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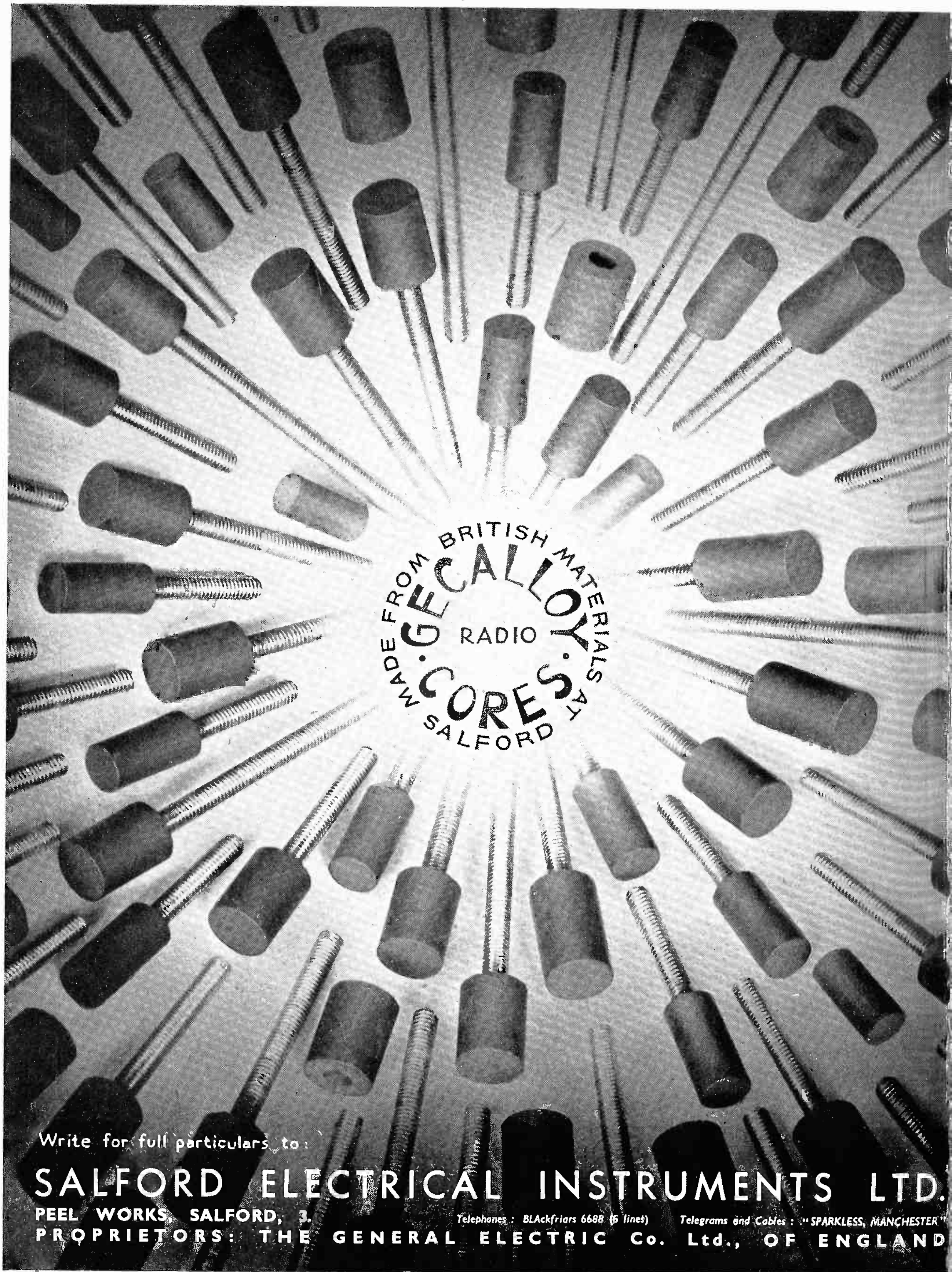
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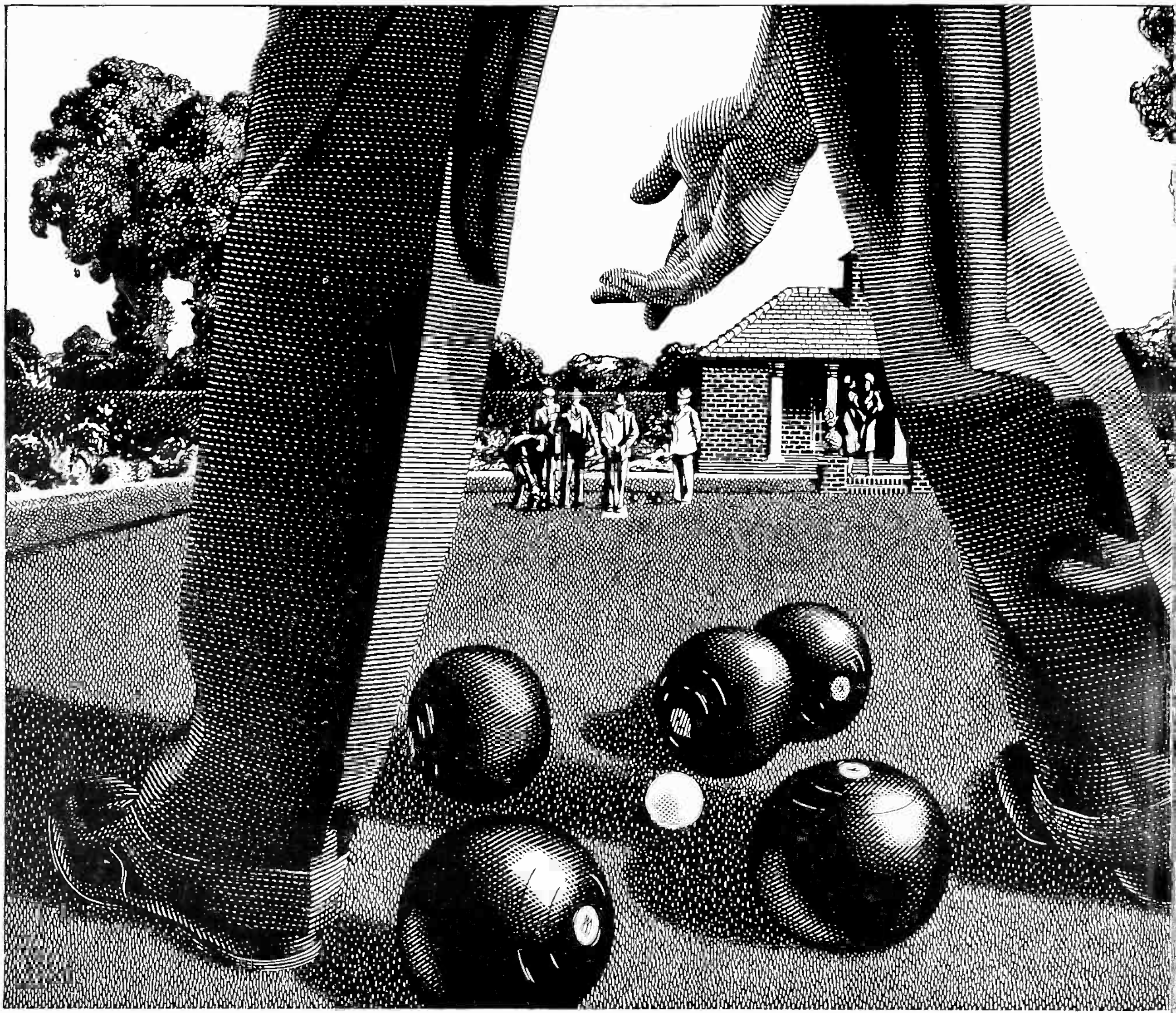

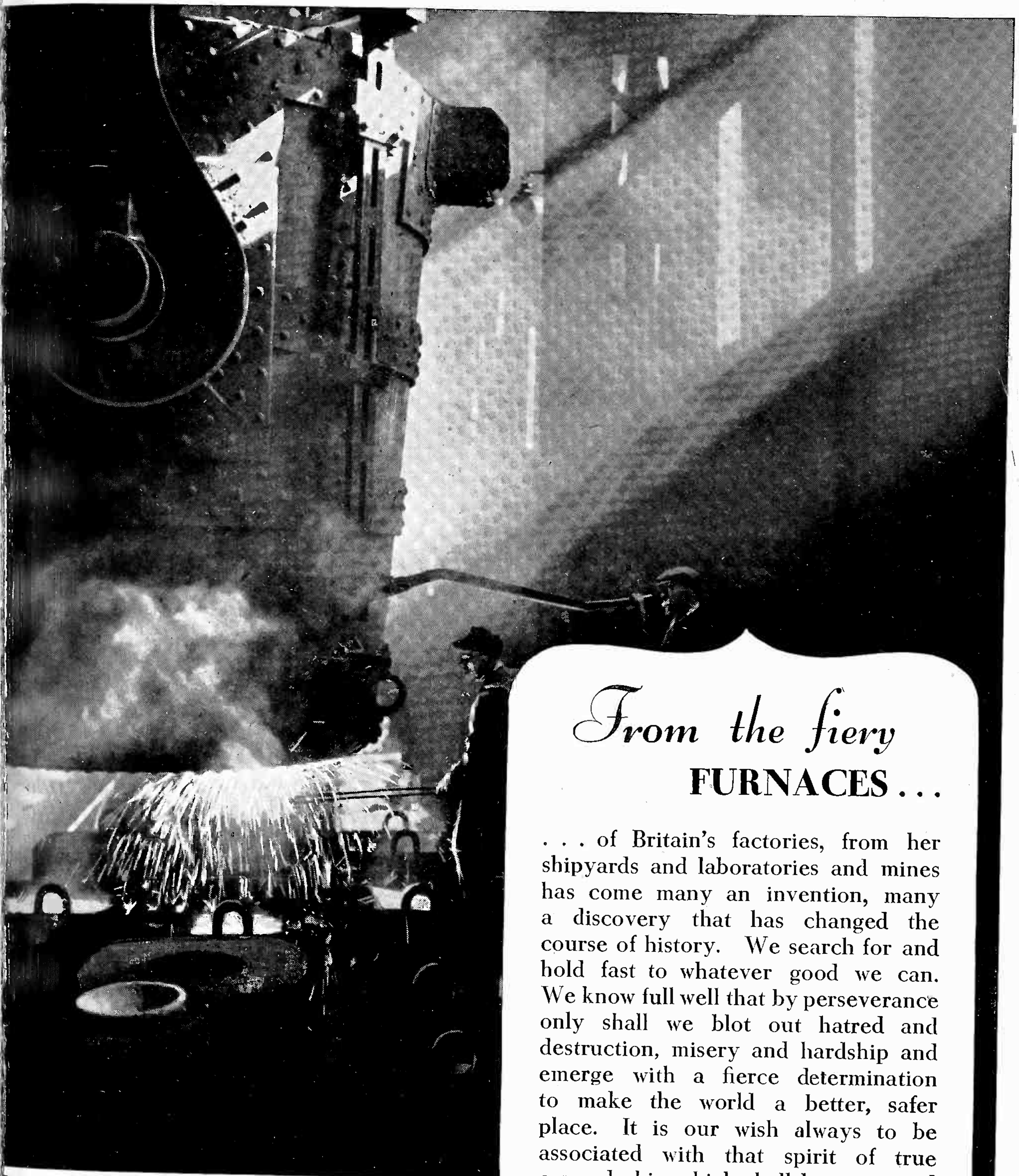

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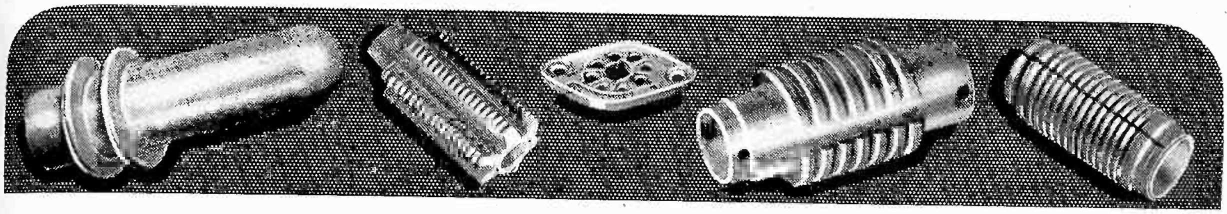

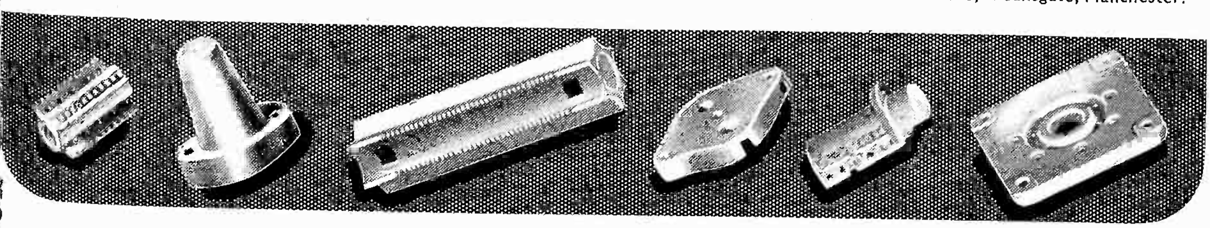

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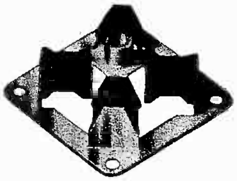

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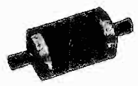

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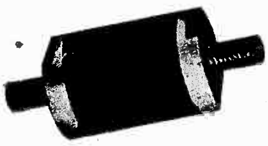

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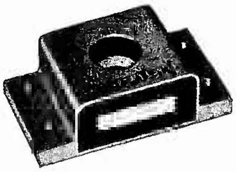

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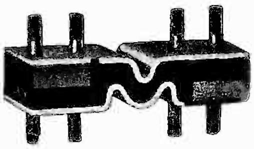

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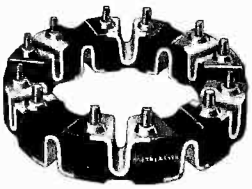

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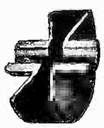

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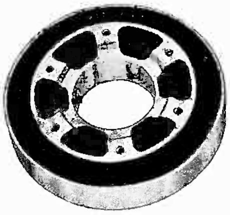

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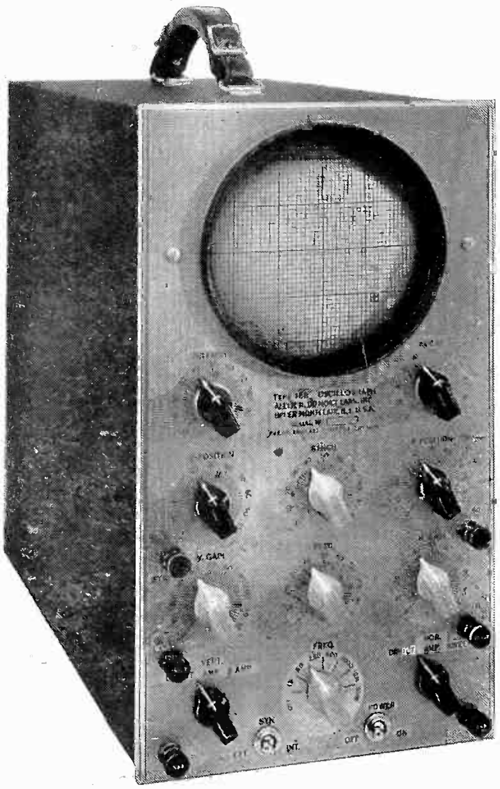

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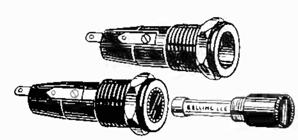

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THE

WIRELESS ENGINEER

Editor HUGH S. POCOCK

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Post-War Broadcasting

The Question of an Alternative Medium

THERE can be no doubt that the question of what medium should be used for the dissemination of broadcasting will have to be reconsidered when peace conditions once more prevail.

Before the war it seemed as if we had settled down to accept broadcasting by wireless means as unlikely to be challenged for a long time by the alternative of some form of wire distribution, although evolutionary changes in the wavelengths were to be expected. True, there was, as there still is, wire distribution conducted as private enterprises in various parts of the country. But these are on a comparatively small scale and the fact that the wires have to be erected for the purpose, and permission obtained from private and public owners of property over which they pass, naturally tends to limit the speed of development of this arrangement. The Post Office, it may be remembered, did proceed some years ago with the project of trying out broadcast distribution over the telephone wires at Southampton, but strong local objection was raised and this and the protests of the radio manufacturing industry prevailed to bring the project to a halt. The third alternative wire system is that where it is proposed to employ the electric supply mains as the means of distribution, augmented where necessary by other wire means. Special legislation would be needed in most cases before electric mains could be utilised, since the monopoly granted to the supply authorities would at present preclude their use for additional services.

The subject of broadcast distribution is one of great importance and it would be well to give the alternative arrangements most careful consideration now, lest there should be any risk of being stampeded after the war into the adoption of a change from our present wireless broadcasting system without properly considering not only the technical but other considerations as well.

Once broadcast receivers ceased to be essential for home listening, it is questionable whether their sale in any quantity would continue. Remove the incentive to maintain a domestic receiver and the democratic nature of our broadcasting system, where any station can be listened to at will, disappears.

Research and development in radio and allied subjects have been financed from the profits of the sale of radio sets. If radio sets become standardised as mere telephones, research must suffer profoundly.

To put our broadcasting system "underground" would be to deprive post-war Europe of the ability to follow our democratic ideals and mode of life. A programme "designed" for Continental consumption would never represent the British people but would always remain propaganda.

It is unnecessary to say more at this stage in order to emphasise that the whole subject should remain fluid pending the opportunity for all aspects being considered by an impartial commission.

Transit-Time Phenomena in Electronic Tubes*

A Graphical Method for Investigation

By Rudolf Kompfner

(1) Introduction.
(2) General equation of motion.
(3) Graphical solution and proof.
(4) Discussion.
(5) Some particular applications of the method.
 (a) Unbiased Diode.
 (b) Biased Diode—Voltmeter.

(1) Introduction

A METHOD is described in this paper which uses a combination of mathematical and graphical analysis for the purpose of understanding phenomena in vacuum tube at very high frequencies. The equation of motion of electrons, or charged particles generally, are developed mathematically for certain initial conditions and brought into a graphical form in which they yield some useful information. As nearly all the equations concerned are transcendental, it is easily understood that a graphical method is most suitable to produce results to any desired degree of accuracy.

The usual assumptions are made, viz.: electrodes are plane and of infinite extent, and the distance between them is small compared with the wavelength in vacuo of the oscillations in question. Current densities are so low that space charge effects can be neglected. Initial velocities are assumed to be uniform.

It will be noted that some assumptions usually made in the treatment of these subjects are absent in this paper. There is, for instance, no limit in respect of so-called "signal amplitude," in other words, this is not a "small signal theory." Nor is there a restriction laying down that electrons may move in one direction only, or that the velocities at any point or time must be single-valued.

(2) General Equation of Motion

Consider two plane infinitely extended electrodes, at a distance d apart. The electrodes are supposed to be ideally permeable to electrons, but impermeable to electric fields. Let there be a constant difference of potential of P volts between them and superimposed on that a sinusoidally alternating potential of amplitude E_0 volts so that the field strength between the electrodes as a function of time is given by

$$\frac{P + E_0 \sin \omega t}{d}$$

Let electrons enter the space between the two electrodes with a velocity V_0, ($V_0 = \sqrt{\frac{2e}{m}} . \sqrt{U_0} \approx 6.10^7 \sqrt{U_0}$, where U_0 is the potential difference in volts through which the electrons may be imagined to have fallen).

The acceleration of an electron

$$a = \frac{dv}{dt} = \frac{e}{md}(P + E_0 \sin \omega t) \qquad \text{.. .. (1)}$$

Successive integrations give the velocity v as a function of the time t_1 of entering the space;

$$v = \frac{eP}{md}(t - t_1) + \frac{eE_0}{m\omega d}(\cos \omega t_1 - \cos \omega t) + V_0 \qquad \text{.. .. (2)}$$

and the distance z covered by an electron during the time $t - t_1$

$$z = \frac{eP}{2_1 md}(t - t_1)^2 + (V_0 + \frac{eE_0}{m\omega d}\cos \omega t_1)(t - t_1) - \frac{eE_0}{m\omega^2 d}(\sin \omega t - \sin \omega t_1) \qquad \text{.. .. (3)}$$

For convenience we replace ωt_1 by x and ωt by y; further we divide (3) by $\frac{eE_0}{m\omega^2 d}$ and obtain

$$\frac{2m\omega^2 d}{eE_0} = \frac{P}{2E_0}(y - x)^2 + (\frac{m\omega d}{eE_0}V_0 + \cos x)(y - x) - (\sin y - \sin x) \qquad \text{.. .. (4)}$$

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

Let us denote the velocity of an electron falling through a potential difference of E_0 by v_0; and let us assume an electron to be shot into the space between the electrodes with the velocity v_0 in the absence of any field. Then we denote the angle covered by the radius vector of the oscillation during the time an electron covers the distance d by θ, which we will call the "E_0-transit angle." Thus $\theta = \frac{\omega d}{v_0}$. The corresponding "$U_0$-transit angle" $\phi = \frac{\omega d}{V_0}$.

$$\frac{z}{d} \cdot 2\theta^2 = \frac{Q}{2}(y-x)^2 + \left(\frac{2\theta}{\sqrt{M}} + \cos x\right)(y-x) - (\sin y - \sin x) \quad .. \quad (5a)$$

Equation (5) and (5a) constitute the relation between y and x in dependence on the system parameters θ, Q, M, and d at any point z. Being a fairly complicated transcendental equation, it seems analytically insoluble; for the purpose of obtaining $y = f(x)$ for instance. But a graphical representation will be given in the next section which allows the evaluation of $y = f(x)$ and also of several other functions.

(3) Graphical Solution and Proof

We draw (see Fig. 1) a sine curve having its origin at O, and its axis coinciding with the x axis and a similar curve, which we will call an "equidistant" with its origin at A, where $OA = \frac{z}{d}2\theta^2$. An ordinate drawn

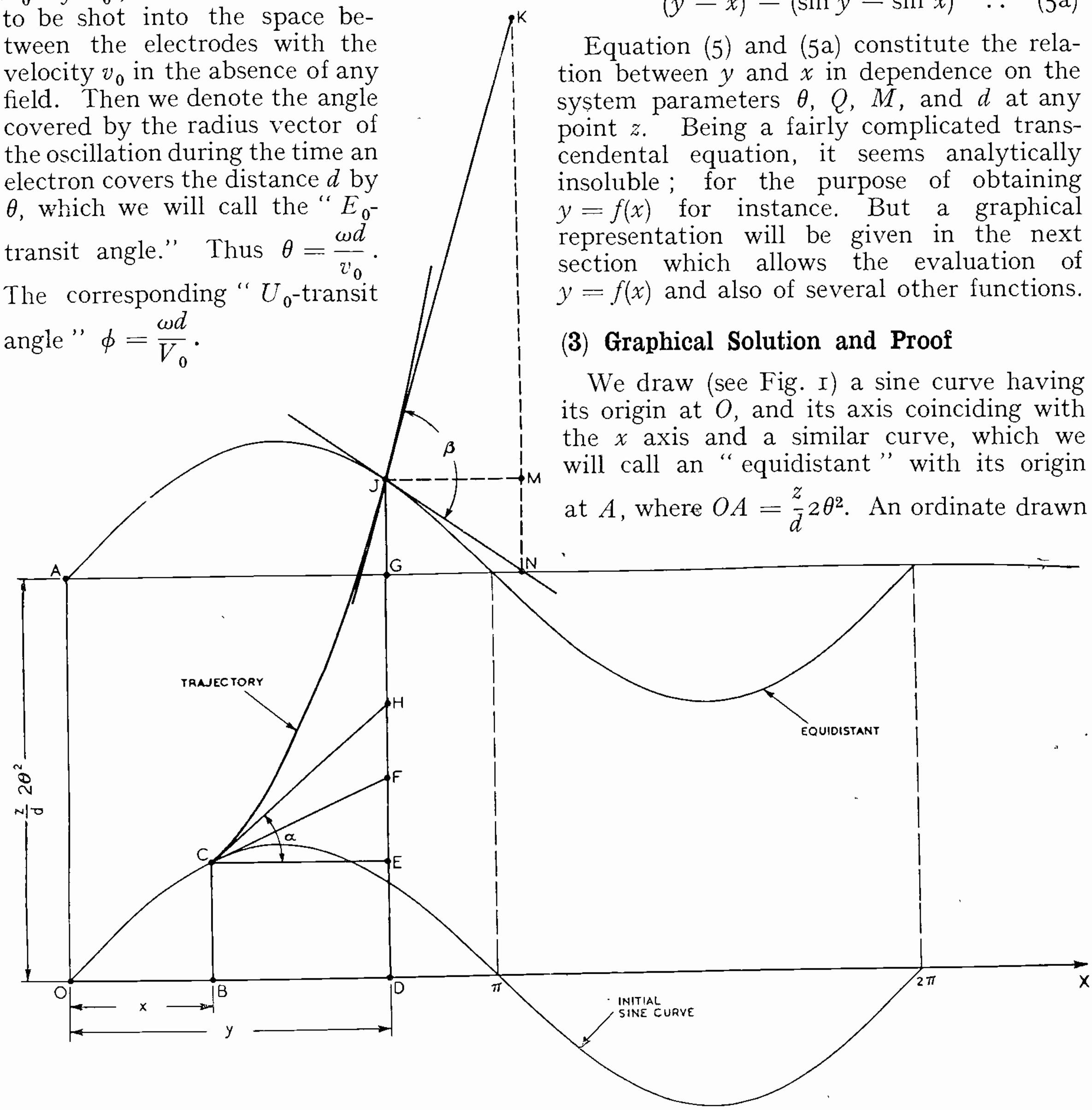

Fig. 1.

With this equation (4) becomes

$$\frac{z}{d} \cdot 2\theta^2 = \frac{P}{2E_0}(y-x)^2 + \left(\frac{2\theta^2}{\phi} + \cos x\right)(y-x) - (\sin y - \sin x) \quad .. \quad (5)$$

or if we introduce the so-called "depth of modulation" $M = \frac{E_0}{U_0}$ (as known in velocity modulation technique) and denote $\frac{P}{E_0}$ by Q,

at an arbitrary point B will give us C, and $BC = \sin x$. At C we draw a tangent CF to the initial sine curve, having the slope $\frac{d(\sin x)}{dx} = \cos x$. Further we draw a straight line CH, having the slope $\left(\frac{2\theta}{\sqrt{M}} + \cos x\right)$. Finally we construct a parabola, based on the last-mentioned straight

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line, plotting $\frac{Q}{2}(y-x)^2$ as ordinates with $(y-x)$ taken along the x axis as abscissae. This parabola intersects the "equidistant" in a point J. A perpendicular upon the x axis through J will produce the points of intersection H, G, F, E and D.

It can be shown that the distance OD or AG corresponds to y as determined by equation (5a).

The proof is relatively simple: consider angle α in the rectangular triangle C, E, H. Its tangent will be given by

$$\tan\alpha = \frac{DG + GJ - HJ - DE}{BD}$$

$$= \frac{\frac{z}{d} \cdot 2\theta^2 + \sin y - \frac{Q}{2}(y-x)^2 - \sin x}{y - x}$$

$$= \frac{2\theta}{\sqrt{M}} + \cos x \quad \ldots \quad \ldots \quad (5b)$$

This is, of course, identical with (5a) and hence the correctness of the graphical representation is proved.

Equation (2) can be transformed to read

$$v_z = V_0 \frac{\sqrt{M}}{2\theta}\left[Q(y-x) - (\cos y - \cos x) + \frac{2\theta}{\sqrt{M}}\right] \quad \ldots \quad \ldots \quad (2a)$$

and it can be shown that, if we draw tangents to both the "equidistant" and the parabola through the point J, the distance NK between the points of intersection of those tangents with a vertical straight line drawn at a distance $\frac{\sqrt{M}}{2\theta}$ from the point J, will equal v_z/V_0.

