reasons, there must be a considerable amount which could readily be put to good account in the national war effort as salvage.

The Wireless Engineer library was not blameless in regard to sentimentality, but that has gone by the board, and as a result many hundredweights of paper were added to the national waste paper basket.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

538 058.—Gramophone pick-up, adapted for mass production, comprising an elongated moving coil which does not embrace any stationary part of the magnetic circuit.

P. G. A. H. Voigt. Application date 12th January, 1940.

538 486.—Amplifier with variable gain control over a wide band of frequencies effected without substantial change of grid bias.

Standard Telephones and Cables; A. H. Roche; and T. Blashill. Application date 2nd February, 1940.

AERIALS AND AERIAL SYSTEMS

538 036.—Aerial system comprising two or more dipoles for transmitting horizontally-polarized waves, particularly for radio-navigational purposes.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 26th April, 1939.

538 458.—Method of grouping and winding the turns of a frame aerial in order to eliminate or compensate the so-called "vertical" effect.

The Mullard Radio Valve Co. Convention date (Netherlands) 4th April, 1939.

538 994.—Directive aerial array in which provision is made for varying both the relative spacing of the aerial elements and the phasing of the currents with which they are fed.

F. Twyman. Application date 22nd February, 1940.

DIRECTIONAL WIRELESS

538 030.—Radio direction finder arranged to give an automatic indication, simultaneously, of radio heading, magnetic compass reading, and true bearing.

Marconi's W.T. Co. (assignees of I. Wolff). Convention date (U.S.A.) 31st January, 1939.

538 214.—Means for displaying say the rate-of-turn of an aeroplane by means of vertical and horizontal line-traces moving simultaneously over the screen of a cathode-ray tube.

Marconi's W.T. Co. (assignees of D. S. Bond). Convention date (U.S.A.) 31st March, 1939.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

538 389.—Method of band-spread tuning in a short-wave receiver which is provided with a number of tuning dials, for different frequency bands, traversed by the same pointer.

Philips Lamps. Convention date (Netherlands) 28th February, 1939.

538 921.—Arrangement for tuning a Lecher-wire system by a shunt capacitance which is controlled by means of a rotating dial.

Marconi's W.T. Co. (assignees of J. R. Schick). Convention date (U.S.A.) 22nd March, 1939.

538 946.—Narrow band-bass filter circuits, including piezo-electric crystal elements fitted with three electrodes to neutralise their inherent capacitance.

Marconi's W.T. Co. and A. T. Starr. Application date 13th December, 1939.

539 130.—Driving and coupling gear for a radio pre-selected tuning system of the press-button type.

The British Thomson-Houston Co. Convention date (U.S.A.) 22nd June, 1939.

539 170.—Amplifier with a negative feed-back circuit for ensuring linearity over a range of operating frequencies, particularly in conjunction with automatic or manual gain-control.

Standard Telephones and Cables (assignees of F. B. Anderson). Convention date (U.S.A.) 5th August, 1939.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

538 054.—Television system in which each elemental picture-area is scanned a number of times in succession, the signal currents so derived being combined in phase.

I. J. P. James. Application date 13th November, 1939.

538 064.—Saw-tooth oscillation generator provided with means for controlling the frequency or amplitude, either independently, or together.

Hazeltine Corpn. (assignees of J. C. Wilson). Convention date (U.S.A.) 16th February, 1939.

538 103.—Separating the synchronising impulses from the picture signals in a television receiver combined with means for black-level setting and automatic volume control.

Hazeltine Corpn. (assignees of R. L. Freeman). Convention date (U.S.A.) 15th March, 1939.

538 206.—Valve circuit of low plate impedance for modulating a short-wave carrier with a wide frequency-band of signals, particularly for television.

Standard Telephones and Cables (assignees J. Le Matériel Téléphonique Soc. Anon.). Convention date (France) 14th February, 1939.

538 587.—Method of separating the picture signals from the synchronising impulses and for suppressing random impulses in a television receiver.
Hazeltine Corpn. (assignees of J. C. Wilson). Convention date (U.S.A.) 16th March, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

538 040.—Ultra-short-wave oscillator associated with means for protecting it against undesired effects due to reflection from conductors in the near vicinity.
Marconi's W.T. Co. (assignees of R. A. Braden). Convention date (U.S.A.) 31st March, 1939.

538 149.—Switching arrangement for a high-powered radio transmitter operating on one or other of a number of predetermined wavelengths.
Marconi's W.T. Co. (assignees of R. F. Guy). Convention date (U.S.A.) 22nd April, 1939.

538 221.—Circuit for generating rectangular wave-forms by means of a relaxation oscillator including a pentode having a steep plate-current/grid-volts characteristic and a small anode saturation current.
Standard Telephones and Cables; R. M. Barnard; and W. Kram. Application date 10th November, 1939.

538 775.—Circuit for imposing a high percentage of frequency or phase modulation on a carrier wave whilst, at the same time, preventing any appreciable amplitude modulation.
Marconi's W.T. Co. (assignees of W. van B. Roberts). Convention date (U.S.A.) 10th March, 1939.

538 795.—Frequency-changing circuit comprising a Wheatstone Bridge arrangement of non-linear resistances, suitable for modulating or de-modulating.
Standard Telephones and Cables (assignees of W. F. Kannenberg). Convention date (U.S.A.) 5th April, 1939.

538 814.—Impedance circuit comprising a variable resistance element used for applying phase or frequency modulation to a carrier wave without introducing any appreciable amplitude modulation.
Marconi's W.T. Co. (assignees of W. van B. Roberts. Convention date (U.S.A.) 18th March, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

538 207.—Arrangement for preventing secondary emission in a power valve by the application of a magnetic control field.
The Mullard Radio Valve Co. Convention date (Germany) 17th February, 1939.

538 321.—Photo-electric cell with a spherical cathode and an auxiliary electrode which combine to focus the primary electrons on to a secondary emission target.
The Mullard Radio Valve Co. Convention date (Germany) 28th March, 1939.

538 381.—Valve electrode system in which secondary emission is utilised to produce positive reaction which increases the mutual conductance of the valve without causing self-oscillation.
Standard Telephones and Cables and B. B. Jacobsen. Application date 30th January, 1940.

538 412.—Television transmitter tube in which a sheet-like beam of electrons sweeps the mosaic screen after the latter has been scanned by a high-velocity beam.
Marconi's W.T. Co. (assignees of H. Nelson). Convention date (U.S.A.) 31st January, 1939.

538 479.—Cathode for an electronic-discharge device comprising an alkaline-earth-oxide coating on a core which is free from material capable of reducing the oxide. [Addition to 534 154.]
Marconi's W.T. Co. (assignees of E. G. Widell). Convention date (U.S.A.) 1st February, 1939.

538 610.—Cathode-ray in which the principle of velocity modulation is applied to the measurement of high-frequency voltages without any appreciable absorption of power.
Standard Telephones and Cables and J. H. Fremlin. Application date 6th February, 1940.

538 684.—Cathode-ray tube with an electrode arrangement for preventing "black-spot" damage to the fluorescent screen caused by the presence of ions in the electron stream.
Philco Radio and Television Corpn. (assignees of H. Branson). Convention date (U.S.A.) 25th February, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

537 966.—Wired-wireless multiplex system in which means are provided for protecting the supervisory relays from being falsely operated by the speech signals.
Standard Telephones and Cables and B. B. Jacobsen. Application date 1st January, 1940.

538 006.—Automatic gain-regulating system for a telegraphic circuit comprising a radio link or other channel subject to bad fading.
Electrical Research Products, Inc. Convention date (U.S.A.) 8th July, 1939.

538 111.—Safeguarding devices for a wired-wireless signalling system operating over high-voltage power lines.
The General Electric Co.; E. V. Newbery; and E. P. L. Westell. Application date 10th May, 1940.

538 124.—Means for automatically maintaining the level of the electrolyte in an accumulator, whilst at the same time allowing the gases to escape.
C.A.V. and S. Leeson. Application date 19th January, 1940.

538 361.—Method of utilising ultra-short-wave energy for killing bacteria and other micro-organisms.
Westinghouse Electric International Co. Convention date (U.S.A.) 22nd December, 1938.

538 369.—Valve circuit for generating, say, a saw-tooth oscillation in which any variation from the desired form of wave sets up a correcting reaction. (Addition to 522 637.)
E. L. C. White and E. W. Bull. Application date 29th January, 1940.

Abstracts and References

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research

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

356. MEASUREMENT OF THE ATTENUATION AND PROPAGATION VELOCITY OF ELECTROMAGNETIC OSCILLATIONS IN METALLIC TUBES [Experiments to check the Special Behaviour of the H_{01} Wave predicted by Carson, Southworth, & others: and Other Uses of the Equipment].—A. Riedinger. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 21–25.)

From the German P.O. research laboratories. The principle of the measuring method was to introduce a short train of the H_{01} waves into an aluminium-tube line (internal diameter 14.65 cm, length about 5 m) closed at each end by a metal plunger, and to let the wave train be reflected to and fro from end to end till it had died away: the decrement could then be calculated from the amplitude ratio of successive pulses and the length of the path traversed. In practice, to enable a cathode-ray tube to be used for the measurements the pulse transmission must be repeated periodically, with intervals long enough for each wave train to be practically extinct by the time the next one arrives. The spacing length must therefore be several times the wave-train length: Fig. 3 shows the 30 kc/s modulating pulse (lower curve) which is arranged to lower the anode voltage of the centimetric-wave magnetron oscillator so that the latter oscillates only during the spaces between the pulses (upper curve). This modulating pulse is generated by a tungsten-cathode triode with its grid biased strongly positive and driven by suitably amplified signals from the signal generator on the left of Fig. 1: its voltage is about 60 v, and this is superposed on the magnetron anode voltage. The spacings, three or four times as long as the train, which are obtained in this way are long enough only in cases when the wave attenuation in the tube is very high: larger ratios can be obtained by raising the grid bias or lowering the grid alternating voltage, but this spoils the square-wave form of the pulse and tends to produce an unwanted frequency-modulation of the magnetron. The system is therefore modified in such a way that the previous wave-train curve reproduced in Fig. 4c is combined with the curve of Fig. 4b to give that of Fig. 4c, with doubled spacing.

The first method used for exciting the H_{01} wave in the tubular line is shown in Fig. 6: a Lecher pair is bent round the outside of the tube, which is provided with slits (parallel to the axis) at the current antinodes of the same polarity, the electrical length of the Lecher pair being adjusted by Trolitul spacers bulging-out the wires. If the tube perimeter is approximately a whole multiple of the wavelength these bulges can be omitted, and the tube surface takes over the rôle of the second conductor. This outside loop, however, was found at the higher frequencies to produce some interfering waves in addition to the H_{01} wave, and was replaced (at any rate for these frequencies) by an internal Lecher-pair circular loop (Fig. 7) near one end-plunger of the tube.

The wave trains are picked up by a very small dipole introduced into the tube in the neighbourhood of the input system (*see* Fig. 1) or, in some experiments, mounted in a resonance cavity behind that system. The oscillations are rectified by a crystal detector, amplified in a wide-band amplifier, and taken to the c.r. oscillograph, whose time base is provided by the pulse generator. The attenuation oscillograms were taken on four different wavelengths between 6 and 12 cm: a typical oscillogram (Fig. 10) shows clearly the exponential character of the damping. Incidentally, the smallness of the exciting pulse compared with the first peak (which it would have been expected to exceed), shown in this oscillogram and repeated in all of them, has not been accounted for. The frequency characteristic of the attenuation, plotted from the measurements at the four frequencies, is compared in Fig. 12 with the calculated curve. It displays the decrease with increasing frequency expected from this type of wave (as distinct from the other types, whose attenuation with increasing frequency passes through a minimum and then rises steadily) but the whole measured curve lies above (*i.e.* in the region of higher attenuation than) the calculated characteristic. This is attributed to the poor surface conductivity of the tube employed, which was built up from thin aluminium foil, with a rubber-strip winding to keep out moisture, and whose inner surface, in spite of precautionary measures, must have been far from perfect.

Fig. 14 shows the apparently complete agreement between the group and phase velocities calculated and those (shown by the four open dots) taken from the oscillograms with the help of a time scale provided by the known frequency of the modulating pulses.

357. THE PROPAGATION VELOCITY OF THE ENERGY OF MONOCHROMATIC ELECTROMAGNETIC WAVES IN DIELECTRIC MEDIA.—F. Borgnis. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 642–650.)

"The question of the group velocity of a monochromatic wave in the sense of a 'signal' velocity is, from what has been said above [earlier in the paper], a meaningless one; on the other hand it is justifiable to ask with what velocity the mean energy of a wave in the steady state is propagated. For electromagnetic waves the energy velocity can be defined with the help of the Poynting vector $\mathfrak{S}$. If the wave and its energy move in the direction of the coordinate x_i, and if we consider the plane x_i = const. normal to the direction of propagation, then the x_i-component of $\mathfrak{S}$ gives the amount of energy flowing per second through that plane. Putting the mean energy flow equal to the product of the mean electromagnetic energy $\overline{W}$ of the wave and the energy velocity u_E, we have

$$\int \overline{\mathfrak{S}}_{xi} df = \int [\overline{\mathfrak{E}\mathfrak{H}}]_{xi} df = \overline{W} . u_E \quad . . . \text{(eqn. 6)}.$$

The calculation now given allows the value of u_E to be determined for electromagnetic waves of a very general character.

"For free monochromatic waves with, for example, plane, cylindrical, or spherical phase surfaces, energy and phase velocities coincide: these types of wave are therefore of no interest from our point of view. But the case is different, for instance, with guided waves: *i.e.* waves which move along any kind of metallic limits (here considered as infinitely good conductors). For such a wave type there exists between wave number h and angular frequency ω a functional relation of the form $h = \sqrt{\epsilon\mu\omega^2 - A^2}$ . . . (eqn. 7). Even when the medium constants ϵ and μ are independent of frequency, dispersion occurs in the sense that the phase velocity (defined by $v = \omega/h$) is a function of frequency.

"The following investigation shows that quite generally the energy velocity of a monochromatic electromagnetic wave, as defined in eqn. 6, is given by $u_E = h/\omega\epsilon\mu$. Representing the velocity of light c, in the medium concerned, by $1/\sqrt{\epsilon\mu}$, this equation, combined with that for the phase velocity just given, yields $v . u_E = c^2$ . . . (eqn. 9), a relation known from another field of physics.

"If no dispersion exists in the medium, it follows also that the energy velocity u_E of a monochromatic wave is identical with the group velocity, defined as $u = d\omega/dh(\omega)$. If however there is dispersion in the medium (frequency-dependent ϵ or μ) the two velocities are different, since in the calculation of the group velocity the derivatives $d\epsilon/d\omega$ and $d\mu/d\omega$ make a contribution. These derivatives play no rôle in the energy velocity of the monochromatic wave, as is obvious since here the frequency ω_0 of the wave determines on its own account the values $\epsilon(\omega_0)$ and $\mu(\omega_0)$, and consequently the value of u_E according to eqn. 6. The physical grounds for the difference between energy and phase velocities for the electromagnetic processes considered are discussed in Section 5": when a dispersion corresponding to eqn. 7 (*see above*) occurs, the energy velocity is smaller than the velocity of light, and the phase velocity larger, according to eqn. 9 (above). The physical cause for this inferiority of the energy velocity to that of the velocity of the phase surfaces lies ultimately in eqn. 6 (above). The mean energy flow in the propagation direction x_i receives contributions from the field components E_2, E_3, H_2, and H_3, but not from the component E_1 (in the electric type) or from H_1 (in the magnetic type). These components produce a swinging of energy *perpendicular to* the direction of propagation, with a zero mean value in time: they are included in the total electromagnetic energy content, but that fraction of the energy which is contained in them does not "flow." The larger, therefore, the contribution by E_1 or H_1 to the mean total energy, the smaller the value of the energy velocity: on the other hand, if the components E_1 and H_1 in the direction of propagation disappear, the whole energy flows in the direction of the wave motion, so that for such purely transverse waves the energy and phase velocities must be identical.

358. THE RELATION OF RADIO SKY-WAVE TRANSMISSION TO IONOSPHERE MEASUREMENTS.—N. Smith. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 14–32.) Slightly abbreviated translation of the *Proc. I.R.E.* paper dealt with in 3042 of 1939.

359. ON THE QUESTION OF THE EVALUATION OF IONOSPHERIC OBSERVATIONS:- REMARKS ON A PAPER BY H. G. BOOKER & S. L. SEATON.—K. Rawer. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 49–52.)

Booker & Seaton (1588 of 1941), assuming a parabolic distribution curve, have suggested that the actual height of the level of max. density can be taken as equal to the observed virtual height for a frequency of five-sixths (0.834) of the penetration frequency. "Various applications," says Rawer, "have already been made of this method and it has actually been applied to disturbed ionospheric conditions [Berkner & Seaton's paper, 677 of 1941, is here quoted: actually, Booker & Seaton refer to the Berkner, Wells, & Seaton paper mentioned in 1757 of 1940]. There are, however, serious objections to its use." In his introductory paragraph he has already referred to his own calculation (3879 of 1939 and back ref.), for an "Epstein" layer with its very smooth, symmetrical characteristic, of the virtual-height/frequency curve, which showed the existence of a "special" frequency at 0.707 times the penetration frequency: and also to Petersen's suggestion that this "special" wavelength should be used to determine the actual heights from the records of multi-frequency runs—a suggestion which was abandoned because it was considered that a comparatively small change in the layer characteristic would render the wavelength value no longer correct.

This argument is now applied to Booker & Seaton's suggestion, and is elaborated with the help of Figs. 4 a–f and Table 1, which show different types of layer—exponential, triangular, parabolic, parabolic-with-"tail" (4d & 4e, for two different points of attachment for the exponential "tail,") and "Epstein"—with the multi-frequency curve corresponding to each and (in the table) the corresponding "special" frequencies. It is concluded that the latter may range between 65 and 90% of the penetration frequency, according to the shape of the layer density form: the most frequent values being likely to lie between 70 and 85%. "So long as these values cannot be determined more accurately, any height determination based on them must remain uncertain. For the F_2 layer the uncertainty may amount to as much as 50 km." This argument applies, of course, with particular strength to magnetically disturbed days, when the density-distribution form is bound to vary from the normal, whatever that may be; so that even if the true heights could, on normal days, be obtained from a "special" frequency derived in some way or other, it would be quite wrong to use that same frequency for disturbed days. But even for quiet days the Booker-Seaton technique and the results cited in support of it are condemned (p. 50).

Coming finally to alternative possibilities, the writer considers the work of Rydbeck (23 of 1941) and the interesting promise it contains of enabling, among other things, a "special" frequency to be found (though laboriously) for the rapid evaluation of undisturbed night observations. Even here some slight uncertainty is likely to remain, because broadcast interference would probably impede, in most localities, the required measurements where they extend into the very low frequencies. In any case, until Rydbeck's work has been developed a simple procedure giving the fullest possible information as to the form of the distribution curve is badly needed. In Germany, Goubau's suggestion is followed, and in addition to the penetration frequency and minimum height, care is taken to measure also the virtual height for the extra-ordinary component at the penetration frequency of the ordinary component. Since the magneto-ionic splitting produces a fixed frequency difference (0.7 Mc/s in Germany) the resulting virtual height is that for a frequency ($f_0 - 0.7$). This value gives a certain amount of information regarding the thickness of the layer: "it is certainly not ideally defined, but has the advantage of easy readability." No doubt it would be better to determine a well-defined characteristic quantity relating to the layer. The determination of the layer-centre height quickly and reliably is impeded, as has been seen, by the fact that such an absolute quantity must be based on the whole of the multi-frequency record. Things are much better if only *relative* values are sought, such as can be obtained from a portion of the record. Booker & Seaton's "parabola breadth" τ would be such a value if it were defined in respect to two definite test frequencies: but it must be realised that what would be measured would not be the "layer breadth at very low concentrations" (as τ is mathematically defined) but merely a property of curvature of the layer between the concentrations at which the measurements were performed. Another quantity of the same kind is the layer breadth at 90% of the max. concentration, which may be called the "summit breadth." In some ways this is a better measure of the effective layer thickness than a value taken at lower concentrations, and it can be derived from two virtual-height measurements near the penetration frequency, where the shape of the layer characteristic has little influence: for instance, if Δs is the difference between the virtual heights at $0.95 f_0$ and $0.90 f_0$, a parabolic layer would give $1.52 \Delta s$ for the "summit breadth" and an Epstein layer $1.63 \Delta s$. "In practice, it would be good enough to take $1.5 \Delta s$ as the 'summit breadth,' since the difference given by the two methods of calculation is no larger than the usual error of measurement."

360. MEASUREMENT OF THE ANGLE OF INCIDENCE AT THE GROUND OF DOWNCOMING [European] SHORT WAVES FROM THE IONOSPHERE.—Chaman Lal. (*Indian Journ. of Phys.*, Aug. 1941, Vol. 15, Part 4, pp. 289–305.)

The apparatus consists of two commercial superheterodyne receivers connected to two parallel horizontal dipole aerials: the internal oscillators were put out of action and a common local oscillator was connected to the two mixer stages: additional i.f. amplifiers made up for the reduced gain of the receivers due to low ohmic resistances connected across their input terminals to keep the input impedances steady and resistive (p. 292), and gave signals strong enough to work the cathode-ray oscillograph. In any measurement, two successive photographs were taken of the ellipse on the screen, the aerials being interchanged by a change-over switch: the mean of two such measurements was taken as the final result. The photographs were taken at the moment when the ellipse reached its maximum size, and therefore represent the principal ray (*see* Appendix II on the interpretation of the ellipse forms). It would only be possible to investigate the subsidiary rays if the stations would transmit short-duration pulses.

The average value for the downcoming angle of B.B.C. transmissions was 16, 20.6, 15.2, and 14.2 degrees for May, June, September, and November respectively: of German transmissions, 20.8, 19, and 15 degrees for May, June, and November. "The results, as will be apparent, indicate a general lowering of the F_2 layer during the winter evenings."

361. THE REFLECTION OF ELECTROMAGNETIC WAVES AT A LAYER WITH NEGATIVE DIELECTRIC CONSTANT [and the Explanation of Non-Linear Effects in the Ionosphere, particularly the Luxembourg Effect].—S. M. Rytow [Rytov] & F. S. Judkewitsch [Yudkevich]. (*Journ. of Phys.* [of USSR], No. 2, Vol. 3, 1940, pp. 111–124: in German.) The original Russian version was dealt with in 1592 of 1941.

362. ON THE ORIGIN OF THE SUDDEN FADE-OUTS [Calculations leading to Conclusion that Any Radiation penetrating to Height of 80 km must be Longer than 1750 AU].—R. Jouaust & E. Vassy. (*Comptes Rendus* [Paris], 21st July 1941, Vol. 213, No. 3, pp. 139–141.)

This conclusion "leads to the renunciation of the hypothesis of the action of the Lyman-α ray [Martyn & others: *cf.* Deb, Bhar, 8 & 9 of 1941]: we now proceed to propose another. The presence of sodium, probably of meteoric origin, in the atmosphere has been detected spectroscopically. Bernard has given 60 km as the height of the luminescent layer, Cabannes, Dufay, & Gauzit have given 130 km. But Vegard has shown that these results are not contradictory (*cf.*, for example, Cario & Stille, 1016 of 1941), the first being obtained from the sky at twilight, the second at night. Ionisation, at an altitude of 80 km, of the sodium atoms could be produced by the ultra-violet radiation from the solar eruptions, for the ionisation potential of sodium is such that only radiation below 2412 AU in wavelength is effective. Two rays intense enough to be held responsible for the ionisation of the sodium are to be expected in the spectrum of the eruptions, namely those due to CaII, one at 1840 and the other at 1838 AU. Equally to be expected are the ultra-violet rays of sodium and of magnesium (d'Azambuja, 3452 of 1939), and it is not impossible to suppose that atoms of other elements present in the meteorites are ionised. The quantity of matter imported into the atmosphere by these meteorites is 4 gm/km^2/year, corresponding (for sodium) to about 2.5×10^3 atoms/cm^2/sec."

363. UTILISATION OF THE CORRELATION COEFFICIENT IN HARMONIC ANALYSIS.—V. Frolow. (*Comptes Rendus* [Paris], 16th July 1941, Vol. 213, No. 2, pp. 56–57.)

For two sinusoidal waves having the same period but differing in amplitude and phase, this coefficient can be written in a form showing it to be a function of the length of the two series examined. Integration between the limits 0 and a multiple of 2π gives $r = \cos \phi$. For a whole number of periods, the correlation coefficient of two such sinusoids is therefore equal to the cosine of the difference in phase of the sinusoids.

This property of the correlation coefficient allows the calculation of the phase displacement of the homologous sinusoidal components obtained by the method of analysis by linear combinations of ordinates, due to H. and Y. Labrouste (*see* reference given, and *cf.* 23 & 488 of 1940). A way is thus provided of obtaining, better than by a measurement on the graph, the phase displacement of a component of given period calculated for the different stations. The property described allows above all, this determination to be made even when the phase differences are small. It is thus possible to extend the study of the progression of the hydrological and meteorological components to limited perimeters, and to proceed to analyses finer than have hitherto been possible.

364. THE MAINTENANCE OF THE ELECTRICITY OF THE EARTH'S ATMOSPHERE [Survey, including Published & Unpublished Work of the Writer].—H. Israël. (*Naturwiss.*, 21st Nov. 1941, Vol. 29, No. 47, pp. 700–706.)

"Nevertheless it must not be said that partial phenomena of the maintenance of atmospheric electricity may not be attributed to cosmic causes. It is just in this connection that field-variographic recordings have shown certain connections with ionospheric and geomagnetic conditions. According to this work, not yet completed [report not yet published], on the average an increasing unrest in the ionosphere and in the geomagnetic field is accompanied by an increase in the unrest of the atmospheric-electrical field."

365. CORRELATIONS OF SHORT-WAVE RADIO TRANSMISSION ACROSS THE ATLANTIC WITH MAGNETIC CONDITIONS.—H. E. Hallborg. (*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, p. 205.) A paper covering the same ground was dealt with in 2973 of 1941.

366. GEOMAGNETIC TIME-RELATIONSHIPS, *and* THE FUTURE OF WORLD MAGNETIC SURVEYING.—S. Chapman. (*Proc. Phys. Soc.*, 1st Nov. 1941, Vol. 53, Part 6, No. 300, pp. 635–650: pp. 650–657.). Following the same writer's address on Chree and his work (2977 of 1941).

367. THE GREAT MAGNETIC STORM OF SEPTEMBER 18TH–19TH, 1941.—A. G. McNish. (*Scient. Monthly*, Nov. 1941, Vol. 53, No. 5, pp. 478–481.)

368. THE AURORA OF SEPTEMBER 18TH, 1941 [probably the Most Brilliant ever observed at Washington: the Two Stages of an Ionospheric Storm (Turbulent Stage: Stage of Expansion & Diffusion of Higher Ionosphere) & Their Effects on Wireless Transmission].—Nat. Bur. of Stds. (*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, pp. 373–375.)

369. A NEW RADIATION IN THE AURORA OF 18th/19TH SEPT. 1941 [Spectral Observations at the Arosa Observatory: Bright Line at about 5190 AU].—F. W. P. Götz. (*Naturwiss.*, 7th Nov. 1941, Vol. 29, No. 45/46, p. 690.)

370. THE SUN AND THE IONOSPHERE [Kelvin Lecture].—S. Chapman. (*Journ. I.E.E.*, Nov. 1941, Vol. 88, Part I, No. 11, pp. 400–413.) Summaries were referred to in 2351 of 1941.

371. THE MOTION OF GASES IN THE SUN'S ATMOSPHERE: PART III—ON THE STRATIFICATION OF THE SOLAR ENVELOPE [Theory yielding Heights of Reversing Layer, Chromosphere, & Quiescent Prominences, in Agreement with

Observation].—A. K. Das. (*Indian Journ. of Phys.*, April 1941, Vol. 15, Part 2, pp. 79–93.)

For Part I *see* 1830 of 1941 : *cf.* also 1012 of 1941. " Incidentally it is to be noted that the relations (VI) may be expected to have a bearing on the forms of active prominences and their movement towards apparent centres of attraction. I hope to discuss these questions in a later paper."

372. On the Radial Limitation of the Solar Magnetic Field [Examination of Problem on Rigorous Mathematical Basis incorporating Revised Outlook about Behaviour (Discrete, Quantised) of Electrons in Magnetic Field].—B. Majumdar. (*Indian Journ. of Phys.*, April 1941, Vol. 15, Part 2, pp. 131–143.)

373. New Identification, in the Solar Spectrum, of Bands belonging to the CH Molecule [Certainty of Presence of Raffety Band and Probability of 3157 AU Band].—J. Dufay. (*Comptes Rendus* [Paris], 11th Aug. 1941, Vol. 213, No. 6, pp. 224–226.) For the presence of the Raffety band in the nuclei of comets *see* Dufay, *ibid.*, 28th July 1941, No. 4, pp. 160–162.

374. Determination of Soil Constants at Broadcast and Ultra-High Frequencies [Methods : Conductivities of Allahabad Soils at Normal Moisture Contents 2×10^{-13} e.m.u. at Broadcast Frequencies, 1.6×10^{-12} e.m.u. at 423 M/cs : etc.].—I. A. Ansari, B.D. & G.R. Toshniwal. (*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, pp. 191–192.) *Cf.* 295 & 2620 of 1941.

375. Contribution to the Theory of the Zenneck Field Inclination to the Surface of the Earth [$E_x/E_z = 1/n$ Formula].—O. Schriever. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 35–38.)

In spite of its justification by the success of the long-wire receiving aerial whose development was based on it, Zenneck's formula is not completely satisfactory, since for an inclination of 45°, such as must occur, according to it, for a refractive index n = unity, no physical grounds can be found. In this limiting case we should rather expect that the ratio of the horizontal field component to the vertical would be zero, *i.e.* that the electric lines of force would pass perpendicularly from the upper to the lower half-space, both of which are now filled with air as a medium. If, therefore, the formula possesses no universal validity, it is all the more important to learn whether it deals correctly with the properties of the ground and whether it can properly be used as a basis for a method of measuring the conductivity of the ground, as Grosskopf & Vogt have used it (1833 of 1941 : *see* also 376, below). " We shall see that this question, on the assumption of a correct choice of wavelength, can be answered in the affirmative. It has become customary to speak of the Zenneck phenomenon as surface waves. Since the present work derives the wave inclination from the space-wave reflection theory [for a vertical dipole : Weyl, Strutt], in a form valid for all values of n, we not only show its independence of the debatable surface-wave idea but also gain information as to the range of validity of the Zenneck formula."

The treatment adopted has already been used by Wise (1690 of 1937) who, however, " did not reach the result of the present paper." The equation arrived at is $E_x/E_z = \sqrt{n^2 - 1 + \sin^2\eta}/n^2 \cdot \cos\eta$, where $\eta = \delta_1 - \pi/2 = \pi/2 - \delta_2$ in Fig. 1, in which D represents the dipole : for a completely horizontal ray, where η is zero, the wave inclination becomes $E_x/E_z = \sqrt{n^2 - 1}/n^2$, which for $n = 1$ becomes zero, thus fulfilling the physical requirement mentioned above. When $n^2 \gg 1$ the formula is converted into the Zenneck formula $E_x/E_z = 1/n$. " The range of validity of the Zenneck formula is given by a simple comparison of Figs. 2 and 3 : it is unrestrictedly valid over water ; valid over damp ground ($\epsilon = 5$–15, $\sigma = 10^{-13}$–10^{-14}) for waves longer than about 10 m ; over dry ground ($\epsilon = 2$–6, $\sigma = 10^{-15}$) only for long waves exceeding about 1000 m in length." But it is found as an essential " condition of measurement " that the height of the measuring point above the earth's surface must be very small compared with the wavelength. This causes no difficulties for long and medium waves, but does so for short and still more for ultra-short waves. For instance, with a 2 m wave it would be necessary to make z (height of measuring point P above ground, Fig. 1) much less than 16 cm : this renders investigations on ultra-short waves impossible, since the apparatus would have to be too small and the unevenness of the ground (even the ripples on a water surface) would have too much effect.

Apart from this wavelength region, however, measurements of the inclination and the phase angle (ellipticity of rotating field) will allow a determination of the dielectric constant and conductivity. For the former, the frequency must be chosen high enough for the measuring point to fall in the upper horizontal portion of the ρ curve (*see* top of p. 37, r-h col.) so that σ need not be known and the refractive index can be taken as real : $n^2 = \epsilon$. The exact formula must be used. Owing to the " condition of measurement," only dry ground and fresh water can be dealt with. For the conductivity, the frequency chosen must be so low that the opposite condition holds good and the displacement current becomes negligible compared with the conduction current. From the values of ρ and ϕ (top of p. 37, r-h col.) thus obtained the conductivity can be calculated as in Grosskopf & Vogt's paper (*loc. cit.*), the Zenneck approximation being adequate here. For dry soil and fresh water, wavelengths over 1000 m should be used, but for wet soil and sea water it is possible to go down to about 50 m, provided care is taken to observe the " condition of measurement."

The discussion, mentioned above, of the comparison between the writer's curves (Fig. 2), for ρ and ϕ, derived from his equation $E_x/E_z = \sqrt{n^2 - 1}/n^2 = \rho \cdot \epsilon^{i\phi}$, and those of Zenneck (Fig. 3), points out among other things that for $\epsilon = 1$ and 2 his ρ-curve has a maximum, sharp in the first case and flat in the second : for both figures the wave frequency is 5×10^5 c/s. " Since dielectric constants as small as this do not exist in soil, it is hardly likely that maxima would be observed. It is more probable that such phenomena may play a part in the ionosphere."

376. THE MEASUREMENT OF ELECTRICAL CONDUCTIVITY FOR STRATIFIED GROUND.—J. Grosskopf & K. Vogt. (*Hochf:tech. u. Elek:akus.*, Sept. 1941, Vol. 58, No. 3, pp. 52–57.)

In their paper dealt with in 1833 of 1941 the writers describe a method by which, in the simplest cases, the ground conductivity could be determined, by means of a rotatable dipole, from the inclination of the lines of the electric field to the vertical (Zenneck's "surface waves": *cf.* Schriever, 375, above). Since then, they have made numerous conductivity measurements with the method in a more fully developed form, and the results of these have shown that a homogeneous ground is seldom found, and that in general a stratified formation must be taken into account. In the previous paper it was mentioned that a variation of the test frequency would provide a good way of investigating the stratification present, as regards its thickness and electrical properties (dielectric constants and conductivities). In the present paper, after a short recapitulation of the previous work and a further development of the theory, especially in relation to stratification, measurements of the frequency-dependence of the "effective" conductivity are reported. The technique should be of use not only in the selection of sites for transmitting stations and Adcock d.f. installations (*cf.* Keen's book *Wireless Direction Finding*), for which neither the field-strength method nor the parallel-wire technique gives a complete picture of the electrical properties of the ground, but also as an additional tool in radio-geological prospecting.

The final form of the dipole conductivity-measuring equipment is seen in Fig. 4: it can be carried in two canvas cases. It gives the ratio of the axes of the rotating-field ellipse and also the inclination of the major axis to the vertical (or more accurately, that of the minor axis to the horizontal). The measurements described were made on a particularly level and clear piece of land. The transmitter was 5 km away and had a vertical aerial. The field strength at the receiving end averaged 20 mv/m, but strengths down to 1–2 mv/m could be measured if desired. The frequency range covered was 150–1500 kc/s. Results from the distant Berlin station and the Deutschlandsender (841 and 191 kc/s respectively) agreed with those from the near-by transmitter, so that in this frequency region no sign of a variation with distance was found. Preliminary tests showed that the apparatus worked accurately from 200 to 1500 kc/s, while at the 150 kc/s frequency at the bottom of the range there were directional errors of a few degrees and amplitude errors of a few per cent.

The measured frequency dependence of the amplitude ratio a/b and of the angle of inclination γ of the rotating-field ellipse is shown in Fig. 5. Fig. 6 shows the frequency dependence of the "effective" ground conductivity as calculated from these measured amplitude-ratios by the formula (22), quoted from the previous paper, which is accurate only for homogeneous ground with negligible ϵ. This so-called "effective" conductivity is seen to tend towards a practically constant value at the higher frequencies: the sharp rise at the low frequencies, beginning around 300 kc/s, indicates a stratification with a considerably better conducting under-layer. A layer of smaller thickness than that in the above case would be expected to yield an "effective" conductivity curve like that seen in Fig. 7: the constant value at low frequencies would allow direct conclusions to be drawn as to the conductivity of the under-layer, while from the values at high frequencies only qualitative conclusions could be drawn as to the conductivity of the upper layer, since here the dielectric constant plays a part which cannot be neglected, and leads to an unlimited rise of the "effective" conductivity as the frequencies are raised.

Fig. 8 shows the frequency dependence of the product $\gamma \,.\, a/b$, which for homogeneous ground must be equal to or greater than unity. The deviation from this relation shown by the measured curve (which nearly touches 0.5 at its minimum and nowhere reaches 1) is another indication of stratification. The same diagram also gives ϕ (phase difference between E_x and E_z), obtained from $\tan \phi = b/a\gamma$, as a function of frequency: this curve shows a qualitative agreement with the theoretical curves of Fig. 3. Finally, the diagram also gives ρ' (the measured ratio of horizontal to vertical component of the electric field) as a function of frequency. It is these last two curves which the writers discuss in detail, particularly their deviations from the theoretical curves and the conclusions to be drawn (Figs. 9 & 10). They reach the conclusion that it is of great importance to extend the measurements to very long waves on the one hand and to ultra-short waves on the other, the latter waves yielding information regarding the "dielectric" stratification, while the medium and long waves do the same for the "conductivity" stratification. The investigation is proceeding on these lines.

377. THE PROBLEM OF TWO PLANE WAVES IN CLASSICAL NON-LINEAR ELECTRODYNAMICS.—A. A. Smirnov. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 447–453: in English.)

"It can thus be seen that the change in the initial two plane waves in non-linear electrodynamics amounts to the following: (1) The distortion of the fields of the initial waves (of the zero approximation) which is expressed in the change of their velocity of propagation and in the appearance of a difference in the amplitudes of the electric and magnetic vectors: (2) the appearance of four small scattered waves in the form of eqn. 44 with greatly changed frequencies and velocities of propagation. Thus the effect obtained here does not reduce solely to the effect so often discussed in literature of 'the scattering of light by light,' because besides the scattered light we have an effect of distortion of the initial waves themselves . . . Owing to such large values of the critical field the effect of distortion and scattering will be very small and is experimentally unobservable."

378. A METHOD FOR THE SOLUTION OF A CERTAIN CLASS OF ELECTROSTATIC AND RELATED PROBLEMS [by Determination of "Free"

Charges occurring at Surfaces of Separation between Different Media].—G. A. Grünberg. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 401–416: in German.)

Extension, to a three-dimensional field, of the work referred to in 4469 of 1940: *see* also Kontorowich & Lebedev, 492 of 1940 (in connection with wave diffraction).

379. The Light diffused Backwards by a Drop of Mist [Photographic Investigation, & Comparison with Sokulejkin's Calculation].—J. Bricard. (*Comptes Rendus* [Paris], 21st July 1941, Vol. 213, No. 3, pp. 136–139.) Further development of work described in *Ann. de Physique*, Vol. 44, 1940, p. 187 onwards.

380. A Corollary to the Ring Hypothesis [for Explanation of Permian Circumpolar Glaciations: Effects of Particles of Diameter below & above 1.85 Microns on Radiation: etc.].—R. L. Ives. (*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, pp. 357–363.)

381. Attenuation of Rayleigh Waves [Identification, on Seismogram taken at Ksara, of Waves which have made Complete Circuit of Earth].—P. Bernard. (*Comptes Rendus* [Paris], 16th July 1941, Vol. 213, No. 2, pp. 77–79.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

382. Lightning Phenomena: III—Field Studies [including Wave Shapes, Characteristics of Long-Duration Tails, etc.].—C. F. Wagner & G. D. McCann. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, pp. 483–500.) For previous parts *see* issues for August and September.