For $JM = \frac{\sqrt{M}}{2\theta}$, $\frac{MN}{JM} = \cos y$ and

$$\frac{MK}{JM} = \tan\beta = \tan\alpha + \frac{d\left[\frac{Q}{2}(y-x)^2\right]}{dx}$$

$$= \frac{2\theta}{\sqrt{M}} + \cos x + Q(y-x)$$

Now $NK = MK + MN$

Hence

$$\frac{v_z}{V_0} = JM(\tan\beta - \cos y)$$

$$= \frac{\sqrt{M}}{2\theta}\left[Q(y-x) - (\cos y - \cos x) + \frac{2\theta}{\sqrt{M}}\right]$$

The "time of arrival" angle y_d, indicating when electrons which entered through the first electrode at x, reach the second electrode, is simply found by putting $z = d$ in (5) and drawing the corresponding "equidistant."

(4) Discussion

Taking a more comprehensive view of the results in this section we observe that the motion of an electron between two plane electrodes at an A.C. and D.C. potential difference, taking into account an initial velocity, is represented by a parabola connecting the time of entry into the field with the time of exit. The horizontal projection of the distance between the two points represents the transit-time of the electron in question, while the angle between the parabola and an "equidistant" is representative in a simple specified way of the velocity of the electron at that point and time. If a parabola, for instance, touches without intersecting an "equidistant," this can be interpreted to mean that the velocity of the electron is zero at that point and time. For convenience we will henceforth call the curve connecting the points of progress of an electron a "trajectory."

A trajectory, originating as it does at the first electrode symbolised by the initial sine-curve, must also terminate at an electrode. If it intersects the "equidistant" symbolising the second electrode, the electron in question will have succeeded in traversing the electrode space. If the trajectory returns to the initial sine-curve that means that the electron returns to the first electrode.

Electrons originating at the first electrode without initial velocity will be represented by trajectories tangential to the initial sine-curve. Positive bias will be represented by parabolae convex in respect of the initial sine-curve, and negative bias by concave parabolae. In the absence of a D.C. potential difference between the electrodes, the trajectories will be straight lines.

The contribution of an electron in transit across the tube to the current in the external circuit is given by $i = \frac{ev}{d}$ at any instant.

The total current per unit area I_{ind} is therefore given by the sum of all the electrons between the two electrodes multiplied by their instantaneous velocities:

$$I_{ind} = \sum_{1}^{N} \frac{ev}{d} \qquad \ldots \quad \ldots \quad (6)$$

This can be evaluated graphically by a somewhat laborious process to any desired degree of accuracy. We divide one period into a suitable number of intervals, and draw the trajectories for the electrons entering the space at these intervals. The accuracy of the result will depend on the number of intervals. Then we draw vertical lines in the same intervals and note the intersections of these verticals with the trajectories. Each vertical will intersect the "equidistant" at an angle given by the cosine of the distance x of the vertical from the origin. If we now draw the tangents to all the trajectories where they cut say one particular vertical at x_1 the angles between those tangents and the tangent to the "equidistant" will determine the velocities at each point. Thus we find the number and the velocities of the electrons in transit at that particular time-angle x_1. Plotting a curve of those velocities on a convenient scale we have in the area of the curve a measure of the total current at that instant.

Repeating this procedure for successive instants we finally can plot the total current over a whole cycle. By comparing this current curve with the initial sine-curve and noting the phase-shift and amplitude of the cyclic variation of the total current thus obtained, we will be able to indicate the kind and magnitude of an impedance which would be equivalent to the two-electrode system in question.

Another matter of interest will be the "convection" current. This current consists only of electrons actually arriving at the second electrode and it has to be pointed out that it is entirely independent of the total or "induction" current. This "convection" current, denoted by I_{conv}, is comparatively easily obtained.

Having plotted $y = f(x)$, we then plot a new function $\psi = \frac{\partial x}{\partial y}$, that is, the differential quotient of $x = f(y)$ based on the y axis, with y as the independent variable. If I_0 is the D.C. current entering at the first electrode,

$$I_{conv} = I_0 \cdot \frac{\partial x}{\partial y} \qquad \ldots \quad \ldots \quad \ldots \quad (7)$$

It is possible in certain circumstances that I_{conv} is zero throughout, while I_{ind} is different from zero. I_{ind} in that case would be entirely an alternating current.

In all these considerations the so-called capacitive current I_{cap} has been disregarded, as it can very well be treated by methods of ordinary circuit analysis.

Still another matter of interest will be a computation of the energy transfer between electrons and external circuit averaged over one period of the cycle. This is done by plotting the squares of the values v_d (the exit velocities) as function of the time of entry and deducting V_0^2 (and $\frac{2e}{m}P$ if bias is present); the area of this curve (if it be positive) will be an indication of the power taken from the circuit. A negative area will correspond to a negative resistance, pointing to the generation of oscillations.

(5) Applications of Graphical Method

(a) Unbiased diode

The simplest arrangements amenable to the graphical method is the unbiased diode, in the absence of initial velocities.

Equation (5) reduces to

$$2\theta^2 = \cos x(y - x) - (\sin y - \sin x) \qquad \ldots \quad \ldots \quad (8)$$

as P, in this case, is zero and $\phi = \infty$.

The trajectories are straight lines tangential to the sin x curve, and it can easily be seen from Fig. 2 that if $2\theta^2 \geqslant 2$, only the electrons entering the system between $x = 0$ and $x = \pi/2$ will ever succeed in reaching the second electrode. The electrons entering between $x = \pi/2$ and $x = \pi$ will return to the first electrode, while the remainder will not enter the space at all. This seems to contradict a statement by F. B. Llewellyn, in "Electron Inertia Effects," p. 85, where he says: . . . "Hence . . . it follows that the rectified current approaches a limiting value of just half the low-frequency value as the frequency is raised *indefinitely* (my italics) in the absence of space charge." According to the graphical method this will happen if $\theta \geqslant 1$, that is to say: when the frequency is equal to or larger than

$$\frac{v_0}{2\pi d} = 4{\cdot}7 \cdot 10^6 \frac{\sqrt{E_0}}{d}.$$

In a practical example, e.g., $E_0 = 4V$, $d = 10^{-1}$ cm., the critical frequency would be 94 Mc/sec.

(*b*) *Diode as Voltmeter*

A preliminary investigation has been made of the diode acting as a voltmeter at very high frequencies with the help of the graphical method developed above. Neglecting space charge effects and initial velocities it appears possible to determine the ratio of the voltage showing across the condenser to the true voltage across the diode electrodes to any desired degree of accuracy.

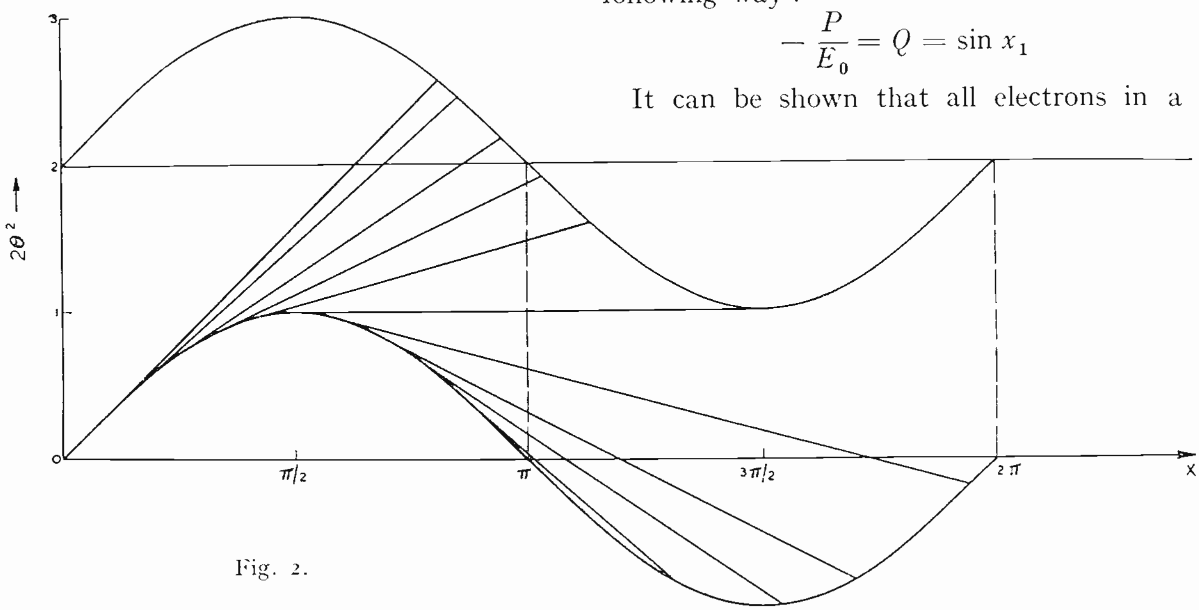


Fig. 2.

The diode, with the condenser connected across a circuit whose voltage is desired to measure, can be regarded as a plane electrode system under the influence of a negative bias, but in the absence of initial velocities. Equation (5) then reduces to:

$$2\theta^2 = \frac{Q}{2}(y - x)^2 + \cos x(y - x)$$
$$- (\sin y - \sin x) \quad .. \quad .. \quad (10)$$

Q in our case is the ratio of the known voltage P across the condenser to the unknown peak voltage E_0 across the circuit and diode.

Supposing the condenser to be initially uncharged and operations about to begin. There will at first be no bias and the first electrons, attracted by the growing positive field, will start to move across, depicted by "straight" trajectories. As soon as they have arrived there, the cathode will charge up positively, and the subsequent trajectories will become parabolic and bend increasingly away from the "equidistant" symbolising the anode. One trajectory finally will touch the anode equidistant tangentially, i.e. land there with zero velocity, and all subsequent trajectories will fail to reach the anode-equidistant. This critical trajectory will have originated at the cathode at a time when the potential there was P volt; the condenser thus will only charge up to P volt. The time angle of entry $x = x_1$ of that critical electron is connected to the negative bias $-P$ in the following way:

$$-\frac{P}{E_0} = Q = \sin x_1$$

It can be shown that all electrons in a diode with a given bias ratio Q entering later than x_1 will describe parabolae lying within the parabola originating at x_1; at least in the region which interests us most. This can also be appreciated by remembering some simple ballistic principles.

If we draw therefore a number of parabolic trajectories (shown dotted), originating at various points x_1, x_2, x_3 . . . etc., on the sin x curve (see Fig. 3) the "scales" of the parabolae being $\frac{Q}{2} = \frac{\sin x_1}{2}, \frac{\sin x_2}{2}, \frac{\sin x_3}{2}$, etc., those will all be critical trajectories of electrons travelling against a negative bias of corresponding values P_1, P_2, P_3 . . . etc.

It remains now to draw the anode-equidistants (sine curves) in such positions that they just touch the successive critical

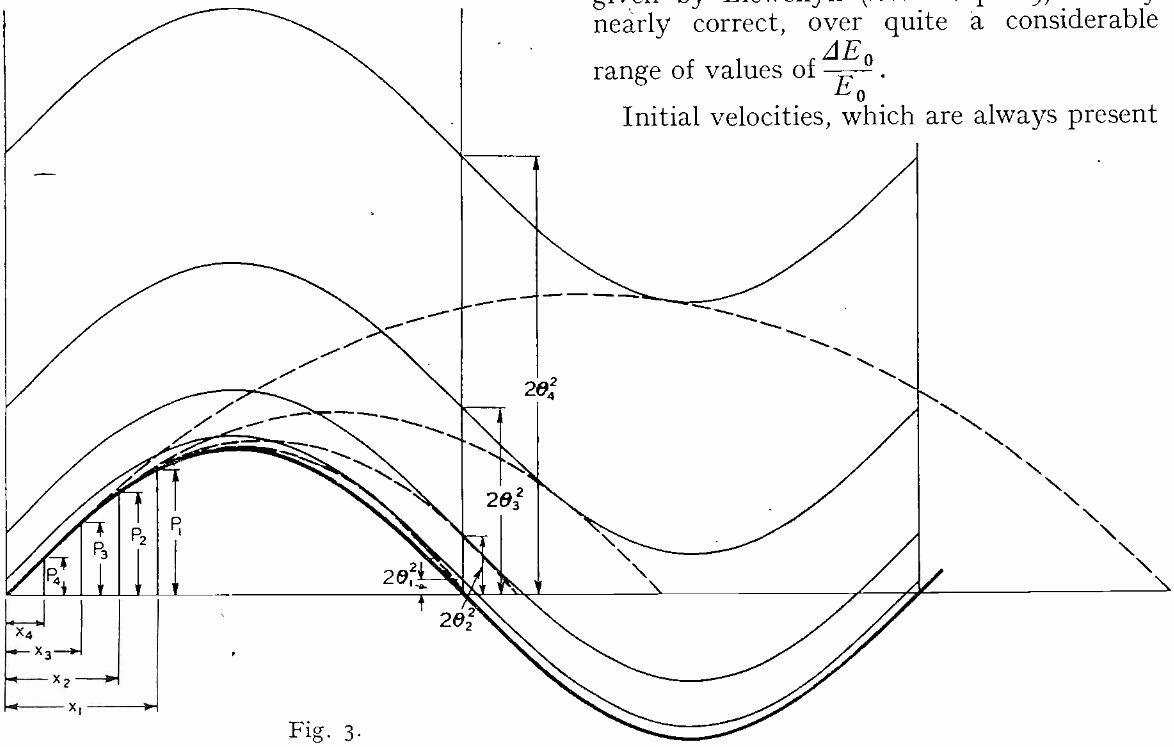


Fig. 3.

trajectories and to note the corresponding distances of those equipotentials from the initial $\sin x$ curve. These distances will correspond to $2\theta_1^2$, $2\theta_2^2$, $2\theta_3^2$ . . . etc., which are plotted as the abscissae in Fig. 4, the ordinates being the corresponding values of Q.

It enables one, for a given frequency and diode spacing, to obtain the real value of the voltage across the circuit directly from the voltage across the condenser and the graph.

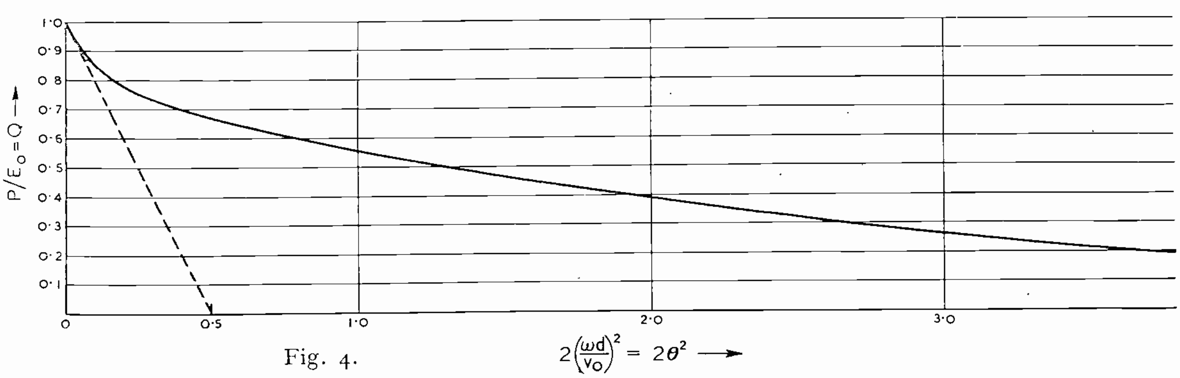


Fig. 4.

It will be found that the relation

$$\frac{\Delta E_0}{E_0} = \frac{2110d}{\lambda\sqrt{E_0}}$$

given by Llewellyn (*loc. cit.* p. 89) is very nearly correct, over quite a considerable range of values of $\frac{\Delta E_0}{E_0}$.

Initial velocities, which are always present in practice, will modify the relations given above to a considerable extent, when the voltages to be measured can no longer be assumed to be large compared with the initial velocities (as was done tacitly above).

But it is expected that an analysis conducted on somewhat similar lines as the one described above, but taking into account initial velocities, may yield positive and useful results.

Recent Improvements in Air-Cored Inductances*

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

SUMMARY.—The essential difference between inductances of high and low power is defined and the stability, accuracy and frequency characteristics of the latter are discussed in detail.

Details of the various types of modern temperature compensated coils are given together with precautions to be taken in their construction, testing and use.

The difference between the stability of *effective* value and that of *true* value is dealt with in detail.

The discovery of the dependence of the stability of *effective* inductance upon humidity is explained and illustrated by experiments—the precautions necessary to prevent this effect from giving erroneous results in the measurement of *temperature* coefficient are given. A method is given for the elimination of the humidity component of instability and the efficacy of the method is shown graphically by the results of experiments.

A new frequency compensated inductance standard is described.

Graphical presentation is given of the frequency limits which should, by considerations of stability (in addition to those of accuracy), be imposed upon inductance coils when they are used for various purposes—frequencies which should always be associated with coils of good quality and which are, in fact, as important as any other factor of calibration.

The dependence of temperature coefficient of inductance upon frequency in solid wire coils is explained simply by an approximate method which leads to the computation of the frequencies to be avoided in such coils.

SOME years ago the present author described in this journal a method of thermal compensation which could be employed on coils of any inductance value.

Since this article appeared very many coils have been constructed on this principle of compensation and have been used with success on wavemeters and oscillators of the highest precision. Much experience has been gained in their manufacture and use; their limitations—especially their frequency limitations—are more thoroughly understood in consequence.

More recently a new feature has been introduced in the design which has resulted in more perfect thermal compensation and greater secular stability.

Some criticism of the author's designs has been made and from this and from the description of his coils appearing in a recently published work[1] by a specialist in this field, it is clear that the finer and most essential features of the application of the principle are not appreciated. To some extent the present author is to blame for this in not having published the subsequent improvements without which the principle itself would be of little value, and about which little could be published until their efficacy had been proved after long and patient observation throughout a reasonable "life."

Moreover, it does not seem to be generally realised that a great difference exists between inductances intended for use as standards or substandards and those required to carry current of high value.† In the former classification should be included coils which are used in the resonant circuits of wavemeters and oscillators of low power and those incorporated in alternating current bridges as well as standards of reference. Such coils are not self-heated and it is only necessary therefore to compensate them against the temperature changes of a gradual nature experienced in the atmosphere of a laboratory.

Since this is the author's object, it is obvious that it is only necessary to compensate the coil former because the conductor and the insulating materials of the former follow such slow temperature changes together even though their thermal constants are very different. It is important to remember this, for the properties of good coils of the author's design having low and

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

[1] "Theory and Design of Valve Oscillators," by H. A. Thomas, D.Sc., M.I.E.E., pp. 220–221 (Chapman and Hall, 1939).

† The maximum values of current which can be carried by *standard* inductances is given later in the article and will be found to be appreciable.

perfectly cyclic temperature coefficients of inductance have been impaired by a rate of change of temperature, produced artificially for the purpose of testing, in excess of any which would be experienced under natural conditions. After such treatment the coils have been found to have non-cyclic temperature coefficients and thus to have unstable values.

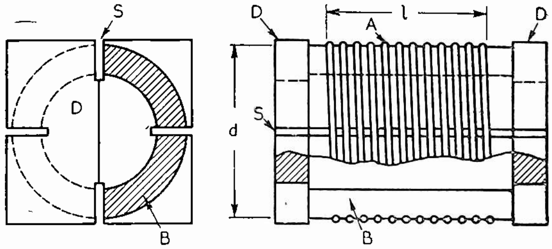


Fig. 1.

Having, it is hoped, corrected the apparent misconceptions of the uses for which the author's thermal-compensated coils are especially intended and in the thermal tests which should be applied to them the special constructional details which are necessary to secure the efficacious application of the principle will be described. The briefest reference to the principle will suffice here. A stout walled tube *B* (see Fig. 1) of good loaded ebonite having the minimum possible power loss factor and as free as possible from "cold flow" is reinforced at its ends by stout end cheeks *D* of a special grade of Bakelite. This Bakelite, although having a much higher power loss factor than loaded ebonite, has a much greater mechanical rigidity and does not suffer permanent distortion from thermal changes. Upon the stronger Bakelite, therefore, the geometrical permanence of the structure of the coil former depends. The temperature coefficient of expansion of the Bakelite end cheeks is nearly the same as that of the copper conductor of the coil, but in order that the Bakelite alone shall govern the radial expansion of the former the saw cuts *s* in the periphery of tube *B* are essential to destroy the circumferential continuity of the latter.

Now the inductance of a single layer helix is given by :—

$$L = \pi^2 d^2 N^2 \cdot \frac{1}{l} \cdot K$$

the factors d^2, $\frac{1}{l}$ and K are all affected by the temperature coefficients of the various members of the coil former. K is a constant dependent upon the ratio d/l.

If α, β and δ are the temperature coefficients of linear expansion of the conductor A, longitudinal members B and the radial members D respectively, the temperature coefficient of the ratio d/l is $\delta - \beta$. The percentage change (γ) of K for a 1 per cent. change in the ratio d/l has been calculated and is given in the curve of Fig. 2 and the temperature coefficient of K is therefore $\gamma(\delta - \beta)$.

The resultant temperature coefficient of inductance

$$\frac{\Delta L}{L} = 2\delta - \beta + \gamma(\delta - \beta) \quad \quad (1)$$

For given former materials the temperature coefficient of inductance may be varied by varying the ratio d/l and if these materials are loaded ebonite and Bakelite this ratio may be so adjusted that the temperature coefficient is zero, slightly positive or slightly negative.

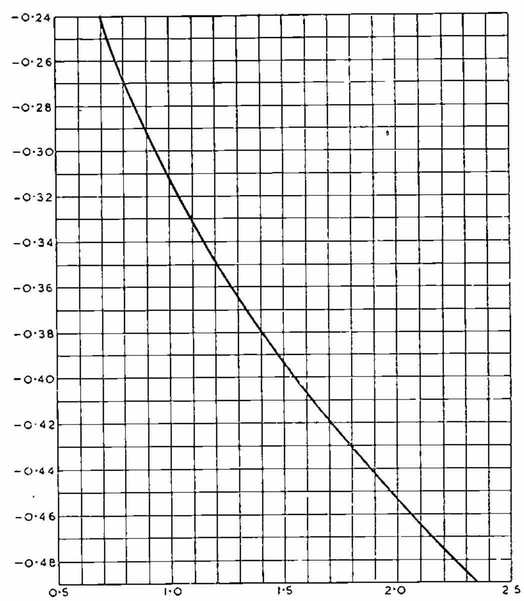


Fig. 2.

Such is the principle concisely stated. It is a simple principle but its application presents many difficulties. Only when great care is exercised in practical design of such a compensated coil and extreme skill employed in its construction is it possible to apply the principle successfully. Since the principle alone is of little use without details of its application the author feels it to be his duty to explain the more important of these details in the present article.

It will be noted that the expression for temperarure coefficient of inductance contains no term which is a function of the temperature coefficient of the conductor. Because of this the thermal expansion of the conducting helix must be either the same as that δ of the D members or it must, in effect, be governed by it. In order to be governed by the expansion of the D members the conductor must be annealed sufficiently to prevent any tendency to become a self-supporting helix. The best way of accomplishing this is to wind the coil with annealed flat copper strip in rectangular grooves in the B members. The strip must be thin enough (in a radial direction) to ensure that it is readily controlled by the expansion of the former and must therefore be of considerable width in order that the resistance shall not be excessive. Inductances of low value are very effectively wound in this way and are, in addition, of low decrement at high radio frequencies. It will be seen later that the smallness of the radial thickness of the strip gives the coils another important advantage at high frequencies. For a coil former of given dimensions there is naturally an upper limit of inductance value above which this wide, thin strip cannot be employed. Highly stranded Litzendraht wire is the next best type of conductor and may be used with success in thermal-compensated coils of higher inductance. This wire is "limp" enough to be controlled by the expansion of the former and, fortunately, produces coils of low decrement at the medium frequencies at which such coils are most likely to be used. It is important that the wire used is not heavily covered or braided and that it is wound into slots which are sufficiently flat bottomed to ensure that the slightest movement of the B members is imported immediately to the conductor. Although these precautions ensure a degree of stability, a perfectly cyclic temperature coefficient is obtained only by making the temperature coefficient of radial expansion of the former equal to that of the expansion coefficient of the conductor. A method of construction which ensures this will be described later.

The next constructional defect which may cause instability of inductance is the different circumferential thermal expansion of the conductor and the B members on to which it is intimately bearing. Fig. 3a shows the construction of a former used to illustrate the principle of the author's method of compensation and this, it is feared, has been copied slavishly by some readers of the author's original article. It is clear that the total difference between the circumferential

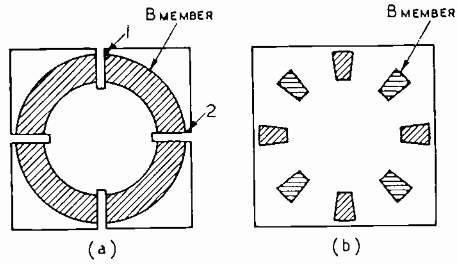


Fig. 3.

expansion of conductor and B member from points 1 to 2 is considerable since their expansion coefficients are of necessity very different. The defect, the exact result of which it is difficult to foretell, is overcome to a large extent by increasing the number of B members and by increasing the peripheral gap between adjacent members as is shown in Fig. 3b. Experience has shown this to be sufficient to ensure that there is no non-cyclic thermal behaviour due to this cause.

The chief cause of non-cyclic temperature coefficient and general residual instability of inductance remains however—the non-equality of the temperature coefficients of expansion of the conductor and the radial dimensions of the D members. If this equality does not exist there is a tendency for the conductor to be elongated by the former throughout some period of a cycle of temperature and this often results in instability of inductance value. As explained previously, Bakelite is chosen for the D members because it has approximately the same expansion coefficient as copper. The difference is sometimes as much as 13×10^{-6} per deg. C. however, and, moreover, the expansion coefficient of Bakelite sheet is rarely the same in all directions parallel to its surface. In order to overcome both of these imperfections the author has more recently devised the method of construction shown in Fig. 4. In this design a number of

B members of good loaded ebonite are supported rigidly by the two stout end cheeks or *D* members of special Bakelite. The conductor in this case takes the form of the flat copper strip *A* already mentioned as being desirable. All the features depicted in the drawing are, in fact, those of the most modern type of compensated coil.

The pins *P* form the *chief* locating means for the relative positioning of the *B* and *D* members and are fitted with extreme accuracy because of this.

The Bakelite sheet is laminated and the temperature coefficient of expansion in the directions parallel to and at right angles to the "grain" of the sheet are influenced by the relative number of paper sheets placed in either direction when building up to the required thickness of sheet. The temperature coefficients in the two dimensions may be as different as 18 and 30×10^{-6} per deg. C, but 21 and 28 were found to be the mean figures upon testing a large number of sheets of standard production.

The object of the present design is to produce a resultant temperature coefficient of the dimension w exactly equal to that of the linear expansion coefficient of the conductor *A*.

Thus if the temperature coefficients of expansion of the *D* members are measured and found to be δ', δ'' and δ''' in the radial directions p, q and r respectively and the temperature coefficients of linear expansion of conductor and *B* members are α and β respectively, β being uniform in all directions, the following condition must be satisfied :—

$$\delta'(w + x) - \beta x = \delta''(w + y) - \beta y = \delta'''(w + z) - \beta z = \alpha w \quad .. \quad (2)$$

From this it is seen that the radial dimensions of the pins *Px*, *Py* and *Pz* are given respectively by :—

$$x = \frac{\alpha - \delta'}{\delta' - \beta} w \quad .. \quad .. \quad .. \quad (3)$$

$$y = \frac{\alpha - \delta''}{\delta'' - \beta} w \quad .. \quad .. \quad .. \quad (4)$$

$$z = \frac{\alpha - \delta'''}{\delta''' - \beta} w \quad .. \quad .. \quad .. \quad (5)$$

It should be noted that if these radial differences are of positive algebraic sign the *points of attachment* between the *B* and *D* members are at a radius greater than that of the winding and if negative they are at a lesser radius.