383. Lightning Over-Voltages in Underground Cables [generally thought to be Impossible: Johannesburg Results, leading to Deduction of Travelling Waves of at least Two Different Velocities: etc.].—H. D. Einhorn & B. L. Goodlet. (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part II, No. 4, pp. 342–348.)

384. The Surge Characteristics of Tower and Tower-Footing Impedances [including Comparison with D.C. or Power-Frequency Behaviour, for Various Soils: Measuring Technique: etc.].—R. Davis & J. E. M. Johnston. (*Journ. I.E.E.*, Oct. 1941, Vol. 88, Part II, No. 5, pp. 453–465.)

385. Discussion on "Developments in Surge Recording by means of the Klydonograph."—J. L. Candler. (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part II, No. 4, pp. 370–371.) *See* 697 of 1941.

386. "Die Wolken" [Clouds: Book Review].—R. Süring. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, p. 208.) Volume 16 of the series "Probleme der Kosmischen Physik": second, expanded edition.

387. "An Introduction to the Study of Air Mass and Isentropic Analysis: Fifth Edition" [Book Review].—J. Namias. (*Current Science*, Bangalore, Aug. 1941, Vol. 10, No. 8, p. 376.) Including sections on the Shaw "Tephigram" and its application, and on the origin, classification, and forecasting of thunderstorms.

388. "Einführung in die synoptische Wetteranalyse" [Book Review].—S. P. Chromow. (*Physik. Zeitschr.*, Aug. 1941, Vol. 42, No. 11/12, p. 220.) Originally published in Russian.

389. The Earth's Electric Field and Atmospheric Pressure.—R. Guizonnier. (*Comptes Rendus* [Paris], 21st July 1941, Vol. 213, No. 3, pp. 141–143.)

The writer's previous study of the diurnal and semi-diurnal components (1933 Abstracts, p. 561, and 1331 & 4257 of 1938) led to the conclusion that the value of the space charges plays a fundamental rôle in the formation of the electric field measured at the surface of the earth. The results given in the present paper bring to light a parallelism between the fluctuations of the *mean* electric field and those of the *mean* atmospheric pressure, and thus confirm this conclusion.

390. The Maintenance of the Electricity of the Earth's Atmosphere.—Israel. (*See* 364.)

PROPERTIES OF CIRCUITS

391. Proximity Effect in Solid and Hollow Round Conductors [with New Formula including Both].—A. H. M. Arnold. (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part II, No. 4, pp. 349–359.)

392. "Theorie der linearen Wechselstromschaltungen: Band I" [Book Review].—W. Cauer. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 47–48.) Enthusiastic review by Zenneck.

393. The Equivalent Characteristics of Vacuum Tubes operating in Feedback Circuits [Simple Graphical Method of calculating Feedback Effects by assuming that Characteristics of Valves are Changed].—J. H. Pratt. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 102–113.)

394. On raising the Q of Valve Circuits by means of Combined Feedback.—S. S. Kogan. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 57–61.)

Positive feedback is normally used to raise the Q of a circuit connected to the grid of a valve, the disadvantage being, of course, a tendency to start self-oscillation. Accordingly a method has been developed in which this disadvantage is obviated by the use of combined positive and negative feedback. The operation of a pentode valve stage (Fig. 1) utilising this principle is discussed, and it is shown that although the resistance of the circuit is lowered, the amplification factor of the stage is not increased and the stage is operated under conditions sufficiently removed from the threshold of self-oscillation. In a particular example quoted the Q of a circuit was raised in this manner from 170 to 1020. This principle was successfully adopted in an amplifier (Fig. 2) used in a 12-channel carrier-telephone system to select the necessary frequency for group modulation.

395. AMPLIFIERS WITH NEGATIVE FEEDBACK IN MULTI-CHANNEL TELEPHONE SYSTEMS.—S. S. Kogan. (*Elektrosvyaz* [in Russian], No. 12, 1940, p. 35–47.)

The operation of multi-stage amplifiers with negative feedback is discussed theoretically under the following headings :—Stability and amplification factor ; the effect of negative feedback on valve parameters ; phase characteristic ; matching output impedance and load ; the case of a complex load.

396. CORRECTIONS TO A PAPER ON AMPLIFIER DESIGN.—H. Goltsman. (*Elektrosvyaz* [in Russian], No. 11, 1940, p. 78.) In *Elektrosvyaz*, No. 4, 1940.

397. FLUCTUATIONS IN SPACE-CHARGE-LIMITED CURRENTS AT MODERATELY HIGH FREQUENCIES : PART V (contd.)—FLUCTUATIONS IN VACUUM-TUBE AMPLIFIERS AND INPUT SYSTEMS [Television Pick-Up Tubes : Receiver Input Circuits : Antenna Noise : Feedback].—B. J. Thompson, D. O. North, & W. A. Harris. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 114–124.) Contd. from 3050 of 1941.

398. A VACUUM-TUBE INVERTER CIRCUIT [Use of High-Vacuum Valves in "Blocking Oscillator" Circuits, to replace Ionic-Valve Circuits : Inverter Circuit for Frequency Meter, Counter, F.M. Detector, Cathode-Ray Switch, etc : Advantages].—W. E. Kock. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 510–511.)

399. SUBSIDENCE TRANSIENTS IN CIRCUITS CONTAINING A NON-LINEAR RESISTOR, WITH REFERENCE TO THE PROBLEM OF SPARK-QUENCHING.—A. Fairweather & J. Ingham. (*Journ. I.E.E.*, Sept. 1941, Vol. 88, Part I, No. 9, pp. 330–339 : Discussion pp. 340–342.)

400. THE CALCULATION OF DISTORTIONS FOR GIVEN STATIC CHARACTERISTICS [with Special Application to Sound Recording].—J. Peters. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 39–40.)

Author's summary :—" Harmonic analysis with the Fourier integral is used to analyse periodic non-sinusoidal functions. If such a function is produced by a sinusoidal function of time being distorted by a non-linear characteristic, the distortion will be dependent on the amplitude and oscillation mid-point of the original sinusoidal function. Methods are given by which the distortions can be calculated from a comprehensive representation of the characteristic. For the case where the characteristic is given mathematically by a power series, a simple procedure free from limitations is given. This should be particularly desirable in cases where the static characteristic is easily determined, while on the other hand the recording of distorted sine-functions encounters serious difficulties. That is especially so in photographic sound-recording processes."

For small amplitudes, only that part of the characteristic in the neighbourhood of the oscillation mid-point need be considered, so that the power series can be cut short after, say, the third term. By adding terms of higher power, larger amplitudes can be dealt with. For the special case when the characteristic follows an exponential function or a sum of several such functions, the treatment given by Strutt (eqns. 3–5) is used. For cases where the characteristic cannot be expressed in this mathematical form, the power series $f(x) = a + bx + cx^2 + dx^3 + \ldots$ can be developed for the oscillation mid-point contemplated, by putting $x = x_0 \,.\, \cos \omega t$. Then when the mid-point is changed, $x = m + x_0 \,.\, \cos \omega t$ must be introduced. But it is simpler to carry out this shift by transforming the above series into $f(x + m) = a + b(x + m) + c(x + m)^2 + \ldots$ before introducing $x = x_0 \,.\, \cos \omega t$, thus obtaining eqn. 8, in cosine powers, which can be converted into $f(x) = k_0 + k_1 \,.\, \cos \omega t + k_2 \,.\, \cos 2\omega t + \ldots$ by using the known expression for cosine powers, according to which each term corresponds to a series expression of the form $C_{on} \,.\, \cos^n \omega t = \Sigma c_{n\nu} \,.\, \cos \nu\omega t$. The writer gives, in the table, the values of $c_{n\nu}$ for values of n from 1 to 20. This covers all probable cases in practice, but the table can be extended if necessary. In actual use, matters are considerably simplified by the fact that many values of $c_{n\nu}$ disappear (*e.g.* all values when the sum $n + \nu$ makes an odd number) and that all the series have a finite length, since $c_{n\nu} = 0$ when $\nu > n$.

401. ON THE TREATMENT OF THE STABILITY OF MECHANICAL-ELECTRICAL REGULATING SYSTEMS [by Conversion into an Equivalent Electrical System].—W. Artus. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 186–206.)

"The method has great advantages over the experimental measurement of stability, which is very difficult on account of the low limiting frequency and of the high non-linearity of the system. The stabilising methods considered are valid for regulating technique in general, and are not limited to mechanical-electrical systems : the application of the treatment is illustrated in connection with a carbon-powder regulator," for 1 ampere at 212 volts. For a preliminary paper *see* 3256 of 1941.

402. CIRCUIT DIAGRAM AND ELECTRO-MECHANICAL ANALOGY [in connection with Vibratory Systems].—Hecht. (*See* 587.)

TRANSMISSION

403. PAPER ON THE TRANSMISSION CHARACTERISTICS OF ASYMMETRIC-SIDEBAND COMMUNICATION NETWORKS.—Cherry. (*See* 475.)

404. PHASE SELECTION IN RADIO COMMUNICATION [for Multi-Channel Working, Broadcasting, etc.].—Momot. (*See* 420.)

405. A 56 Mc/s Transmitter for Mobile Work [on 7″ × 12″ × 3″ Chassis: controlled by 7 Mc/s Crystal: 12 Watts, with Amplitude Modulation].—B. Goodman & H. Bubb. (*QST*, Oct. 1941, Vol. 25, No. 10, pp. 50–52.)

406. A Transit-Time [Velocity-Modulated] Generator with Only One Cavity Resonator.—J. J. Müller & E. Rostas. (*Hochf: tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 41–43: summary, from *Helvetica Phys. Acta*, Vol. 13, 1940, p. 435 onwards.)

Cf. Lüdi, 57 of January. In this theoretical paper the writers show that a beam of electrons can excite electromagnetic oscillations in a resonator (in particular a cavity resonator) even when the electron ray traversing the resonator enters it with a definite velocity and with a density constant in time. In a certain aspect such a transit-time generator represents a generalised case of the older diode transit-time generator (J. Müller, 1934 Abstracts, pp. 493–494 and back ref.), since it may be considered as a kind of diode with electrons of higher initial velocity. But in contrast to the work on the diode generator, the present treatment is not limited to the consideration of oscillations of infinitely small amplitude, and it is thus able to derive, for this case of a beam of constant entrance-velocity and density, not only the conditions which must exist in order that the generator may build up its oscillations, but also the conditions for maximum efficiency, etc.

Eqn. 15 shows that for the building-up of oscillations it is not enough that the efficiency ρ should be negative, *i.e.* that a negative resistance R_D should act on the ray (eqn. 13): the absolute value of R_D must be smaller than the effective resonance resistance S of the oscillatory circuit. The curves of Fig. 3 show that the calculated max. efficiency ($\rho = 14.5\%$) is obtained for a transit-time ratio α of 5/4 (α is the ratio of the transit time l/v_0 through the resonator, in the absence of the alternating field, to the a.c. period T), and for a modulation coefficient $k = 4$ approx. Linked to these values is the approximate relation that the effective resonance resistance S should be of the order of 50 times the d.c. resistance R_0 ($= V_0/i_0 = 2\rho R_D/k^2$). The writer mentions, without discussion, that the efficiency can be increased to 22% by the introduction of a retarding voltage equal to the velocity (measured in volts) of the slowest electrons leaving the resonator.

The advantages claimed for the generator thus theoretically discussed, over generators of the klystron type, are (i) the elimination of tuning difficulties, because of the use of one resonator only, and (ii) freedom from the klystron limitation that α must not exceed 1/4: the resonance resistance can therefore be made larger, and the limiting wave-length decreased. A spherical or cubic resonator can be used, which is impossible in the case of a normal klystron. Another difference is that the modulation factor k, for a suitable transit-time ratio α, is considerably greater than unity; *i.e.*, the alternating potential can be a multiple of the steady d.c. potential, which is not the case in the normal klystron or in the normal triode: or, indeed, in the transit-time diode generator, where an alternating potential exceeding the steady potential would block the emission during a part of the period.

407. Velocity-Modulated Transit-Time Valves: Contribution to the Theory.—B. Kockel. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 22, 1941, pp. 77–85.)

For previous work *see* 2218 of 1940. Author's summary:—"The mode of action of the Heil chamber and of an arrangement consisting of two Heil chambers, with a drift tube free from high-frequency fields between them, is investigated. With the Heil chamber there is found to be a gain of h.f. power from the electron flow for path-time angles of about 0 to π, 2π to 3π, 4π to 5π, and so on. The optimum efficiency is 25%, for a path-time angle of about $2\frac{1}{3}\pi$ and a modulation depth of about 0.5.

"With the arrangement with two Heil chambers, the first one assumes the task of producing the most favourable phase-focusing possible for the entry of the electrons into the second chamber. At low modulation factors in the first chamber the functioning of the second depends on four quantities, namely the path-time angle and modulation depth in the second chamber, the focusing strength of the first chamber, and an angle λ which is composed of the path-time angles of the drift space and of the first chamber, and the phase difference between the two a.c. potentials applied to the chambers. For a given working point (modulation depth, path-time angle) of the second chamber, at which, without connecting the first chamber, a favourable efficiency can be obtained, the possible improvement is investigated which can occur when the second chamber is added, with suitable choice of λ and of its focusing power. It is found that the efficiency can be increased in this way by a factor 2.3": *cf.* Lüdi, 57 of January.

408. Self-Excitation of Triode Circuits in the Ultra-Short-Wave Region.—H. König. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 10–27.)

Author's summary:—"Under the influence of the path-time effect the internal conductances of a triode become dependent on frequency and consist of a resistive component and a reactive component. They can be reduced to three complex admittances $\mathfrak{G}_0$, $\mathfrak{G}_1$, and $\mathfrak{G}_2$, of which $\mathfrak{G}_0$ represents the slope, $\mathfrak{G}_1$ the grid/anode admittance, and $\mathfrak{G}_2$ the grid/cathode admittance. The external circuit can be considered as three further complex admittances $\mathfrak{F}_1$, $\mathfrak{F}_2$, and $\mathfrak{F}_3$, arranged in a star connection between cathode, grid, and anode, and forming thus a three-point connection. As a result, an equivalent circuit is obtained for the triode circuit, from which the self-excitation condition is derived. In its most general form it contains six complex admittances and the real 'Durchgriff' D. It is obtained from the requirement that the input admittance (eqn. 20) of the system must vanish [eqn. 21: $\mathfrak{F}_e = 0$: the 'modulating' generator neither gives nor receives any real or wattless energy. This condition for self-excitation is more general than that of Barkhausen, since it takes into account the internal admittances of the valve: section III].

"The self-excitation condition gives the self-excitation region for the three [external] real conductances $F_1 \ldots F_3$. They must lie within this region if self-excitation is to be possible by a suitable choice of the wattless admittances $X_1 \ldots X_3$ [by the use of Lecher wires or cavity resonators, admittances can be made to have any value from $+\infty$ to $-\infty$, so that any real values for $X_1 \ldots X_3$ can be chosen which satisfy eqn. 25]. If two of these three admittances, hitherto assumed as independent, are made equal, the self-excitation region is reduced. It is shown, for the case $X_3 = X_2$, that in the long-wave region [by 'long wave' is meant a wavelength above 5 m] the reduction does not occur in the $F_3 = F_2$ plane and only becomes important in the remaining region. In the ultra-short-wave region [*e.g.* 20 cm : Fig. 14b], on the other hand, the self-excitation zone suffers a serious shrinkage even in the $F_3 = F_2$ plane . . ." Fig. 14 shows that the "unshrunk" 20 cm-wave zone contains practically the whole of the "unshrunk" "long"-wave zone, while the "shrunk" zone of the latter wave includes the whole of the "shrunk" zone of the 20 cm wave : *see* footnote, p. 26. Similar considerations apply to the other restrictions on the degrees of freedom ($X_3 = X_1$, $X_2 = X_1$).

Finally, the writer considers the limiting wavelength at which a given valve can be made to oscillate : this depends on the internal valve losses and also on the external circuit losses. Assuming, for simplicity, that no power is taken from the valve and that the external losses are limited to the conduction and radiation losses of the circuit elements, then for a definite frequency the corresponding loss conductances F_1, F_2, and F_3 characterise a point in the diagram of Fig. 10. If this point lies inside the self-excitation region for the frequency in question, self-excitation can be produced by a suitable choice of the three admittances : it is assumed that the tuning process upsets the real conductances little or not at all. If only two of the three external admittances are used for tuning, it may happen that no self-excitation will set in, owing to the "shrinkage" of the self-excitation region throwing the working point out of that region.

409. The Long-Wave Oscillations in the Whole-Anode Magnetron [with End Plates].—O. Döhler & G. Lüders. (*Hochf: tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 29–32.)

An experimental investigation to clear up various contradictory reports on these long-wave magnetron oscillations, to which Megaw (1933 Abstracts, p. 324) gave the name "spiral oscillations." Author's summary :—" The waves found by Hollmann (1931 Abstracts, pp. 617–618), more than 20 m in length, are certainly to be attributed to a static negative resistance [as maintained by Hollmann]. Such negative resistances appear also in the plotting of the characteristics in an oblique magnetic field. The spiral oscillations, however, cannot be attributed to this cause alone, as Slutzkin & Leljakov found [there is something wrong with this reference, but the paper meant is probably that referred to in 1934 Abstracts, p. 33, r-h col : *see* also p. 612]. The $\lambda^2 . U_a =$ const. relation, the dependence on angle, and the dependence of wavelength on length of anode, all given by Slutzkin & Leljakov, were *not* found. A striking point is that the spiral oscillations behave practically exactly like the Začek oscillations, the wavelength merely increasing in the ratio of the magnetic field employed to the critical magnetic field [eqns. 4 & 5]. A theoretical explanation of these spiral oscillations is not yet available. An obvious suggestion is to attribute them to an oscillation on Groos's 'leading-circle' paths, since a relation similar to the [wavelength] equation 2 applies to the 'leading-circle' frequency. But so far there has been no success in determining, on this hypothesis, the constant C within an order of magnitude, or in explaining the mechanism of energy transfer from the electrons.

"Whether the oscillations are of practical importance will depend on the power obtainable from them, and on the efficiency. Hollmann gives some milliwatts as the output power. On the other hand the dissipated power is also fairly small, so that by the use of higher voltages the output could, in certain circumstances, be made considerably higher. Experiments now in progress in connection with this question of power will be reported in a later paper."

410. The Control and Modulation of Low Pressure Arc Discharges in Inert Gases [and Hydrogen] with the Help of a Grid in the Plasma of the Discharge.—E. Leimberger. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 621–641.)

A probe, whose potential is negative to the plasma about it, becomes surrounded by a space-charge region of positive carriers, the Langmuir layer. This region is impenetrable to the plasma electrons whose volt velocity is small. If a meshed grid is brought into the plasma, so that the plane of the grid is at right angles to the flow-path of the discharge, this grid will behave in principle like such a probe. When the grid is negative, the ion layers formed at it will represent for the plasma electrons a contraction of the discharge cross section.

Since the thickness of the positive space-charge layers depends on the value of the negative grid voltage, a variation of this voltage, and its resulting contraction of discharge cross section, will produce also a variation of the anode current ("modulation") or even a complete interruption ("extinction"). Fetz has recently undertaken a thorough investigation of the physical processes in this type of arc control by Langmuir layers : *see* 2549 (also 2548) of 1940 : and *cf.* Sichling, 111 of January, and Schumann, 2685 of 1941. Since up to now the only experiments have been on mercury vapour, the present investigation deals with the various inert gases, helium and neon at pressures of 10^{-2} to 10^{-1} mm Hg, and xenon, argon, and krypton at 10^{-3} to 10^{-2} mm : the "experimental thyratron" with which the tests were made was provided with a way of easy exchange for grids of different mesh.

Table 1 shows that the extinction voltages (given for various gas pressures : helium) measured statically do not differ much from those obtained with a control frequency of 1.5 Mc/s (in the latter case the extinction voltage is taken as that at which the anode voltage rises to 100 volts) : and most of the results regarding the dependence on pressure and on grid mesh found statically apply also to the h.f. case. Section v deals with tests on power amplification at this frequency. The paper ends with some results obtained with a hydrogen filling. The tube was brought by retroaction to self-excitation: this was facilitated by connecting a Lecher system between anode and grid, bridged at its end by a condenser, so that both anode and grid were blocked to direct current. The negative bias was zero or some small value. As the gas pressure was varied continuously (heated palladium method) a value was reached, for each different grid, at which oscillation set in: *see* Table 4, which refers to wavelengths between 5 m and 11 m, though 3 m waves are also mentioned.

411. Oscillators with Electrical Control of Frequency [for Automatic Tuning Correction, Frequency Modulation, Measuring Technique, etc.].—A. S. Vitnitski. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 43–61.)

The article is a comprehensive survey of various possible circuits for the utilisation of the "Miller effect," coupled with an indication of possible applications. Each circuit is discussed in detail and its advantages and disadvantages pointed out. The possibility of using this type of control over a wide frequency range is also discussed. In conclusion, a numerical example is given illustrating the design of the complete oscillating circuit. A bibliography of 40 items [mainly papers in English and German) is appended.

412. The Theory of a Leaky-Grid Auto-Oscillator.—S. I. Evtyanov. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 33–42.)

Concluded from 1645 of 1941. An analysis of the equations derived in sec. 4 shows that the following two sets of operating conditions can exist: (a) grid bias and r.f. drive both constant, and (b) both varying in time. In sec. 8 the limiting cycles on the phase plane existing in the latter case are determined by graphical integration of the above equations. In sec. 9 the nature of the variations of grid bias and drive taking place during self-modulation, and as determined by the capacity of the grid-leak, is investigated. In sec. 10 the conditions necessary for the absence of self-modulation are established.

413. Background Noise in Large Short-Wave Radio Transmitters. — G. S. Vasil'ev. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 18–23.)

A detailed report, with numerous oscillograms, of a laboratory investigation of the variation of background noise through the various stages of a multi-stage short-wave telegraph transmitter. The author is concerned not with the origin of the noise but with its transference from stage to stage. The conclusions are that the noise modulation increases in depth owing to the use not only of frequency multipliers but also of straight amplifiers, and that it can be reduced by increased drive, particularly at the early stages.

414. A Simplified Water-Cooling System for Use in Radio Transmitting Stations.—S. V. Laguzinski. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 77–78.)

The water-cooling system of a radio transmitting station consists as a rule of two circuits, one using distilled and the other ordinary water. As a result of an investigation carried out in the U.S.S.R. it has been found possible to render water chemically pure, and suitable for direct contact with the valve anodes, by passing it consecutively through two base-exchange filters, the first of which is of the H-ion type and the other of the OH-ion type. With this method only one circuit becomes necessary, with consequent economy in space and plant. For a broadcasting station with heat dissipation of 200 000 calories per hour, corresponding to 100 kw in the aerial, the necessary filters take the shape of two tanks 80 cm high and of 40 cm diameter.

415. The Secrets of Good Sending [Development of Rhythm: Correct Character Formations: etc.].—E. L. Battey. (*QST*, Oct. 1941, Vol. 25, No. 10, pp. 43–45.) Concluded from the September issue. *Cf.* 70 of January.

RECEPTION

416. The Exponential Detector for Frequency-Modulated Oscillations.—V. N. Milshtein. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 33–37.)

The detection of oscillations frequency-modulated in accordance with eqn. 3 is discussed. It is assumed that detection is effected firstly by a frequency detector whose characteristic is represented by a sum of exponentials (eqn. 1), and then by a square-law detector of the type $i = au^2$. A formula (eqn. 4) is quoted, determining the result of detection by the frequency detector when oscillations corresponding to eqn. 3 are applied to it, and also eqn. 5 giving the amplitude and phase of any k-th harmonic of the modulating frequency after detection by the square-law detector. For low modulating frequencies eqn. 5 is reduced to eqn. 6. Errors which may appear in approximating the characteristics of electrical circuits by sums of exponentials are discussed, and an example of such an approximation is given.

417. Frequency-Modulated Transmissions Virtually Unaffected by Recent Ionospheric Storm.—(*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.) "Except for sporadic freak long-range reception at distances as great as thousands of miles": paragraph based on American Press reports.

418. New Utilisation of a Gaseous-Discharge Gap as a High-Frequency Demodulator [Experimental Investigations in the Medium- & Ultra-Short-Wave Regions]—J. Himpan. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, pp. 840–841: long summary, from *Postarchiv*, 1940.)

Previous attempts to use gaseous-discharge gaps, particularly glow discharges, for rectification and demodulation have all indicated results inferior to those given by a crystal detector, as regards power, efficiency, and freedom from distortion. The writer, however, finds that a specially designed glow-discharge gap is surprisingly satisfactory in this way. The electrodes must be equal or nearly equal, the normal cathode-fall region of the characteristic must be large, the working point must be in the middle of this region, and the demodulation of the oscillation must take place practically only in this region.

For a carrier of 1293 kc/s modulated with a 800 c/s note, a Stabilisator STV 280/80 was used: the l.f. energy obtained, as a function of the load resistance, is seen in Fig. 7, one of a series in the full article, for a h.f. current of 60 mA (100% modulated). The useful and over-all efficiencies are also shown. About 250 mw of l.f. energy can be taken from the "gas demodulator," with a coefficient of non-linear distortion not exceeding the usual permissible value. The useful efficiency (l.f.output/sideband-power) is seen to be up to about 83% and the over-all efficiency (taking into consideration the d.c. power consumed by demodulator discharge) up to about 5%. The curves also indicate how the optimum matching and working-point position are to be chosen: matching of phase as well as of quantity would increase the efficiency. Actually, a medium-sized loudspeaker gave good results on speech when fed directly by the demodulator.

For a carrier of 44 Mc/s modulated at 50 c/s, a Stabilisator STV 75/15/11 was used. Here again the best result was obtained when the working point was at about the centre of the straight part of the current/voltage curve (normal cathode-fall region), but with u.h. frequencies, unlike the results with medium frequencies, the distortion did not exceed the permissible limit even when the effective h.f. current component reached as far as the curved parts of the characteristic. A l.f. output of 70 mw was obtained at a useful efficiency of about 6.2% and an over-all value of about 3.8%. But the demodulation practically vanished when the modulating frequency was altered from 50 c/s to 3 Mc/s: what happened at intermediate modulating frequencies is not mentioned in the summary.

The paper ends with a discussion of the physics of the "gas demodulator." The result that the best action was obtained over the linear part of the curve (contrary to one's usual ideas of demodulation) is explained as due to the formation of a second, curved characteristic, different from the static characteristic, on the application of h.f. field changes: this arises from the differing mobilities of the ions and electrons. A circuit is given of a broadcast receiver with one h.f. stage and the demodulator directly feeding the loudspeaker.

419. Devices for the Reception of Ultra-Short Waves [Cathode of Detector Diode connected in Centre (Current Antinode) of Receiving Dipole: Gaseous-Discharge Gap, with Steady Polarisation, exposed to Radiation from Dipoles situated between the Electrodes & acted on by the Incident Waves].—W. Kriebel: H. E. Hollmann. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 45: p. 45.) Telefunken patents. *Cf.* 2397 of 1941.

420. Phase Selection in Radio Communication.—E. G. Momot. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 4–13.)

Continuing from 1650 of 1941, various aspects of the proposed system of transmission are considered. The inadequacy of the usual nomenclature for describing different types of modulation (amplitude, frequency, phase) is pointed out, and a new graphical method is suggested in which modulation is classified in accordance with the type of movement of the end point of a vector. Using this method, parasitic modulation and the passing of sidebands in the radio transmitter are discussed. A comparison is then made between the proposed system and single-sideband transmission from the standpoint of the possible increase in the number of available communication channels, and it is claimed that by adopting the proposed system a definite advantage is gained in both selectivity and the efficient use of available power output. Finally, possibilities are indicated of using the system for (a) multi-channel radio (or wire) telegraphy, and (b) broadcasting with an extended (doubled) modulating frequency band. In the latter case the extended audio-frequency band is divided into two parts and each is applied to a separate modulator. At the receiving end, the two parts are added together.

421. High-Frequency Copper-Oxide Rectifiers of High Stability.—V. T. Renne & A. V. Bogdanov. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 67–70.)

For previous work *see* 3572 of 1940. Experience has shown that the forward resistance of copper-oxide rectifiers used in modulating and demodulating circuits of carrier-telephone systems increases with time; the rectifier "ages." The experimental investigation here reported showed that this effect is caused by humidity, but it was also shown that this effect cannot be entirely accounted for by the rise in the resistance of the contacting layer (aquadag), although this resistance is greatly affected by the humidity. As a result of the investigation it is recommended that the rectifiers should be assembled in hermetically sealed casings containing some deliquescent material. A short description of such a rectifier is given.

422. N.B.C. Short-Wave Listening Post.— G. O. Milne. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 82–87.)

423. High-Voltage Porcelain Insulators: Characteristics and Performance [Radio-Interference Method of Location of Faulty Units found to be Not of General Application].—J. S. Forrest. (*Electrician*, 28th Nov. 1941, Vol. 127, pp. 306–307: summary of I.E.E. paper.) In most cases, "the voltage drop across faulty units was too small to cause an intense discharge" and produced no increase in interference level. For a slightly abridged reproduction of the paper see *BEAMA Journal*, Nov. & Dec. 1941, Nos. 53 & 54, pp. 170–173 & 194–196, and for a long summary, *Journ. I.E.E.*, Nov. 1941, Vol. 88, Part I, No. 11, pp. 414–418.

424. The Impulse Characteristics of Porcelain Insulators.—G. W. Bowdler & W. G. Standring. (*Journ. I.E.E.*, Oct. 1941, Vol. 88, Part II, No. 5, pp. 443–452.)

425. Improved Hardware cuts Radio Interference [New Designs of Insulators & Pins for 12 kV System].—J. S. Crooks & others. (*Sci. Abstracts*, Sec. B, Oct. 1941, Vol. 44, No. 526, p. 208.)

426. Aerial Coupling: Which is the Best Circuit for All-Round Efficiency?—S. W. Amos. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, pp. 302–304.)

427. Supplementary A.V.C. [for reducing Effects of Selective Fading: Limiter whose Threshold Working Point is determined by Normal A.V.C. Voltage].—R. G. Young. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 318.)

428. Oscillators with Electrical Control of Frequency [for Automatic Tuning Correction, etc.].—Vitnitski. (*See* 411.)

429. "Normas sobre Receptores de Radio" [Translation into Castilian of the I.R.E. "Standards, 1938": Book Notice].—Buenos Aires Section, I.R.E. (*Elec. Communication*, No. 1, Vol. 20, 1941, pp. 67–68.)

430. "Radio Upkeep and Repairs for Amateurs: Fifth Edition" [Book Review].—A. T. Witts. (*Electrician*, 21st Nov. 1941, Vol. 127, p. 292.)

431. "Total War" Receiver: a Lightweight Portable for Emergencies.—W. H. Cazaly. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, pp. 305–307.)

432. "Einhundert neuzeitliche Rundfunk-Empfänger- und Verstärker-Schaltungen" [One Hundred Modern Broadcast Receiver & Amplifier Circuits: Book Review].—W. W. Diefenbach. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 47.)

433. Bum Superhets [Editorial on Abundance of Visible Sales Features & Omission of Refinements necessary for Freedom from Interference].—(*QST*, Oct. 1941, Vol. 25, No. 10, pp. 7–8.)

434. Numbers of Broadcast Listeners in Germany, 1st April, 1941.—(*Zeitschr. V.D.I.*, 15th Nov. 1941, Vol. 85, No. 45/46, p. 900.)

AERIALS AND AERIAL SYSTEMS

435. Measurements on Dipoles in the Decimetric-Wave Region.—P. Lange. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 25–29.) *See* long abstract, 3039 of 1941.

436. On the Theory and Possibilities of Application of a Radiating System composed of Dipoles: Contribution to the Problem of Directive Broadcasting on Short or Ultra-Short Waves.—G. Rutelli. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, pp. 169–178.)

Further development of the work dealt with in 3331 of 1941. The aerial system previously described gave in all cases, all-round or directive, a better radiation efficiency than the Franklin and the Brown ("Turnstile": *see* 2595 of 1936) types but required, for directive radiation, special phase (90° difference) and amplitude relations to be observed. The new system now described involves no such difficulties, and its good efficiency is accompanied by superior regularity and better shape of field diagram. Each element consists of three vertical double-dipoles arranged so that their points of intersection with a horizontal plane form an equilateral triangle whose sides are $\lambda/2$ in length. In the Type A version (horizontal diagram Fig. 3, vertical Fig. 4) the three currents are equal in amplitude and in phase. The all-round characteristic is a good regular one, but the radiation efficiency is not greater than that of a Franklin aerial and is therefore not so high as that of the four-dipole type previously described (Type A_1), which is thus considered to be preferable for all-round radiation.

In the Type B directive version (Fig. 5 and Figs. 6, 7) the three currents are again equal in amplitude, but one of them is 180° out of phase with the other two, this result being obtained simply by a reversal of the feeder connection. The "N and S" directivity is good, and the radiation efficiency is, under certain conditions, higher than that of the aerial described previously of the same geometrical height. For directive purposes, therefore, everything is in favour of the Type B system. A vertical stacking of such elements (Fig. 8) gives a still more efficient system: it is suitable for short and ultra-short waves.

437. Acoustic Aerials: a New Technique for Predicting the Polar Characteristics of Complex Arrays.—E. C. Jordan & W. L. Everitt. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, pp. 315–316.) Based on the *Proc. I.R.E.* paper dealt with in 2702 of 1941.

438. Noise in Receiving Aerial Systems: Discussion.—R. E. Burgess: D. A. Bell. (*Proc. Phys. Soc.*, 1st Nov. 1941, Vol. 53, Part 6, No. 300, pp. 720–722.)

See 2122 of 1941. In his reply, Burgess refers to the papers by Fränz (2699 of 1941: the full reference to the original paper is *Telefunken-Hausmitt.*, No. 83, Vol. 21, 1940, pp. 49–54) and by Thompson, North, & Harris (397, above.)

439. On Determining the Optimum Ratio of Conductor Diameters in a Coaxial Cable.—Rakovich. (*See* 477.)

440. The Radiation Resistance of Lines carrying Standing and Travelling Waves.—A. L. Drabkin. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 44–45.)

A formula derived by the author is quoted for determining the power P_Σ radiated from a two-wire transmission line of characteristic impedance ρ with its conductors spaced d cm apart. The line is assumed to be loaded by a pure resistance at the far end. Formulae for determining the radiation resistance R_Σ in a number of particular cases are also quoted.

441. Short-Wave Directive Aerials: the Rhombic *versus* Multi-Dipole Discussion.—G. Z. Ayzenberg: M. S. Neyman. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 77–80.)

Continuation of the correspondence dealt with in 3040 of 1941. Ayzenberg thinks that for long-distance links rhombic aerials should be used and the Telefunken type should be confined to short-distance working. Neyman considers that no definite statement can be made until more information is available on various factors affecting the propagation of radio waves.

442. The Heating of Aerials for De-Icing.—G. V. Shuleykin. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 38–43.)

A formula (5) is derived for determining the current I necessary for clearing ice of thickness D (Fig. 2) from a bronze conductor of cross-section F and diameter d in a given time t. The danger of overheating the conductor and affecting its tensile strength is pointed out, and a formula (9) is derived for determining the maximum current I so as not to exceed the permissible maximum temperature $t_2°$ of the conductor. A numerical example shows that the power required for clearing ice is not excessive; in the case of a T-type aerial (Fig. 3) with a horizontal portion of 6 parallel conductors 200 m long suspended 150 m above the ground, 45 kw is sufficient for clearing ice 2 cm thick in 22 minutes. It is pointed out, however, that the best method for combating ice formation is to make use of "prophylactic" heating at the beginning of the period when ice is likely to form. For this purpose the conductors should be kept at a temperature of +2° to + 5° C, and in the above example 17.3 kw would suffice. Methods are indicated for heating the aerial without interference with transmission.

443. The Design of Mast Guys.—G. A. Savitski. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 46–52.)

The mast is regarded as a rigidly supported beam, and approximate values of the reactions at the supports are found analytically. The guys are then designed by the use of a method of successive approximations. It is pointed out that the tensile stresses thus derived for the guys should be checked as regards the elasticity of the support formed by the guys, and a method is proposed for doing this. A numerical example is included.

VALVES AND THERMIONICS

444. A Transit-Time [Velocity-Modulated] Generator with Only One Cavity Resonator, *and* Velocity-Modulated Transit-Time Valves: Contribution to the Theory.—Müller & Rostas: Kockel. (*See* 406 & 407.)

445. Applications of the Inductive-Output Tube [Type RCA-825].—Dow. (*See* 482.)

446. The Orbital-Beam Multiplier Tube for 500-Megacycle Amplification. — W. R. Ferris & H. M. Wagner. (*Proc. Radio Club of Am.*, Aug. 1941, Vol. 18, No. 4, pp. 53–56.) A summary was dealt with in 1945 of 1941.

447. Midget Amplifiers [for Ultra-High Frequencies: Types RCA-9001-2-3].—R.C.A. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 514–515.) *See* also 110 of January.

448. The Control of Low-Pressure Arc Discharges in Inert Gases with the Help of a Grid in the Plasma [at High Frequencies].—Leimberger. (*See* 410.)

449. Use of the Action Function to obtain the General Differential Equations of Space-Charge Flow in More than One Dimension [All Previous Analyses of Space-Charge Flow have dealt only with One-Dimensional Case, whereas All Valves except Simple Diode involve Two or Three Dimensions: Introduction of Action Function (by use of Hamilton-Jacobi Differential Equation) so that Current Density can be expressed in Vector Form: etc.]. — K. Spangenberg. (*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, pp. 365–371.)

450. The Calculation of Distortions for Given Static Characteristics [with Special Application to Photographic Sound-Recording].—Peters. (*See* 400.)

451. On Some Simple Bases of Calculation for the Design of Multi-Stage Electron-Multipliers.—H. Schnitger. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 1–9.)

The development of commercial multipliers has led to various secondary-emission layers and types of electrode: "since many parameters are involved (required multiplication, max. available voltage, number of multiplier electrodes, etc.) it is often difficult to hit on the correct choice. An attempt has therefore been made to calculate some of the important data of the different multiplier constructions, in a generally valid form: here, among other things, the introduction of the logarithmic measuring scale for the multiplication is found to be very useful." Thus if the logarithmic multiplications (over-all and mean-per-stage) are represented by P and p, so that $P = \log_e P^*$ and $p = \log_e p^*$ (where the asterisks denote the ordinary values), then instead of the relation $P^* = p^{*n}$ we have $P = n.p$, and by replacing n by U/u (the voltage ratio from eqn. 2, for multipliers with equal stages), $P = U/u/p$. Thus for a given over-all voltage the multiplication depends only on u/p, which is seen to represent the over-all voltage which must be applied in order that the logarithmic multiplication P may be equal to unity (or P^* equal to 2.718 · ·). For a given type of multiplier the voltage per stage is generally prescribed, so that for this type u/p has a fixed value, from which it can be deduced how far that particular type will fulfil the requirement of a certain multiplication at as small an over-all voltage as possible. The writer therefore gives the name "characteristic voltage" to u/p, and denotes it by U_K: the relation thus reduces to the simple form $U = P.U_K$, which enables the important data for a multiplier to be derived quickly and simply. For example, in comparing multipliers with different types of layers and electrodes, to produce a given multiplication, only the U_K values have to be considered, since in the comparison P is a constant.

A case of general importance is when the stage-multiplication p^* is equal to the s.e. factor δ. In Fig. 1, δ as a function of the stage-voltage is given for silver-oxide/caesium and magnesium-oxide layers, and from these curves the function $U_K = g(u)$ is calculated and shown in Fig. 2. Both these curves have a marked minimum, and from $U = P.U_K$ this means that for a definite stage-voltage the over-all voltage required for a given multiplication is a minimum. The value of U_K corresponding to this optimum stage-voltage is called the "smallest characteristic voltage" and is represented by $\bar{U}_K$: for silver-oxide/caesium films it is 43 v and for magnesium-oxide films 71 v. The corresponding values for $\bar{u}$ are 30 v and 60 v. Thus for optimum working a multiplier with the latter type of layer would require about 1.6 times the voltage of one with the former type.