Other fixing means are, of course, necessary in addition to the pins, but there should be a tendency to easy fitting everywhere except in the pinning at this *point of attachment*.

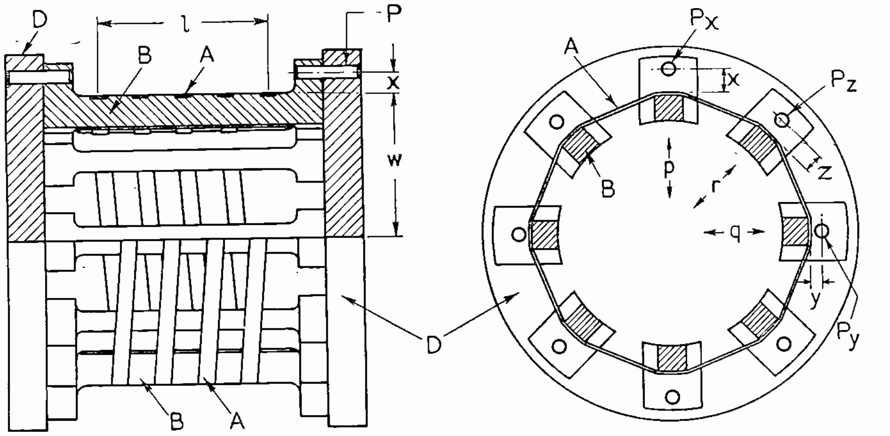


Fig. 4.

Having, by the determination of the correct dimensions $x + w$, $y + w$ and $z + w$ from (3), (4) and (5), ensured that the coefficient δ of expression (1) may be replaced by α, it is seen that the expression for the resultant temperature coefficient of inductance may now be re-written :—

$$\frac{\Delta L}{L} = 2\alpha + \gamma(\alpha - \beta) - \beta \quad .. \quad (6)$$

where γ is read from the curve of Fig. 2.

There is now no tendency for the conductor to be stressed and the temperature coefficient of inductance of a coil designed in this way is found to be perfectly cyclic and improved stability results. A finished coil constructed on this principle is shown in Fig. 5.

The same principle of differential radial expansion is also applied to a multi-layered coil as shown in Fig. 6 in which the *B* and *D* members are indicated. In this case the radial differences X, Y and Z are those which produce an effective temperature coefficient of expansion of the radial dimension W to the mean turn C equal to the linear expansion coefficient of the conductor. Thus the dimensions X, Y and Z to be added algebraically to the dimension W are

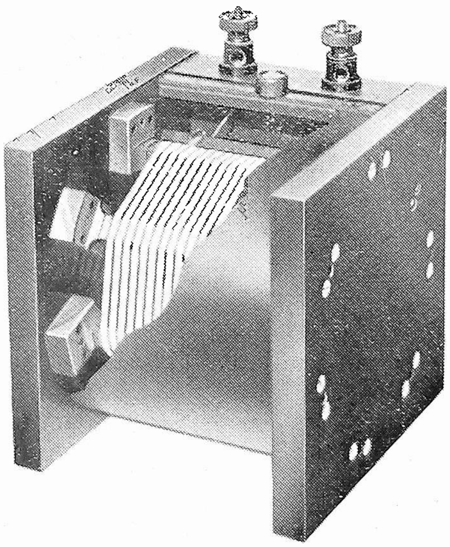


Fig. 5.

governed by the temperature coefficients of linear expansion of the D members in the directions p, q and r respectively. The combs BC into which the conductor is wound are of the same homogeneous material as the B members and may therefore be regarded as parts of these members for the purpose of viewing the thermal expansion of the mean turn C.

An almost perfectly temperature - coefficientless inductance standard has been described elsewhere[2] by H. A. Thomas. Each turn of this coil consists of three rigid brass rods arranged in one plane on three sides of a square. These rods, although having good electrical continuity, meet at sliding junctions so that the temperature coefficient of the area of the turn is governed solely by the expansion coefficient of a marble slab on which the rods are mounted. Thus the temperature coefficient of a single turn is governed by the linear expansion coefficient of marble ($+ 4 \times 10^{-6}$ per deg. C) and the small positive temperature coefficient of the complete coil which results from the radial expansion of the turns is then compensated by a negative coefficient of mutual inductance between the individual turns due to the thermal expansion of steel rods on which the marble slabs are spaced axially. In effect the expansion of the steel rods increases the axial dimension of the complete coil in the same way as the B members of the author's coil, and in this connection it is interesting to note that the ratio of the coefficients of steel and marble is the same as that of the loaded ebonite and Bakelite used in the author's coils—naturally so, as the basic principle of compensation is the same. It is of interest to note that the calculated temperature coefficient of inductance using the present author's expression (1) is -2 parts in one million per deg. C. when using designer's figures of 4×10^{-6} and 11.6×10^{-6} for the linear temperature coefficients of marble and steel respectively. If the assumed temperature coefficient of the marble used is raised by only one part in 10^6 the calculated temperature coefficient of the coil becomes sensibly zero. The coil actually constructed on these lines has seven turns of 3 inches square with an axial length of some 5 or 6 inches. It has an inductance of 2.1 μH and its measured temperature coefficient is some-

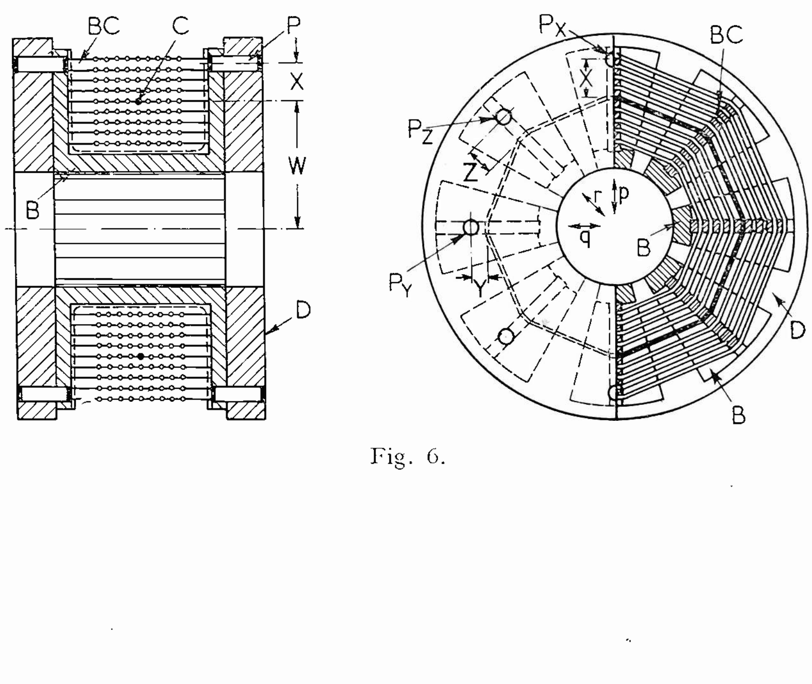


Fig. 6.

[2] *loc. cit.*, pp. 222–224.

what less than 1×10^{-6} per deg. C. Its long period stability (measured for about 1 month) is of the order $\pm 20 \times 10^{-6}$.

The designer is to be congratulated on the high degree of perfection that has been attained in this standard; it is, however, a design so costly that it can hardly be considered commercial. Moreover, to extend the design to values above, say, 10 μH would probably be impracticable, and the method of compensation employed may be regarded therefore as applicable only to coils of very low inductance. Coils of the type described in this article may however be constructed with almost equal success from a few microhenries to a henry. Those of low values up to 100 μH or so are of the single layer helix type shown in Fig. 4 and have a mean winding diameter of about 9.5 cms. Average coils of this type have temperature coefficients within ± 3 parts in one million per deg. C and ± 5 parts in one million is the extreme tolerance allowed.

Coils of from 150 μH to 3,000 μH inductance are of the type shown in Fig. 6 and have a mean diameter of 9 cms. Average coils of this type have temperature coefficients somewhat higher—within the limits 0 to $+ 5$ parts in a million per deg. C with an exceptional limit of $+ 7$ parts in a million. Coils above 3,000 μH are of the same design but have mean diameters of 15 cms. and temperature coefficients varying from $+ 5$ to $+ 10$ parts in a million depending upon inductance value.

In order to prove the degree of reproducibility of temperature coefficient in coils constructed to the same design, two coils of 2,000 μH *bearing consecutive serial numbers* (799 and 800) were sent to the National Physical Laboratory. The report of that body is quoted in full.

"The temperature coefficient of each coil was determined by measurements of the self-inductance at temperatures between 18 deg. C. and 30 deg. C., using alternating voltage of sine wave form at a frequency of 800 cycles per second.

"The temperature coefficient of inductance of each coil was approximately $+ 5$ parts in 10^6 per degree Centigrade over this range of temperature."

It is obvious that no better proof of exact reproducibility could be desired since these coils were just two consecutive units of a number being constructed together.

The long period stability of these coils is of a very high order—not as high as Thomas's standard, but such permanence is hardly expected of commercial standards. Very many of these coils of various values have maintained their values to within ± 50 parts in one million over periods of *many years.*

Before coils of the types described in this article may be considered either stable or

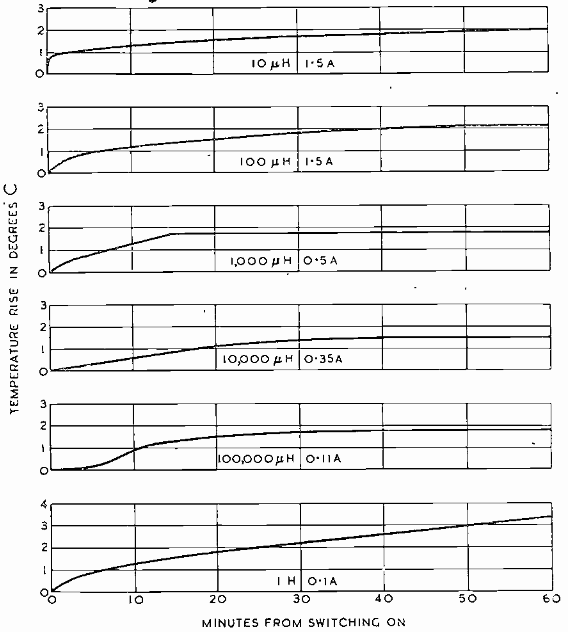


Fig. 7.

permanent they must be subjected to rigorous artificial ageing. During this ageing the coil is subjected to many slow cyclic changes of ambient temperature in which the rate of change does not exceed 5 deg. C. per hour. Experience has shown that the coils of the multi-layer type need this temperature cycling more than those of the single-layer type—this treatment undoubtedly effects a mutual "settling down" of the many "comb" members and the relief of many small stresses in consequence.

In coils of this design the cyclic nature of the temperature coefficient may sometimes be impaired if an upper limit of temperature of 35 deg. is appreciably exceeded. Although the precaution of limiting the temperature to 35 deg. is necessary if the best long period permanence is required, the coils may be employed in tropical climates with success—they will, of course, prove far better than uncompensated coils under these conditions.

Although the rate of change of *ambient* temperature permissible is 5 deg. C. per hour, the rate of internal *self* heating of these coils must be limited to the order 2 deg. C. per hour. This more drastic limitation is necessary in order that there shall not be, at any time, an appreciable difference between the temperature of the conductor and that of the former. The maximum permissible power dissipated in the coils is not governed entirely by the rate of steady rise of temperature of the conductor as, owing to the very different thermal systems formed by the conductor and former in the various coils, these show different characteristics of conductor temperature rise at the commencement of current flow as shown by the curves of Fig. 7. It is seen that it is necessary to limit not only the steady increase of conductor temperature to 2 deg. C. per hour, but also any sudden rise to, say, 1 deg. C. The 10 μH and 100,000 μH coils are cases where a greater power dissipation would be permissible were it not for the steep initial rise of conductor temperature. Because of these different thermal characteristics the maximum power dissipation cannot be fixed merely by the dimensions of a given *type* of coil but must be determined for each coil by actual test. The maximum values of current permissible at low frequency are shown by the full line curves of Fig. 8; these will be found ample for any purpose for which the coils are intended. The broken line curves of Fig. 8 give the current maxima permissible at frequencies corresponding to the optimum efficiency ($\omega L/R$) of the coils. At such frequencies, however, an even more serious current limitation should be imposed on any design of standard by voltage considerations.

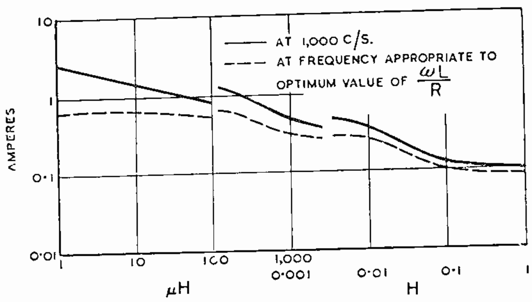


Fig. 8.

Another form of inductance having low temperature coefficient is that in which the conductor is deposited on a solid former of ceramic material having low thermal expansion. The elasticity of the thinly deposited metal is sufficient to accommodate any stresses which occur due to the difference between the expansion coefficients of the conductor and former. The temperature coefficient of inductance is therefore governed by the expansion of the ceramic former only. The temperature coefficient of inductance

$$\frac{\Delta L}{L} = 2\delta + \gamma(\delta - \beta) - \beta$$

of this coil should therefore be equal to the coefficient of linear expansion of the ceramic material since $\delta = \beta$. This is approximately true and the temperature coefficient of inductance is therefore found to be from + 8 to + 10 parts in one million per deg. C. In a coil of this nature there is no possibility of employing temperature compensation. Owing to the difficulty of constructing this type of coil in any form other than that of a single layer helix, coils of values greater than, say, 500 or 1,000 μH are not possible. Moreover, this type of coil suffers from a disadvantage in that it cannot be adjusted closely to a nominal value for use as a standard. The accuracy to nominal value to which the author's coils are adjusted is given in Fig. 9 in which the full line curves show the normal commercial adjustment accuracy and the broken line curves the accuracy possible as supported by the evidence of Fig. 10 regarding three *consecutively* numbered coils. Tolerances of at least ± 5 per cent. have to be associated with deposited ceramic coils.

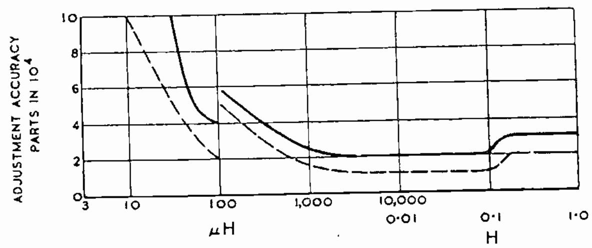
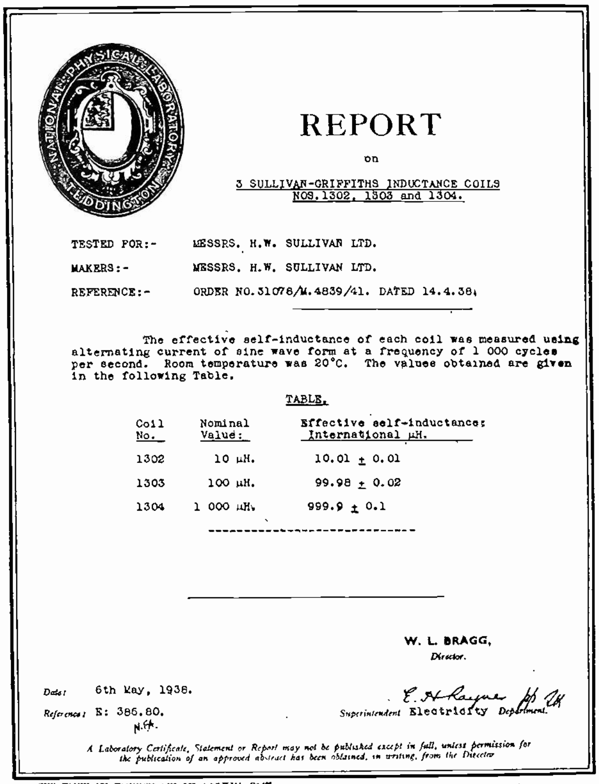


Fig. 9.

In addition to the limitation of value and the impossibility of accurate adjustment, the ceramic coils have lower magnification or " Q " values than former wound coils as is shown by the broken curve of Fig. 11. Included for comparison are curves of the " Q " values of the three types of coil to the author's design.



NATIONAL PHYSICAL LABORATORY TEDDINGTON

REPORT

on

3 SULLIVAN-GRIFFITHS INDUCTANCE COILS
NOS. 1302, 1303 and 1304.

TESTED FOR:- MESSRS. H.W. SULLIVAN LTD.

MAKERS:- MESSRS. H.W. SULLIVAN LTD.

REFERENCE:- ORDER NO. 31078/M.4839/41. DATED 14.4.38.

The effective self-inductance of each coil was measured using alternating current of sine wave form at a frequency of 1 000 cycles per second. Room temperature was 20°C. The values obtained are given in the following Table.

TABLE.

Coil No.	Nominal Value:	Effective self-inductance: International μH.
1302	10 μH.	10.01 ± 0.01
1303	100 μH.	99.98 ± 0.02
1304	1 000 μH.	999.9 ± 0.1

W. L. BRAGG,
Director.

Date: 6th May, 1938.
Reference: E: 386.80.

Superintendent Electricity Department.

A Laboratory Certificate, Statement or Report may not be published except in full, unless permission for the publication of an approved abstract has been obtained, in writing, from the Director

Fig. 10.

Attempts have, it is thought, been made to increase the " Q " values of ceramic coils by adding to the width of the cross section of the conductor. This is only possible, it would seem, by depositing metal on the three sides of a rectangular shaped helical slot which is turned in a ceramic rod. The result is a conductor of U shaped cross section of considerable radial depth, and it has been shown by Thomas[3] that such depth causes a very appreciable augmentation of the temperature coefficient of inductance of a coil throughout wide bands of radio frequencies—bands which are almost invariably within the useful frequency range. Such dependence of temperature coefficient upon frequency is due to the change of inductance consequent upon current redistribution within the cross section of the conductor with increasing frequency. At certain frequencies the temperature coefficient of a ceramic coil with a U shaped deposited conductor may be increased to several times its low frequency value.

Deposited ceramic coils will, in general however, be found to be very useful at radio frequencies and their long period stability should be of a high order.

An inductance coil has two distinct values of temperature coefficient—a coefficient of " true " inductance and one of " effective " inductance. The temperature coefficient of true inductance is affected only by thermal changes in the geometry of the coil. It is unaffected by thermal changes in self-capacitance and is not therefore a function of frequency.* The temperature coefficient of " effective " inductance however *is* affected by such changes. Because of this the author suggests that a frequency figure should always be associated with a statement of temperature coefficient of inductance—the frequency above which such coefficient will become a function of frequency. Such a figure, however, in high value coils of good design, might conceivably be determined by considerations other than those of temperature coefficient of self-capacitance as will be seen later.

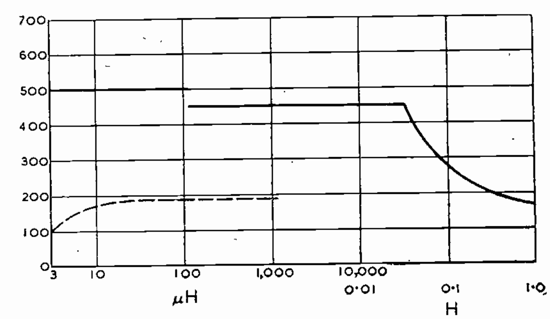


Fig. 11.

The author separates the component of temperature coefficient of effective inductance due to the geometry of a coil from that due to its self-capacitance in the following manner. The coil is associated in turn with

[3] *loc. cit.*, p. 213.

* Except for possible changes of inductance due to the change with frequency and resistance of the current distribution within the section of the conductor as explained later.

two air condenser standards of known capacitance to form the resonant circuit of a dynatron oscillator of precision. The condensers have small and known temperature coefficients of capacitance. The temperature coefficient of the LC product of the circuit is measured in each case and a correction made for the temperature coefficient of the condensers. Two figures are thus obtained for the temperature coefficient of the *effective* inductance of the coil under examination.

If A = measured temperature coefficient of effective inductance at frequency f_A

B = measured temperature coefficient of effective inductance at frequency f_B

$\frac{\Delta L}{L}$ = temperature coefficient of true (geometric) inductance

and $\frac{\Delta C_A}{C_A}$ = temperature coefficient of circuit capacitance due to temperature coefficient of self capacitance of coil at frequency f_A

then
$$\frac{\Delta L}{L} + \frac{\Delta C_A}{C_A} = A$$

and
$$\frac{\Delta L}{L} + \left(\frac{f_B}{f_A}\right)^2 \cdot \frac{\Delta C_A}{C_A} = B$$

from which
$$\left\{\left(\frac{f_B}{f_A}\right)^2 - 1\right\}\frac{\Delta L}{L} = \left(\frac{f_B}{f_A}\right)^2 A - B$$

or
$$\frac{\Delta L}{L} = \frac{\left(\frac{f_B}{f_A}\right)^2 A - B}{\left(\frac{f_B}{f_A}\right)^2 - 1} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

The values of the standard condensers used are large compared with any self-capacitance likely to be met with in practice and if the capacitance of the first is exactly twice that of the second so that $f_B = \sqrt{2} f_A$, the temperature coefficient of true inductance will be simply

$$\frac{\Delta L}{L} = 2A - B$$

The temperature coefficient $\frac{\Delta L_{eff}}{L_{eff}}$ of *effective* inductance at any other frequency f may now be computed from

$$\frac{\Delta L_{eff}}{L_{eff}} = \frac{\Delta L}{L} + \left(\frac{f}{f_A}\right)^2 \cdot \frac{\Delta C_A}{C_A}$$

where
$$\frac{\Delta C_A}{C_A} = A - \frac{\Delta L}{L} \quad \ldots \quad \ldots \quad (8)$$

and the frequency F below which the temperature coefficient of effective inductance becomes sensibly constant and equal to that of the true inductance is given by :—

$$F = \sqrt{\frac{10^{-6} f_A^2}{\frac{\Delta C_A}{C_A}}} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

The true inductance may be under or over compensated to include the effect of temperature coefficient of self-capacitance at one particular frequency, but if compensation for temperature coefficient of self-capacitance is desired at all frequencies it must be effected by a capacitance variation method; it cannot be translated into terms of inductance.

The self-capacitance of a coil comprises a part—the larger part usually—due to the electric field in air which is sensibly unaffected by temperature change and a part due to the field through the solid insulating material of the coil former in the immediate vicinity of the winding. The latter part is, of course, that which, due to the temperature coefficient of permittivity of the solid material, produces the temperature coefficient of self-capacitance. By reducing the amount of solid support for the winding, therefore, the temperature coefficient of self-capacitance may usually be made small. When making the measurements of temperature coefficient of effective inductance in the manner just described it is necessary to change the temperature of the coil in a chamber in which the humidity is controlled so as to be roughly constant with varying temperature. If this is not possible the relative humidity should not exceed, say, 65 per cent. at the lowest temperature. If this precaution is not taken it is difficult to dissociate the effects due to change of temperature from those due to change of humidity since the second of these variables at times may be very dependent upon the other under natural ambient conditions as is well illustrated in Fig. 13. Coils of large inductance have correspondingly large self-capacitance and because of this there is a stronger tendency for the *effective* inductances of such coils to be affected by temperature and humidity. Carefully designed coils of the author's temperature - compensated type having values greater than 3,000 μH were found to possess at high frequencies what were at first thought to be very unusual temperature coefficients of self-capacitance although they were sensibly temperature-coefficientless at low frequencies. The algebraic sign of the apparent coefficient of some coils was, under certain conditions, highly negative. Most coils tested under these conditions were found to possess apparent coefficients of effective inductance less positive than their coefficients of *true* inductance. Since the temperature coefficients of permittivity of the insulating materials of the former were known to be positive and since a positive coefficient of self-capacitance will make a positive coefficient of inductance *more* positive, the apparent coefficients obtained were at once seen to be due to a cause other than temperature.

Changing humidity was at once suspected to be the cause and in order to make quite sure of separating the effects of temperature and humidity, measurements of effective inductance were made upon coils subjected to the ordinary open-air atmosphere for a period of about a fortnight during the autumn.

The coil first chosen for the investigation was one of 5,800 μH of the temperature-compensated type shown in Fig. 6 but wound more closely than usual in order to exaggerate any effect that might be present. The coil was set up in association with a temperature-coefficientless variable air-condenser to form the resonant circuit of a dynatron wavemeter which was tuned to resonance with a harmonic of a frequency standard. The effective inductance variations were obtained in terms of the variation of the capacitance of the variable condenser necessary to keep the wavemeter in exact resonance with the selected harmonic by slow synchronisation beating and thus compensate for the changes occurring in the coil under examination.

It at once became evident that large changes of *effective* inductance were caused by subjecting the coil to extremes of humidity. The changes were observed to be proportional to the square of the frequency of measurement or inversely proportional to the total circuit capacitance and it was apparent therefore that the effect was due either to a change of self-capacitance or to a serious loss of insulation resistance—both of which causes could, in turn, have been produced by excessive humidity.

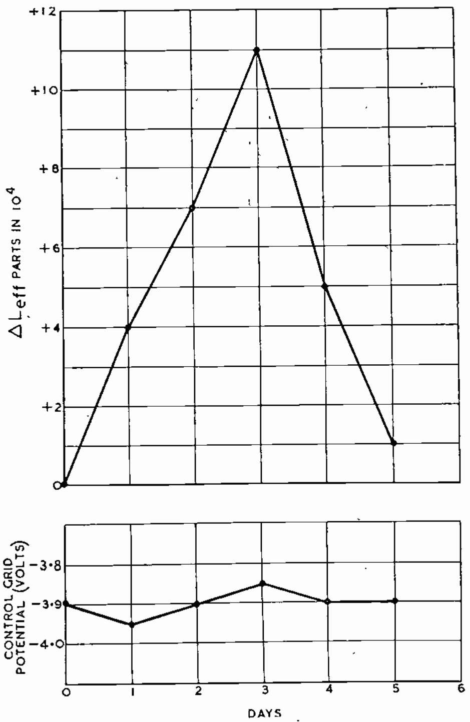


Fig. 12.

The change ΔC in the effective capacitance of the resonant circuit for changes of percentage relative hunidity of 50 per cent. to 95 per cent. was found to be of the order $+ 11$ parts in 10^4. The frequency was about 105 kc/s and the total circuit capacitance about 400×10^{-12}. From

$$C_e = C\left[1 + \frac{1}{\omega^2 C^2 r^2}\right]$$

where C_e is the effective capacitance of C due to a parallel resistance r, it is seen that the insulation resistance would have to have fallen to about 1.1×10^5 ohms.

Such a deterioration of insulation would have reduced the order of dynamic resistance L/CR from 10^6 to 10^5 ohms and a corresponding reduction in the value of the negative resistance of the screened grid valve would have been necessary in order to maintain the oscillation of the dynatron circuit. The control grid potential would have to have been reduced by over 1 volt in order to produce this change of valve resistance. Such was not the case however—the potential was constant to $\pm$ 0.05 volt as is shown by the curve of Fig. 12.

The change ΔC must therefore have been due to a change of actual capacitance. But

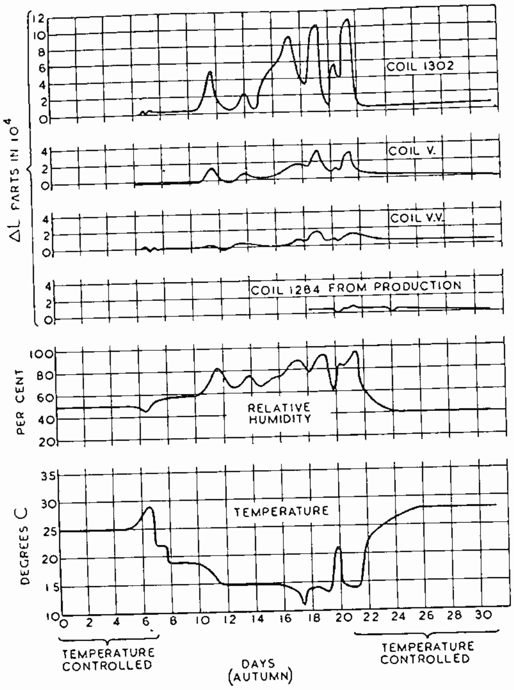


Fig. 13.

throughout the experiments the author had been careful to check the stability of the variable condenser standard at a somewhat higher frequency using a coil of lower inductance value. No appreciable change of frequency was obtained with the check coil in circuit for all conditions of humidity. ΔC must have been due entirely to a change of coil self-capacitance and it was at once decided to construct two similar coils in which the solid insulating material of the *B* members was treated with varnish, one with one coat, Coil *V*, and another with two coats, Coil *VV*. The original coil (No. 1302) was then tested again together with Coil *V* and Coil *VV*. The improvement due to the varnish treatment shown in Fig. 13 proves conclusively that the instability of effective inductance was due to humidity and not to temperature. Moreover, the similarity between the character of the instability curve of Coil 1302 and that of humidity is further proof—if any is needed.

Coil 1284 was one taken from production after treatment in the same manner as Coil *VV* and it is seen that its stability is unaffected by very great changes of both humidity and temperature.

Also tested throughout the same period were two compensated inductance standards of 100 000 μH, one (Coil *G*) with its *B* members treated and another (Coil 36) without the treatment. The curves of Fig. 14 show the improvement effected in the stability of the effective inductance by the treatment. They show also the instability of the bad coil to be of *effective* inductance and not of *true* inductance since its magnitude is very nearly inversely proportional to the circuit capacitance and therefore very nearly proportional to the square of the frequency.

These experiments prove the necessity for protecting stable temperature com-

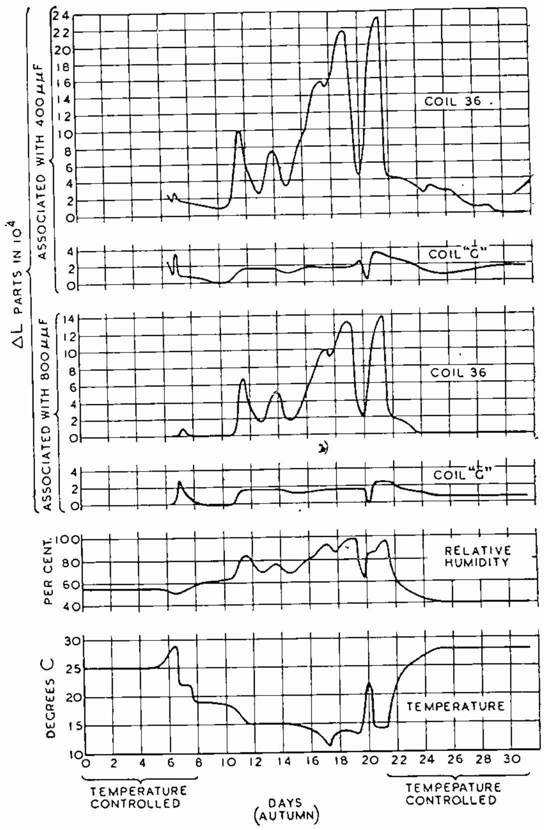


Fig. 14.

pensated coils of medium and large inductance values against the effects of humidity although it should be remembered that the inductance changes in the unprotected coils of Fig. 13 are not likely to be experienced in practice, at any rate in this country. A study of the temperature curve will show that the coils were exposed to open-air conditions continuously throughout the day and night for a fortnight. The normal indoor humidity during the whole of this period was at no time higher than 78 per cent. and during the day with sufficient artificial heating to maintain the laboratory temperature at 20 deg. C. the humidity was still lower. During the winter when the humidity during the daylight hours may not improve much from its peak night value the difference between the out-of-doors and indoors temperatures is great and the laboratory conditions are therefore not severe, it is in fact the author's experience that laboratory conditions are best during the winter. A word of warning must, however, be added in regard to winter conditions. It is possible to have very humid conditions at low temperatures without experiencing the bodily discomfort which is more popularly associated with "humid" atmosphere during the summer months. For this reason actual measurements of percentage relative humidity by a hygrometer are essential, although the author has found that there are still a number of important laboratories in which "impressions" are relied upon.

(To be concluded.)

Standards for Condensers

TWO specifications, one dealing with the rating and dimensions of paper and electrolytic condensers and the other with their colour coding of capacitances, were prepared by the Radio Manufacturers' Association some time ago. These were recently combined and published as War Emergency British Standard 271—1941 by the British Standards Institution.

Although in effect it is a revision of the specification issued in 1926, its object is to increase the efficiency of manufacture by limiting the range of sizes and types to those considered sufficient to meet wartime requirements. It provides for nine types of electrolytic condenser, with D.C. working voltages ranging from 12 to 500 and capacitances from 8 to 50 μF. Tubular paper condensers are divided into three types with rated D.C. working voltages of 250, 500 and 1,000. In each of these ranges eight capacitance values from 0.001 to 0.25 μF. are provided.

Copies of the specification (271—1941) may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s. 3d., including postage.

British Standards Institution

THE continued expansion of the work of the British Standards Institution and the development of its relations with the Government Departments as a result of the war have led to the appointment of an executive committee which will keep all the activities of the Institution under review and report from time to time to the General Council.

Mr. C. le Maistre, C.B.E., who has been associated with the movement almost from its inception, and who for the past 25 years has been its chief executive officer, has been appointed full-time chairman of the committee. His place as director and secretary of the Institution will be taken by Mr. P. Good, C.B.E., who for several years was deputy director and more recently joint-director.

Salving Paper

IT is a fact that, generally speaking, wireless can make no very spectacular response to the appeal for salvage. All the more reason why we should all make a special effort to do what we can, particularly in regard to paper, for which the need is still urgent. It is perhaps permissible to point out that a salvage scheme must be efficiently carried out, or the waste in man-power may well cancel out the value of the material salved. For example, it behoves collectors and those who direct their efforts to see that the sorters' time is saved by keeping together paper of the same kind (newsprint, packing paper, office waste, etc.)

Index to Abstracts

THE inclusion of a subject index to the Abstracts and References section as part of the December issue was discontinued last year, and instead, this Index, incorporating also an Index to Authors, will shortly be published separately.

A charge of 2s. 6d. will be made for the separate Index, and it will be necessary that those requiring copies should make early application for them to the Publishers, as otherwise it will not be possible to guarantee that copies will be available.

Book Received

Introducing Radio Receiver Servicing.—By E. M. Squire. As its title implies, this book is intended to provide the newcomer to service engineering with a concise introduction to the operation of receivers and to give him such information as will help him in his initial training. Throughout the book, the practical aspects of the theoretical discussions are emphasised. Pp. 100, Figs. 106. Sir Isaac Pitman & Sons, Ltd., Parker St., London, W.C.2. Price 6s.

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

537 437.—Balanced pick-up arrangement for eliminating "needle scratch" in gramophone reproduction.

Scophony and A. J. Gale. Application date 8th January, 1940.

537 524.—Microphone designed to prevent diaphragm displacement due to changes in atmospheric air pressure or temperature variations. (Addition to 507 183.)

G. R. Fountain, Ltd.; G. R. Fountain; A. E. C. Snell; and H. J. Houlgate. Application date 26th January, 1940.

537 558.—High-powered amplifier in which means is provided to minimise the high negative grid bias normally applied to the last stage to secure high efficiency.

Standard Telephones and Cables (assignees of F. E. Terman). Convention date (U.S.A.) 13th May, 1939.

537 931.—Electrostatic loudspeaker comprising a multiple-section electrodes different sections being fed with different frequencies to improve the response.

D. E. L. Shorter. Application date 21st February, 1940.

DIRECTIONAL WIRELESS

537 389.—Means for eliminating the 180° ambiguity in a direction-finding system using Adcock aerials.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique). Convention (France) 7th March, 1939.

537 530.—Short-wave radio transmitter with balanced feed-line, or other transmission system, for more accurately defining a radio-navigational course by overlapping beams.

Standard Telephones and Cables (assignees of P. Byrne). Convention date (U.S.A.) 22nd March, 1939.

537 626.—Radio direction finder in which the modulation effect due to the constantly-rotating aerial is utilised to give a phase indication relative to a fixed datum position.

Marconi's W.T. Co. (assignees of W. S. Eaton). Convention date (U.S.A.) 30th January, 1939.

537 627.—Phase indicator for a radio compass operating through 360° and showing both direction and "sense."

Marconi's W.T. Co. (assignees of W. S. Eaton). Convention date (U.S.A.) 30th January, 1939.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

537 303.—Variable coupling transformer, particularly for a wireless receiver, and comprising two parallel coils, one of which is angularly movable at right angles to the common axis.

Fabrica Italiana Magneti Marelli. Convention date (Italy) 29th December, 1938.

537 350.—Wireless receiver designed to give distortionless detection of single or double side-band signals.

Marconi's W.T. Co. (assignees of D. G. C. Luck). Convention date (U.S.A.) 28th February, 1939.

537 439.—Tetrode valve circuit with stabilised negative impedance capable of use as a high-pass, low-pass, or band-pass filter.

S. P. Chakravarti. Application date 15th September, 1940.

537 803.—Piezo-electric band-pass filter, particularly for a broadcast receiver, giving a bandwidth of 8 to 9 kilocycles with a sharp cut-off.

Standard Telephones and Cables (assignees of Le Matérial Téléphonique Soc. Anon.). Convention date (France) 8th August, 1939.

537 893.—Automatic volume control system, depending upon the use of auxiliary pilot signals, particularly for carrier-wave working over line wires.

Standard Telephones and Cables (assignees of J. G. Kreer, Jun.; J. H. Bollman; R. W. Chesnut; and C. O. Mallinckradt). Convention date (U.S.A.) 21st June, 1939.

537 900.—Amplifier circuit in which the negative slope of the characteristic of an auxiliary cathode producing secondary emission is utilised to produce regeneration.

Philips' Lamps. Convention date (Germany) 27th February, 1939.

537 926.—Optical-lever method of measuring the rotation of the tuning-control spindle for receiving short-wave signals.

Marconi's W.T. Co. and T. B. Hyde. Application date 30th January, 1940.

537 937.—Automatic diversity-reception system for preventing fading in a standard broadcast receiver.

Marconi's W.T. Co. (assignees of H. O. Peterson). Convention date (U.S.A.) 15th March, 1939.

537 944.—Automatic volume control system actuated only by the rising portion of syllabic impulses, an auxiliary control coming into action when signal strength exceeds a predetermined value.

Electrical Research Products Inc. Convention date (U.S.A.) 15th July, 1939.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

537 310.—Saw-tooth oscillation-generator, for a television time-base circuit, designed to operate with a comparatively low grid bias and a high anode voltage.

The British Thomson-Houston Co. and D. J. Mynall. Application date 8th February, 1940.

537 375.—Method of generating synchronising signals, particularly for television, in which all the "edges" determining horizontal spacing have a fixed time relation.

Marconi's W.T. Co. (assignees of A. V. Bedford). Convention date (U.S.A.) 30th November, 1938.

537 378.—Preventing phase and amplitude distortion in a single side-band modulating system, particularly for television signals.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique). Convention date (France) 17th December, 1938.

537 599.—Means for stabilising the value of the control voltage developed in a television receiver for reinstating the "background-illumination" component of the transmitted signal.

Hazeltine Corporation (assignees of J. C. Wilson). Convention date (U.S.A.) 9th June, 1939.

537 695.—Cathode-ray television transmitter in which the periodic deflecting voltage which blocks the ray during the return stroke also applies a negative bias to the grid if the deflecting voltage fails.

Marconi's W.T. Co. (assignees of W. J. Poch). Convention date (U.S.A.) 30th December, 1938.

537 832.—Photo-electric alarm device which gives an automatic warning should the relay, for any reason, cease to be sensitive to changes in light-intensity.

Baird Television and L. C. Bentley. Application date 5th January, 1940.

537 856.—Automatic volume control particularly for maintaining the correct background illumination in a television receiver.

Philco Radio and Television Corp. (assignees of A. R. Applegarth, Jun.). Convention date (U.S.A.) 16th July, 1938.

537 878.—Method of separating signal and synchronising impulses in a television receiver and of eliminating the effect of interference.

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

537 986.—Means for separating the sound and picture signals in a combined radio and television receiver using a common heterodyne oscillator.

Marconi's W.T. Co. (communicated by Radio Corporation of America). Application date 15th January, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

537 217.—Short-wave oscillation generator of the kind in which an electron stream is rapidly deflected from one curved path to another.

Marconi's W.T. Co. Convention date (U.S.A.) 1st October, 1938.

537 546.—Crystal-controlled short-wave oscillator with a balanced bridge arrangement to counterbalance the effect of the static capacitance of the crystal in the feed-back circuit.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 5th January, 1939

537 689.—Facsimile signalling system in which, in order to reduce distortion, the frequency spectrum is deliberately limited prior to reproduction.

Press Wireless Inc. Convention date (U.S.A.) 27th October, 1939.

537 699.—Frequency-modulating system utilising the variable impedance of a screen-grid valve, particularly for facsimile signalling.

Press Wireless Inc. Convention date (U.S.A.) 27th October, 1939.

537 731.—Modulating system utilising "bridge" rectifiers with means for offsetting capacitance leakage across the rectifiers.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 15th July, 1939.

537 798.—Variable concentric-tube resonator unit for stabilising the frequency of a short-wave oscillation generator.

The Mullard Radio Valve Co. Convention date (Netherlands) 23rd March, 1939.

537 836.—Short-wave oscillation generator comprising a split spherical resonator, one half of which is connected to the grid and the other to the anode.

Akt Brown, Boverie, et Cie. Convention date (Switzerland) 25th January, 1939.

537 848.—Modulating system of the absorption type in which the dissipating device presents an impedance which is substantially resistive and free from frequency variation.

Philco Radio and Television Corp. (assignees of W. N. Parker). Convention date (U.S.A.) 21st January, 1939.

537 918.—Short-wave oscillation generator comprising a resonator or cavity in which standing waves are produced.

Marconi's W.T. Co. (assignees of E. G. Linder). Convention date (U.S.A.) 30th November, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

537 276.—Electrode arrangement of an electron-multiplier tube using a single magnetic field to control the general path of the stream.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 29th December, 1938.

537 658.—Molybdenum-nickel alloys with characteristics particularly suitable for the manufacture of thermionic-valve electrodes.

Kemet Laboratories Co. (assignees of J. A. Holladay). Convention date (U.S.A.) 17th February, 1939.

538 020.—Electron multiplier in which the photo-electric cathode is of conical form and feeds electrons to secondary emitters arranged further along the cathode axis but normal to it.

R. W. Kersey and Vacuum-Science Products. Application date 10th January, 1940.

538 021.—Electrode system for a cathode-ray tube designed to eliminate the type of distortion normally produced by the Wehnelt cylinder.

Electrical Research Products, Inc. Convention date (U.S.A.) 8th February, 1939.

538 198.—Pentode valve in which the wires of the suppressor grid are arranged in line with the spaces between the wires of the accelerating grid in order to extend the straight-line part of the characteristic curve.

Standard Telephones and Cables and J. H. Fremlin. Application date 23rd January, 1940.

SUBSIDIARY APPARATUS AND MATERIALS

536 545.—Transmission-line coupling devices for frequencies of the order of 2500 megacycles.

Marconi's W.T. Co. (assignees of R. A. Braden). Convention date (U.S.A.) 14th February, 1939.

536 583.—Negative feed-back arrangement for stabilising a band-pass amplifier independently of the operating characteristics of the associated valves.

Marconi's W.T. Co.; N. M. Rust; J. D. Brailsford; and E. F. Goodenough. Application date 19th October, 1939.

536 645.—Flexible electrode structure for a telegraphic facsimile recorder of the drum and helix type.

H. J. C. Forrester (communicated by Radio Inventions Inc.). Application date 17th November, 1939.

536 591.—Construction of a cabinet, including at least one wall of perforated fabric, for containing a loudspeaker and associated amplifiers.

Kolster-Brandes and W. A. St. Clair-Smith. Application date 18th November, 1939.

536 888.—Means for distributing the incoming signals into separate channels in a multiplex telegraphic receiver.

Marconi's W.T. Co. (assignees of A. Kahn). Convention date (U.S.A.) 30th November, 1938.

536 969.—Microphone designed to be operated by contact with the cheek or throat of the speaker.

E. H. Greibach. Application date 31st August, 1939.

537 126.—Construction of a "blocking layer" cell for use as a low-frequency rectifier or a high-frequency detector.

Philips' Lamps. Convention date (Germany) 12th December, 1938.

537 167.—Piezo-electric crystal coupled to impedances to give a linear percentage change of its characteristic oscillation frequency.

Standard Telephones and Cables (assignees of L. F. Koerner). Convention date (U.S.A.) 3rd May, 1939.

537 177.—Throat microphone adapted to produce unusual vocal effects, for use in broadcasting and cinema films.

G. M. Wright. Convention date (U.S.A.) 27th March, 1939.

537 233.—Dry-contact rectifiers of the "blocking layer" type.

Philips' Lamps. Convention date (Germany) 12th December, 1938.

537 251.—Materials and process for making selenium crystal-layer rectifiers.

Nurnberger Schraübenfabrik G.m.b.h. Convention date (Germany) 1st June, 1939.

537 596.—Means for equalising the magnetic flux density of transformers and reactances of the wound core type.

The British Thomson-Houston Co. Convention date (U.S.A.) 25th May, 1939.

537 662.—Time base generator for a photo-electric cell used to correlate, say, the cylinder pressure with the piston displacement in an "engine indicator."

A. C. Cossor; F. A. Jollyman; T. D. Humphreys; and E. M. Dodds. Application date 28th December, 1939.

537 797.—Wide-band piezo-electric filter with stabilised negative impedance and low temperature coefficient.

S. P. Chakravarti. Application date 19th March, 1940.

537 889.—Construction of contact rectifiers or modulators of the "blocking-layer" type.

Philips' Lamps. Convention date (Germany) 25th March, 1939.

538 002.—Method of cutting and grinding a piezo-electric crystal-oscillator so as to increase its power output at a given frequency and temperature.

Automatic Telephone and Electric Co.; R. A. Spears; and P. Kenyon. Application date 5th April, 1940.

538 056.—Holder or mounting for short-wave valves of the Acorn type having radial prongs which engage with corresponding clips.

Johnson Laboratories, Inc. (assignees of D. V. Sinninger). Convention date (U.S.A.) 25th February, 1939.

538 131.—Arrangement and construction of the contact electrodes in a rectifier of the so-called blocking-layer type.

Philips' Lamps. Convention date (Germany) 23rd January, 1939.

Abstracts and References

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

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PROPAGATION OF WAVES

1. Hollow Pipes of Relatively Small Dimensions.—Barrow & Schaevitz. (*See* 96.)

2. Five-Metre Wave Paths: Parts I and II [Local: Lower-Tropospheric ("Air-Mass") Bending, 50–400 Miles: Sporadic-E-Layer Skip, 400–1250 Miles: Aurora-Type Skip, covering up to 15° of Longitude: F-Layer Skip, up to 2400 Miles (No Data: probably only during Peaks of Sunspot Activity)].—M. S. Wilson. (*QST*, Aug. & Sept. 1941, Vol. 25, Nos. 8 & 9, pp. 23–26 and 88: pp. 23–27 and 84.)

Chief attention is given to sporadic-E refraction, including the subject of wave-path-plane tilting. The discussions in Part II deal with tropospheric bending and its effect in increasing or decreasing the sporadic-E skip: the occurrence of a cycle of one-way, two-way, and reverse one-way communication (*cf.* Tyndall's "Sound"): polarisation of signals refracted from a sporadic mass: and the phenomena of "double skip", including the types with reflection from earth, with upward tropospheric bending preventing a central reflection from earth, and with direct upper-atmospheric path between the two sporadic masses. The possibility of occasional multiple refractions is mentioned: the most likely would be a combination of the third type of "double skip" and a single skip.

3. Ultra-High Frequencies and the Weather [System of Prediction].—M. S. Wilson. (*Radio*, Jan. 1940.) Mentioned in the paper dealt with in 2, above.

4. Calculation of the Effects of Humidity, etc., on the Propagation of Sound.—Eagleson. (*See* 129.)

5. Reflection of Electromagnetic Waves at an Inhomogeneous Layer. — W. Geffcken. (*Ann. der Physik*, 19th Sept. 1941, Vol. 40, No. 4/5, pp. 385–392.)

Recent work on such reflection (Kofink & Menzer, 2967 of 1941: Schröder, 2077 of 1941: Försterling, 1932 Abstracts, p. 217, and earlier work) prompts the writer to publish his own treatment of the problem, by a method quite different and particularly simple, developed primarily in connection with the films formed on glass surfaces by the action of acids, etc. Normal incidence is assumed, and the inhomogeneity is in this direction only. The final equations 14 & 14a have the advantage over most previous ones of giving not only the amplitude but also the phase of the reflection. The method is illustrated by application to cases where the increase in refraction occurs extremely steeply, where it varies linearly between 0 and z_1, and where the index passes continuously from n_0 to n_1 without any discontinuity in the function or in one of its derivatives.

6. Radio Observations of the Ionosphere during an Eclipse [of the Sun: Period of Totality 282 Seconds at Ground].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, Sept. 1941, Vol. 232, No. 3, pp. 278–280).

During the eclipse the ion density of the E and F_1 layers decreased to about 22% of normal. The minimum density corresponds to recombination coefficients of about 2×10^{-8} and 1×10^{-8} respectively, but the rate of decrease, and the fact that the time of minimum density occurred at the middle of totality, indicate much greater coefficients. "An apparent anomalous effect was observed, in that the ion density began to increase before third contact." In the case of the F_2 layer, information was not complete, but "the minimum of ion density approached about half of normal and apparently reached a minimum about one hour after totality."

Up to the end of totality the decrease in density corresponded to a recombination coefficient of about 10^{-10}, but the density observed some time after totality was much less than would have been expected for this coefficient. "A definite decrease in ion density was observed at the same time that the moon obscured a large sunspot. This may be significant in identifying the source of certain ionising radiation with given areas of the sun."

7. SOLAR PHENOMENA PRECEDING THE IONOSPHERIC STORM OF MARCH 1st, 1941 [Two Exceptional Eruptions (Helium Lines appearing in Bright Emission, instead of in Absorption as in Usual Eruptions) followed, at Intervals of $2^d\ 9^h$ & $1^d\ 12^h$, by the Unusually Severe Ionospheric & Magnetic Storm].—Helen W. Dodson & Suzanne E. A. van Dijke. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, p. 360.)

8. POLARISATION STUDIES OF ECHOES REFLECTED FROM THE ABNORMAL-E LAYER FORMED DURING GEOMAGNETIC STORMS [Tromsö Results & Conclusions].—L. Harang. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 279–282.)

On the lower frequencies, the echoes reflected from the ionised layer in the E region formed during geomagnetic perturbations consist mainly of the ordinary component, but in a number of cases a faint or medium extra-ordinary component has also been noted; this faint e-o component is not usually found in echoes from the normal-E layer. On higher frequencies, just before the waves penetrate, only the e-o component is received. The tendency to reflect the e-o component on the lower frequencies with noticeable intensity is explained by the sharp lower boundary which the layer must exhibit (the short penetration gives rise to a reduced differential absorption of the two components): this sharpness is confirmed by the approximate constancy of the virtual heights over the whole frequency range. The occurrence of only the e-o component on the highest frequencies on which echoes occur shows that this highest frequency must be regarded as a *critical* frequency of the layer in the usual sense (there has been some doubt on this point), and it is thus possible to calculate the max. electron-density of the layer formed during geomagnetic perturbations, using the appropriate formulae: in the cases here dealt with it would have been correct to use the formula containing the e-o ray.

9. THREE-HOUR-RANGE INDICES, K, FOR TWELVE MAGNETIC OBSERVATORIES, JULY TO DECEMBER, 1940, AND SUMMARY FOR 1940, *and* K-INDEX ACCORDING TO THE U.S.S.R. OBSERVATORIES.—H. F. Johnston: N. P. Benkova & O. Y. Kosuhia. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 301–308: pp. 343–344.)

10. THE VARIABILITY OF LUNAR MAGNETIC VARIATION [Results tending to confirm Writer's Belief that It contains a Considerable Independent Part, Not Correlated with Solar Magnetic Variation].—O. Schneider. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 283–300.)

11. DIRECTIONAL AND DIURNAL CHARACTERISTICS OF AURORAS AT SOME PLACES IN CANADA.—B. W. Currie & C. K. Jones. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 269–278.)

12. THE COSMIC-RAY LATITUDE EFFECT AND THE SINGLE PRIMARY COMPONENT HYPOTHESIS.—W. F. G. Swann. (*Phys. Review*, 15th Sept. 1941, Vol. 60, No. 6, pp. 470–471.)

13. A NEW LABORATORY FOR COSMIC-TERRESTRIAL RESEARCH [at Needham, Massachusetts: associated with M.I.T.].—H. T. Stetson. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 313–318.)

14. REPORTS ON THE IONOSPHERE AT WATHEROO, WESTERN AUSTRALIA, AND HUANCAYO, PERU, APRIL/JUNE 1941.—W. C. Parkinson, P. G. Ledig, & others. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 347–350 & 351–354.)

15. THE BEHAVIOUR OF ELECTRONS IN OXYGEN [Experimental Curves giving Townsend's Energy Factor, Electron Drift Velocity, & Ratio Probability-of-Attachment/Pressure, as Functions of Z/p: Derived Curves for Mean Free Path, Mean Proportion of Energy lost by Electron at Collision with Gas Molecule, & Probability of Attachment, as Functions of R.M.S. Velocity: etc.].—R. H. Healey & C. B. Kirkpatrick. (*A.W.A. Tech. Review*, 1st June 1941, Vol. 5, No. 4, pp. 155–164.)

For previous work see 1739 of 1935 and 3375 of 1939 & back reference: *see* also 16, below. The knowledge was required for study of the motion of electrons in ozone.

16. "THE BEHAVIOUR OF SLOW ELECTRONS IN GASES" [Book].—R. H. Healey & J. W. Reed. (Mentioned in 15, above.)

17. ON THE LIGHT ACCOMPANYING THE THERMAL DECOMPOSITION OF OZONE.—D. Barbier, D. Chalonge, & M. Masriera. (*Comptes Rendus* [Paris], 9th June 1941, Vol. 212, No. 23, pp. 984–986.)

18. THE MAGNETIC CURRENT [Beam of Light causes or induces not only Heat & Electricity but also Magnetism: etc.].—F. Ehrenhaft: C. M. Focken. (*Science*, 5th Sept. 1941, Vol. 94, pp. 232–233.) *See* also 1304 & 2974 of 1941. For Focken's "entirely negative" results on the magnetisation of matter by ultra-violet radiation see *Nature*, 11th Oct. 1941, Vol. 148, p. 438.

19. MULTIPOLE NATURE OF ELEMENTARY SOURCES OF RADIATION—WIDE-ANGLE INTERFERENCE [Experiments with Fluorescent Films].—S. Freed & S. I. Weissman. (*Phys. Review*, 15th Sept. 1941, Vol. 60, No. 6, pp. 440–442.)

20. PLANE WAVES IN IDEAL GASES WITH FRICTION AND HEAT CONDUCTION.—K. Bechert. (*Ann. der Physik*, 30th Aug. 1941, Vol. 40, No. 3, pp. 207–248.) For previous work *see* 2991 of 1941.

21. A Five-Figure Table of the Bessel Function $I_n(x)$.—H. B. Dwight. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 135–136.) A summary was dealt with in 694 of 1941.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

22. Radio Static is used to locate Hurricanes [Puerto Rico & Florida Work, using Continuous Photographic Recording].—G. W. Kenrick. (*Sci. News Letter*, 4th Oct. 1941, Vol. 40, No. 14, p. 211.) *Cf*, for example, 3692/5 of 1936, 1318 of 1938, and 2185 & 2913 of 1940.

23. Propagation of Lightning Leader Strokes.—J. M. Meek: Bruce. (*Nature*, 11th Oct. 1941, Vol. 148, pp. 437–438.)

Experimental data on glow-to-arc transition, on which Bruce's theory (2364 of 1941: for later work *see* 2993) is largely based, "are not directly applicable to the leader stroke, which is a gas-dependent phenomenon". The writer suggests ways in which, for negative and positive leader strokes respectively, the excess charge in the channel (necessary in order that the leader stroke may carry forward a localised intense field about its tip, without which it could not maintain its progress in fields of such relatively low gradient) is probably produced.