Section II gives the calculation of the course of the p^* curves from the δ curves, first for plate electrodes and then for "net" electrodes (Weiss type), the results for the latter being compared with some of Hartmann's measurements: *cf.* 2334 of 1940. For the best "net" electrode at present reported on, the optimum stage-voltage is only 28 v. But to reduce the effects of voltage fluctuations it is desirable to work not with the optimum stage-voltage but with a higher one and a corresponding smaller number of stages (Section III). The final section compares multipliers with "net" and with plate electrodes: whether the condition is that the over-all voltage shall be as low as possible (case 1) or that it should be the same for both multipliers (case 2), the plate type comes out on top: particularly in the second case, where it needs only 5 stages instead of 15 to give a multiplication of 1000.

452. The X-Ray Photon Efficiency of a Multiplier Tube [12-Stage, with Pure Tantalum Photosurface & Multiplying Electrodes covered with Oxidised Beryllium: Multiplication about 18 000 (about 1 Photon in 500 recorded at Wavelength 10^{-8} cm)].—J. S. Allen. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 484–488.)

"The results show that the sensitivity of a multiplier tube may approach that of a Geiger-Müller tube only for wavelengths greater than 1.0 AU."

453. Temperature Dependence of the Periodic Deviations from the Schottky Line [Re-examination of Nottingham's Data show These to be Not Inconsistent with the Theory, according to which the Amplitudes should be Inversely Proportional to the Absolute Temperature: etc.].—E. Guth & C. J. Mullin. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, p. 535.) *See* 1909 of 1941 and back reference.

454. Discussion on "The Extraction of Electrons from Cold Metals at High Field Strengths."—Willis Jackson & Chester. (*See* 522.)

DIRECTIONAL WIRELESS

455. Equipment for Direction Finding free from Night Effect [Pulse D. F. Method applied to Observations on Telegraphic Signals, by C.R. Tube Reception with Time Base controlled by the Successive Signals].—F. Johnske. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 46.) Telefunken patent.

456. A Target-Flight Direction Finder with C.R. Oscillographic Indication.—T. Elmquist. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, p. 46.) Telefunken patent.

457. Automatic Direction Finding: the Principle of Aeronautical ADF Systems.—R. Gibbons. (*QST*, Oct. 1941, Vol. 25, No. 10, pp. 48–49.)

458. An Omnidirectional Radio-Range System: Part I—Principles of Operation.—D. G. C. Luck. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 55–81.) *See* 3439 of 1940. "Believed to be the first omnidirectional radio range to reach a practically useful stage of development . . ."

459. Airport Communications [with Special Reference to Facilities at La Guardia Field, New York].—R. H. Riddle. (*Elec. Communication*, No. 1, Vol. 20, 1941, pp. 5–22.)

ACOUSTICS AND AUDIO-FREQUENCIES

460. The "Thermoregenerated" Tube as a Sound Receiver.—K. F. Theodortschik [Teodorchik] & K. Welezhanina. (*Journ. of Phys.* [of USSR], No. 1, Vol. 3, 1940, pp. 29–30: in German.)

"On the basis of the theory of a simple thermo-acoustic self-exciting system, the so-called 'thermoregenerated Helmholtz resonator' [*ibid.*, Vol. 2, 1940, p. 437 onwards: *cf.* also 2299 (and 2538) of 1940, and 32 of January], it may be expected that all thermoregenerated acoustic systems will behave as regenerated sound receivers when an external acoustic field is applied. For experimental investigation the most suitable system is one consisting of a vertical tube open at both ends and containing, in its lowest quarter, a ring spiral heated by an electric current. In such a tube, when the heating is gradually increased, a 'soft' setting-in of the self-excited oscillations occurs, if the tube is guarded from the influence of stray air currents.

"Such a tube was connected, through a narrow side branch, to a microphone leading to a single-valve amplifier, and its output voltage measured. With the help of an a.f. generator and a moving-coil loudspeaker an external acoustic field was produced, its frequency being measured with a valve frequency-meter. With this apparatus a series of resonance curves was plotted for various values of heating of the regenerating spiral. Fig. 1 gives a series of such curves, from which it can be seen that by increasing the heating current, from 0 to 2.6 A, an unbroken increase of the peak value of the resonance curve is obtained, from 0.8 to about 4 v [actually 5 v in the diagram]. Thus the sensitivity of the sound receiver is increased five times by the thermoregeneration, before the setting-up of self-excitation of the tube, if the latter is subjected to a potential-self-oscillating régime. As soon as the heating current exceeds 2.6 A, self-excitation sets in. Resonance curve 5 was plotted at 2.7 A, that is, for a self-oscillating régime of the tube. The curve has a shape which is typical of the action of an external periodic force on a self-exciting system. At a change of frequency of the external field, corresponding to the dotted portions of the curve, beats occur. In the interval *AB* the beats disappear, and the tube oscillations are 'pulled-in' by the external acoustic field [for the first report of an acoustic "mitnahme" effect *see* the writer & Haykin, *Journ. of Tech. Phys.* [in Russian], Vol. 2, 1932, p. 111 onwards].

"The family of curves in Fig. 1 show that the resonant frequency increases continuously with an increase of thermoregeneration ... Measurements of the air temperature in the tube showed that the whole of the observed increase of frequency could be explained as a thermal effect" [and not a regeneration effect].

461. CALIBRATION OF MICROPHONES BY THE PRINCIPLES OF SIMILARITY AND RECIPROCITY [including Results on Commercial-Type Velocity Microphone].—H. F. Olson. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 36–42.)

462. ABSOLUTE PRESSURE CALIBRATION OF MICROPHONES.—R. K. Cook. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 415–420.) Already dealt with in 1089 of 1941.

463. CRYSTAL CUTTER AND CHANNEL FOR LATERAL RECORDING [specially for Instantaneous Play-Back: General Theoretical Requirements of Lateral Recording, Properties of Rochelle-Salt Crystals (including Temperature & Humidity Effects), and Design of Cutter-Head & Supply Channel].—F. W. Stellwagen. (*Proc. Radio Club of Am.*, April 1941, Vol. 18, No. 3, pp. 29–44.)

464. THE CALCULATION OF DISTORTIONS FOR GIVEN STATIC CHARACTERISTICS [with Special Application to Photographic Sound-Recording].—Peters. (*See* 400.)

465. AN ELECTROSTATIC METHOD OF MAINTAINING THE VIBRATIONS OF TUNING FORKS AND BARS [Advantages over Electro-Magnetic Methods (Absence of Damping due to Permanent Magnetic Field: Possibility of Working at Very Small Amplitudes, thus Reducing the Internal Friction: Increased Frequency Range: Use of Aluminium-Plated Quartz, Very Suitable for Standards): etc.].—P. Grivet. (*Comptes Rendus* [Paris], 11th Aug. 1941, Vol. 213, No. 6, pp. 231–233.)

466. THE AUDIO NOISE OF TRANSFORMERS [and Its Calculation & Measurement: Comparison between Theoretical & Tested Behaviour], *and* A STUDY OF SOUND LEVELS IN TRANSFORMERS.—W. C. Sealey: H. Fahnoe. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 109–112: June 1941, No. 6, Transactions pp. 277–283.)

467. A SOUND-MEASUREMENT ROOM UTILISING THE LIVE-END/DEAD-END STUDIO PRINCIPLE.—M. D. Stahl & W. C. Louden. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 9–15.)

468. SPECIFIC NORMAL IMPEDANCES AND SOUND-ABSORPTION COEFFICIENTS OF MATERIAL.—P. E. Sabine. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 317–322.) *Cf.* Morse & others, 120 of 1941.

469. THE ABSORPTION OF STRIPS, EFFECTS OF WIDTH AND LOCATION.—L. G. Ramer. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 323–326.)

470. SOUND-PREVENTION MECHANISM OF NON-POROUS MATERIALS: PART II, *and* TRANSMISSION LOSS OF NON-POROUS PLATE HAVING MULTIPLE RESONANT POINTS.—S. Kawashima. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 327–331: pp. 332–334.) For Part I *see* 4347 of 1940.

471. A NOVEL, HIGHLY EFFECTIVE SOUND-ABSORBING ARRANGEMENT, AND THE CONSTRUCTION OF A DEAD ROOM.—E. Meyer & others. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 191–193.) Long summary of an extended version of the paper dealt with in 2745 of 1941.

472. DURATION THRESHOLDS FOR THE PERCEPTION OF CERTAIN TRANSIENT PHENOMENA [Experimental Investigation: Duration Thresholds for Pitch Perception: the Physiological Building-Up Process: Limits in Ability to differentiate Stimuli with Various Envelopes].—W. Türk. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 65–70: summary, from *Akust. Zeitschr.*, Vol. 5, 1940, pp. 129–145.)

473. REVIEW OF [U.S.] ACOUSTICAL PATENTS.—H. A. Erf. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 456–460.) A regular feature.

474. STUDY OF STATIONARY SUPERSONIC WAVES IN LIQUIDS [Mathematical Treatment in Connection with High-Frequency Modulation of Light], *and* THE MODULATION OF LIGHT AT HIGH FREQUENCY BY STATIONARY SUPERSONIC WAVES.—Goudet. (*See* 487.)

PHOTOTELEGRAPHY AND TELEVISION

475. PAPER ON THE TRANSMISSION CHARACTERISTICS OF ASYMMETRIC-SIDEBAND COMMUNICATION NETWORKS [with Particular Reference to Television: an Experimental Receiver: etc.].—E. C. Cherry. (*Electrician*, 12th Dec. 1941, Vol. 127, pp. 333–334: summary of I.E.E. paper.)

476. A RÉSUMÉ OF THE TECHNICAL ASPECTS OF R.C.A. THEATRE-TELEVISION.—I. G. Maloff & W. A. Tolson. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 5–11.)

477. ON DETERMINING THE OPTIMUM RATIO OF CONDUCTOR DIAMETERS IN A COAXIAL CABLE.—O. S. Rakovich. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 71–76.)

An analysis of the method used in American and European practice for determining the optimum ratio of conductor diameters in a coaxial cable is given, and it is shown that this method gives a cable of minimum dimensions but not necessarily the one in which the minimum amount of copper is used. Accordingly, more exact formulae are derived which enable a considerable saving in copper to be effected. This saving is somewhat off-set by the extra amount of lead which would be required for covering the cable, and it is suggested that cheaper substitutes should be used in place of lead. Formulae in which lead is taken into account are also derived, and a number of curves useful for certain sets of conditions are shown.

478. A New Pulse Generator for Television [for Line & Frame Synchronising Signals: Cathode-Ray Device].—A. Castellani. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, pp. 178–183.)

From the Italian S.A.F.A.R. works. The writer begins by outlining the deficiencies of previous methods of obtaining synchronising signals, particularly for the high requirements of interlaced scanning: he has developed his device with the object of overcoming such defects and also with a special eye to the possible general application, in the future, of the principle of external deflection-control. The basis of his generator is a cathode-ray tube with a circular time base, the fluorescent screen being replaced by two metal discs, close together but insulated from each other, the front one smaller than the other but having one or more projecting tongues (with parallel sides) reaching nearly to the edge of the rear disc and each intercepting the ray once in each revolution, thus producing a pulse in the resistance-system connecting the two plates.

Great care had to be taken to obtain the utmost uniformity of ray-deflection velocity. Preliminary tests with a rotating magnetic field produced by three-phase current showed an inclination towards a hexagonal distortion: two-phase current was therefore tried, with much better results. The best arrangement of all, however, was a mixed system of electrostatic and single-phase magnetic deflection (Fig. 2): this gave trouble from a rather large interference-voltage, which modulated the rectangular pulse in time with the deflecting frequency and caused not only a periodic fluctuation of the repose current but also an inequality in the steepness of the two flanks. These effects ruined the pulse for the purposes in view: they were eliminated by generating the high voltage by a "blocking generator" (Sperrschwinger) running in synchronism with the 11 000 c/s deflection frequency, and by arranging that a fraction of this voltage modulated the repose current in the sense opposed to the hum voltage, and thus compensated the fluctuations and suppressed the inequality of the flank slopes.

After a short discussion of the application of the arrangement to sequential scanning with 220 lines, the writer comes to the diagram (Fig. 3) for interlaced scanning with a large number of lines. Here two tubes (top row of diagram) are used for the line-change signals: the two circular time bases are worked in series from a 2200 c/s supply, and are adjusted so that one ray cuts the axis of one of the five tongues exactly when the other ray cuts the centre line of a space between two tongues. The two rays must be active alternately for a period of 1/50th second: this result is obtained by a ray-releasing frequency of 50 c/s derived from a multivibrator. The third tube, with its time base supplied from a 1000 c/s supply, provides the frame-change signals: this tube has a disc with one main tongue and a supplementary, narrow tongue (Fig. 4) which generates the "satellite" pulse (Trabant: *see* for example 222 of 1940). The slight departure of the resulting pulse-mixture from the ordinary German standards is discussed on p. 181: for external deflection-control this would have no adverse influence on the regular formation of the raster, but for self-oscillating time bases (thyratron or high-vacuum valve) it would involve the loss of a few lines, the number depending on the nature of the "kipp" circuit. This would be remedied by pushing up the deflecting frequencies. It is also pointed out that the system described offers the chance, not provided by other methods, of obtaining interlaced scanning with an even number of lines. Moreover, the interlacing is completely stable and independent of fluctuations in the supply conditions: no anode-voltage stabilisation is necessary: the equipment takes comparatively little space, and it is easy to adjust and reliable in action. Finally, the 50 c/s mains supply can be employed, with modifications to the frequencies shown in Fig. 3 and mentioned above: this would give interlaced scanning with 512 lines and 25 frames.

479. On the Synchronisation of a Thyratron Generator.—V. P. Guljaev [Gulyaev]. (*Journ. of Phys.* [of USSR], No. 1, Vol. 3, 1940, pp. 21–27: in English.)

The original Russian paper was dealt with in 2402 of 1940. A footnote calls attention to the good agreement with Builder & Roberts's results, both theoretical and experimental (2926 of 1940), and also to Kholodenko's "very interesting" paper (3009 of 1941).

480. Fluctuations in Space-Charge-Limited Currents at Moderately High Frequencies: Part V (contd.)—Fluctuations in Television Pick-Up Tubes, etc.—Thompson, North, & Harris. (*See* 397.)

481. The Orbital-Beam Multiplier Tube for 500-Megacycle Amplification.—Ferris & Wagner. (*See* 446.)

482. Applications of the Inductive-Output Tube [Type RCA-825: as Wide-Band Amplifier, Frequency-Tripler, & Frequency Converter, All in connection with Television Repeater Station on 500 Mc/s].—O. E. Dow. (*Proc. Radio Club of Am.*, Aug. 1941, Vol. 18, No. 4, pp. 56–61.) For previous papers on this "inductive-output" valve *see* 1849 of 1939, 3023 & 4277 of 1940, and 2127 of 1941.

483. Recent Developments in Phototubes [with Curves for Surfaces S1–4: the R.C.A. Phototubes Types 929 & 931: Signal/Noise Ratio of a Multiplier Tube: Dark Currents: etc.].—R. B. Janes & A. M. Glover. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 43–54.) *See* also 1130, 3426 & 3427 of 1941: *also* 3093 of 1941 and back reference.

484. CONTROL OF SPONTANEOUS FLUCTUATIONS IN AMPLIFICATION OF VERY SMALL PHOTO-CURRENTS.—M. J. O. Strutt & A. van der Ziel. (*Physica*, June 1941, Vol. 8, p. 576 onwards: reference only, in *Review Scient. Instr.*, Oct. 1941, p. 524.)

485. NOTE ON THE PHOTOELECTRIC THRESHOLD OF BISMUTH FILMS OF MEASURED THICKNESS [Details of Increase of Threshold Wavelength with Thickness above That of First 44 Atom Layers], *and* ELECTRICAL CONDUCTANCE AND PHOTOELECTRIC EMISSION OF THIN BISMUTH FILMS.—A. H. Weber, L. J. Eisele, D. F. O'Brien. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, pp. 570–573: pp. 574–578.)

486. AN ANOMALOUS CRYSTAL PHOTOEFFECT IN *d*-TARTARIC ACID SINGLE CRYSTALS.—C. K. Lui. (*Phys. Review*, 1st Oct. 1941, Vol. 60, No. 7, pp. 529–531.) A summary was dealt with in 3429 of 1941.

487. STUDY OF STATIONARY SUPERSONIC WAVES IN LIQUIDS [Mathematical Treatment in Connection wirh Use of Phenomenon for the High-Frequency Modulation of Light], *and* THE MODULATION OF LIGHT AT HIGH FREQUENCY [10 Mc/s] BY STATIONARY SUPERSONIC WAVES.—G. Goudet. (*Comptes Rendus* [Paris], 21st July 1941, Vol. 213, No. 3, pp. 117–119: 11th Aug. 1941, No. 6, pp. 228–231.)

(1) The writer concludes: "This example shows that it is difficult to increase the distance of the quartz from the reflector much beyond the value selected, without exposing oneself to an instability resulting from the influence of temperature. Moreover, such an increase would reduce the ratio P_V/P_N and consequently the depth of modulation," P_V and P_N being the resonance pressures at the antinodes and nodes respectively. (2) Among the advantages over other methods (Kerr cell, etc.) brought out in this Note are the depth of modulation attainable and the ease with which the method can be applied to ultra-violet light.

488. THEORY OF NON-STATIONARY STATES OF THE ELECTRIC DISCHARGE PLASMA [at Low & Medium Frequencies: with Application to Modulated Discharges for "Image Transmission & Television," and to Deionisation Processes].—B. Granovsky. (*Journ. of Phys.* [of USSR], No. 3, Vol. 3, 1940, pp. 195–218: in English.) *Cf.* Weizel & others, 597, below.

489. THEORY OF THE OPTICAL AND MAGNETIC PROPERTIES OF FERROMAGNETIC SUSPENSIONS.—W. C. Elmore. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, pp. 593–596.)

Arising out of the work dealt with in 3499 of 1940 and back reference. Among other results of the theory is the deduction that the greatest changes in transmission are produced by a magnetic field when the cell transmits about $(1/e)$ of the light which it would transmit if it contained pure liquid.

490. DUPLEX TRANSMISSION OF FREQUENCY-MODULATED SOUND AND FACSIMILE [General Discussion of Multiplex Frequency Modulation: Laboratory & Field Tests on Simultaneous Sound & Facsimile: Technically Possible, but probably Undesirable for Technical & Commercial Reasons].—M. Artzt & D. E. Foster. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 88–101.)

491. PHOTOTELEGRAPHIC RECORDING USING LINES OF VARIABLE WIDTH.—E. L. Orlovski. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 24–32.)

In a previous paper (3423 of 1941) a correcting circuit was proposed for improving half-tone reception when a gas-filled lamp is used as a light modulator. In the present paper, however, it is pointed out that the electrical correction of half-tones complicates the circuit and that the gas-filled lamp also possesses certain disadvantages. Accordingly a theoretical discussion is presented of the operation of a phototelegraphic system in which an electromechanical modulator (either ribbon or mirror, Figs. 2 and 3) is used to produce lines of variable width. Eqns. 21 and 28 are derived determining the relationship between the optical densities of the transmitted and recorded image elements for negative and positive recording respectively. An analysis of these equations shows that as regards half-tone reproduction the two types of recording are equivalent. Furthermore, if the amplifiers of the system are operated on linear portions of their characteristics, true half-tone reproduction is effected without any correcting circuits.

492. MONITORING OF SIGNALS IN RADIO COMMUNICATION.—I. F. Agapov. (*Elektrosvyaz* [in Russian], No. 2, 1941, pp. 5–17.)

A short description is given of various methods for checking the quality of telegraphic and phototelegraphic signals by means of a cathode-ray oscillograph, and a number of typical oscillograms are reproduced to enable the operator to discriminate between different types of distortion. In dealing with telegraphic signals, distortion introduced in the transmitter and receiver as well as during propagation (including that due to echo) is considered, and methods are also indicated for measuring the telegraphic speed and signal bias. The difficulties of monitoring phototelegraphic signals are pointed out, and, as before, distortion introduced at various stages of transmission is discussed. The paper is interspersed with practical suggestions with a view to improving the quality of transmission.

MEASUREMENTS AND STANDARDS

493. ABSOLUTE VOLTAGE MEASUREMENT IN THE DECIMETRIC-WAVE REGION [Wollaston-Wire Voltmeter for Check Calibrations of Thermionic Voltmeters].—A. Ditl. (*Hochf:tech. u. Elek:akus.*, Aug. 1941, Vol. 58, No. 2, pp. 32–35.)

Diode voltmeters, which give good results on wavelengths down to about 3 m, show serious errors in the 20–100 cm region owing to the impedance of their connections and to electron inertia. Both types of error are hard to deal with by calculation or estimate, and methods have therefore been suggested (Strutt & Knol, 1527 of 1940: Gundlach, 1447 of 1941) for the absolute calibration of such voltmeters. These methods convert the voltage measurement into measurements of current and impedance, which can be carried out accurately in the decimetric wave region. They require, however, a special adjustment for every frequency measured, so that a calibration is an elaborate proceeding. The writer has therefore developed a platinum-thread voltmeter in coaxial form, with errors in the decimetric-wave region which can be calculated. The outer conductor is a thick-walled, short tube of copper, about 1.3 cm long and of internal diameter about 4 mm, in the largest model made: the shortest wavelength measured was 20 cm. The Wollaston wire (with a resistance of 1800–460 ohms/cm according to its thickness) forms the inner conductor, and is stretched axially from the centre of the metal disc closing one end of the tube to a copper rivet carried at the centre of a mica disc covering the (electrically) open end. To avoid circuit errors, the copper rivet must really receive the voltage to be measured—*i.e.*, the connections must be very short—and the outer conductor must be kept at zero potential. This is done by covering its outside with copper foil over an insulating layer of polystyrol, forming a condenser which is a satisfactory short circuit for ultra-high frequencies: for the low frequencies further condensers are connected in parallel.

When the voltage is applied to the copper rivet, a current flows through the platinum thread, warms it, and raises its resistance. The rise in resistance is therefore a measure of the applied voltage. The various errors involved when the calibration curve, made at a low frequency, is used for decimetric waves are calculated: errors due to skin effect, to radiation at open end, etc. The circuit diagram of Fig. 2 shows the absolute voltmeter in use for calibrating a diode voltmeter *DRG*: the generator box *Tr* contains also an oscillatory circuit *LC* tuned to the frequency in question, and representing a short circuit for the direct-current measurement (r-h top corner of diagram) of the resistance-rise in the platinum thread. The copper rivet is connected to the anode of the diode by the shortest possible lead and the test voltage brought to both from the *LC* circuit. The cathode of the diode, and the outer condenser-layer of the copper tube, are connected to the screening of the test box, which is also connected through suitable condensers to the closed end of the tube (*see* above) and to the diode's heater-filament connections. The preliminary l.f. calibration is carried out by replacing the generator box by a l.f. generator and transformer, and measuring the voltage at the copper rivet by a thermojunction.

494. D.C. SUBSTITUTION METHOD OF MEASURING HIGH-FREQUENCY ATTENUATION [of Open-Wire Lines, etc: Accuracy of Measurement practically Independent of Calibration & Stability of Thermocouple: Pointer brought to Scale Section where Meter is Most Sensitive, and viewed by Lens mounted coaxially: High Accuracy at 5 Mc/s].—H. B. Noyes. (*Bell Lab. Record*, Oct. 1941, Vol. 20, No. 2, pp. 38–42.)

495. THE "PULLING-IN" OF A MULTIVIBRATOR.—V. V. Vitkevich. (*Elektrosvyaz* [in Russian], No. 11, 1940, pp. 62–76.)

The operation of the multivibrator when an e.m.f. is applied in opposition to the grids of the two valves (Fig. 1) is discussed from the standpoint of "disrupted" oscillations taking place in the circuit. Eqn. 11 determining the current between the "jumps," together with conditions (7) and (8) for the jumps, gives a complete picture of the current changes in the multivibrator. A system of general equations (12) determining the operation of the system is also derived. The pulling-in of the multivibrator at the frequency of the applied e.m.f. is then discussed, and eqns. 17 & 20 are derived determining respectively the minimum amplitude of the e.m.f. necessary for the pulling-in to be effected, and the corresponding permissible displacement between the applied frequency and the natural frequency of the multivibrator. The main object of the paper is, however, to study the pulling-in at sub-harmonics of the applied e.m.f., which (the author claims) has not been investigated before. The odd and even sub-harmonics are considered separately, and the treatment is similar to that employed for the fundamental. The pulling-in at the *n*th harmonic, or more generally at the ratio m/n, where m and n are the frequencies of the applied e.m.f. and of the multivibrator, is also discussed. The paper ends with a report on experiments made to check the theory.

496. EXTENSION OF THE FOUCAULT CURRENT THEORY [leading to a New Frequency Meter Principle giving Great Simplicity of Construction for the Usual Accuracy & Sensitivity].—Bászel. (*See* 538.)

497. A PULSE GENERATOR OF REGULABLE FREQUENCY, AMPLITUDE, AND PHASE [primarily for Researches on Ferromagnetic Frequency Conversion].—R. Dehors. (*Comptes Rendus* [Paris], 11th Aug. 1941, Vol. 213, No. 6, pp. 233–235.)

One thyratron circuit, in the classic "time-base" connection, controls the grid of a second thyratron which acts as a synchronous interrupter. The resulting pulses are all of the same sign: their duration, continuously regulable, is shorter than, or equal to, a half-period of the a.c. source supplying the apparatus: their amplitude can be varied within wide limits, and may reach several tens of amperes: their phase with respect to that of the supply source can be adjusted: they are stable, and their frequency can be any submultiple of the supply frequency: and finally they can take the form of periodic trains each containing several consecutive pulses.

498. A GENERATING VOLTMETER OF EXTREMELY HIGH SENSITIVITY [for D.C. Voltages (10^{-3} Volt Full Scale) or Currents (10^{-12} Ampere Full Scale): Easy to Use and Reliable: Applications include X-Ray Therapy Dosage].—E. H. Greibach. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 472–477.) *See* also 536, below.

SUBSIDIARY APPARATUS AND MATERIALS

499. On the Accuracy of Measurements taken from Recordings of Harmonic Oscillations [and the Optimum Speed of the Film or Tape].—Bungers. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 22, 1941, pp. 136–137.)

In "a very important paper" (319 of 1936) Kaiser obtained an answer to the question of how, in photographic recording, the film velocity v_l should be chosen in order to resolve successfully a harmonic oscillation of given frequency ν: he derived the inequality $v_l \geq 0.004\,\nu$ cm/s, for very thin traces. The present writer extends this work, and his results are applicable to other types of recording, such as by an inkwriter or smoked-drum recorder. The problem he sets himself is to find the paper speed which, with the greatest economy in paper, will give the greatest accuracy of results in the recording of a harmonic oscillation of given amplitude A and given period T: he assumes a constant thickness of trace at all paper speeds, pointing out that this is always true for the smoked-drum recorder, and with optical recording can be arranged for in the manner described by Kaiser. The reading error for the period T is defined as the ratio $s : T$ (Fig. 1: both s and T are measured in cm along the zero line) where $s = b/\sin \alpha$: here b is the error in measuring the amplitude A and depends on the sharpness of the trace (for a trace with perfectly sharp edges b would be the trace thickness), and α is the slope of the curve at the zero line. The general equation $f(T) = s/T = (b/2\pi A) . \sqrt{1 + (2\pi A)^2/T^2}$ is found, and in Fig. 2 the function $f(T)$ is plotted against the ratio period/amplitude, T/A. This curve therefore gives the increase in accuracy (*i.e.* decrease in reading-error s/T) obtained by an increasing paper velocity (*i.e.* increase in T/A). The increase in accuracy is rapid at first, but after the point $T/A = 3.6$ is reached a further increase of T/A to infinity only gives a 100% increase—to the limiting value where the reading-error is equal to $b/2\pi A$: the point of the curve to be chosen must depend on a compromise between technical requirements and economy. But another limit on paper speed is set by the increasing difficulty in recognising the harmonic nature of the trace, especially when no zero line is recorded, as usually occurs, for instance, in seismic recording.

500. Measurements of the Grain and Resolving Power of Photographic Films [Perutz and Agfa Emulsions: using Siedentopf's (Cathode-Ray) Oscillographic Photometer].—Raudenbusch. (*Physik. Zeitschr.*, Aug. 1941, Vol. 42, No. 11/12, pp. 208–212.) *See* 602, below.

501. The Attainment of High Recording Speeds with a Sealed-Off Cathode-Ray Tube with Fully Electrostatic Action: Part II.—Katz & Westendorf. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 22, 1941, pp. 121–124.)

For previous work on this tube *see* 4098 of 1939 (and reference in Ganswindt & Pieplow's paper on decimetric-wave oscillography, 2198 of 1941: also the present writers, *Zeitschr. f. tech. Phys.*, Vol. 21, No. 7 or 8, p. 156 onwards). Further development is now reported: thus the introduction of a stop B in the intermediate cylinder Z_2 of the electron gun (Fig. 1) ensures that even when the Wehnelt cylinder G has only a small negative bias (*i.e.* when the ray current is large) practically no electrons from the ray can hit the anode stop C, so that no secondary electrons are produced there to make themselves troublesome at the deflecting plates. Further, the design of the intermediate cylinder and of the anode is modified so that the tube will now stand definitely higher voltages (up to 30 kv) than the previous 20 kv: at these very high voltages small point discharges showed themselves and caused faint spots on the screen, but this trouble was eliminated by an annular disc of mica completely filling the space between the anode and the wall of the tube (Fig. 1, "Glimmerring"). Finally, Bey has shown that for anode voltages up to 4 kv a zinc-silicate screen is sufficiently discharged by its secondary emission (4549 of 1938), but that for higher electron energies the s.e. coefficient becomes less than unity and the screen charges up, so that the velocity of incidence of the electrons is reduced. Special care was therefore taken to arrange that these charges were carried away: the resulting gain in luminous output, for a recording speed of 2000 km/s, is seen in Fig. 2: at 20 kv the blackening produced is increased about 2.5 times. At this voltage, recording speeds were obtained of 50 000 km/s, with a static deflection sensitivity of 0.05 mm/v: this sensitivity was increased to 0.125 mm/v when the working voltage was reduced to 8 kv, with a recording speed of 2500 km/s.

502. Remarks on the Construction of Modern Cathode-Ray Oscillographs.—Pieplow. (*E.T.Z.*, 25th Sept. 1941, Vol. 62, No. 38/39, p. 804: summary, from *Arch. f. Elektrot.*, No. 6, Vol. 35, 1941, p. 319 onwards.)

This is presumably the paper promised in 2198 of 1941. It is shown that for stationary images obtained by saw-tooth time-base voltages the difficulties in synchronisation increase as the frequency of the process under investigation is increased, so that at ultra-high frequencies the obtaining of stationary images is not easy. A newly developed time-base circuit with "kipp" frequencies up to 5 Mc/s and charging speeds up to 2300 v/μs produces linear and well resolved oscillograms at frequencies up to 80 Mc/s, as the specimens reproduced show: above 100 Mc/s synchronisation is generally impossible, and phenomena at such frequencies must be recorded as non-recurring processes.

This task, however, makes considerably increased demands on the oscillograph tube, and the writer here deals with the successful production of the recording speeds required, now of the order of $10^4 - 10^5$ km/s instead of about 2000 km/s. The ground covered in this part of the paper is much the same as that mentioned in the earlier paper (*loc. cit.*) and in 503, below. Finally, an investigation of the errors and limits in the measurement of such rapid processes leads to a discussion of transit-time phenomena in non-recurring pulses, and the building-up processes for various pulse-shapes are calculated.

503. ELECTROTECHNICAL PROBLEMS IN THE CONSTRUCTION OF HIGH-PERFORMANCE [Cathode-Ray] OSCILLOGRAPHS.—Ganswindt. (*E.T.Z.*, 25th Sept. 1941, Vol. 62, No. 38/39, pp. 803–804: summary, from *Arch. f. Elektrot.*, No. 6, Vol. 35, 1941, p. 337 onwards.)

Circuit arrangements for a sealed-off oscillograph: the time-base functions symmetrically and linearly in time and gives sweep times down to 10^{-7} s, or in special cases down to 3×10^{-8} s. The brightness-control circuit, releasing the ray for the duration of the record, is kept at the cathode potential: this plan has the advantage that the anode potential need not be fully smoothed, which simplifies the equipment. The delay time (from the beginning of the process under investigation to the beginning of the sweep and of the Wehnelt-cylinder control) is reduced to 10^{-7} s by the use of gaseous-discharge tubes. The oscillograms reproduced, which illustrate the usefulness of the equipment for high-voltage and ultra-short-wave measurements, include the record of a 300 Mc/s wave which shows the resolving power mentioned above and a quite serviceable blackening of the film even at the points of the maximum recording velocity, 50 000 km/s.

504. MEASURING APPARATUS FOR THE DETERMINATION OF THE PRINCIPAL ELECTRON-OPTICAL DATA OF ROTATIONALLY SYMMETRICAL ELECTRON LENSES, WITH THE OBJECT OF GEOMETRICAL IMAGE CONSTRUCTION.—Sándor. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, p. 843: summary, from *Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 401–423.)

For previous work *see* 201 of January. The image-formation processes of such lenses have hitherto been dealt with by tests on the actual c.r. tubes, except in comparatively simple cases where the potential distribution in the lens field could be calculated or measured, so that the graphical method could be applied by the drawing of the electron paths. Such methods are inclined to waste a good deal of time. It is obviously desirable, therefore, to take advantage of the far-reaching analogy to ordinary optics to represent the image-formation processes purely geometrically, without any knowledge of the potential distribution and with the help only of the principal optical values such as focal length and principal planes: practically aberration-free paraxial image-formation, and object and image regions free from refraction, are assumed, and curved carrier paths inside the lens field are replaced by straight-line " auxiliary rays." Magnetic lenses can be dealt with as isotropic (like electrostatic lenses) by taking as the constructional plane a plane rotating with the electrons about the optical axis: *see* 3123 of 1941.

In the present paper, practical measuring apparatus for such constructions are described or suggested for all types of rotationally symmetrical electron-lenses with converging action. The apparatus for purely magnetic lenses is particularly simple, consisting of a sealed-off cylindrical c.r. tube along whose axis the lens under test is slid coaxially. Other types are an apparatus specially for electrostatic tubular lenses, a precision apparatus for all types of electrostatic lenses, and finally a " universal " apparatus for all forms of electric, magnetic, and combined systems. Besides the determination of the principal electron-optical data, the course of the electron paths, the image rotation of magnetic lenses, and the most important aberrations for rays entering parallel to the axis can be dealt with by such apparatus.

505. ELECTRIC CYLINDRICAL ELECTRON LENSES.—Straschkewitsch [Strashkevich]. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 507–523: in German.) The original Russian paper was dealt with in 3476 of 1941.

506. ELECTRON-OPTICAL FOCUSING BY QUASI-STATIC PATHS.—Wallauschek. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 565–574.)

Author's summary:—" The focusing properties of electron-optical cylindrical lenses are obtained from the theory of quasi-static paths, and general formulae are given for the calculation of the focusing angle from the potentials of arbitrary rotationally-symmetrical fields: in general, electron-optical cylindrical lenses show, for variously oriented ray planes, a phenomenon analogous to astigmatism. The following fields are calculated as examples: homogeneous magnetic field, cylindrical condenser, electrical Coulomb field, electric doublet, magnetic doublet [as investigated by Störmer in his aurora theory], and the combination of a homogeneous magnetic field, a cylindrical condenser, and a magnetic doublet " [dealt with by Henneberg: 1934 Abstracts, p. 451].

507. ELECTRON-OPTICAL INVESTIGATION WITH A MULTIPLE OSCILLOGRAPH TUBE [of New Type].—Leitner: Hinderer. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 22, 1941, pp. 85–89.)

Among the various ways of carrying out the simultaneous recording of several processes is the " switching " method of c.r. multiple oscillography, in which the various processes are applied in succession, by a mechanical or electronic switch, to the deflecting system of an ordinary single-ray tube. But the " switching " can be made to occur in the c.r. tube itself, in such a way that the single ray passes in succession through several deflecting systems, and the present paper describes two forms of equipment (patented by Hinderer) for such a technique. Thus in Fig. 2 the single ray takes up in succession six different positions under the influence of a magnetic transverse field H^I produced by a pair of external coils traversed successively by six d.c. currents of different strengths: in each of these six positions the ray lies between the plates of one of six deflecting systems. Such a simple system would be adequate to deal with slow switching. The figure, however, shows a more elaborate arrangement, suitable for rapid switching: the magnetic field H^{II}, about half-way between the " pivot " point of the ray (in H^I) and the screen, compensates the deflections produced by H^I and brings the spot back to the centre of the screen. The calculation of the necessary field strength H^{II} is dealt with in eqns. 2–6: if the coils of H^I and H^{II} are of the same length and number of turns, the " restoring " current must be twice as large as the "deflecting" current; Fig. 4 shows the small measured deviation from the theory, due to neglected leakage fields. Eqns. 7–11 deal with an electrostatic "restoring" field, but this is not applicable to the present purpose because of the ray distortion at the larger deflections and the different electron velocities through the six deflecting systems, which would falsify the records.

With the addition of H^{II}, the currents through the magnetic coils can vary continuously, so that both fields can be produced by alternating currents. But things are not completely straightforward, and on p. 88 the steps necessary to avoid the various types of aberration are discussed: the cylindrical-lens action of each pair of deflecting plates assists here, and Fig. 8 shows the good results obtained. Another design of tube is shown in Fig. 9: here the necessity for a "restoring" field is avoided by the provision of a stop system with an aperture in front of each of the four pairs of deflecting plates now shown. This plan has certain defects, however, leading to a reduction of the recording speed: this could be avoided by replacing the four-apertured stop by an electrostatic lens system.

508. A DISCONTINUOUS OSCILLOGRAPHIC SWEEP CIRCUIT [using High-Vacuum Valves: Sweep occupies Any Desired Interval of Time during Cycle under Observation, with Controllable Delays before & after Transit: Applications, including Multiple-Sweep Photography].—Haworth. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 478–482.) Used in the fluorescence-decay-time measuring apparatus dealt with in 2801 of 1941.

509. A VACUUM-TUBE INVERTER CIRCUIT [to replace Ionic-Valve Circuits for Cathode-Ray Switch, etc.].—Kock. (*See* 398.)

510. ON THE SYNCHRONISATION OF A THYRATRON GENERATOR.—Guljaev. (*See* 479.)

511. VALVE REGULATOR FOR D.C. VOLTAGE EQUIPMENTS [for Supplies to Electron-Optical Instruments, etc: Arrangement avoiding Usual Undesirable "Compensation" Battery (& thus improving the Efficiency) by Bridge Circuit containing Two Elements passing Constant Current (Screen-Grid Valves): Constancy within ± 1 V obtained for 1000 V Generator: Applicable also to Measuring Purposes].—Holzmüller. (*Physik. Zeitschr.*, Aug. 1941, Vol. 42, No. 11/12, pp. 218–219.)

512. ELECTRON MICROSCOPE WORKING AT APPROXIMATELY FIVE TIMES THE USUAL VOLTAGE, FOR DEEPER PENETRATION.—R.C.A. Laboratories. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.) Potentials of 300 kv are mentioned.

513. ON A METHOD OF CORRECTING THE SPHERICAL ERROR OF ELECTRON LENSES, ESPECIALLY OF THOSE EMPLOYED WITH ELECTRON MICROSCOPES [by Use of Electron Velocities increasing with Distance from Axis: Method of Velocity Modulation: Chromatism of Beam also Corrected].—Kompfner. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 410–416.)

Suggestion of a method of increasing the resolution (now about 5×10^{-7} cm and approaching its limit for conventional design) by about one order of magnitude: this would enable objects of atomic dimensions to be investigated. For Nesslinger's paper, referred to, *see* 2219 of 1940, and for that of von Borries & Ruska, 4104 of 1939.