24. Calculation of Initial Breakdown Voltages in Air [or Other Gases for which α and N are known].—D. W. Ver Planck. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 99–104.) A summary was dealt with in 881 of 1941.

25. Impulse and 60-Cycle Characteristics of Driven Grounds.—P. L. Bellaschi. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 123–128.) A summary was referred to in 765 of 1941.

26. Atmospheric-Electric Results from Watheroo, Western Australia, for the Period 1924/1934.—G. R. Wait & O. W. Torreson. (*Terr. Mag. & Atmos. Elec.*, Sept. 1941, Vol. 46, No. 3, pp. 319–342.)

27. Interpretation of [Radiosonde] Temperature Measurements made at High Levels.—J. C. Ballard. (*Sci. Abstracts*, Sec. A, Sept. 1941, Vol. 44, No. 525, p. 262.)

28. Recent Applications of Radio to the Remote Indication of Meteorological Elements [Short Survey of Radiosonde Systems].—H. Diamond. (*Elec. Engineering*, April 1941, Vol. 60, No. 4, pp. 163–167.) For previous work *see* 3342 of 1940.

29. The Radiosonde: the Stratosphere Laboratory [Survey, including New Formula for Upward Velocity of a Flight in terms of Free Lift].—E. T. Clarke & S. A. Korff. (*Journ. Franklin Inst.*, Sept. & Oct. 1941, Vol. 232, Nos. 3 & 4, pp. 217–238 & 339–355.)

30. Transparent Plastic as a Substitute for Aluminium in Radiosonde Casings.—(*Sci. News Letter*, 20th Sept. 1941, Vol. 40, No. 12, p. 181.) Saving six tons of aluminium on a recent order for 31 200 instruments.

PROPERTIES OF CIRCUITS

31. Non-Linear Distortion, with Particular Reference to the Theory of Frequency-Modulated Waves: Part I.—E. C. Cherry & R. S. Rivlin. (*Phil. Mag.*, Oct. 1941, Vol. 32, No. 213, pp. 265–281.)

Most of the analytical work on frequency modulation deals only with a single sinusoidal modulating frequency. "Exceptions to this are van der Pol, who considers a square modulating wave, and Carson & Fry, who have developed from first principles a variable-frequency electric-circuit theory. It is interesting to note that these latter authors consider the analysis of the problem on traditional 'steady-state' lines, such as we have used here, to be mathematically intractable. Although the analysis . . . in this paper is immediately concerned with the application of a wave of e.m.f. to a thermionic valve of non-linear resistive characteristic, it is by no means limited to such use, but may be supplied to the solution of many other problems which may be reduced to the same mathematical form." The theory developed is directly applicable also to phase-modulated waves.

32. Auto-Oscillations, including Harmonics, in Non-Linear Systems of the Thomson Type, examined from the Standpoint of the Energy Balance in the Circuit.—K. F. Teodorchik. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 10, 1940, pp. 627–632.)

Auto-oscillating systems of the Thomson type are again considered. Using the method of "energy cycles" (2538 of 1940), equations are derived for determining the building-up of auto-oscillations in the circuit, both of the fundamental and of harmonic frequencies. The discussion is applied to the case of a freely oscillating system, and the amplitude and phase of auto-oscillations, as well as their frequency, are determined. The method also applies to the cases of a system subjected to the action of an external harmonic force and of a non-linear system whose parameters are harmonically modulated by an external agency.

33. Graphical Solution of Rectifier Circuits [for Calculation of Output Voltage, Percentage Ripple, & Regulation of Half-Wave Rectifier & Filter Power Supplies (*e.g.* for Television)].—W. K. H. Panofsky & C. F. Robinson. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 42–44 and 109.)

34. Voltage-Multiplier Circuits [for H.T. Supply for Small Receivers, Cathode-Ray Tubes, etc: Doubler & Quadrupler Circuits, & the Writer's Tripler Circuit].—D. L. Waidelich. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 28–29.) Including Garstang's quadrupler (1932 Abstracts, pp. 358–359): for Honnell's paper on new applications of such circuits (diode detector, valve voltmeter, etc.) *see* 1423 of 1940.

35. On the Thermal Noise of a Quadripole.—H. Takahasi. (*Proc. Phys-Math. Soc. Japan*, July 1941, Vol. 23, No. 7, pp. 548–552: in German.)

Author's summary:—"The Nyquist formula for the noise of thermal agitation [in a two-pole network] has been extended to the case of a four-pole network, the mean value of the product of the noise voltages at both terminals being determined. The extended formula is $E_1E_2^* . \tau = kT (Z_{12} + Z_{21}^*)$, where Z_{12} and Z_{21} represent the appropriate elements of the complex resistance matrix. The possibility of proving this formula experimentally is pointed out " [the amplified voltages could be applied to both pairs of c.r.o. plates: but the formula can be applied to mechanical as well as electrical quadripoles, so that it may be tested on the Brownian movement of a sensitive system such as two mirrors suspended on a common fine thread].

36. Optimum Q and Impedance of R.F. Inductors: Design Charts for Solenoids and Toroids.—Naslund. (*See* 187.)

37. Nomogram for Inductance of Two Parallel Wires [Feeders, Connections].—T. S. E. Thomas. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 5–6.)

38. Additive [Decade-Type] Frequency Scales for a Circuit tuned by a Variable Condenser.—Builder. (*See* 88.)

39. The Analysis of Pulses by Means of the Harmonic Analyser [Applicable to Various Problems involving Evaluation of Fourier Integral].—Shankland. (*See* 153.)

40. On Transient Similarity and Equivalence in n-Mesh Linear Networks [Concept of "Transient Similarity" used to give Complete Classification of All Such Networks with respect to Transient Behaviour: Case of $n = 2$ studied in Detail, giving Complete & Improved Solution of Problem undertaken by Quade ("Classification of Oscillation Processes in Coupled Circuits"): etc.].—M. D. Cooper & R. S. Burington. (*Phil. Mag.*, Oct. 1941, Vol. 32, No. 213, pp. 302—314.)

41. A New Method for introducing Relaxed Initial Conditions in Transient Problems.—W. C. Johnson. (*Elec. Engineering*, April 1941, Vol. 60, No. 4, Transactions pp. 178–181.)

42. The Suitability of Resistance-Capacitance-Coupled Amplifiers for the Amplification of Direct-Current Pulses.—H. Köhler. (*E.N.T.*, May 1941, Vol. 18, No. 5, pp. 97–105.)

Although a strict solution of this task can only be obtained by the use of delay-free d.c. amplifiers, it is shown here that in many practical cases the much simpler and more reliable RC-coupled amplifier, such as is used for the amplification of "stationary" processes, can well be employed. When thus used for "non-stationary" processes, such an amplifier does not give amplification in the ordinary sense of the word: it is shocked into its own building-up process and the max. amplitude of this transient process is amplified like an alternating voltage. This involves, it is true, a flattening of the original pulse, and brings with it, for a multi-stage amplifier, several passages through a null point: nevertheless it is possible, by suitable choice of the circuit elements, to vary very widely the constants of the building-up process, so that in almost any practical case a serviceable compromise solution can be found. For this purpose, however, it is necessary to have a precise knowledge of the transient process, and in spite of a large amount of published work (McLachlan, 4129 of 1936 [*see* also 221 of 1937]: Kellogg & Phelps, 1347 of 1938: Pieplow, 4022 of 1937) there are still important gaps in our knowledge.

The writer therefore analyses the behaviour of ordinary RC-coupled amplifiers, single-stage and multi-stage, on application of a d.c. unit impulse to the input terminals. For a single stage, the building-up process can be reckoned in a first approximation as the sum of two charging-up processes of RC elements. The first maximum of the curve is reached after a delay time t_m, depending chiefly on the time constant of the parallel circuit R_a, R_i, R_g, C_g, C_a and on a dimension-less correction factor F_t which is a function of C/C_k and of $R_g/R_i + R_g/R_a$ (F_t decreases as the first expression increases, and reaches a minimum when the second expression is equal to unity—Fig. 7). The height of this first maximum corresponds, in the first approximation, to the amplification coefficient in the pass-band region of frequency. The second branch of the building-up curve represents the charging-up of the coupling condenser C_k over R_g and over R_i in parallel with R_a. Equations and curves are given from which all the important values can be obtained with adequate exactness.

The treatment is extended to multi-stage amplifiers. The delay time of the first maximum can, in the first approximation, be put equal to that of a single stage. In an n-stage amplifier this maximum amplitude is in general equal to the nth power of the max. amplitude of a single stage. For a sufficiently small C/C_k the attainable impulse-amplification corresponds to the amplification coefficient in the pass-band region. An increase of C/C_k causes a decrease in amplification by the factor $\{(1 - \delta_1)/(1 + C/C_k)\}^n$: here $1 - \delta_1$ is the amplification correction factor for a single stage (p. 100).

The theoretical results are confirmed by oscillograms taken with a single-stage and a two-stage amplifier.

43. A Pentode Lock-in Amplifier of High Frequency Selectivity [as Detector for Bridges (eliminates Noise and balances In- & Out-Phase Components separately) and generally for Isolation of Small Effects masked by Large Backgrounds].—W. C. Michels & N. L. Curtis. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, pp. 444–447.)

Work on light reflected from the upper atmosphere (910 of 1940) and on the Coronaviser (4202 of 1940) are mentioned as applications. The principle is that proposed by Cosens (511 of 1935).

44. Peak and Null Indicating Circuit [Triode (or Double Triode) Circuit for the "Sharpening-Up" of Maxima & Minima, in Detection of Resonance Peaks, Null Points of Bridges, etc.].—R. Hofstadter & L. I. Schiff. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, p. 448.)

45. Calculation of the Class C Amplifier.—Tanasescu. (*See* 71.)

46. Simple Quartz-Crystal Filters of Variable Band-Width [for General-Purpose Communication Receivers: Comparison of Bridge-Balanced (Marrison, Robinson), Bridged-T (Mason), & Conventional *m*-Derived Circuits].—G. Builder & J. E. Benson. (*A.W.A. Tech. Review*, 1st Feb. 1941, Vol. 5, No. 3, pp. 93–103.) *See* also 47, below.

47. A Note on the History of Piezoelectric Crystal Filters [as used in the "Stenode Radiostat" & elsewhere: with Patent References to Work of Cady, Robinson, Espenschied, Marrison, Hansell, & Byrnes].—J. E. Benson. (*A.W.A. Tech. Review*, 1st Sept. 1941, Vol. 5, No. 5, pp. 191–192.) Supplement to 46, above.

48. The Crystal Filter treated as an Impedance Bridge Circuit [Two Solutions, Resistance & Reactance Balances: etc.].—J. E. Willson. (*Communications*, April 1941, Vol. 21, No. 4, pp. 18 and 20.)

49. High-Frequency Equalising Filters [for Broadcast Receivers, etc.].—E. Hudec. (*E.N.T.*, March 1941, Vol. 18, No. 3, pp. 29–38.)

"The object of the equalising filter is to balance out the rise of attenuation, in the pass band, of one or several band-pass filters. The attenuation characteristic of an equalising filter is shown in Fig. 6a. If a h.f. amplifier contains several band-pass filters which combine to give an attenuation curve like that of Fig. 6b [bullet-nose trough], and also an amplifying stage with an equalising filter corresponding to Fig. 6a [two wide shallow troughs separated by a mound] the resultant attenuation curve will run like Fig. 6c [blunted (nearly flat) bullet-nose], and the attenuation change in the pass-band zone will be greatly diminished.

"Such an equalising filter can be obtained fundamentally by multiple coupling of a multiple band-pass filter. In the present paper a capacitively coupled four-circuit equalising filter is dealt with theoretically and experimentally. It is shown that the equalising attenuation can readily be adjusted to the required value by altering the coupling capacitance between the first and fourth oscillatory circuits. The attenuation minimum of the equalising filter has a maximum value for a definite critical coupling, so that a definite minimum can generally be obtained for two different values of coupling. The calculated curves [Fig. 9] agree quite well with the measured curves" [Fig. 11: in this figure the curve calculated for $C_{14} = 4$ pF is superposed (broken line) on the measured curve: the small discrepancies are explained by stray couplings, etc.]. *See* also 50, below.

50. The Filter Arrangements of a Receiver for Picture and Teleprinter Radio Systems [by the "Impulse" Method, as used between Berlin & Buenos Aires].—E. Hudec. (*E.N.T.*, March 1941, Vol. 18, No. 3, pp. 46–57.)

For the main filter, Hässler's carrier-telephony filter with a flank steepness around 22 nepers per kc/s (middle frequency about 22 kc/s), using compressed-powder cores free from temperature-variation, and mica condensers, was adopted: quartz filters "only bring important advantages at much higher frequencies", such as 1 Mc/s. A three-circuit filter is used for the first-i.f. amplifier (1.5 Mc/s), the shape at the bottom of its trough being improved by the equalising filter dealt with in 49, above.

51. Filter Design: Design and Characteristics of Low- and High-Pass Filters [with Chart & Curves].—L. J. Giacoletto. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 14–15.)

52. Insertion Loss in Filters [with Chart].—J. Kritz & E. L. Gruenberg. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 45–46.)

53. Band-Width Factors for Cascade Tuned Circuits [Equations, Tables, & Graphs].—C. E. Dean. (*Electronics*, July 1941, Vol. 14, No. 7, pp. 41–42.) Data prepared originally by H. A. Wheeler and found useful over several years.

54. Frequency Response of Parallel Resonant Circuit [Curves & Table based on Complete Mathematical Study of Wave-Trap Circuit].—M. B. Reed. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 43–44.)

55. Bridged Tee Pads [with Advantages of Tee Pad over Other Attenuators].—Preisman. (*See* 190.)

TRANSMISSION

56. Graphical Determination of Electron Transit Times in Homogeneous Electric Oscillating Fields [Velocity Modulation].—Geiger. (*See* 109.)

57. On a New Type of Ultra-Short-Wave Generator with Phase Focusing: II.—F. Lüdi. (*Hochf:tech. u. Elek:akus.*, July 1941, Vol. 58, No. 1, pp. 15–17: summary, from *Helvetica Phys. Acta*, Vol. 13, 1940, p. 498 onwards.)

For I *see* 62 of 1941. A simpler form of velocity-modulated tube is now discussed, having only one oscillatory circuit: it was developed because of the constructional difficulties presented by a sealed-off klystron, due particularly to the use of two cavity resonators exactly tuned to each other, in a vacuum, and provided with a variable feedback connection. The paper begins with an analysis, applicable to all velocity-modulated tubes, of the conditions for optimum feedback: eqn. 9 shows that the optimum feedback factor ϵ depends only on the drift-tube length l and the spacing d_a between the "catcher" electrodes. For a practical case, $d_a/l = 0.1$, ϵ is about 0.12. Owing, however, to the broad maximum of the Bessel function $J_1(p)$ in eqn. 1, the condition for attaining the max. efficiency of 58%, instead of being $p = 1.84$ as assumed for the derivation of ϵ, may vary between 1.4 and 2.2 without the "catcher" potential being appreciably diminished.

The writer next considers the effect of a finite distance d_{st} between the modulating electrodes:

hitherto an infinitely small spacing has been assumed, corresponding to an energy-free velocity modulation. For a finite spacing the energy change of the electrons during their passage through the modulating space must be taken into account. In particular, if $d_{st} = h \cdot v_o \cdot T/2$ (where h is an even number) the velocity modulation disappears, since every entering electron is as much retarded as accelerated during one oscillation period: if d_{st} is too large, "bunching" may occur already in the modulating field, which is undesirable for perfect functioning. Finally, departures from the correct length of the "catcher" field (the transit time should be an uneven multiple of a half-period) will upset the necessary phase relations and prevent the attainment of the max. efficiency.

Coming now to the new type of tube, the writer describes how the usual two cavity resonators of the klystron are replaced by a parallel-wire system, to which the double grids of the modulating and "catcher" fields are directly connected (Fig. 2a). The system can be closed on one or both sides by a short-circuiting bridge. The parallel-wire line, replacing the oscillatory circuit, also provides a back-coupling between the two fields. Practical values for a 30 cm-wave tube are given. In such a tube the optimum feedback factor, $\epsilon = 0.12$, is approximately attained when the two modulating electrodes are connected as close as possible to the short-circuiting bridge: the potential distribution along the line is then almost sinusoidal. Since the internal generator resistance is about 5000 ohms, while the usual load resistance amounts to about 70 ohms, some method of matching is necessary.

One advantage over the devices of the two Varians and of Webster lies in the absence of coupling waves. On the other hand, the parallel connection of the roughly equal tube resistance and Lecher-wire resonance resistance reduces the efficiency of the present arrangement to about a quarter of the theoretical maximum of 58% for phase-focusing generators: an actual value measured was 10%. Among other ways of improving this the writer suggests the use of a wave-guide tube closed at both ends, to replace the Lecher wires.

58. Cathode-Ray-Tube Circuit for the Generation and Emission of Short and Ultra-Short Waves.—A. Recknagel. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, p. 163: D.R.P. 700 378, assigned to A.E.G.)

The max. output is obtained when $f.L/2v = 3.8$, where f is the frequency of the circuit connected to the deflecting plates (of axial length L) between which and the ray an exchange of energy occurs.

59. On the Value of the Static Anode Potential in a Retarding-Field Circuit with a "Free" Anode.—N. F. Otpushchennikov. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 594–595.)

Referring to a previous work (3104 of 1939) it is pointed out that the anode in the circuit under investigation receives a definite static charge. In the present paper results are published of measurements of the potential of this charge under various operating conditions.

60. Non-Linear Distortion, with Particular Reference to the Theory of Frequency-Modulated Waves.—Cherry & Rivlin. (*See* 31.)

61. Measurements on Frequency-Modulated Transmitters [Special Techniques to meet Rigid F.C.C. Requirements].—Thomas. (*See* 178.)

62. New System of Frequency-Modulation [Preliminary Report on Electro-Optical Method (yielding Modulating Voltages which are Sine & Cosine Functions of the Modulating Signal) to give Very Large Phase Shifts].—S. Sabaroff. (*Communications*, Sept. 1941 Vol. 21, No. 9, pp. 8–9). "It is anticipated that . . . phase shifts of 9000 degrees or more are not at all unlikely" (compared with about 30 in the Armstrong system and several hundred in the Shelby).

63. What is Frequency Modulation? [Survey of Development, Characteristics, & Applications].—W. H. Capen. (*Elec. Communication*, No. 4, Vol. 19, 1941, pp. 99–109.)

64. *Electronics* Data Sheets on Frequency Modulation.—(*See* 311.)

65. The Use of Rectangular Resonators in Ultra-High-Frequency Technique.—V. I. Bunimovich. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 10, 1940, pp. 640–646.)

Rectangular resonators discussed in a previous paper (1380 of 1940) were used as frequency stabilisers in magnetron oscillating circuits operating on wavelengths of the order of 17 cm. Various circuits were experimented with, but the one on which a more detailed report is presented is shown in Fig. 2. In this circuit the resonator is inductively coupled to the magnetron anode circuit, which is also coupled to the aerial feed. Curves are plotted showing the effect of the following factors on the wavelength of the oscillator, when this is operated with and without the resonator:—(1) anode current; (2) filament current; (3) magnetic field; (4) length of the anode loop; and (5) coupling to the aerial feeder. It appears that the frequency stability of a circuit using the resonator is so high that a beat note between two oscillators operating on wavelengths of the order of 17 cm can easily be obtained and maintained within the audio-frequency range. As to efficiency, it is estimated that losses in the resonator do not exceed 30 or 40% of the power radiated by an unstabilised oscillator. *See* also 176, below.

66. Water-Cooled Resistors for Ultra-High Frequencies [for Television Transmitters, etc.].—Brown & Conklin. (*See* 222.)

67. A Modulator and Power Supply for the Inexpensive 56 Mc/s Transmitter.—V. Chambers. (*QST*, Aug. 1941, Vol. 25, No. 8, pp. 18–22.) Completing the equipment referred to in 2673 of 1941.

68. "Frequency-Halving" Oscillators: 160-Metre Operation with 80-Metre Crystals.—B. Goodman & H. Bubb. (*QST*, Sept. 1941, Vol. 25, No. 9, pp. 46–47 and 98.)

69. Applying the Dynamic-Shift Principle [Advantages & Disadvantages of Conventional Grid-Bias Modulation: Improvement by "Dynamic-Shift" Principle with Constant Carrier].—F. A. Everest & F. H. Dickson. (*Communications*, July 1941, Vol. 21, No. 7, pp. 3–6.)

70. Morse Key Manipulation [Difference between Recommended American & British Technique].—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, pp. 292–293.)

71. Calculation of the Class C Amplifier [for the Final Stages of a Transmitter].—T. Tanasescu. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, pp. 151–154.)

The accurate calculation of such stages is important not only for installation but also for running costs. It is made difficult by the fact that four variables are involved, whether the theoretical ones derived from the simple diagram or the practical ones generally employed. The most simple treatment of the problem, by diagrams, is impossible because of this multiplicity of variables. The writer therefore assumes two of these as given: the anode voltage (for which the valve was constructed) in all cases, and, in turn, the max. anode dissipation, the max. anode current, and the anode-circuit impedance. The three diagrams obtained by the choice of the second variable can be applied to all valves and all working conditions: they are based on the assumption of a linear valve characteristic and on the neglect of grid current, but corrections for non-linearity and for grid current are given in the two sections preceding the worked-out example.

72. A New Unit-Type Multifrequency 5 Kilowatt Transmitting Equipment.—D. Martin. (*Elec. Communications*, No. 4, Vol. 19, 1941, pp. 93–98.) Eleven have been supplied to United Air Lines.

73. A Remote-Control System [New Automatic System for Receivers and Transmitters].—M. Yardeny. (*Communications*, March 1941, Vol. 21, No. 3, pp. 14–15.)

74. A Versatile Portable/Emergency Transmitter using either 6.3 or 1.5 Volt Valves [for C.W. Operation on Mains, Accumulators with Vibrator or Dynamotor, or Dry Batteries].—C. F. Hadlock. (*QST*, July 1941, Vol. 25, No. 7, pp. 9–11.)

RECEPTION

75. Inductive Tuning at Ultra-High Frequencies [Extension of Mallory-Ware System to Commercial Oscillators & Experimental Receivers covering Ranges 22–150 Mc/s and 35–150 Mc/s, respectively].—B. V. K. French: P. Ware. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 32–35 and 117 . . 120.) *See* 2739 of 1939 and back references.

76. Method of Heterodyne Reception for Ultra-Short Waves [Heterodyning Frequency obtained by Doppler Effect, by Use of Rotating Reflector (of Cardioid Section) close to Receiving Aerial].—E. Gerhard. (*Hochf:tech. u. Elek:akus.*, July 1941, Vol. 58, No. 1, p. 19.) D.R.P. 700 873, assigned to Telefunken.

77. Non-Linear Distortion, with Particular Reference to the Theory of Frequency-Modulated Waves.—Cherry & Rivlin. (*See* 31.)

78. Frequency Modulation and Interference [Analysis on assumption that Signal is Considerably Stronger than Interference: Calculation of "Improvement Ratio": Effectiveness depends on Amplitude, Frequency, & Phase Relations of F.M. Sidebands: etc.).—S. Goldman. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 37–42.)

79. The Reception of Frequency-Modulated Waves [Exhaustive Analysis & Practical Deductions].—T. Vellat. (*E.N.T.*, April 1941, Vol. 18, No. 4, pp. 61–96.)

From the Telefunken laboratories. A—The general problem. B—Detection (the ideal modulation converter, a loss-free inductance: effect of actual losses: the parallel oscillatory circuit as modulation converter: the push-pull modulation converter, and its importance in diminishing the noise level by eliminating the constants in the expression for the rectified voltage, and also in reducing distortion). C—The reduction of interference by the use of frequency modulation (discrete interference, received without amplitude limitation: continuous spectrum, without and with amplitude limitation). D—Frequency-modulated interfering station (sinusoidal modulation, received without and with amplitude limitation: unmodulated desired signal, in pauses of transmission). E—Common-wave transmission, received without and with amplitude limitation (surprisingly good practical results: by moving the aerial only a few metres it is possible to avoid the overlapping zone). F—Non-linearities and their effects (neither modulation distortion nor, strictly speaking, cross-modulation occurs in frequency-modulation reception; only an interfering background). G—Guiding lines for receiver design (push-pull modulation converter and its design: i.f. amplifier design calculations, without and with amplitude limiter). H & I—Amplitude limiters. Finally, "much remains for further investigation: in particular, the development of special circuits for the amplifier stages and for the modulation converter, to yield the greatest possible amplification with the least possible distortion. The problem becomes specially important where it is desired to make use of frequency modulation for the multiple utilisation of wide bands . . ."

80. The Effect of Distortion in the Transmission of Frequency-Modulated Oscillations.—E. Hölzer. (*E.N.T.*, May 1941, Vol. 18, No. 5, pp. 106–117.)

Author's summary:—"Phase and frequency modulation differ in the matter of the dependence of the frequency deviation on the modulating frequency [in phase modulation the deviation Ω_m, for equal a.f. modulation amplitudes A, is not constant but increases with the modulation frequency ω; $\Omega_m = A . \omega$: in frequency modulation it is constant, and $\Omega_m = A$]. In the first part of the paper it is shown that a series of similar types of modulation can be developed [$\Omega_m = A \,.\, \omega^n$: "phase modulation" is thus a frequency modulation of the first order, the usual "frequency modulation" is one of zero order], but that of all types of modulation, frequency modulation gives the greatest freedom from interference.

"In the second part the effects of various distortions are considered. Of these, the attenuation distortion and the curvature of characteristics in the train of transmission have practically no effect [thanks to the inclusion of amplitude limitation, as regards the former, and to the smallness of Ω_m with respect to Ω_o, as regards the latter], while curvature of the modulation characteristic brings new problems only if strong phase distortions occur. This type of distortion leads to non-linear effects. The influence of phase distortion is therefore examined more closely in the third part of the paper. It is found that the 'klirr' [non-linear distortion] spectra in frequency modulation are derived from the corresponding amplitude-modulation spectra by distorting these in proportion to the frequency and multiplying them by the reducing factor $\omega_o T_o$, where ω_o is the middle frequency of the transmitted band and T_o the duration of transmission of the phase-distorting network.

"Certain 'klirr' spectra of the second and third degree are calculated. In the fourth part of the paper the calculated results are checked by measurements, for which a new, very distortion-free circuit for the demodulation of frequency-modulated escillations was employed [patent applied for: Fig. 18, and 'M_2' in the equipment lay-out of Fig. 12: amplitude changes in an oscillatory circuit, not the phase deviations, are utilised, the demodulated oscillations being taken, after amplification, to a frequency analyser working on the exploring-note principle]. The measured results show that the approximation used for the calculation of the non-linear disturbances is sufficiently accurate for practical requirements."

81. Detection in Frequency-Modulation Receivers.—W. Weiss. (*Communications*, March 1941, Vol. 21, No. 3, pp. 16 and 18.)

82. A Signal Generator for Frequency Modulation [Special Requirements of S.G. for testing F.M. Receivers].—Barber & others. (*See* 179.)

83. Frequency Modulation Receivers, *and* An Amplitude-Modulation/Frequency-Modulation Broadcast Tuner.—M. L. Levy: S. G. Taylor. (*Communications*, March 1941, Vol. 21, No. 3, pp. 5–7: pp. 10–11 and 24..26.)

84. On the Action of Various Screenings and Gaps in Screening in Concentric Cables [including Screening of Sparking-Plug Interference].—Schäffer & Viehmann. (*See* 104.)

85. High-Voltage Bushings designed to meet Modern Service [including Avoidance of Radio Interference].—T. F. Brandt & H. L. Rorden. (*Elec. Engineering*, June 1941, Vol. 60, No. 6, Transactions pp. 255–260.)