514. THEORY OF THE ELECTROSTATIC ELECTRON MICROSCOPE FOR EMITTING OBJECTS.—Recknagel. (*Zeitschr. f. Phys.*, 15th Aug. 1941, Vol. 117, No. 11/12, pp. 689–708.)

The two main differences between the optical system of such a microscope and that of the "penetration" type for non-emitting objects are first discussed. Author's summary:—"For the calculation of the electron paths in the emitting-object microscope, a method is given which is free from the assumption, not fulfilled by emitting objects, of a consistently small angle between electron path and optical axis. The method can be considered as a series development involving $\sqrt{\epsilon/U}$, where ϵ is the voltage corresponding to the energy of emergence and U the accelerating voltage. The Gaussian approximation is calculated and the aberrations are determined to such an approximation that the so-called 'third order' errors are contained completely in the calculated values. The limitation of the resolving power through the geometrical-optical and chromatic aberrations is found, and the calculated resolving power compared with experimentally obtained values. The aberrations have the less influence on the resolving power, the narrower the energy-distribution curve of the electrons and the greater the field at the cathode. The conditions are determined, and applied to the Johannson immersion objective, under which this system can become a supermicroscope."

515. ON THE TESTING OF SHORT-FOCUS ELECTRON LENSES: A SIMPLE METHOD AND ITS RESULTS.—von Ardenne. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 602–611.)

This method has proved extremely useful in the development of the writer's Universal electron microscope for ray voltages up to 200 kv (3490 of 1941). It is based on the Hartmann "extra-focal" method of optics, and is represented in Fig. 1, where a practically parallel beam of rays from a distant point source (*i.e.* beam from the objective of an electron microscope) is seen to fall on a fine-mesh wire net in front of the lens under test. The shadow-image of the net is photographed by an ordinary vacuum-camera, and from this photograph the focal length, aperture error, and (in the case of a magnetic lens) image-field rotation are obtained. Special steps must be taken if the lens is of such a short focus that the object comes into its field (this does not happen with the author's latest designs, because the lens field is so highly concentrated). In a variation applicable only to magnetic lenses the wire gauze is not fixed but attached to a device by which it can be moved along the axis through the whole lens field.

503. ELECTROTECHNICAL PROBLEMS IN THE CONSTRUCTION OF HIGH-PERFORMANCE [Cathode-Ray] OSCILLOGRAPHS.—Ganswindt. (*E.T.Z.*, 25th Sept. 1941, Vol. 62, No. 38/39, pp. 803–804: summary, from *Arch. f. Elektrot.*, No. 6, Vol. 35, 1941, p. 337 onwards.)

Circuit arrangements for a sealed-off oscillograph: the time-base functions symmetrically and linearly in time and gives sweep times down to 10^{-7} s, or in special cases down to 3×10^{-8} s. The brightness-control circuit, releasing the ray for the duration of the record, is kept at the cathode potential: this plan has the advantage that the anode potential need not be fully smoothed, which simplifies the equipment. The delay time (from the beginning of the process under investigation to the beginning of the sweep and of the Wehnelt-cylinder control) is reduced to 10^{-7} s by the use of gaseous-discharge tubes. The oscillograms reproduced, which illustrate the usefulness of the equipment for high-voltage and ultra-short-wave measurements, include the record of a 300 Mc/s wave which shows the resolving power mentioned above and a quite serviceable blackening of the film even at the points of the maximum recording velocity, 50 000 km/s.

504. MEASURING APPARATUS FOR THE DETERMINATION OF THE PRINCIPAL ELECTRON-OPTICAL DATA OF ROTATIONALLY SYMMETRICAL ELECTRON LENSES, WITH THE OBJECT OF GEOMETRICAL IMAGE CONSTRUCTION.—Sándor. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, p. 843: summary, from *Arch. f. Elektrot.*, 25th Aug. 1941, Vol. 35, No. 7, pp. 401–423.)

For previous work *see* 201 of January. The image-formation processes of such lenses have hitherto been dealt with by tests on the actual c.r. tubes, except in comparatively simple cases where the potential distribution in the lens field could be calculated or measured, so that the graphical method could be applied by the drawing of the electron paths. Such methods are inclined to waste a good deal of time. It is obviously desirable, therefore, to take advantage of the far-reaching analogy to ordinary optics to represent the image-formation processes purely geometrically, without any knowledge of the potential distribution and with the help only of the principal optical values such as focal length and principal planes: practically aberration-free paraxial image-formation, and object and image regions free from refraction, are assumed, and curved carrier paths inside the lens field are replaced by straight-line " auxiliary rays." Magnetic lenses can be dealt with as isotropic (like electrostatic lenses) by taking as the constructional plane a plane rotating with the electrons about the optical axis: *see* 3123 of 1941.

In the present paper, practical measuring apparatus for such constructions are described or suggested for all types of rotationally symmetrical electron-lenses with converging action. The apparatus for purely magnetic lenses is particularly simple, consisting of a sealed-off cylindrical c.r. tube along whose axis the lens under test is slid coaxially. Other types are an apparatus specially for electrostatic tubular lenses, a precision apparatus for all types of electrostatic lenses, and finally a " universal " apparatus for all forms of electric, magnetic, and combined systems. Besides the determination of the principal electron-optical data, the course of the electron paths, the image rotation of magnetic lenses, and the most important aberrations for rays entering parallel to the axis can be dealt with by such apparatus.

505. ELECTRIC CYLINDRICAL ELECTRON LENSES.—Straschkewitsch [Strashkevich]. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 507–523: in German.) The original Russian paper was dealt with in 3476 of 1941.

506. ELECTRON-OPTICAL FOCUSING BY QUASI-STATIC PATHS.—Wallauschek. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 565–574.)

Author's summary:—" The focusing properties of electron-optical cylindrical lenses are obtained from the theory of quasi-static paths, and general formulae are given for the calculation of the focusing angle from the potentials of arbitrary rotationally-symmetrical fields: in general, electron-optical cylindrical lenses show, for variously oriented ray planes, a phenomenon analogous to astigmatism. The following fields are calculated as examples: homogeneous magnetic field, cylindrical condenser, electrical Coulomb field, electric doublet, magnetic doublet [as investigated by Störmer in his aurora theory], and the combination of a homogeneous magnetic field, a cylindrical condenser, and a magnetic doublet " [dealt with by Henneberg: 1934 Abstracts, p. 451].

507. ELECTRON-OPTICAL INVESTIGATION WITH A MULTIPLE OSCILLOGRAPH TUBE [of New Type].—Leitner: Hinderer. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 22, 1941, pp. 85–89.)

Among the various ways of carrying out the simultaneous recording of several processes is the " switching " method of c.r. multiple oscillography, in which the various processes are applied in succession, by a mechanical or electronic switch, to the deflecting system of an ordinary single-ray tube. But the " switching " can be made to occur in the c.r. tube itself, in such a way that the single ray passes in succession through several deflecting systems, and the present paper describes two forms of equipment (patented by Hinderer) for such a technique. Thus in Fig. 2 the single ray takes up in succession six different positions under the influence of a magnetic transverse field H^I produced by a pair of external coils traversed successively by six d.c. currents of different strengths: in each of these six positions the ray lies between the plates of one of six deflecting systems. Such a simple system would be adequate to deal with slow switching. The figure, however, shows a more elaborate arrangement, suitable for rapid switching: the magnetic field H^{II}, about half-way between the " pivot " point of the ray (in H^I) and the screen, compensates the deflections produced by H^I and brings the spot back to the centre of the screen. The calculation of the necessary field strength H^{II} is dealt with in eqns. 2–6: if the coils of H^I and H^{II} are of the same length and number of turns, the " restoring " current must be twice as large as the "deflecting" current; Fig. 4 shows the small measured deviation from the theory, due to neglected leakage fields. Eqns. 7–11 deal with an electrostatic "restoring" field, but this is not applicable to the present purpose because of the ray distortion at the larger deflections and the different electron velocities through the six deflecting systems, which would falsify the records.

With the addition of H^{II}, the currents through the magnetic coils can vary continuously, so that both fields can be produced by alternating currents. But things are not completely straightforward, and on p. 88 the steps necessary to avoid the various types of aberration are discussed: the cylindrical-lens action of each pair of deflecting plates assists here, and Fig. 8 shows the good results obtained. Another design of tube is shown in Fig. 9: here the necessity for a "restoring" field is avoided by the provision of a stop system with an aperture in front of each of the four pairs of deflecting plates now shown. This plan has certain defects, however, leading to a reduction of the recording speed: this could be avoided by replacing the four-apertured stop by an electrostatic lens system.

508. A DISCONTINUOUS OSCILLOGRAPHIC SWEEP CIRCUIT [using High-Vacuum Valves: Sweep occupies Any Desired Interval of Time during Cycle under Observation, with Controllable Delays before & after Transit: Applications, including Multiple-Sweep Photography].—Haworth. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 478–482.) Used in the fluorescence-decay-time measuring apparatus dealt with in 2801 of 1941.

509. A VACUUM-TUBE INVERTER CIRCUIT [to replace Ionic-Valve Circuits for Cathode-Ray Switch, etc.].—Kock. (*See* 398.)

510. ON THE SYNCHRONISATION OF A THYRATRON GENERATOR.—Guljaev. (*See* 479.)

511. VALVE REGULATOR FOR D.C. VOLTAGE EQUIPMENTS [for Supplies to Electron-Optical Instruments, etc: Arrangement avoiding Usual Undesirable "Compensation" Battery (& thus improving the Efficiency) by Bridge Circuit containing Two Elements passing Constant Current (Screen-Grid Valves): Constancy within ± 1 V obtained for 1000 V Generator: Applicable also to Measuring Purposes].—Holzmüller. (*Physik. Zeitschr.*, Aug. 1941, Vol. 42, No. 11/12, pp. 218–219.)

512. ELECTRON MICROSCOPE WORKING AT APPROXIMATELY FIVE TIMES THE USUAL VOLTAGE, FOR DEEPER PENETRATION.—R.C.A. Laboratories. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 312.) Potentials of 300 kV are mentioned.

513. ON A METHOD OF CORRECTING THE SPHERICAL ERROR OF ELECTRON LENSES, ESPECIALLY OF THOSE EMPLOYED WITH ELECTRON MICROSCOPES [by Use of Electron Velocities increasing with Distance from Axis: Method of Velocity Modulation: Chromatism of Beam also Corrected].—Kompfner. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 410–416.)

Suggestion of a method of increasing the resolution (now about 5×10^{-7} cm and approaching its limit for conventional design) by about one order of magnitude: this would enable objects of atomic dimensions to be investigated. For Nesslinger's paper, referred to, *see* 2219 of 1940, and for that of von Borries & Ruska, 4104 of 1939.

514. THEORY OF THE ELECTROSTATIC ELECTRON MICROSCOPE FOR EMITTING OBJECTS.—Recknagel. (*Zeitschr. f. Phys.*, 15th Aug. 1941, Vol. 117, No. 11/12, pp. 689–708.)

The two main differences between the optical system of such a microscope and that of the "penetration" type for non-emitting objects are first discussed. Author's summary:—"For the calculation of the electron paths in the emitting-object microscope, a method is given which is free from the assumption, not fulfilled by emitting objects, of a consistently small angle between electron path and optical axis. The method can be considered as a series development involving $\sqrt{\epsilon/U}$, where ϵ is the voltage corresponding to the energy of emergence and U the accelerating voltage. The Gaussian approximation is calculated and the aberrations are determined to such an approximation that the so-called 'third order' errors are contained completely in the calculated values. The limitation of the resolving power through the geometrical-optical and chromatic aberrations is found, and the calculated resolving power compared with experimentally obtained values. The aberrations have the less influence on the resolving power, the narrower the energy-distribution curve of the electrons and the greater the field at the cathode. The conditions are determined, and applied to the Johannson immersion objective, under which this system can become a super-microscope."

515. ON THE TESTING OF SHORT-FOCUS ELECTRON LENSES: A SIMPLE METHOD AND ITS RESULTS.—von Ardenne. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 602–611.)

This method has proved extremely useful in the development of the writer's Universal electron microscope for ray voltages up to 200 kV (3490 of 1941). It is based on the Hartmann "extra-focal" method of optics, and is represented in Fig. 1, where a practically parallel beam of rays from a distant point source (*i.e.* beam from the objective of an electron microscope) is seen to fall on a fine-mesh wire net in front of the lens under test. The shadow-image of the net is photographed by an ordinary vacuum-camera, and from this photograph the focal length, aperture error, and (in the case of a magnetic lens) image-field rotation are obtained. Special steps must be taken if the lens is of such a short focus that the object comes into its field (this does not happen with the author's latest designs, because the lens field is so highly concentrated). In a variation applicable only to magnetic lenses the wire gauze is not fixed but attached to a device by which it can be moved along the axis through the whole lens field.

Various results are described and discussed. For electron microscopy the most important is the establishment that the magnetic "pole-shoe" lens (Fig. 3) possesses not merely one minimum focal length but (for strongly increased flux) at least a second, less than half of the first; so that at 150 kv the hitherto unrealisable focal length of 1.6 mm was obtained, and highly enlarged pictures of diatoms were recorded.

516. ON THE OPTICAL CHARACTERISTIC VALUES OF "STRONG" ELECTRON LENSES [as used in Electron Microscopes].—Dosse. (*Zeitschr. f. Phys.*, 15th Aug. 1941, Vol. 117, No. 11/12, pp. 722–753.)

The paper begins with definitions of "weak" lenses (also called "short" or "thin" because the axial length of their field is short compared with the focal length: *cf.* Glaser, 1166 of 1941) and "strong" lenses. Author's summary:—"A procedure is described for the calculation of the electron paths near the axis in electrostatic and magnetic lenses of arbitrary field shape. The optical values, particularly the focal length, aperture-error [spherical-aberration] constant and chromatic-aberration constant, of a strong magnetic lens are calculated from the measured field curves of this lens, and actually measured in an electron microscope. The calculated and measured aberration constants of a magnetic and of an electrostatic lens are compared [agreement with measured values is satisfactory, which has not been the case, at any rate for "strong" magnetic lenses, by previous methods of calculation]. Some deductions regarding resolving power are made."

517. DISCRETE ENERGY LOSS OF FAST ELECTRONS IN SOLID BODIES [Experimental Investigation: of Interest in connection with Interference Processes & Electron-Microscopic Work].—Ruthemann. (*Naturwiss.*, 17th Oct. 1941, Vol. 29, No. 42/43, p. 648.)

518. IMPROVEMENT IN ELECTRON OPTICS FOR EXPERIMENTS ON INTERFERENCE [Production of "Electron Probe" of Diameter 1μ (compared with 40–100μ): Results].—Möllenstedt & Ackermann. (*Naturwiss.*, 17th Oct. 1941, Vol. 29, No. 42/43, pp. 647–648.) For previous fine electron beams *see* Boersch, 1174 [and 1736/7] of 1941, and von Ardenne, 2208 of 1941 [*see* also back references in 1567 of 1940].

519. ON THE STRUCTURE OF THE INTERFERENCE IMAGES OCCURRING IN A CONVERGENT ELECTRON BEAM, *and* MEASUREMENTS ON THE INTERFERENCE PHENOMENA IN A CONVERGENT ELECTRON BEAM.—Kossel: Möllenstedt. (*Ann. der Physik*, 27th July 1941, Vol. 40, No. 1, pp. 17–38: pp. 39–65.) *See* also 518, above.

520. PHOSPHORESCENCE AND SCINTILLATION SPECTRA.—Kutzner. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 575–588.)

The writer has already shown that the scintillations produced in zinc-sulphide phosphors by the action of alpha rays emit band spectra consisting of a superposition of several component bands all lying in the visible region. The previous paper did not deal with the comparative behaviour under alpha-ray and light excitations: the literature merely states that the same spectra are produced, but quantitative measurements are not given. The present investigation shows that the two types of spectra are qualitatively the same, but that the intensity relations show marked differences, some of the component bands being emphasised in the alpha-ray spectra and others in the light spectra: on the whole, the intensity in the whole spectrum is displaced towards the shorter wavelengths when alpha-ray excitation is employed, since these rays, more rich in energy, bring more electrons to the higher excitation states. They might indeed be expected to excite the ultra-violet bands which, by Stokes's rule, cannot be produced by irradiation with light: but actually such a radiation, even if liberated, would not be found, since it would be re-absorbed in the crystal and lead to self-excitation of the phosphor.

521. NEW COMPOUNDS FLUORESCENT TO X-RAYS [& showing No Fluorescence to Ultra-Violet Light: if Fired, rival Most Highly Fluorescent Calcium Tungstates in Brilliancy: etc.].—Renwick & Tasker. (*Nature*, 6th Dec. 1941, Vol. 148, p. 698.) Note on a British patent (Ilford laboratories).

522. DISCUSSION ON "THE EXTRACTION OF ELECTRONS FROM COLD METALS AT HIGH FIELD STRENGTHS" [and the Validity of Field-Strength Values determined without Specific Reference to Atomic Surface Structure].—Willis Jackson & Chester. (*Journ. I.E.E.*, July 1941, Vol. 88, Part I, No. 7, pp. 267–268.) *See* 3148 of 1941.

523 THE CONTROL OF LOW-PRESSURE ARC DISCHARGES IN INERT GASES WITH THE HELP OF A GRID IN THE PLASMA [at High Frequencies].—Leimberger. (*See* 410.)

524. ON THE THEORY OF NON-STATIONARY DISCHARGES: THE MODULATION OF THE HIGH-PRESSURE ARC, *and* THEORY OF NON-STATIONARY STATES OF THE ELECTRIC DISCHARGE PLASMA [with application to Deionisation Processes, etc.].—Granovsky: Weizel, Rompe, & Schulz. (*See* 488 & 597.)

525. BREAKDOWN POTENTIALS IN H_2, O_2, N_2, NO, HCl, HBr, and HI [Agreement with Ionisation Theory only when Molecules are composed of Atoms of a Single Element].—Kowalenko [Kovalenko]. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 455–462: in German.)

526. INVESTIGATION OF THE AMORPHOUS STATE: XVIII — ELECTRICAL CONDUCTIVITY OF BODIES IN THE AMORPHOUS AND CRYSTALLINE STATES [including Rochelle Salt].—Kobeko & others. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 287–296: in German.) For some previous papers in this series *see* 773 & 2116 of 1939.

527. The Electric Strength of Mica and Its Variations with Temperature [Experimental Investigation: Intrinsic Strengths agree well with Fröhlich's Theory for Polar Crystals: Application of Results to Industrial Practice].—Hackett & Thomas. (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part I, No. 8, pp. 295–303.) Based on E.R.A. Reports Refs. D/T22 & D/T28.

528. The Electric Strength of Solid Dielectrics under Impulse Voltages [Measurements on Mica, Micanite, Mycalex, Panilax, etc.: Discussion of Results].—Standring. (*Journ. I.E.E.*, Aug. 1941, Vol. 88, Part II, No. 4, pp. 360–365.) E.R.A. Report Ref. L/T109.

529. The Impulse Characteristics of Porcelain Insulators.—Bowdler & Standring. (*Journ. I.E.E.*, Oct. 1941, Vol. 88, Part II, No. 5, pp. 443–452.)

530. Styrene and Its Insulation Potentialities.—Scott. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, pp. 487–480.)

531. High-Frequency Copper-Oxide Rectifiers of High Stability.—Renne & Bogdanov. (*See* 421.)

532. Calculation of the Boundary-Layer Capacitances in the Framework of the Space-Charge Theory of the Dry-Plate Rectifier [Introduction (by W. Schottky): General Method of Calculation of Impedance: Results for Limiting Case of High Bias in Blocking Direction: for Zero Bias].—Spenke. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 40–67.)

The same simplifying assumptions are made as in a previous paper on the crystal rectifier (2976 of 1940): for a comparison with experimental results *see* 2828 of 1941.

533. On the Temperature Dependence of the Resistance of Selenium Rectifiers.—Scharawskij [Sharavski]. (*Journ. of Phys.* [of USSR], No. 4/5, Vol. 3, 1940, pp. 379–384: in German.)