86. Preselection in Inexpensive Broadcast Receivers [Tuned R.F. Stage made possible in Fifteen-Dollar Receiver by Development of New Three-Gang Condenser & Circuit: Comparisons of ENSI].—E. B. Passow. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 50 and 95.) From Zenith Radio. For "ENSI" *see* 3050 of 1941.

87. Superheterodyne Tracking Charts [Modifications to Two-Point Tracking Analysis lead to Formulae suitable for Slide-Rule Computations: Charts for Correction Factor].—A. L. Green. (*A.W.A. Tech. Review*, 1st Feb. 1941, Vol. 5, No. 3, pp. 77–91.)

88. Additive [Decade-Type] Frequency Scales for a Circuit tuned by a Variable Condenser [Analysis, with Experimental Confirmation, of Scale-Alignment to give Such Scales, enabling Wide Frequency Band to be covered by Single Direct-Reading Scale & a Range Switch: for Receivers, Frequency-Meters, etc.].—G. Builder. (*A.W.A. Tech. Review*, 1st June 1941, Vol. 5, No. 4, pp. 145–154.)

"Such devices are attractive to the designer in that, for a given degree of reading accuracy of the frequency scale, the mechanical design of the tuning mechanism is much simplified by the restricted frequency coverage on each of the tuning ranges. Against this, it is obvious that the total frequency range covered by any single instrument is, in practice, severely restricted by the number of tuning ranges required; but it is doubtful whether this restriction is always a serious limitation to the designer. Certainly in the increasingly important field of ultra-high frequencies, in which a large number of communication channels may be accommodated within a band of low frequency-ratio, the restriction is of little importance". The results of the investigation are "simpler than one might have expected."

89. A Remote-Control System [New Automatic System for Receivers and Transmitters].—M. Yardeny. (*Communications*, March 1941, Vol. 21, No. 3, pp. 14–15.)

90. Producing Communications Receivers [Hallicrafters System].—S. G. Taylor. (*Communications*, May 1941, Vol. 21, No. 5, pp. 22–24 and 26,)

91. Receivers for the Tropics [Review of Present Unsatisfactory Situation, and Suggestions].—W. E. Stewart. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 28 and 66.) From an engineer living in Panama.

92. Powdered-Iron Cores and Tuning Units [Use of Permeability Tuning to save Aluminium].—(*Communications*, Sept. 1941, Vol. 21, No. 9, p. 26.)

93. Priorities—What Effect on the Radio Industry? *and* Priorities and the Engineer.—(*See* 251.)

94. Measuring the Public Taste ["Audimeter" Recording Unit attached to Tuning-Condenser Shaft].—(*Electronics*, March 1941, Vol. 14, No. 3, p. 29.) Used by the Nielson Radio Index.

95. Under-Trained Service-Men [Suggested Reason & Cure].—J. H. Webb. (*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 292.) Prompted by the July Editorial.

AERIALS AND AERIAL SYSTEMS

96. Hollow Pipes of Relatively Small Dimensions.—W. L. Barrow & H. Schaevitz. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 119–122.) *See* 757 of 1941, where the second writer's name is mis-spelt.

97. Losses in Feeders [for Short & Ultra-Short Waves].—Ya. N. Feld. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 10, 1940, pp. 706–714.)

Formulae sufficiently simplified for practical use are derived for determining the loss resistance in the following cases :—(a) two-wire transmission line using wires of different diameters (Fig. 1) : the proximity effect is taken into account (7) : (b) a wire parallel to an infinite plane ; loss resistances in the wire and the plane are given by (8) and (9) respectively : (c) a symmetrical two-wire transmission line (10) : (d) as (c) but enclosed in a rectangular shield (Fig. 3) ; loss resistance in the shield due to the current in one of the wires (23) : and (e) a ribbon conductor ; the edge effect is taken into account (27).

98. Antennas for Frequency-Modulation Reception [on Frequencies around 45 Mc/s : including Noise-Reducing Dipole & Transmission-Line Systems for F.M. & A.M. Reception].—J. G. Aceves. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 42–45.)

99. Antennas and Transmission Lines at the Empire State Television Station.— N. E. Lindenblad. (*Communications*, April & May 1941, Vol. 21, Nos. 4 & 5, pp. 10–14 and 24 . . 26 : pp. 9–13 and 31 . . 33.) For the first part of this series *see* 3837 of 1940 : *see* also 2759 of 1939.

100. $1\frac{1}{4}$ m Signals improved from Inaudibility to S5 by Square-Corner Reflector System (with One Director) and Use of Horizontal Polarisation.—A. Winchell. (*QST*, Aug. 1941, Vol. 25, No. 8, pp. 38–39.) *See* Kraus, 389 of 1941.

101. Notes on Ultra-High-Frequency Antenna Heights [with Chart of Optical & Radio Lines-of-Sight (Latter on Assumption that Refraction Effect increases Earth's Radius by Factor 4/3)].—W. J. Stiles, Jr. (*QST*, July 1941, Vol. 25, No. 7, pp. 38–39.)

102. *Electronics* Data Sheets on Aerials and Transmission Lines.—(*See* 311.)

103. Nomogram for Inductance of Two Parallel Wires [Feeders, Connections].—T. S. E. Thomas. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 5–6.)

104. On the Action of Various Screenings and Gaps in Screening in Concentric Cables. —H. Schäffer & H. Viehmann. (*E.N.T.* March 1941, Vol. 18, No. 3, pp. 39–45.)

The screening action of any screen is generally taken to be the ratio of the field strength at a point outside the space to be screened to the field strength at the same point when the screen has been introduced. For concentric lines this ratio can only be obtained by assuming, for the case of the unscreened conductor, an infinitely distant return lead. Such an assumption is not permissible in practice, and a better measure for the screening action is given by taking the ratio of the electric field strength outside the screening to the current flowing through the inner conductor and back along the outer. This ratio has the dimension of a resistance per unit length, and in wide-band-cable technique is called the " coupling resistance " : it contains the attenuation of the electromagnetic field in the screening conductor (skin effect), and has the advantage that it can easily be measured and that it depends only on the frequency and on the construction of the screening conductor, whereas in the other case the spacing between the two conductors is also involved. Droste (4134 of 1936) has also used, as a measure of the screening action, the ratio of the longitudinal electric field strength on the outer side of the screening to that on the inner side, but this method is not so practical since it fails for braided screening, as is shown in the present paper (Section 5).

Taking, then, the " coupling resistance " as the measure of the screening action, the writer investigates both theoretically and experimentally the action of a braided-wire outer conductor (of copper, aluminium of various gauges and braidings, and a material designated " Legal I "), with particular reference to the variation with frequency (10^5–10^7 c/s). For five out of the seven samples taken, the measured " coupling resistance " first decreases slightly with increasing frequency (curves II and III of Fig. 6) and then increases as the square root of the frequency : over about 3 Mc/s it rises sharply, but this is merely a resonance effect in the measuring equipment, depending on the length of the test sample. This square-root behaviour is explained with the help of Fig. 7. The entirely different behaviour of a copper tube conductor is seen in curve I (different ordinate scale, on left). The quite anomalous behaviour of braidings 5 and 7 (table 1, and curve IV of Fig. 6) is discussed : no explanation can yet be found. Thus braiding 5, at around 1 Mc/s, has a lower " coupling resistance", and therefore a better screening action, than the copper braiding of curve I, although it has fewer wires, less optical " covering ", and higher d.c. resistivity. Practical interference tests on sparking-plug leads (Fig. 8) confirm this unexpected result. At the end of this section the effect of a broken or imperfectly gripped wire is discussed : it is only a small one.

In Section 4 the effect of transverse gaps in the screening is examined : they are likely to occur in the screening of spark-plug systems. It is found, unexpectedly, that between 10^4 and 10^5 c/s a tube with a gap gives a lower " coupling resistance " than a continuous tube : this result is explained.

105. A 3.5 Mc/s Fishing-Rod Aerial for Emergencies [Space-Wound over Top 14 ft & Close-Wound for 3 ft: Telephone Communication, with 40 W Input, from South California to East Coast].—V. C. Edgar. (*QST*, July 1941, Vol. 25, No. 7, p. 41.) *Cf.* 1892 of 1941.

106. Adjusting Rotary-Antenna Elements by Remote Control [Pulley-Operated Threaded Shaft lengthens or shortens the Elements].—H. K. Hentz. (*QST*, July 1941, Vol. 25, No. 7, p. 40.)

VALVES AND THERMIONICS

107. Theory of the Magnetron: I [Inaccuracy of Previous Treatments neglecting Space Charge or Effect (on Space Charge) of Magnetic Field: Impracticability of Solutions hitherto obtained when These Omissions have Not been made: Complete Calculation of Space Charge & Potential Distributions: Importance of Critical Distance L ($L^2 = eI/m\omega^3_H$, where ω_H is Larmor's Angular Velocity), and the Rôle played by Frequencies of Order of $\sqrt{2}\,.\,\omega_H$ (Internal Negative Resistance: Motion unconnected with Rotational Frequency ω): etc.].—L. Brillouin. (*Phys. Review*, 1st Sept. 1941, Vol. 60, No. 5, pp. 385–396.)

108. On a New Type of Ultra-Short-Wave Generator with Phase Focusing: II.—Lüdi. (*See* 57.)

109. Graphical Determination of Electron Transit Times in Homogeneous Electric Oscillating Fields.—M. Geiger. (*Hochf: tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, pp. 157–158: summary, from *Telefunken-Röhre*, No. 19/20, 1941, p. 109 onwards.)

In connection with velocity-modulated valves: for previous work *see* 1639 of 1941. Most previous treatments of the problem of calculating these transit times assume only small alternating voltages compared with the electron-accelerating voltage: the process now described will deal with any desired alternating voltage. Space-charge effects are not taken into account. Eqn. 3′ is obtained, suitable for graphical treatment: it is $2\theta_1^2/a_1 + \cos(\psi + \tau) = \cos\psi + (2\theta_1/a_1 - \sin\psi)\tau + \frac{1}{2}(b_1/a_1)\tau^2$. Here b_1 is $(U_2 - U_1)/U_1$, so that if, as in a klystron, the d.c. potentials of the two parallel plates with respect to the cathode are equal, b_1 disappears and with it the term containing τ^2. The solution of the equation is then given by the point of intersection of a cosine curve $c_3(\zeta) = 2\theta_1^2/a_1 + \cos\zeta$ with a straight line $g(\zeta) = \cos\psi + (2\theta_1/a_1 - \sin\psi)(\zeta - \psi)$. The necessary construction is described, and illustrated in Fig. 1 on the assumption of a modulation factor $a_1 = 1.28$ and a *static* transit-time angle $\theta = 1.6$.

In this particular case the electrons leave the modulating chamber in the same order as in entering—there is no "catching up". The writer examines the conditions as a_1 is increased, always keeping the path angle at $\theta = 1.6$. The first overtaking in the oscillating field ("phase focusing") occurs, for electrons entering the chamber at a time $\psi = \pi$, at a modulation $a_1 = 1.38$. As a_1 is increased still further, individual electrons are retarded in the oscillating field, then driven back; they then reverse and finally emerge ("first electron swinging"): in the nomogram (Fig. 1) this occurs when the straight line g is tangential to the curve c_3. The resulting transit-time "jump" gives the beginning of the reversal zone: its end is found from the velocity curve of the electrons (eqn. 2). Further increase of a_1 prevents some of the driven-back electrons from recovery and final emergence: they fly back to the plane of entry. When $a_1 = \pi$, an electron-return zone forms, for various entrance-phases, just after the zone of "straight-through" electrons.

In Fig. 2 the transit-time angle as a function of the entrance angle, for an oscillating chamber with $\theta = \pi/2$, is plotted for four different modulation factors from 1 to π. In the last curve the zone of returning electrons is shown by the broken portion of the curve.

Finally, it is pointed out that the method can be applied also when the two plates are not at the same d.c. potential, *i.e.* when b_1 is not zero: in this case a parabola must be superposed on the straight line g.

110. The New Miniature Ultra-High-Frequency Receiving Tubes [Type 9001–2–3, Single-Ended] in a 56– and 112–Mc/s Converter.—G. Grammer. (*QST*, Sept. 1941, Vol. 25, No. 9, pp. 18–22 and 80 .. 84.)

111. High-Frequency Probe Measurements in Mercury-Vapour Arcs, at $10^5 - 6 \times 10^7$ Cycles/Second.—G. Sichling. (*Ann. der Physik*, 19th Sept. 1941, Vol. 40, No. 4/5, pp. 330–366.)

The a.c. resistance of high-vacuum valves has already been thoroughly investigated at high and ultra-high frequencies by Müller, Strutt & van der Ziel, and others: Hasselbeck's paper (1932 Abstracts, p. 399) is mentioned as including a good survey of such work. In contrast, the investigation of the a.c. resistances of gaseous-discharge tubes with hot cathodes has been neglected. Such tubes have recently increased their importance considerably, especially since it has been possible to control them by grids, not only during the extinction period but also during the discharge, so that they can now be applied to power amplification. For proper matching to the external circuits it is necessary, as with high-vacuum valves, to know the values of their input and output resistances. In addition to these practical objects, experiments with probes are calculated to provide information on the physics of gaseous discharges. Small probes, unlike large grids, leave the discharge practically undisturbed, and many complications due to the controlling action of the grids are thus avoided. Previous researches on the a.c. resistance of gaseous discharges (such as those of Hasselbeck, *loc. cit.*) have been mostly in connection with ionospheric research, and their results are difficult to compare with the writer's, because their frequencies were generally higher (over 10^8 c/s) and their plasma densities very different from his. Actually Gerber (1935 Abstracts, p. 113) found values, for a high-pressure arc, between 5 and 15 ohms, which agree in order of magnitude with the writer's values with the probe at about the plasma potential. Schäfer's work (341 of 1941) is also mentioned, and another worker referred to is Fetz (*see* 2548/9 of 1940).

The present paper begins with a theoretical investigation. Previous researches have always assumed a homogeneous plasma, but the writer's experience has shown that measurements give the resistance of the homogeneous plasma only if the grid or probe is about at the plasma potential: if it is negative to the plasma, the resistance measured is that of the Langmuir layer formed in front of the probe, whether the latter is inside the plasma (as here) or in the form of an external coating to the glass wall. This phenomenon is first considered: the electrons are driven off, and a layer of positive ions forms in front of grid, screens the grid field from the discharge, and finally reduces to zero the field strength at the boundary of the layer. If the grid potential is changed, the layer boundary takes up a new position where again the field strength is zero. The mechanism of this "pendulum" motion is analysed by an extension, contributed by Schumann, of Müller's technique for high vacua (1933 Abstracts, pp. 443–444). The converse process is then treated—formation of a negative electron-layer at the probe surface when the probe is made positive with respect to the cathode, and passes the plasma potential. As the frequency is increased, the ions at the layer boundary can no longer follow the a.c. field, and in the limit can be considered as stationary: the capacitance is then the geometrical capacitance given by the layer thickness. The ratio of the capacitances of the electron and ion layers is given by eqn. 11, and under the experimental conditions comes out at 0.7.

Finally, the condition is considered when, during the transition of the probe potential from negative to positive, and before the plasma potential is passed, an intermediate condition between positive and negative layers is reached: that is, a positive-ion layer with some intruding electrons—those above a certain velocity. Agreement between theory (eqn. 16) and experiment indicates that the ohmic resistance can be considered as located chiefly in the probe layer. Experiment, however, shows the presence also of an inductive component, and the rejection of other alternatives (p. 342) leads to the conclusion that this arises in the plasma itself: not as an electro-magnetic effect but as a hysteresis-type phenomenon. Ionosphere research is here brought in: the "quasi-elastic forces" mechanism is rejected as improbable in the frequency range considered, and application is made of the Eccles-Salpeter theory to calculate the resistance and inductance of the plasma.

The experimental work gave good agreement at all points with the theoretical conclusions: the a.c. potentials applied were kept so small that they did not affect the form of discharge.

112. NEW, SENSITIVE, AND INEXPENSIVE GAS CONTROL TUBES [Hot-Cathode Tetrodes RCA–2050 & 2051, for Control of Power up to 65 Watts].—W. E. Bahls & C. H. Thomas. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 33–37 and 94.) For previous reference *see* 4279 of 1940, and for industrial applications *see* 2000 of 1941.

113. ELECTROBALLISTIC MEASURING METHOD FOR THE CONSTRUCTION OF ELECTRON PATHS IN A ROTATIONALLY SYMMETRICAL MAGNETIC FIELD.—Sándor. (*See* 201.)

114. AN EXPERIMENTAL DUO-PENTODE [Shielding Design gives Interaction Factors below 1%, providing Great Flexibility in A.F. & R.F. Operation (Cascading at R.F., Mixing, etc.): Other Advantages: Possible Application to Gaseous Multiple-Unit Valves].—M. K. Goldstein. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 34–36.)

115. REPLACING A TRIODE-PENTODE: HEPTODE AS A SUBSTITUTE.—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 291.)

116. POSITIVE AND NEGATIVE THERMIONIC EMISSION FROM MOLYBDENUM [Measurement of Electron & Positive-Ion Work Functions: Comparison with Theory].—R. W. Wright. (*Phys. Review*, 15th Sept. 1941, Vol. 60, No. 6, pp. 465–467.)

117. IMPROVED METHOD OF PREPARING MAGNESIUM-ALLOY SECONDARY ELECTRON EMISSIVE ELECTRODES FOR ELECTRON MULTIPLIERS.—V. K. Zworykin & others. (*Sci. News Letter*, 13th Sept. 1941, Vol. 40, No. 11, p. 169.) Note on U.S. Patent 2 233 276: the electrodes work satisfactorily even at high temperatures.

118. SECONDARY ELECTRON EMISSION FROM MgO.—E. Nishibori, H. Kawamura, & K. Hirano. (*Proc. Phys-Math. Soc. Japan*, July 1941, Vol. 23, No. 7, p. 570: in English.)

"The δ of this surface [MgO layer of thickness about 10^{-5} cm] . . . decreases from about 11 to 5 (at $V_p = 400$ volts) as the surface temperature is raised from 50° to 300°, contradicting the results of Schnitger [2718 of 1941]". At room temperature the surface was found to be charged up to about 50 volts: this p.d. decreased when the temperature was increased, and changed with the s.e. current according to the relation $\log i = BE$, where i is the s.e. current minus the primary electron current and E the p.d. between surface and base. "We can thus conclude that E and δ decrease simultaneously with the decrease of electric resistance of the layer due to temperature rise." As stated by Nelson (3171 of 1939), "the high δ of MgO is the result of the pulling-out of secondary electrons created in the layer by the strong electric field."

119. TRACING TUBE CHARACTERISTICS ON A CATHODE-RAY OSCILLOGRAPH [Technique (using D.C. Coupled Amplifiers with Equal Phase Shifts, giving Accurate Tracing) permitting High Current & Voltage Values without Damage].—J. Millman & S. Moskowitz. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 36–39.)

120. MANUFACTURE OF THERMIONIC VALVES [Fluctuations in Contact Potential with Different Grades of Purity of Cathode & Grid Material: Geometrical Arrangement of the Elements: Details of Processes: etc.].—A. Schleimann-Jensen. (*Sci. Abstracts*, Sec. B, Sept. 1941, Vol. 44, No. 525, p. 182.)

121. TESTING AND TEST EQUIPMENT IN TRANSMITTING-VALVE MANUFACTURE [Design Tests (Degree of Vacuum: Cathode Emission: Additional Design Tests): Production Tests: Life Tests].—D. M. Sutherland. (*A.W.A. Tech. Review*, 1st Sept. 1941, Vol. 5, No. 5, pp. 199–216.)

DIRECTIONAL WIRELESS

122. METHOD OF DETERMINING THE DISTANCE OF A RECEIVER FROM A TRANSMITTER [based on Fact that with Ultra-Short Waves, and with All Horizontally Polarised Waves, the Field Strength increases Sinusoidally with Height, from Zero at the Ground].—W. Runge. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, p. 164: D.R.P. 700 283, assigned to Telefunken.)

123. TWO NEW METHODS OF GAUGING THE ALTITUDE OF AIRPLANES [Simple Short-Wave Frequency-Change Method, with "Altitude" Knob turned till Zero Beat is obtained: Phase-Indicator Method, using Wavelength longer than Distance to be Measured (in One Form, Altitude as well as Distance from Ground Station is given by Same Receiver)].—E. F. W. Alexanderson: H. T. Budenbom. (*Sci. News Letter*, 26th July 1941, Vol. 40, No. 4, p. 52: *Science*, 25th July 1941, Vol. 94, Supp. pp. 9–10) Assigned to General Electric and Bell Telephone Laboratories, respectively.

124. AUTOMATIC CONTROL OF AIRCRAFT [by Combination of Automatic Pilot, Radio Compass, U.H.F. Marker Beacon, Altitude-Control Apparatus, Power-Control Device, & Coordinating System].—C. D. Barbulesco. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, pp. 122–126.)

ACOUSTICS AND AUDIO-FREQUENCIES

125. DETECTING TRAPPED PERSONS [after Air Raids: St. Pancras Emergency Committee's Initiative with Sound-Amplifying Apparatus].—(*Elec. Review*, 10th Oct. 1941, Vol. 129, p. 363.)

126. TWENTY-THIRD [Washington], TWENTY-FOURTH [Chicago], AND TWENTY-FIFTH [Rochester] MEETINGS OF THE ACOUSTICAL SOCIETY OF AMERICA: SUMMARIES OF PAPERS.—(*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 461–469 & 470–476: July 1941, Vol. 13, No. 1, pp. 80–88.)

127. SYMPOSIUM ON THE STEREOPHONIC SOUND-FILM SYSTEM BY THE BELL TELEPHONE LABORATORIES.—(*See* 126, above: 25th Meeting.)

128. THE CONTROL OF ACOUSTIC CONDITIONS ON THE CONCERT STAGE ["Robeson Technique"], *and* THEATRICAL USES OF THE REMADE VOICE, SUBSONICS, AND REVERBERATION CONTROL [Successful Use of Vocoder: Subsonics Effective in Suitable Case: Reverberation Control (by Steel-Tape Recording: 3388 of 1941), in Widor's "Toccata in *F*", received Enthusiastically].—H. Burris-Meyer. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 335–337: July 1941, Vol. 13, No. 1, pp. 16–19.) For other work by the same writer *see* 3390 of 1941.

129. THE INFLUENCE OF CERTAIN ATMOSPHERIC CONDITIONS UPON SOUND TRANSMISSION AT SHORT RANGES [Derivation of Formula giving Sound Intensity as Function of Temperature, Humidity, & Barometric Pressure: Experimental Confirmation].—H. V. Eagleson. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 427–435.) *Cf.* Sieg, 3379 of 1941.

130. THEORY OF CONICAL SOUND RADIATORS [for More Exact Treatment of the Directly Radiating Loudspeaker Diaphragm: Axially Symmetrical Non-Rigidity taken into Account: Comparison with Plane Piston].—W. N. Brown, Jr. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 20–22.)

131. HYPEX HORNS [Family of Horns, based on Recent Investigation of Plane-Wave Infinite-Horn Theory, to replace Exponential Type: for Loudspeakers, Sound-Ranging Devices, etc.].—V. Salmon. (*Electronics*, July 1941, Vol. 14, No. 7, pp. 34–35.) *See* also photograph in *Communications*, June 1941, p. 21.

132. CRYSTAL ELEMENTS [Development and Applications of "Bimorph" Rochelle-Salt Crystals].—Williams & Duffield. (*See* 351.)

133. UNIPHASE UNIDIRECTIONAL MICROPHONES [Diaphragm-Type Piezoelectric Microphone, & Moving-Coil Microphone, Each giving Cardioid Diagram with help of "Uniphase" Structure (Phase-Shifting Network)].—B. B. Bauer. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 41–45.)

134. MICROPHONE COMBINATION INSENSITIVE TO NOISE AND ACOUSTIC RETROACTION [Opposed Microphones each with Kidney-Shaped Characteristic].—S. Sawade. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, p. 165: D.R.P. 701 141, assigned to Telefunken.)

135. METHOD OF MICROPHONE PICK-UP FOR MOVING AND/OR EXTENSIVE SOUND SOURCES [by Formation of a Reduced Image of the Actual Room (by a Reflector) and Suitable Distribution of Microphones in This].—H. Benecke. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, p. 164: D.R.P. 700 646, assigned to Telefunken.)

136. FREQUENCY-RESPONSE CURVE TRACER [for Microphones, Receivers, Filters, etc: A.F. Generator with Frequency varied Logarithmically, and C.R. Oscilloscope with Logarithmic Sweep Voltage].—S. F. Carlisle, Jr., & A. B. Mundel. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 22–23.)

137. A Ruler for Record Patterns [for Quick Interpretation of Diffraction Pattern (Buchmann & Meyer Principle: *see* 1099 of 1941) in testing Over-All Frequency Response].—D. R. King. (*Electronics*, May 1941, Vol. 14, No. 5, p. 47.)

138. Standards for Electrical Transcriptions [Present Complete Lack of Standardisation: NAB Committee Meeting].—H. A. Chinn. (*Communications*, Sept. 1941, Vol. 21, No. 9, pp. 10–11 and 33.)

139. Variable Equaliser Amplifier [for Maximum Fidelity, in Recorded Broadcasting, consistent with Recording Characteristics & Signal/Noise Ratio of Record Material].—H. Rahmel. (*Electronics*, July 1941, Vol. 14, No. 7, pp. 26–29 and 61.)

140. Electronic Interlocking for Intercommunicators [Automatic Prevention of Howling from Acoustic Feedback: Normal Conversation without Switching].—H. J. McCreary. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 30–32.)

141. Parliamentary Sound System [Argentine Chamber of Deputies].—S. D. Wilburn & S. C. Tenac. (*Communications*, April 1941, Vol. 21, No. 4, pp. 15–16 and 32.) Arising out of the work dealt with in 3059 of 1940.

142. Possibility of Fuller Utilisation of Submarine Cables, by Local Analysis of Speech, Transmission of Corresponding Signals, and Automatic Speech Reconstruction [Suggestion prompted by Vocoder Developments].—W. G. Radley. (*Electrician*, 31st Oct. 1941, Vol. 127, p. 257.) In an address on "Future Telecommunications."

143. The Solovox.—F. D. Merrill, Jr: L. Hammond. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 30–32.) "For less than two hundred dollars." *See* 115 of 1941.

144. Musical Theory in Retrospect [including the Prime Importance of the Subjective Response of Ear & Brain, Ignorance of which led the "Theoreticians" astray].—Ll. S. Lloyd. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 56–62.)

145. "The Voice, Its Production and Reproduction" [Book Review].—D. Stanley & J. P. Maxfield. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 70–71.)

146. Averaging Decibel Measurements [with Graphs].—M. Rettinger. (*Communications*, July 1941, Vol. 21, No. 7, pp. 11–12.)

147. Electronics in Auditory Research [with Descriptions of Instruments used for Diagnosis, etc: from an Otological Research Laboratory].—D. M. Speaker. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 38–41 and 92, 93.)

148. Method of Measuring Audio-Frequencies [particularly in Studies of Pitch: Inadequacy of Commercial Instruments: Technique for Rapid, Accurate, & Wide-Range Measurement].—D. Lewis & P. E. Griffith. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 412–414.)

149. Sound-Level Meter Performance [and the Reasons for Lack of Agreement in spite of Conformity with ASA Requirements].—J. E. Tweeddale. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 421–426.)

150. The Acoustic Wattmeter, an Instrument for measuring Sound-Energy Flow [Combination of Crystal Pressure & Miniature Ribbon Velocity Microphones with Thermocouple-Type A.F. Wattmeter].—C. W. Clapp & F. A. Firestone. (*Journ. Acous. Soc. Am.*, Oct. 1941, Vol. 13, No. 2, pp. 124–136.)

151. Absolute Sound-Pressure Measurements with Tourmalin [Thin Disc suspended by Fine, Very Flexible Electrodes].—L. J. Sivian. (*See* 126, above: 23rd Meeting.)

152. Apparatus for Measuring the Total Sound Power radiated by Small Sources [Integration over a Sphere], *and* A Method of Measuring the Total Output of Speakers [analogous to Globe Photometer].—R. L. Hanson & E. M. Boardman: D. B. Green. (*See* 126, above: 23rd Meeting.)

153. The Analysis of Pulses by Means of the Harmonic Analyser [for Study of Amplifiers, Musical Instruments, etc: Applicable to Other Problems involving Evaluation of Fourier Integral].—R. S. Shankland. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 383–386.)

154. A Portable Beat-Frequency Oscillator [30–13 000 c/s, Output constant within 1 db: Max. Output 200 mW into 600-Ohm Load].—J. B. Rudd. (*A.W.A. Tech. Review*, 1st Sept. 1941, Vol. 5, No. 5, pp. 171–179.) Uniform with the portable c.r. oscillograph and the portable modulated oscillator, 198 and 180, below.

155. The Approximate Calculation of the Electric Field and Capacitance for Some Simple Forms of Telephone Cable.—H. Meinke. (*E.N.T.*, May 1941, Vol. 18, No. 5, pp. 118–120.) Supplement to previous papers (2447 of 1941), prompted partly by comments by Sommer (3287 of 1941).

156. Elastic-Wave Filtration in Non-Homogeneous Media [Analysis on Assumption of *Gradual* Transition: Stratified Medium passes All Frequencies in Absence of Discontinuous Change in either Acoustical Properties or Their Gradients].—R. B. Lindsay. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 378–382.)

157. Plane Waves in Ideal Gases with Friction and Heat Conduction.—K. Bechert. (*Ann. der Physik*, 30th Aug. 1941, Vol. 40, No. 3, pp. 207–248.) For previous work *see* 2991 of 1941.

158. Observations on the Effects of Sound and Supersonic Waves on the Protein of the Tobacco-Mosaic Virus [with help of Electron-Microscope].—G. A. Kausche & others. (*Naturwiss.*, 19th Sept. 1941, Vol. 29, No. 38, pp. 573–574.)

159. University of California Work on H.F. Sound Generation [9.3 kc/s] and the Lethal Effects on Bacteria, etc.—A. P. Krueger. (*Science*, 5th Sept. 1941, Vol. 94, Supp. p. 12.)

PHOTOTELEGRAPHY AND TELEVISION

160. Groundwork laid for Commercial Television [Account of F.C.C. Hearing (with Evidence of Many Witnesses) in March 1941]. —(*Electronics*, April 1941, Vol. 14, No. 4, pp. 18–19 and 70..80.)

161. Audio and Video on a Single Carrier [Sound Programme transmitted by Frequency Modulation during Synchronising Pulses: Limit is 7875 c/s for 525-Line 30-Frame Picture: Higher Frequencies if Line Frequency is Increased, as is necessary for Colour Television].—H. E. Kallmann. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 39–42.) From Scophony, New York.

162. Photographic Analysis of Television Images [with Miniature Camera: Two Methods (using Densitometer & Table of Negative Densities from Fluorescent Light: using Calibrated Photographic "Step-Tablet")].—D. G. Fink. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 24–29.) *See* also 3412 of 1941.

163. A Simple Television Pre-Amplifier [for improving Signal Strength & Signal/Noise Ratio in "Twilight Zone" or where Long Transmission Lines are necessary from Aerial].—R. Muniz & A. Tait. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 39–41 and 103, 104.)

164. Antennas and Transmission Lines at the Empire State Television Station.—Lindenblad. (*See* 99.)

165. On the Action of Various Screenings and Gaps in Screening in Concentric Cables. —Schäffer & Viehmann. (*See* 104.)

166. Coaxial Cable Attenuation Measurements at 300 Megacycles.—Race & Larrick. (*See* 175.)

167. Picture Transmission by Submarine Cable [and the London/New York Cablephoto Service].—J. W. Milnor. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 105–108.)

168. The Filter Arrangements of a Receiver for Picture and Teleprinter Radio Systems [" Impulse " Method, Berlin/Buenos Aires].—Hudec. (*See* 50.)

169. Facsimile Design Chart [for Mechanical Part of Scanning Unit].—R. R. Haugh. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 45–46.)

170. Facsimile speeds Air Reconnaissance.—Finch Telecommunications. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 30–31: photographs & captions.)

171. On the Emission from Antimony-Caesium Cathodes.—N. D. Morgulis & B. I. Dyatlovitskaya. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 10, 1940, pp. 657–670.)

The primary as well as secondary electron emission from antimony-caesium photocells was investigated experimentally. For primary emission two types of photocell (Fig. 1) were experimented with. The effect of the emitter temperature T on the photocurrent was studied (Figs. 2 and 3). The "most debatable" question of volt-ampere characteristics was thoroughly investigated under various conditions (Figs. 4–14) and definite conclusions were reached. The fatigue of the cells (hardly noticeable) is illustrated by a curve in Fig. 15.

Cells with one stage of secondary-electron amplification of the primary photocurrent (photodynatrons) were used in the investigation of secondary-electron emission. The effects of the primary-electron energy V_p (from about 100 v to nearly 1500 v), emitter temperature T, and primary photocurrent I_p on δ are represented by curves in Figs. 16, 18, and 19 respectively. The efficiency of secondary emission is indicated by the curves in Fig. 17. The absence of the Dember effect (Borzyak, 2260 of 1940) is proved by the curves in Fig. 20. No signs of the fatigue of the photodynatrons was observed during 4 hours operation (Fig. 22). Finally, the physical structure of the photocathodes, and the processes taking place in them during emission, are discussed. For a letter from Morgulis, criticising certain statements in a new paper by Khlebnikov in the *Journal of Physico-Mathematical Reports*, see pp. 683–684.

172. Photoelectric Alloys of Alkali Metals [and in particular the Exceptional Properties of $SbCs_3$ Alloy (at Optimum Wavelength of 4600 A.U., One Electron emitted for Five Incident Quanta): Effect of Superficial Oxidation in Increasing the Sensitivity to Longer Wavelengths: etc.].—A. Sommer. (*Nature*, 18th Oct. 1941, Vol. 148, p. 468.)

Further development of Görlich's work (1545 of 1938 & back references [for later work *see* 3695 of 1938, and 3054 & 3093 of 1941 and back references]). "The alloys of the $SbCs_3$ type can therefore be regarded as semiconductors. They represent border-line cases between metallic alloys and ionic crystals . . . From theoretical considerations one would expect that a semiconductor with low surface work function, as represented by the $SbCs_3$ alloy, would be a good photoelectric emitter. But to explain the exceptional properties of the $SbCs_3$ alloy, as compared with the other alloys of the same type, the structure of these alloys would have to be investigated in more detail."

173. On Our Knowledge of the Barrier-Layer Photoeffect [New Observations on CdS & CdSe show Electrons passing from Illuminated Electrode into Semiconductor, against Previous Assumptions and sup-

porting Crystal-Rectifier Boundary-Layer Theory: Difficulty of Complete Absence of Rectification in Thallium Sulphide: etc.].—F. Eckart & B. Gudden. (*Naturwiss.*, 19th Sept. 1941, Vol. 29, No. 38, p. 575.) A footnote adds that the writers had overlooked the results of Kolomiez (4489 of 1938 [for later work *see* 4062 of 1939]).

174. Formation of a Gas Layer on a Silver Surface [and the Suitability of the Farnsworth-Winch Technique for the Study of Adsorption Kinetics].—A. G. Emslie. (*Phys. Review*, 15th Sept. 1941, Vol. 60, No. 6, pp. 458–460.) *See* 1518 of 1940 and 2173 of 1941.

MEASUREMENTS AND STANDARDS

175. Coaxial Cable Attenuation Measurements at 300 Mc/s [Equipment for Measurements on Developmental & Production Lengths: Range 5–40 db with Accuracy within ± 5%, Frequencies 1–500 Mc/s].—H. H. Race & C. V. Larrick. (*Gen. Elec. Review*, Sept. 1941, Vol. 44, No. 9, pp. 507–510.)

176. A Rectangular Resonator used as a Wavemeter for Decimetric and Centimetric Waves.—V. I. Bunimovich. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 10, 1940, pp. 633–639.)

It is pointed out that the interference method would present too many difficulties in measuring decimetric and centimetric waves, while the resonance method is not sufficiently accurate, mainly owing to the comparatively high attenuation of ordinary resonators such as a Lecher system. A new wavemeter is therefore proposed, using a resonator in the shape of a hollow rectangular parallelepiped, the effective length of which is regulated by a piston moving inside it (Fig. 1). Using the conclusions reached in a previous investigation (1380 of 1940), the theory of the resonator is discussed, and methods are indicated for determining the dimensions for obtaining the desired degree of accuracy in regulating the wavelength ($\Delta\lambda/\lambda$ of the order of 0.0006% at $\lambda = 18$ cm). The calibration of the wavemeter is also discussed and a description of two experimental models given. *See* also 65, above.

177. A Sensitive Frequency Meter for the 30 to 340 Mc/s Range [Absorption Type: Coupling to Resonance Indicator (Wide Flat Silicon Wedge with Phosphor-Bronze Spring, Microammeter) by Straight Wire near Current-Carrying Condenser Shaft].—E. L. Hall. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 37–38 and 91..93.) From the National Bureau of Standards.

178. Measurements on Frequency-Modulated Transmitters [Special Techniques to meet Rigid F.C.C. Requirements: Frequency Deviation, Audio Quality, Amount of Amplitude Modulation, etc: Power Measurements: Field Surveys].—H. P. Thomas. (*Electronics*, May & July 1941, Vol. 14, Nos. 5 & 7, pp. 23–27 & 36–39.) From the General Electric Company.

179. A Signal Generator for Frequency Modulation [Special Requirements of S.G. for testing F.M. Superheterodynes: 75 kc/s Frequency Deviation obtained, without Distortion, by beating Variable-Frequency Unmodulated Oscillator against Fixed F.M. Oscillator].—A. W. Barber, C. J. Franks, & A. G. Richardson. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 36–38 and 92..95.) From the Boonton Radio Corporation.

180. A Portable Modulated Oscillator [Battery-Operated (Room for Mains Unit): 140 kc/s to 30 Mc/s in Six Bands: with Piston (Capacitance-Variation) Attenuator calibrated in Microvolts (Characteristics negligibly different at Ends of Complete Range: Robust Design): etc.].—H. L. Downing. (*A.W.A. Tech. Review*, 1st June 1941, Vol. 5, No. 4, pp. 165–169.)

181. A High-Frequency Beat-Method Signal Generator for Frequencies up to 5 Megacycles per Second.—H. Nitsche & H. Reich. (*Hochf:tech. u. Elek:akus.*, July 1941, Vol. 58, No. 1, pp. 1–8.)

From the Rohde & Schwarz laboratories (*cf.* 3449 of 1941). "The most valuable application of this signal generator depends on its wide consecutive range of frequencies: namely measurements on wide-band transmission systems and components. The special qualities of the heterodyne method makes the generator particularly suitable for the production of small voltages. With back-coupled generators the screening of the magnetic field of the oscillatory-circuit coil, in particular, requires great care. This difficulty is completely absent here. Since in the whole apparatus no voltages at the working frequency occur which are higher than that at the anode of the output valve, the demands on screening are light. Moreover, with the method of adjusting the amplitude of the output signal here adopted, this anode a.c. voltage need be no higher than is necessary for the feeding of the associated voltage-divider [the choice of this method is discussed in subsection a on p. 7, where the objections to alternative methods are given. The selected way is based on the fact (curves of Figs. 9 c & d) that there is a linear relation between the beat-frequency voltage at the mixing-valve anode and each of its two alternating grid voltages: these relations are made use of for amplitude adjustment and for modulation]. Fig. 10 shows the signal generator in conjunction with a calibrated voltage-divider. Such a combination forms a complete receiver-testing signal generator. The frequency constancy—the drift is less than 800 c/s per hour—is good enough, also, for the investigation of receivers with very narrow band widths."

The frequency range is 10 kc/s to 5 Mc/s: the adjustable output voltage has a maximum of 10 volts. The constancy of the output voltage over the range of frequencies is ± 15%: the matching resistance is 150 ohms: external modulation is up to 100 kc/s. The paper begins by discussing, in turn, the problems of the choice of the beating frequencies (and which should be the higher, the fixed or the variable) from the viewpoint of frequency constancy and of whistle points: of non-linear distortion, its causes and reduction: and, in particular, of the design of the mixing stage and its two separating amplifiers.

182. An Inexpensive Square-Wave Generator [for Amplifier Testing: Simple & Portable.]—C. W. Goodwin. (*Science*, 26th Sept. 1941, Vol. 94, p. 309.)

183. A Continuously Visible Frequency Indicator for a Broadcast R.F. Monitor [using a Vibrating-Reed Meter, or Substitute made from Gramophone Pick-Up].—L. S. Bookwalter. (*Communications*, July 1941, Vol. 21, No. 7, pp. 7 and 26, 27.)

184. A Direct-Reading Field-Intensity Meter [Type 308-A: Range 20 μV/m to 10 V/m, Frequencies 120 kc/s to 18 Mc/s: Direct Reading by adjusting Continuously Variable Attenuator to give Fixed Reading on Output Meter].—J. P. Taylor. (*Communications*, June 1941, Vol. 21, No. 6, pp. 5–6 and 24 . . 26.)

185. Characteristic Impedance of Lines [Measurement by Ganged Impedance Bridge (A.F. Lines only) and Three-Voltage Method (A.F. & R.F. Lines): Both give Magnitude & Angle].—P. K. Hudson. (*Communications*, Feb. 1941, Vol. 21, No. 2, pp. 7 and 30.)

186. The Measurement of Distributed Capacity and Pure Inductance at Radio Frequencies [with Accuracy equal to That of Calibrated Condenser, by Use of Latter and Standard Broadcast Receiver with A.V.C.].—J. E. Willson. (*Communications*, June 1941, Vol. 21, No. 6, pp. 16 and 24.)

187. Optimum *Q* and Impedance of R.F. Inductors: Design Charts for Solenoids and Toroids [Circular & Rectangular Cross-Sections for Toroids: Effect of Platings of Various Depths & Materials (including "Recent Unjustifiable Use of Tinning"): Allowance for Dielectric & Other Losses: etc.].—R. S. Naslund. (*QST*, July 1941, Vol. 25, No. 7, pp. 28–31 and 62 . . 66.)

188. Lord Hankey's Appeal for Multi-Range Meters, especially Avometers and Avominors, for Service Training Purposes.—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 287.)

189. Additive [Decade-Type] Frequency Scales for a Circuit tuned by a Variable Condenser.—Builder. (*See* 88.)

190. Bridged Tee Pads [with Advantages of Tee Pad over Other Attenuators [Perfect Impedance Matching, Zero Minimum Insertion Loss, etc.) but with Only Two Rheostats].—A. Preisman. (*Communications*, Feb. 1941, Vol. 21, No. 2, pp. 5–6 and 22.)

191. Testing and Performance of Volt Boxes [Resistance Potential Dividers for extending Range of Potentiometers].—F. B. Silsbee & F. J. Gross. (*Journ. of Res. of Nat. Bur. of Stds.*, Sept. 1941, Vol. 27, No. 3, pp. 269–287.)

192. A Pentode Lock-in Amplifier of High Frequency Selectivity [as Detector for Bridges, etc.].—Michels & Curtis. (*See* 43.)

193. Peak and Null Indicating Circuit [for the "Sharpening-Up" of Maxima & Minima, in Detection of Null Points of Bridges, etc.].—Hofstadter & Schiff. (*See* 44.)

194. Visual Null Indication [Null Indicators now the "Weakest Link in the Chain": a Four-Valve Detector eliminating Drawbacks of Vibration Galvanometer].—C. F. Brockelsby. (*Elec. Review*, 18th July 1941, Vol. 128, pp. 829–830.)

195. The Detection of Initial Failure in High-Voltage Insulation, *and* High-Potential Testing Equipment for Quantity Production.—J. B. Whitehead & M. R. Shaw, Jr: C. M. Summers. (*Elec. Engineering*, June 1941, Vol. 60, No. 6, Transactions pp. 267–272: pp. 289–292.) Previews were dealt with in 1140 & 1141 of 1941.

196. Stratosphere Chamber [Testing Chamber for reproducing Sub-Stratospheric Conditions].—J. H. Burges. (*Communications*, July 1941, Vol. 21, No. 7, pp. 8–10 and 12.)

SUBSIDIARY APPARATUS AND MATERIALS

197. Correction to "Decimetric-Wave Oscillography" [Scale of Reproduction was given Wrongly].—Ganswindt & Pieplow. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, p. 155.) *See* 2198 of 1941.

198. A Portable Cathode-Ray Oscillograph [weighing 25 lb: for 200–260 V Mains: R.C.A. Type 902 Two-Inch Tube: Time-Base Frequencies 40 c/s to 40 kc/s].—Richardson. (*A.W.A. Tech. Review*, 1st Feb. 1941, Vol. 5, No. 3, pp. 119–124.)

199. An Electron Microscope for Practical Laboratory Service.—Zworykin & others. (*Elec. Engineering*, April 1941, Vol. 60, No. 4, Transactions pp. 157–162.) A preview was dealt with in 1173 of 1941.

200. From Microscope to Super-Microscope [Survey of German Work on Shadow, Raster, Electrostatic, & Magnetic Types, with Photographs of Some Results].—Brüche. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Feb. 1941, Vol. 7, No. 2, pp. 46–54.) With 8 literature references.

201. Electroballistic Measuring Method for the Construction of Electron Paths in a Rotationally Symmetrical Magnetic Field: II—Ballistic Measuring Apparatus for the Plotting of the Magnetic Field Function: III—Measurements and Their Development.—Sándor. (*Arch. f. Elektrot.*, 29th May 1941, Vol. 35, No. 5, pp. 259–287.)

Part I (3123 of 1941) dealt with the need for, and the theoretical foundations of, this method. The actual apparatus is shown in Fig. 5, and the complete equipment, with ballistic galvanometer, is seen diagrammatically in Fig. 4. The example taken is an iron-cased magnetic lens with asymmetrically situated gaps (Fig. 6), used as a projecting lens for an electron-microscope.

202. FOR WHAT ELECTROMAGNETIC FIELDS IS THE NEWTONIAN IMAGE-FORMATION EQUATION VALID ?—Glaser & Lammel. (*Ann. der Physik*, 19th Sept. 1941, Vol. 40, No. 4/5, pp. 367–384.)

The Newtonian equation of ordinary optics, $ZZ_1 = ff_1$, is known to be valid for "weak" electron lenses (where the focal points lie in a region free from field): in "the most important application of electron-optics, electron-microscopy," however, the object is always in a region of strong field strength, and the question arises whether the equation also applies to "not-weak" fields. The writer has shown (2205 of 1941) that a magnetic lens with a particular field form produces an image formation according to the equation in question: the object of the present work is to determine *all* electric and magnetic "not-weak" fields by this equation. The necessary and sufficient condition for this, and the corresponding electron paths, are given on p. 381. The image formation given by such fields has the property that it is completely known, for all desired points, when it has been found for three points.

203. ON THE OPTICAL-ELECTRICAL PROPERTIES OF LENARD PHOSPHORS: I—THE DIELECTRIC-CONSTANT EFFECT.—Wesch. (*Ann. der Physik*, 19th Sept. 1941, Vol. 40, No. 4/5, pp. 249–294.)

An experimental investigation leading to the following conclusions, among others:—All Lenard phosphors *increase* their basic dielectric constants on illumination by light of any wavelength. They all *alter* them on irradiation by cathode rays and "high-frequency" rays (X-rays), some phosphors showing only a steady decrease in dielectric constant (Fig. 7) while others (Fig. 6) show a decrease at first and then an increase towards a steady value a long way above the original value, to which however they soon return when the irradiation is cut off: while the Hausser phosphor CaS-Cuγ gave an increase only, a specially high one (Fig. 11). The varying behaviour in this respect depends directly on the absorption bands of the phosphor (Schmidt's five "absorption edge" series, p. 267). Measurements of the dispersion curves (variation of dielectric-constant effect with test frequency, up to over 6.4 Mc/s) for ZnS,CdS phosphors showed that this dispersion is dependent on the persistence of the centres (pp. 273–276).

All ZnS/CdS phosphors consist of a mixture of dielectric-constant-raising and dielectric-constant-lowering centres, differing in their ionic states. The *magnitude* of the dielectric-constant variation is determined by the crystal structure and state of combination of the activator: a large increase can only occur in a system in which the activator atom enters into the crystal lattice with a linkage intermediate between homopolar and heteropolar, such as in base materials possessing crystal-transition forms, particularly twinning. "The investigation of the dielectric constant and its dispersion, in phosphors, presents a new possibility for research on the composition of light centres" (*see* also Rüffler, 2517 of 1941: and *cf.* Bergmann & Ronge, 2516, and Lappe, 3415, both of 1941).

204. TWIN-TRIODE CIRCUIT FOR COUPLING TIME-BASE VOLTAGE TO TIME-BASE AMPLIFIER [avoiding Disadvantages of Usual Resistance-Capacitance Coupling (Introduction of Distorting Discharge-Path for Sweep Voltage, etc.)].—Goldberg. (In paper dealt with in 340, below.)

205. A THREE-PHASE ELECTROCARDIOGRAPH MIXING CIRCUIT [for Simultaneous Use of All Three Body-Leads with C.R.O. having only Two Pairs of Plates].—Jordan. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, pp. 449–450.) Suggested by the circuits used to change three-phase a.c. into two-phase.

206. THE SUITABILITY OF RESISTANCE-CAPACITANCE-COUPLED AMPLIFIERS FOR THE AMPLIFICATION OF DIRECT-CURRENT PULSES [for Relays, Counters, etc.].—Köhler. (*See* 42.)

207. A SIMPLE QUICK-ACTING VACUUM LOCK [for Introduction of Successive Targets into Beta-Ray Spectrograph].—Delsasso & Creutz. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, p. 450.)

208. NUMBER OF QUANTA REQUIRED TO FORM THE PHOTOGRAPHIC LATENT IMAGE, AS DETERMINED FROM MATHEMATICAL ANALYSIS OF THE H AND D CURVE: PART II.—Webb (*Journ. Opt. Soc. Am.*, Sept. 1941, Vol. 31, No. 9, pp. 559–569.) For previous work *see* 2802 of 1941.

209. COMPARISON OF GRAININESS AND SPEEDS OF DIFFERENT TYPES OF PHOTOGRAPHIC FILMS—Barthel. (*Journ. Opt. Soc. Am.*, Aug. 1941, Vol. 31, No. 8, pp. 513–520.)

210. NEW ION SOURCES [Survey].—Korsching. (*Physik. Zeitschr.*, March 1941, Vol. 42, No. 4/5, pp. 74–79.) With 15 literature references.

211. HIGH-VOLTAGE ELECTROSTATIC GENERATORS [Survey, with 83 Literature References].—Hochberg. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 177–198.) For previous work *see* 4459 of 1940.

212. AUTOMATIC FREQUENCY CONTROL FOR A CYCLOTRON [Discriminator Circuit compensating for Reactance Changes due to Thermal Effects].—Jacques. (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, pp. 442–444.)

213. VOLTAGE STABILISERS AND MAGNET-CURRENT STABILISER FOR A MASS SPECTROMETER FOR ISOTOPE ANALYSIS.—Brown & others (*Review Scient. Instr.*, Sept. 1941, Vol. 12, No. 9, pp. 435–441.)

214. MAINS VOLTAGE STABILISERS: SUGGESTIONS WHICH HAVE APPEARED IN FOREIGN JOURNALS [Iron-Core Saturation Methods].—Denco. (*Electrician*, 22nd Aug. 1941, Vol. 127, pp. 106–107.) For a letter from the Westinghouse Company see *ibid.*, 10th Sept. 1941, p. 168.

215. Alkaline Type C.E.M.F. Cells [for reducing Discharge Voltage during Charging of Main Batteries: to withstand Momentary Short-Circuits & to be free from Storage Action].—Catt. (*P.O. Elec. Eng. Journ.*, April 1941, Vol. 34, Part 1, pp. 9–11.)

216. Applications of Electric Power in Aircraft [Important Present & Future Needs, including the Reduction of Radio Interference & the Advantages of replacing the D.C. Generator by a Variable-Speed Alternator with Rectifier].—Holliday. (*Elec. Engineering*, May 1941, Vol. 60, No. 5, pp. 218–225.)

217. Electronic Inverter for Interim Power Supply [to bridge Gap between Failure of Commercial Power & Starting-Up of Emergency Generator: for Coaxial (Type L) Carrier System].—Trucksess. (*Bell Lab. Record*, July 1941, Vol. 19, No. 11, pp. 338–341.)

218. A Mobile Battery Supply Unit for Laboratory and Workshop Use [Voltages up to 24 V, Current up to 8000 A].—Armour. (*Journ. of Scient. Instr.*, Sept. 1941, Vol. 18, No. 9, pp. 184–188.)

219. Governing Small Motors: Speed Control of Universal Machines.—Philpott. (*Elec. Review*, 11th April 1941, Vol. 128, pp. 539–540.)

220. Some Characteristics and Applications of Negative-Glow Lamps.—Fett: Ferree. (*Elec. Engineering*, May 1941, Vol. 60, No. 5, p. 244.) The writer gives some applications not mentioned by Ferree (1186 of 1941).

221. Development of the Glow-Switch [primarily for starting Fluorescent Lamps].—Hays. (*Elec. Engineering*, May 1941, Vol. 60, No. 5, Transactions pp. 223–226.) *See* also 4041 of 1940 and 2527 of 1941 (Dench).

222. Water-Cooled Resistors for Ultra-High Frequencies [Coaxial Design, for Television Transmitters, etc.].—Brown & Conklin. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 24–28 and 104..108.) Including theoretical treatment for the determination of design constants.

223. Dielectric Constants of the Order of 420 obtained with Phosphors under Illumination: Inertia-less Light Modulation at 10 kc/s.—Wesch. (In paper dealt with in 203, above.) Only Rutil and Rochelle salt possess values of this order (not affected by light).

224. Plastics in Radio and National Defence.—Winner. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 16 and 30..32.)

225. Dielectric Losses in Insulators with Gap Spacings.—Kanonykin. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 10, 1940, pp. 715–724.)

Discharges through an air gap between two glass plates were investigated experimentally. Measurements were made at a frequency of 50 c/s, and a number of the resulting curves are plotted, including the volt-ampere characteristics of the discharge (Fig. 6). A theoretical interpretation of the results obtained is given, and certain general statements regarding dielectric losses in hard insulators containing one or several gap spacings are formulated. The shape of the curve tan $\delta = f(U)$, where U is the voltage applied to the insulator, is discussed: eqn. 18 is derived for the practical extrapolation of the curve beyond U_m at which the curve passes through a maximum. It is pointed out that the appearance of this maximum is *not* due to a radical change in volt-ampere characteristics, as is generally supposed, and a different explanation is offered.

226. A Comparative Study of Electrical and Mechanical Relaxation Times.—Ponomarev. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 10, 1940, pp. 588–593.)

An experimental study leading to proposals for the classification of the dielectric properties of polymeric substances from the standpoint of the relaxation of the dipole bonds of the polymeric molecule. Measurements were made of the loss angles of rubber, after different periods of vulcanisation, and of methyl methacrylate resin, at frequencies of the order of 10^3 and 10^6 c/s and at temperatures varying from -80 to $+180°$ C. A comparison is made between the numerical values of electrical and mechanical relaxation times. It appears that for small amplitudes the two times coincide, while with increasing amplitude the mechanical relaxation time is greatly increased.

227. Ceramic High-Frequency Insulators: Recent Developments Reviewed: Electrical and Mechanical Design Considerations.—Rosenthal & Nickless. (*Wireless World*, Nov. 1941, Vol. 47, No. 11, pp 281–284.) *See* also 3520 of 1941.

228. Electrical Glass Insulation ["Lewcoglass" Wires].—(*Journ. of Scient. Instr.*, Oct. 1941, Vol. 18, No. 10, pp. 206–207.) *See* also 3582 of 1940.

229. Fibre-Glass Adhesive Tape.—(*Elec. Engineering*, June 1941, Vol. 60, No. 6, Advt. p. 24.)

230. Electro-Deposition of Silver Surfaces (as Basis for Metallisation) on Mica, Moulded Plastics, etc.—Hepburn. (*Elec. Review*, 6th June 1941, Vol. 128, p. 710.) Note on paper at meeting of the Electro-Depositors' Technical Society. *Cf.* 3152 of 1941.