The dependence in the "pass" direction is considerably less than for the copper-oxide type. In the "blocking" direction the temperature coefficient of resistance is negative for small voltages, positive for large: in a particular region of voltage and temperature the resistance of the selenium rectifier is practically independent of temperature. It is shown that all these results can be explained on the basis of recent ideas as to the nature of the rectifying mechanism.

534. Subsidence Transients in Circuits Containing a Non-Linear Resistor, with Reference to the Problem of Spark-Quenching.—Fairweather & Ingham. (*Journ. I.E.E.*, Sept. 1941, Vol. 88, Part I, No. 9, pp. 330–339: Discussion pp 340–342.)

535. Flashlight Batteries which Do Not Deteriorate in Storage [No Contact between Chemicals until Blow breaks Glass Tube].—Triumph Explosives. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 517.)

536. A D.C. Microampere-Hour Meter driven by Motor operating on about One Microwatt.—Greibach. (In paper dealt with in 498, above.)

537. A Pulse Generator primarily for Researches on Ferromagnetic Frequency Conversion.—Dehors. (*See* 497.)

538. Extension of the Foucault Current Theory [Eddy Currents in Solid Ferromagnetic Materials at Low Frequencies: including a New Analytical Formulation of the $\mu = f(H)$ Curve and a New Foucault Current Effect, leading to a New Frequency Meter Principle giving Great Simplicity of Construction for the Usual Accuracy & Sensitivity].—Bászel. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, pp. 184–192.)

539. Theory of the Optical and Magnetic Properties of Ferromagnetic Suspensions.—Elmore. (*See* 489.)

540. Investigations on Electrolytically Prepared Stratified Iron-Nickel Sheets [and Bands: by Alternate Depositing of 0.003 mm Layers of the Two Metals: Poor Properties: Improvement by Heat Treatment & Rolling: Effect of Addition of Arsenic: Advantages of Method].—Heck. (*Wiss. Veröff. a. d. Siemens-Werken*, 25th April 1941, Vol. 20, No. 1, pp. 104–134.) With 84 literature references.

STATIONS, DESIGN AND OPERATION

541. Duplex Transmission of Frequency-Modulated Sound and Facsimile.—Artzt & Foster. (*See* 490.)

542. Phase Selection in Radio Communication [for Multi-Channel Working, Broadcasting, etc.].—Momot. (*See* 420.)

543. Short-Wave Radiophones speed up Fire-Fighting [Recent Developments of Forest Service, including "Wave Sprinklers" (Automatic Relay Stations)].—(*Journ. Franklin Inst.*, Oct. 1941, Vol. 232, No. 4, pp. 397–398.) *See* also 3540 of 1941.

544. Plant Facilities of the Mackay Radio and Telegraph Company in the New York Area [including Remote Control of Transmitters at Brentwood Station by Ultra-High-Frequency Link].—Pratt. (*Elec. Communication*, No. 1, Vol. 20, 1941, pp. 32–43.)

545. Broadcasting over the Mains: "Wired Wireless" Distribution over Electric Supply Networks.—Eckersley. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, pp. 298–301.)

546. Monitoring of Signals in Radio Communication.—Agapov. (*See* 492.)

547. Airport Communications [with Special Reference to Facilities at La Guardia Field, New York].—Riddle. (*Elec. Communication*, No. 1, Vol. 20, 1941, pp. 5–22.)

548. Marine Radio-Telephone [Fool-Proof Unit with Instantaneous Selection from Ten Crystal-Controlled Frequencies].—Western Electric. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 514.)

549. N.B.C.'s International Broadcasting System.—Guy. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 12–35.)

550. N.B.C. Short-Wave Listening Post.—Milne. (*R.C.A. Review*, July 1941, Vol. 6, No. 1, pp. 82–87.)

551. Iran's Broadcasting System.— (*Zeitschr. V.D.I.*, 20th Sept. 1941, Vol. 85, No. 37/38, p. 789: paragraph only, with Localities of Relay Stations).

GENERAL PHYSICAL ARTICLES

552. A Method for the Solution of a Certain Class of Electrostatic and Related Problems [by Determination of "Free" Charges occurring at Surfaces of Separation between Different Media].—Grünberg. (*See* 378.)

553. Special Relativity in Refracting Media [Reformulation of Lorentz Transformations for Observer in Refracting but Non-Dispersive Medium, & Some Consequences].—Michels & Patterson. (*Phys. Review*, 15th Oct. 1941, Vol. 60, No. 8, pp. 589–592.)

554. Diffraction of Waves [X-Rays or Electron Waves] from a Curved Lattice.—Fock & Kolpinsky. (*Journ. of Phys.* [of USSR], No. 2, Vol. 3, 1940, pp. 125–140: in English,), Theory, and experiments with fast electrons and bent mica.

555. On the Electrodynamics of Anisotropic Media, *and* Radiation of an Electron moving in a Crystal with a Constant Velocity exceeding That of Light.—Ginsburg. (*Journ. of Phys.* [of USSR], No. 2, Vol. 3, 1940, pp. 95–100: pp. 101–106: in English.) The original Russian versions were referred to in 601 of 1941.

556. A Remnant Effect in X-Ray Reflection from Quartz, due to a Strong Electric Field: I [Reflection Intensity Several Times Larger than Normal, after Application & Removal of Field].—Kakiuchi. (*Proc. Phys.-Math. Soc. Japan*. Aug. 1941, Vol. 23, No. 8, pp. 637–645: in English.)

557. Magnetic Susceptibility of Two-Dimensional Free Electron Gas [and Comparison with Three-Dimensional Assembly].—Singh. (*Indian Journ. of Phys.*, April 1941, Vol. 15, Part 2, pp. 103–111.)

558. "Reports on Recent Progress in Physics: Vol. VII" [Book Review].—Awbery (Edited by). (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 509–510.) Reviewed by Darrow.

559. "Applied Mechanics, Theodore von Kármán Anniversary Volume" [Book Review].—Einstein, Epstein, & others. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 508–509.)

MISCELLANEOUS

560. Utilisation of the Correlation Coefficient in Harmonic Analysis.—Frolow. (*See* 363.)

561. On a Manner of Smoothing of Statistical Series.—Ono. (*Jap. Journ. of Mathematics*, Aug. 1941, Vol. 17, No. 4, pp. 513–515: in German.)

562. "Statistical Mechanics" [Book Review].—Mayer & Mayer. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 493.)

563. The Constants of Straight-Line Laws [Correspondence on Method of computing Parameters characterising the "Best" Straight Line through Set of Observational Points].—Freeman: Herrenden Harker. (*Engineering*, 21st & 28th Nov. 1941, Vol. 152, pp. 414 & 434.) For the original article *see* issue for 31st October, p. 354.

564. A Mechanical Device for the Determination of the Differential Coefficients of a Given Curve [overcoming Practical Difficulties in obtaining Second Derivative when Diagram is disturbed by Oscillations: an Elastic-Rod Curvature Method].—Teofilato. (*Journ. Roy. Aeron. Soc.*, Nov. 1941, Vol. 45, No. 371, p. 404: summary only.)

565. A Rapid Method for Calculating the Least Squares Solution of a Polynomial of Degree Not Exceeding the Fifth.—Kerawala. (*Indian Journ. of Phys.*, Aug. 1941, Vol. 15, Part 4, pp. 241–276.)

566. On the Numerical Solution of Linear Simultaneous Equations by an Iterative Method [avoiding Necessity of putting Equations into Their Normal Form].—Schmidt. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 369–383.)

567. The Numerical Solution of Equations [Unsolvable Algebraically: Newton's and Iteration Methods of Approximation].—Waidelich. (*Elec. Engineering*, Oct. 1941, Vol. 60, No. 10, pp. 480–482.)

568. Power-Factor Correction Calculator [applicable to Other Calculations involving Addition or Subtraction of Vector Quantities].—Metropolitan-Vickers. (*Journ. of Scient. Instr.*, Dec. 1941, Vol. 18, No. 12, pp. 244–245.)

569. Science and Government [Royal Society Presidential Address].—Dale. (*Engineer*, 5th Dec. 1941, Vol. 172, pp. 391–392: *Nature*, 6th Dec. 1941, pp. 678–680: summaries only.)

570. Broadcast News Presentation.—Dixon. (*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 319.) Letter prompted by the June Editorial.

571. Amateurs and Professionals: Should Post-War "Experimental" Transmitters know Morse?—(*Wireless World*, Dec. 1941, Vol. 47, No. 12, p. 297.) Editorial: for a continuation of the correspondence *see* p. 318.

572. Protective Grounding of Electric Installations: Present Attitude of the American Water Works Association.—Jordan. (*Journ. Am. Water Works Assoc.*, Nov. 1940, Vol. 32, No. 11, pp. 1940–1945.)

573. "Research—A National Resource: II—Industrial Research" [Book Review].—Nat. Research Council. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 506–508.) *See* also 307 of January.

574. "Abriss der Instrumentenkunde," *and* "Instrumentenkunde" [Booklets on Aircraft Instruments: Reviews].—Bürkle. (*Zeitschr. f. Instr:kunde*, Sept. 1941, Vol. 61, No. 9, p. 320: p. 320.)

575. "Handbuch für elektrotechnisches Englisch" [Book Review].—Freeman. (*Zeitschr. V.D.I.*, 1st Nov. 1941, Vol. 85, No. 43/44, p. 874.)

576. "Visibility in Meteorology" [Book Review].—Middleton. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 504.)

577. "Fortschritte der Hochfrequenztechnik" [Vol. 1, with Sections on Propagation (Lassen, Grosskopf, Beckmann, & others), on Velocity-Modulation (Hollmann), etc., etc: Book Review].—Vilbig & Zenneck. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 22, 1941, p. 207.)

578. "The Physical Examination of Metals: Vol. 2—Electrical Methods" [Book Review].—Chalmers & Quarrell. (*Proc. Phys. Soc.*, 1st Nov. 1941, Vol. 53, Part 6, No. 300, p. 731.)

579. "Hochfrequenz-Nachrichtentechnik für Elektrizitätswerke" [H.F. Communication (Telephony, Telemetering, etc.) for Power Stations: Book Review].—Dressler. (*E.T.Z.*, 9th Oct. 1941, Vol. 62, No. 40/41, pp. 847–848.)

580. Temperature Stability of the 2B Pilot Channel [in the Type C Carrier System].—Penick. (*Bell Lab. Record*, July 1941, Vol. 19, No. 11, pp. 334–337.)

581. Peak Voltages in Carrier Telegraphy [Resultant of the Many Frequencies used: Method of Reduction].—Hamilton. (*Bell Lab. Record*, Aug. 1941, Vol. 19, No. 12, pp. 367–369.)

582. The Effect of Radio Transmission on Transposed Telephone Lines.—Apanasenko. (*Elektrosvyaz* [in Russian], No. 12, 1940, pp. 67–76.)

It is shown mathematically that if frequencies of the order of several Mc/s are used for carrier telephony over transposed open-wire (non-ferrous) lines, the absolute value of the interference from radio stations would not exceed that experienced at frequencies used at present.

583. On the Treatment of the Stability of Mechanical-Electrical Regulating Systems.—Artus. (*See* 401.)

584. New Questions in Vibration Technique [Rheo-Linear Oscillations: Non-Linear Oscillations: Oscillation Problems in Internal-Combustion Engines, etc.].—V.D.I. Committee. (*Zeitschr. V.D.I.*, 18th Oct. 1941, Vol. 85, No. 41/42, pp. 826–828.)

585. The Admittance Method for obtaining the Natural Frequencies of Systems [Flywheels on Shaft, etc: also applicable to Numerous Electrical Problems].—Duncan. (*Phil. Mag.*, Nov. 1941, Vol. 32, No. 214, pp. 401–409.)

586. The Mechanical Impedance of Damped Vibrating Systems.—Manley. (*Journ. Roy. Aeron. Soc.*, Nov. 1941, Vol. 45, No. 371, pp. 342–348.) From the de Havilland Company.

587. Circuit Diagram and Electro-Mechanical Analogy [Discussion of Some Difficulties in connection with Vibratory Systems].—Hecht. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 22, 1941, pp. 112–117.) Prompted by certain criticisms of the writer's book—*see* 3241 of 1940.

588. Progress in Telearchics: Controlling Model Aircraft by Wireless.—(*Wireless World*, Dec. 1941, Vol. 47, No. 12, pp. 308–310.) *See* also 314 of January.

589. Cooperation between Instrument Makers and Instrument Users.—Marsh. (*Journ. of Scient. Instr.*, Dec. 1941, Vol. 18, No. 12, pp. 231–234.)

590. Electric Furnaces in Metallurgy [Survey, including High-Frequency Types].—Wagner. (*Naturwiss.*, 31st Oct. 1941, Vol. 29, No. 44, pp. 663–669.)

591. The Use of the Counter Tube in the Destructionless Testing of Materials [by X-Rays & Gamma Rays].—Trost. (*Zeitschr. V.D.I.*, 18th Oct. 1941, Vol. 85, No. 41/42, pp. 829–833.) *See* also 2301 of 1941.

592. Absolute Sensitivity of Geiger Counters.—Craggs. (*Nature*, 29th Nov. 1941, Vol. 148, p. 661.) From the Metropolitan-Vickers laboratories.

593. The Production of High Rotational Speed.—MacHattie. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, pp. 429–435.) A summary was dealt with in 2926 of 1941.

594. High-Production High-Economy Methods for Metal Parts: Part I—Castings.—Basch. (*Gen. Elec. Review*, Sept. 1941, Vol. 44, No. 9, pp. 478–488.) For Part II *see* October issue.

595. Variations of Atmospheric Temperature with Altitude in the United States [in Connection with Rating of Electrical Apparatus: Heights up to 10 000 Feet].—Tenney. (*Elec. Engineering*, May 1941, Vol. 60, No. 5, Transactions pp. 230–232.)

596. INFRA-RED RADIATION AND EQUIPMENT [for Industrial Purposes (Paint Baking, etc.)].—Maxted. (*Electrician*, 19th Dec. 1941, Vol. 127, pp. 351–352 : summary only.) *Cf.* 4266 of 1939.

597. ON THE THEORY OF NON-STATIONARY DISCHARGES : I—THE MODULATION OF THE HIGH-PRESSURE ARC BY AN ALTERNATING COMPONENT SUPERPOSED ON THE DIRECT CURRENT.—Weizel, Rompe, & Schulz. (*Zeitschr. f. Phys.*, 15th July 1941, Vol. 117, No. 9/10, pp. 545–564.) For a greatly shortened version *see* 2954 of 1941. *Cf.* Granovsky, 488, above, and for Goudet's work on modulation of light by use of supersonic waves *see* 487, above.

598. A METHOD OF MEASURING THE INITIAL SPIN OF A BULLET IN MOTION : PART I [Objections to the Only Two Existing Methods : Theory & Experimental Testing of New Method using Bullets Magnetised transversely, with Cathode-Ray-Oscillograph Recording].—Kömmnick & Wehnelt. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 22, 1941, pp. 89–94.)

599. AIDS FOR ANALYSING HIGH-SPEED ACTION [Survey of Principal Methods & Devices].—Watson. (*Gen. Elec. Review*, Oct. 1941, Vol. 44, No. 10, pp. 549–557.)

600. HIGH-SPEED ELECTRONIC COUNTER [up to 200 Pieces per Minute, regardless of Rate or Variation of Flow : using Gas-Triodes, Mains-Operated].—Shallcross Company. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, p. 513.)

601. RECENT DEVELOPMENTS IN PHOTOTUBES [with Curves for Surfaces, R.C.A. Types, Signal/Noise Ratio of Multiplier Tube, etc.]—Janes & Glover. (*See* 483.)

602. AN OSCILLOGRAPH-PHOTOMETER PRIMARILY FOR INVESTIGATION OF TRANSPARENCY-FLUCTUATIONS OF PHOTOGRAPHIC FILMS.—Siedentopf. (*Astron. Nachr.*, Vol. 269, 1939, No. 5). Described in Raudenbusch's paper, 500, above.

603. PHOTOELECTRIC VITAMIN A PHOTOMETER [for Measurement of Absorption of 3280 AU Radiation in Fish-Liver Oils].—Demarest, (*Sci. Abstracts*, Sec. A, Oct. 1941, Vol. 44, No. 526, p. 310.) *Cf.* 275 of 1941.

604. A NEW MICROPHOTOMETER [using Barrier-Layer Photocell to avoid Necessity for Amplifier in Proximity to Powerful Condensed Spark].—Vincent & Sawyer. (*Journ. Opt. Soc. Am.*, Oct. 1941, Vol. 31, No. 10, pp. 639–643.)

605. AN INFRA-RED SPECTROMETER FOR INDUSTRIAL USE [with Thermocouple-Current Amplification around 10^9 by Galvanometer/Photocells Combination].—Avery. (*Journ. Opt. Soc. Am.*, Oct. 1941, Vol. 31, No. 10, pp. 633–638.)

606. A RECORDING SPECTROPHOTOMETER OF SIMPLE CONSTRUCTION.—Boutry & Gillod. (*Comptes Rendus* [Paris], 11th Aug. 1941, Vol. 213, No. 6, pp. 235–238.)

Most photoelectric photometers use constant-deflection or differential (two-cell) methods to overcome deficiencies in the cells employed ; thus renouncing the advantages of simplicity, and also of direct recording, except with very complicated arrangements. The writers, however, return to the simple deviation method, with photoemissive cells of a new type, reliable and giving currents proportional within about 1/1000 to the incident light (4061 of 1939). The photocurrents pass through a single-stage d.c. amplifier with a special circuit practically eliminating drift and giving high stability (Gillod's circuit for electrometer-valve stabilisation, 2470 of 1939), and the amplified current remains proportional to the input current, with an error varying from 1 to 5 thousandths as the amplification is increased from 40 to 40 000.

607. DETERMINATION, BY PHOTOCELLS, OF THE GAS-TEMPERATURE CHARACTERISTICS IN OTTO MOTORS [Accuracy within 0.5%].—Graff. (*Zeitschr. V.D.I.*, 15th Nov. 1941, Vol. 85, No. 45/46, pp. 899–900 : summary, from *Luftfahrt-Forschung*, No. 1, Vol. 18, pp. 8–17.) Using a Pressler cell with inert-gas filling, and a potassium admixture in the fuel tank.

608. ELECTRONIC SPARK GENERATOR FOR SPECTROGRAPHIC ANALYSIS [avoiding Non-Uniform Results (due to Unequal Energy of Discharges) by charging Condenser suddenly with Single Impulse of "Measured" Electrical Quantity].—Malpica & Berry. (*Gen. Elec. Review*, Oct. 1941, Vol. 44, No. 10, pp. 563–565.)

609. USE OF ULTRA-VIOLET SOURCE FOR INTERFEROMETER MEASUREMENTS OF THICKNESS OF THIN FILMS [150–600 AU].—Clark & Fritz. (*Review Scient. Instr.*, Oct. 1941, Vol. 12, No. 10, pp. 483–484.)

610. PHOTON COUNTERS FOR SPECTRUM INVESTIGATIONS IN THE ULTRA-VIOLET REGION [including Use of the "Three-Electrode" Counter]. — Djatschenko [Dyaschenko]. (*Journ. of Phys.* [of USSR], No. 6, Vol. 3, 1940, pp. 479–486 : in German.)

611. ELECTRICITY IN PAPER MILLS [including a Short Section on Miscellaneous Electrical Devices (Photocells, etc.)].—Mason & Emms. (*Journ. I.E.E.*, Oct. 1941, Vol. 88, Part II, No. 5, pp. 467–484.) With Discussions.

612. PHOTOELECTRIC CONTROL FOR A DRINKING FOUNTAIN.—Indianapolis Water Company. (*Journ. Am. Water Works Assoc.*, Nov. 1940, Vol. 32, No. 11, pp. 1884–1885.)

613. FISHER ELECTRO-HAEMOMETER [Direct-Reading].—(*Review Scient. Instr.*, Oct. 1941, Vol 12, No. 10, p. 514.)

614. THE X-RAY PHOTON EFFICIENCY OF A MULTIPLIER TUBE.—Allen. (*See* 452.)