231. Investigations on the Corrosive Action of Layered Cellulose Insulating Material with Synthetic-Resin Binder [Hartpapier].—Spitzer. (*E.N.T.*, Dec. 1940, Vol. 17, No. 12, pp. 269–274.)

Insulation resistance deteriorates under action of moisture and heat: these factors produce electrolytic changes in the prolonged presence of a d.c. potential, leading to corrosion of metallic parts in contact with the insulator: etc.

232. On the Dielectric Strength of Mixed Crystals [Quantitative Calculation of Increase of Breakdown Strength of Ionic Crystals due to Admixture of Foreign Atoms: etc.].—Fröhlich. (*Proc. Roy. Soc.*, Ser. A, 15th Aug. 1941, Vol. 178, No. 975, pp. 493–498.)

233. D.C. Breakdown Strength of Air and of Freon in a Uniform Field at High Pressures.—Trump & others. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 132–135.) A summary was dealt with in 881 of 1941.

234. The Electric Strength of Air at High Pressure: II.—Skilling & Brenner. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 112–115.) For I *see* 3741 of 1939. A preview of II was referred to in 1197 of 1941.

235. Calculation of Initial Breakdown Voltages in Air [or Other Gases for which α and *N* are known].—Planck. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 99–104.). A summary was dealt with in 881 of 1941.

236. Optical Temperature Determinations on the High-Frequency Torch ["Fackel"] Discharge [Unusually Low Voltages (for Air at Normal Pressure), of a Few Thousands of Volts, of Torch Discharge in 10^7–10^8 c/s Oscillatory Circuit, & High Temperatures of the Flame Gases (over 4000° K in Innermost Zone): Deductions as to Ionisation & Electron Velocity].—Cristescu & Grigorovici. (*Naturwiss.*, 19th Sept. 1941, Vol. 29, No. 38, pp. 571–572.) *Cf.* Asami & others, 1196 & 4033 of 1940.

237. High-Frequency Probe Measurements in Mercury-Vapour Arcs, at $10^5 - 6 \times 10^7$ Cycles/Second.—Sichling. (*See* 111.)

238. Some Observations on Electrical Discharges from Pointed Conductors [Survey (including New Work by the Writer) with Sections on Geiger Counters & Effects of Artificial Ionisation].—Zeleny. (*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, pp. 23–37.)

239. Remark on the Theory of the Arc Discharge [Field Emission *versus* Thermal Volume Ionisation].—Seeliger. (*Physik. Zeitschr.*, March 1941, Vol. 42, No. 4/5, pp. 63–67.)

240. The Tearing-Off of Adsorbed Ions by High Electric Field Strengths [Electron-Microscopic Investigation].—Müller. (*Naturwiss.*, 29th Aug. 1941, Vol. 29, No. 35, pp. 533–534.)

From the Stabilovolt laboratories. Phenomena such as the luminous clusters at the anode in certain glow discharges, and particular forms of h.t. breakdown in high vacua, require for their explanation the assumption of the setting free of positive ions from the anode by the action of impinging electrons. Ion release by electron collision cannot be the cause and no "anode sputtering" effect is known, so that it seems probable that the release of the ions is a direct effect of a high electric field, perhaps similar to that occurring in the "spray" discharge (*see*, for example, Paetow, 2136 of 1941). Insulating particles must be present on the anode, and these must be so charged by the electrons as to yield field strengths of the order of 10^8 v/cm, presumably high enough to tear off the adsorbed ions The writer's field-emission electron-microscope (*see*, for example, 4119 of 1937) enabled the effect of field strengths of this order to be examined directly, without the insulating-particle mechanism being used for their production: even adsorption films of oxygen could be torn away.

241. Control of Mercury-Vapour Rectifiers [Manually Operated Methods giving Protection against Application of Anode Voltage when Cathodes are Cold].—Hall. (*E. & Television & S-W.W.*, April 1941, Vol. 14, No. 158, p. 182: summary only.)

242. Anode Spots in Oxygen [Glow-Discharge, at Sufficiently High Anode-Current Density: Reason for Absence in Previous Work].—Henderson & Rubens. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 213–214.)

243. Determination of Mercury-Arc Temperatures by X-Rays.—Kenty & Karash. (*Phys. Review*, 1st July 1941, Vol. 60, No. 1, p. 66: summary only.)

244. The V-Connection in Low-Power Rectifier Technique [and Its Advantages in reducing Ripple].—Stiassny. (*E.T.Z.*, 19th June 1941, Vol. 62, No. 25, pp. 576–578.)

245. On Our Knowledge of the Barrier-Layer Photoeffect [New Observations on CdS & CdSe].—Eckart & Gudden. (*See* 173.)

246. On the Amphoteric Behaviour of Lead Selenide as a Semiconductor [with Possible Important Deductions on "Surplus" & "Defect" Conduction, or alternatively on the Danger of Conclusions from Measurements of Thin Films & Compressed Powders].—Eckart & Raithel. (*Naturwiss.*, 19th Sept. 1941, Vol. 29, No. 38, pp. 572–573.) *See* Bauer & Hintenberger, 183, 1761 of 1941.

247. Selenium Rectifiers for Closely Regulated Voltages [within about 2%, by Bridge Connection and Regulating & Shunt Reactors: Design Calculations].—Yarmack. (*Electronics*, Aug. 1941, Vol. 14, pp. 46–49.)

248. Metal Rectifiers, *and* The Characteristics and Applications of the Selenium Rectifier.—Williams & Thompson: Richards. (*Journ. I.E.E.*, Oct. 1941, Vol. 88, Part I, No. 10, pp. 353–371: Oct. 1941, Vol. 88, Part II, No. 5, pp. 423–438: with Discussions.)

249. A Laboratory Method for the Production of Cuprous-Oxide Rectifiers.—Sharavski. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 10, 1940, pp. 671–678.)

It is pointed out that cuprous-oxide rectifiers for laboratory use can be prepared without much difficulty in the laboratory itself, but that no sufficiently comprehensive and up-to-date description of the manufacturing process is available in Russian technical literature. Accordingly, various stages of this process are described in detail under the following headings: (1) selection and preliminary treatment of material; (2) thermal treatment; (3) removal of cupric oxide and deposition of the upper electrode ; (4) artificial ageing ; (5) grading of rectifier plates and their connection into groups ; and (6) assembly of rectifiers.

250. Some Designs of Dry Rectifier Units for Charging, and Working with, Batteries.—Arvidsson. (*Sci. Abstracts*, Sec. B, July 1941, Vol. 44, No. 523, p. 126.)

251. Priorities—What Effect on the Radio Industry ? [Steps taken to meet Shortages in Aluminium, Tungsten, etc : Substitute Materials & Revised Practices], *and* Priorities and the Engineer.—(*Electronics*, May 1941, Vol. 14, No. 5, pp. 21–22 and 80, 82 : July 1941, No. 7, pp. 15–16.)

See also Aug. issue, pp. 24–29 and 96, 97 (Dudley) : and *Communications*, June & July 1941, pp. 12–14 & 18–19 and 25, 26 (Winner), *and* Sept., pp. 20–21 and 35 : *also* p. 27.

252. Beryllium-Cobalt-Copper Alloy [for Current-Carrying Parts, Diaphragms, etc.].—(*Journ. of Scient. Instr.*, Nov. 1941, Vol. 18, No. 11, p. 227.)

253. G.E.C. Heavy Alloy : Its Production, Properties, and Uses [50% Heavier than Lead, with Tensile Strength of Good Steel].—Price & others. (*G.E.C. Journal*, Aug. 1941, Vol. 11, No. 4, pp. 223–237.)

254. Alloys for Instruments.—Hudson. (*Journ. of Scient. Instr.*, Nov. 1941, Vol. 18, No. 11, pp. 211–216.)

255. The Diffusion of Oxygen in Copper [and the Embrittlement of Copper on Heating in Reducing Atmosphere].—Ransley. (*G.E.C. Journal*, Feb. 1941, Vol. 11, No. 3, p. 218 : summary only.)

256. Researches for Improved Solder Fluxes : Interim Report.—Peters & Gonser : Robinson. (*Electrician*, 29th Aug. 1941, Vol. 127, p. 120 : 12th Sept. 1941, p. 151.)

257. New Technique in Rapid Assembly [the Simmonds' Speed Nut].—(*E. & Television & S-W.W.*, March 1941, Vol. 14, No. 157, pp. 134–135.) To be known in future as "Spear Nuts" (*Wireless World*, Nov. 1941).

258. Reconditioning Instrument Jewels and Pivots.—(*Engineering*, 29th Aug. 1941, Vol. 152, p. 166.)

259. Eddy Currents in a Split Cylinder.—Efros. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 467–471.)

A mathematical investigation of the distribution of eddy currents and of the resulting losses in a solid or hollow cylinder with a split from the centre (or inner edge) to the surface of the cylinder. The discussion is applied to the cases when the base of a solid or hollow cylinder is reduced to a sector (Figs. 2 and 3 respectively).

260. Electro-Magnetic Systems in the Magnetic Field of which the Ponderomotive Force acting on the Grain decreases or remains Constant along its Direction.—Sochnev. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 472–477.)

In the magnetic fields of ordinary electromagnetic systems the ponderomotive force acting on a grain of the magnetic substance increases, the nearer it is to the pole. In this paper multi-pole electromagnetic systems with pole shoes of a special shape are considered which produce the effect described in the title. Practical applications of such systems are also indicated. Fereday's work (1931 Abstracts, p. 627) is referred to.

261. On the Question of the Definition of the Magnetic Moment and Magnetisation [Whether the Magnetic Moment should be defined as the Ratio of Torque to $\mathfrak{H}$ or to $\mathfrak{B}$: Theoretical Investigation of Conditions in Media of Different Permeabilities : Suggested Experimental Decision, & Its Effect on the Definition of Magnetisation].—Diesselhorst. (*E.T.Z.*, 29th May 1941, Vol. 62, No. 22, pp. 497–499.)

262. Thermal Treatment, in a Magnetic Field, of Alloys of High Coercive Force used for Permanent Magnets.—Shur. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 10, 1940, pp. 757–760.)

Experiments have shown that the residual magnetism and the maximum magnetic energy of an alloy can be raised by 10–18% and 15–35% respectively, without reducing the coercive force, by cooling down the alloy in a magnetic field of the order of 1000 oersteds.

263. Alternating Testing and Magnetic Properties [Bending Tests (giving Alternating Compression-Extension to Volume Elements) show Far-Reaching Analogy to A.C. Treatment].—Fink & Lange. (*Physik Zeitschr.*, April 1941, Vol. 42, No. 6, pp. 90–95.)

"What significance these experimental results may possess for the theory of ferromagnetism, and how far it is possible to predetermine the mechanical properties of a ferromagnetic material from magnetic measurements, must be found by further research."

264. Prolonged Testing [Alternating Torsion] and Magneto-Elastic Properties of Steels.—Mönch. (*Zeitschr. V.D.I.*, 2nd Aug. 1941, Vol. 85, No. 31, p. 675 : summary only.)

Experiments on the connection between such testing and the magnetic properties of steels have hitherto had little success, chiefly because the changes in the magnetisation curve produced by the strains are very small. The writer, however, has now found that the magneto-elasticity, that is, the amount by which the magnetic induction is altered by mechanical strain, undergoes very marked changes under prolonged testing when the "magneto-elastic critical strain" (a constant for any particular steel, determinable by a short test) is exceeded.

265. The Effect of Dislocations on Magnetisation near Saturation.—Brown. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, pp. 139–147.) For previous work *see* 2870 of 1941.

266. On the Dislocation Theory of Plastic Deformation.—Koehler. (*Phys. Review*, 1st Sept. 1941, Vol. 60, No. 5, pp. 397–410.)
"A further attempt to develop and to test the validity of dislocation theory": see Seitz & Read, 2235 of 1941, and Brown, 265, above.

267. On the Passage of Neutrons through Ferromagnets [and the Possibility of Investigating the Domain Structure by Tests with Partially Polarised Neutron Beams], *and* through Crystals and Polycrystals.—Halpern & others. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 960–981: pp. 981–996.)

STATIONS, DESIGN AND OPERATION

268. WSM's Relay Transmitter [Emergency 300 Mc/s Radio Link from Studio].—(*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 3–5.)

269. Emergency Radio Communication for an Electric Power System [Ultra-Short-Wave System of American Gas & Electric Organisation: Equipment: Results of Experience: Effect of Partial Change-Over to Frequency Modulation (Average Area about 80% More: under *No* Conditions Inferior: Less Maintenance: etc.)].—Langdon. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 40–43 and 82..87.)

270. Papers on Frequency Modulation: Interference, Distortion, etc.—Cherry & Rivlin, Goldman, Vellat, Hölzer, Weiss, & others. (*See* 77/83.)

271. Frequency-Modulation Broadcasting [with Bibliography, including Items from Periodical *FM*].—(*Communications*, March 1941, Vol. 21, No. 3, pp. 12–13 and 15, 26–28.)

272. The New Radio Freedom [Implications of Frequency Modulation, etc.].—Armstrong. (*Journ. Franklin Inst.*, Sept. 1941, Vol. 232, No. 3, pp. 213–216.)
"The social and political aspects are taking form, for by a combination of a curious property of the new system (the ability to reject the weaker of two signals on the same channel) and the propagation characteristics of a hitherto unused part of the radio spectrum . . . it becomes possible to set up many times the present number of broadcast stations . . ."

273. Operating Problems in Frequency-Modulation Transmitters [Location of Station: Aerial System: Transmitters: Measuring Equipment: Studio Problems: Studio-to-Transmitter Circuit: Field-Strength Contours].—Weir. (*Communications*, May & June 1941, Vol. 21, Nos. 5 & 6, pp. 5–8 and 33..35: pp. 7–11.)

274. High-Fidelity Non-Commercial Programmes to Special Subscribers from Frequency-Modulation Station, with Interfering Signal to restrict Reception.—Muzak Corporation. (*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 286.) *See* also *Electronics*, Aug. 1941, p. 17. The frequency is 117 Mc/s.

275. A Transmitter-Receiver Equipment for Small Aircraft [Total Weight 65 lb: Complete Remote Control].—Honnor & Mathieson. (*A.W.A. Tech. Review*, 1st Feb. 1941, Vol. 5, No. 3, pp. 105–118.)

276. A Portable Wireless Set for the Flying Doctor Services [Low-Power Crystal-Controlled Short-Wave Telegraphy Transmitter & Superheterodyne Receiver: Weight, with Batteries & Aerials, below 21 lb.].—Inglis. (*A.W.A. Tech. Review*, 1st Sept. 1941, Vol. 5, No. 5, pp. 193–198.)

277. Duplex 25-Watt Radio-Telephone with Privacy [for Non-Technical Users, with Occasional Maintenance & Adjustment by Technician: Crystal Control & A.V.C. at Transmitter & Receiver: Speech Inversion: etc.].—Richardson & Brown. (*A.W.A. Tech. Review*, 1st June 1941, Vol. 5, No. 4, pp. 125–143.)

278. Push-Button Switching for the Small Broadcaster.—Wood. (*Electronics*, May 1941, Vol. 14, No. 5, pp. 32–33.)

279. KCMO's 5 Kilowatt Transmitter [with Three-Element Directive Aerial switchable to Non-Directive Aerial for 1-Kilowatt Working: at Kansas City].—Sigmon. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 18–21.)

280. CBS goes to Latin America [Short-Wave Stations at Brentwood, Long Island, with Aerials for South America & West Indies and for Europe or Mexico & Central America].—Chamberlain. (*Electronics*, July 1941, Vol. 14, No. 7, pp. 30–33 and 70, 71.)

281. Planning Post-War Broadcasting: Should Long and Medium Waves be Scrapped?—Butt. (*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 285.)

282. The Montreux Plan [and the Absence of Any Frequency which is a Simple Multiple of 100 kc/s, useful for Laboratories].—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 292.)

283. The Mackay Radio and Telegraph Company Communication System.—Anderson. (*Elec. Communication*, No. 4, Vol. 19, 1941, pp. 81–85.)

GENERAL PHYSICAL ARTICLES

284. Non-Linear Equations of the Electromagnetic Field [Combination of Born & Infeld Field Theory and Whittaker's Theory].—Street. (*Proc. Nat. Acad. Sci.*, Aug. 1941, Vol. 27, No. 8, pp. 413–417.)
Giving "a very general set of field equations, which contain not only these two theories as special cases but also the older theories of Maxwell and Mie."

285. New Model of the Point Electron of Classical Theory [Electron reacts with Maxwellian Field & Scalar Field of Yukawa's Type].—Stueckelberg. (*Sci. Abstracts*, Sec. A, July 1941, Vol. 44, No. 523, p. 201.)

286. Charge and Mass of Electronic Particles [leading to " Reasonable Picture " of how the Charge is determined by Quantum Theory & Relativity].—Landé. (*Phys. Review*, 1st July 1941, Vol. 60, No. 1, p. 66 : summary only.) *See* also 2562 of 1941.

287. Absence of Electronic Raman Effect [Failure to Establish Effect in Atoms or Ions in Optical & X-Ray Regions].—Sibaiya. (*Phys. Review*, 15th Sept. 1941, Vol. 60, No. 6, p. 471.)

288. The Behaviour of Electrons in Oxygen.—Healey & Kirkpatrick. (*See* 15.)

289. The Velocity of Diffusion in a Mixed Gas : the Second Approximation.—Chapman & Cowling. (*Proc. Roy. Soc.*, Ser. A, 10th Oct. 1941, Vol. 179, No. 977, pp. 159–169.)

290. Forces and Atoms : the World of the Physicist.—Darrow. (*Bell S. Tech. Journ.*, July 1941, Vol. 20, No. 3, pp. 340–358.)

291. The Magnetic Current [Beam of Light causes or induces not only Heat & Electricity but also Magnetism : etc.].—Ehrenhaft : Focken. (*See* 18.)

292. Dielectric and Magnetic Media in the Electromagnetic Field [Extension of Modified Form of Maxwell's Theory (1799 of 1941)].—Kneissler-Maixdorf. (*Arch. f. Elektrot.*, 29th May 1941, Vol. 35, No. 5, pp. 307–316.)

293. A Relation between " Motional " and " Transformer " Induction.—Hatfield. (*Nature*, 16th Aug. 1941, Vol. 148, pp. 197–198.)

MISCELLANEOUS

294. A Five-Figure Table of the Bessel Function I_n (x).—Dwight. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 135–136.) A summary was dealt with in 694 of 1941.

295. A Construction Theorem for evaluating Operational Expressions having a Finite Number of Different Roots.—Cromwell. (*Elec. Communication*, June 1941, Vol. 60, No. 6, Transactions pp. 273–276.). A preview was referred to in 1239 of 1941.

296. Method of Finding the Equations of Curves [Simple Practical Method for Almost Any Form of Curve].—Barnes. (*Engineering*, 24th Oct. 1941, Vol. 152, p. 334.) For an alternative method *see* issue for 28th Nov. 1941, p. 434.

297. Probability Graph Paper and Its Engineering Applications.—Rissik. (*Engineer*, 24th & 31st Oct. 1941, Vol. 172, pp. 276–278 & 296–298.) For previous work *see* 625 of 1941.

298. The Varioplex—a New Development in Telegraphy.—Shute. (*Elec. Engineering*, April 1941, Vol. 60, No. 4, Transactions pp. 181–184.) *See* 1234 of 1941.

299. Total Security—a Challenge [Basis for Discussion & Action].—Wilson. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, pp. 99–105.) From the President, General Electric Company. For correspondence *see* May & June issues, pp. 242–244 & 308–309.

300. The Proposed Society for Freedom in Science.—Baker. (*Science*, 26th Sept. 1941, Vol. 94, pp. 304–305.)

301. Youth in Science [Editorial on the International Youth Rally for Victory and on the Conference on Science & World Order].—(*Nature*, 1st Nov. 1941, Vol. 148, pp. 511–513.)

302. Signal Corps Radio School [at Fort Monmouth].—(*QST*, Aug. 1941, Vol. 25, No. 8, pp. 9–11 and 49.)

303. Cathode-Ray Demonstration Panel [for Radio Instruction, Royal Canadian Air Force].—Patrick. (*Communications*, Sept. 1941, Vol. 21, No. 9, pp. 5–7 and 33, 34.)

304. Technicians in Industry : Planning Post-War Training : Absorbing Ex-Service Men.—Rosen. (*Wireless World*, Nov. 1941, Vol. 47, No. 11, pp. 279–280.) From the Chairman, R.M.A. Education Committee. For an Editorial *see* p. 275, and for correspondence *see* Dec. issue, pp. 318–319.

305. Radio Engineers' Qualifications [and Recent Police Proceedings].—Clifford. (*Elec. Review*, 17th Oct. 1941, Vol. 129, p. 395.) Letter from the Secretary of the British Institution of Radio Engineers, prompted by a news item and Editorial note in the issue for 3rd October. *See* also *Wireless World*, Nov. 1941, p. 286.

306. Research Workers and the Patent System : I—Should Inventions be Patented ?—Kapre. (*Current Science*, Bangalore, July 1941, Vol. 10, No. 7, pp. 319–322.)

307. " Industrial Research Laboratories of the United States " [Seventh Edition : Book Notice], *and* " Report on Industrial Research " [Importance of Research to Industry : an American Survey].—(*Journ. of Scient. Instr.*, Nov. 1941, Vol. 18, No. 11, pp. 227–228 : p. 230.)

308. Library *versus* Laboratory Research.—Connolly. (*Elec. Engineering*, May 1941, Vol. 60, No. 5, p. 217 : summary only.)

309. The Place of Microfilm Copying in Library Organisation.—Seidell. (*Science*, 1st Aug. 1941, Vol. 94, pp. 114–115.)

310. Report on I.R.E. Summer Convention, Detroit.—(*Electronics*, July 1941, Vol. 14, No. 7, pp. 21–25.) *See* also 3569 of 1941.

311. *Electronics* Reference Issue [Tables, Charts, & Formulae for Radio Communication, Standard Broadcasting, Frequency Modulation,

Television, Audio & Sound Systems, Industrial Uses of Valves, & Measurements].—(*Electronics*, June 1941, Vol. 14, No. 6, Insert pp. 33–64.)

312. DETECTION OF INCENDIARY BOMBS [Bulletin C.22 of Research & Experiments Department of Ministry of Home Security].—(*Electrician*, 7th Nov. 1941, Vol. 127, pp. 269–270.) Summary only. For the I.E.E. memorandum *see* 3563 of 1941.

313. THE CALCULATION OF THE DISTRIBUTION OF INDUCTION CURRENTS IN A PLATE, AND OF THE FIELD NEAR IT [with Application to Detection of Flaws].—Shilov. (*Journ. of Tech. Phys.* [in Russian], No. 9, Vol. 10, 1940, pp. 695–705.) For previous work *see* 1297 of 1940.

314. RADIO AT THE NATIONAL MODEL AIRPLANE MEET [Contest of Radio-Controlled Models: "Smoke-Writing" and a Radio-Controlled "Loop": etc.].—DeSoto. (*QST*, Sept. 1941, Vol. 25, No. 9, pp. 15–17 and 76, 78.)

315. SHELL "SEES" TARGET AND EXPLODES BEFORE IT STRIKES [Photocell picks up Reflected Radiation: particularly for Fire against Troops in Open].—Ferrel. (*Sci. News Letter*, 27th Sept. 1941, Vol. 40, No. 13, p. 199.) U.S. Patent 2 255 245.

316. READING MATTER FOR THE BLIND [Suggestion of Photoelectric Translator with Headphones) for Paper Rolls printed in Morse Code].—Turnbull. (*Elec. Review*, 29th Aug. 1941, Vol. 129, p. 154.)

For correspondence, including references to Fournier d'Albe's "Optophone" and later devices, *see* issues for 5th, 19th & 26th September. For these and other developments *see* Abstracts, 1930, p. 515: 1931, pp. 504 & 566: 1932, pp. 242, 422, 540, & 659: 1933, pp. 174 (two), 344, & 463: 1934, pp. 111 & 398: and 857 858 of 1936.

317. A PHYSICAL PHOTOMETER [with Thermopile as Non-Selective Receiver, Special Potentiometer, & Luminosity Filter].—Teele. (*Journ. of Res. of Nat. Bur. of Stds.*, Sept. 1941, Vol. 27, No. 3, pp. 217–228.)

318. A ROTATING DIFFERENTIAL PHOTOELECTRIC PHOTOMETER FOR PRECISION WORK [using Selenium Cells].—MacGregor-Morris & Stainsby. (*Proc. Phys. Soc.*, 1st Sept. 1941, Vol. 53, Part 5, No. 299, pp. 584–594.)

319. A SPECTROPHOTOMETER FOR MEASUREMENT OF OPTICAL FILTERS [primarily for Television Development.]—Seeley & Anderson. (*Review Scient. Instr.*, Aug. 1941, Vol. 12, No. 8, pp. 392–395.)

320. A PHOTOELECTRIC FLUORIMETER [Two Photocells in Null Circuit].—Lothian. (*Journ. of Scient. Instr.*, Oct. 1941, Vol. 18, No. 10, pp. 200–202.)

321. A BIBLIOGRAPHY RELATING TO BARRIER-LAYER PHOTOELECTRIC CELLS.—(*Science Library Bibliogr. Series*, No. 558, 1941, 3 pp.)

322. BLOCKING-LAYER-CELL COLOUR-TEMPERATURE PYROMETER.—Malpica. (*Gen. Elec. Review*, Aug. 1941, Vol. 44, No. 8, pp. 439–443.)

323. THE DRIFT OF THE SELENIUM BARRIER-LAYER PHOTOCELL.—Houstoun. (*See* 3433 of 1941.)

324. PHOTOCELLS IN INDUSTRY [with Some Data on a Few Types].—(*Elec. Review*, 18th July 1941, Vol. 128, pp. 831–832.)

325. PHOTOCELL MEASUREMENT OF THE PROTEIN CONTENT OF WHEAT.—U.S. Department of Agriculture. (*Journ. Franklin Inst.*, Sept. 1941, Vol. 232, No. 3, pp. 299–300.)

326. ELECTRONICS APPLIED TO PACKAGING MACHINERY.—Cornock. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 24–27 and 82.)

327. FIVE YEARS OF INDUSTRIAL ELECTRONICS: A PROGRESS REPORT [Protecting "Light Curtains", Temperature & Gap Control (in Sparking-Plug Manufacture), Rock-Salt Sorting, etc.).—Powers. (*Electronics*, July & Aug. 1941, Vol. 14, Nos. 7 & 8, pp. 17–20 and 89: pp. 33–36.)

328. ELECTRON TUBES IN PETROLEUM RESEARCH [Temperature Control, Viscosity Measurement, Indicator for I.C. Engines, etc.].—Penther & Pompeo. (*Electronics*, April & May 1941, Vol. 14, Nos. 4 & 5, pp. 20–23 & 43–46.) From the Shell Development Company.

329. PENETRATION OF FOG BY LIGHT FROM SODIUM AND TUNGSTEN LAMPS.—Luckiesh & Holladay. (*Journ. Opt. Soc. Am.*, Aug 1941, Vol. 31, No. 8, pp. 528–530.)

330. THREE-DIMENSIONAL PHOTOELASTICITY USING SCATTERED LIGHT.—Weller. (*Journ. Applied Phys.*, Aug. 1941, Vol. 12, No. 8, pp. 610–616.) For this method *see* 4786 of 1939. The present paper is in a special photoelasticity issue of the *Journal*.

331. PROPOSED STANDARD SOLAR-RADIATION CURVES FOR ENGINEERING USE.—Moon. (*Journ. Franklin Inst.*, Nov. 1940, Vol. 230, No. 5, pp. 583–617.)

332. PHOSPHORESCENCE AND ITS APPLICATIONS including the Use of the Infra-Red Quenching Effect].—Bowtell & Miles. (*G.E.C. Journal*, Aug. 1941, Vol. 11, No. 4, pp. 256–265.)

333. HEAT-RADIATION TELESCOPE AND MEASUREMENT OF INFRA-RED EMISSION OF THE ATMOSPHERE [Blackened Silver Disc & Thermocouple].—Elsasser. (*Sci. Abstracts*, Sec. A, Aug. 1941, Vol. 44, No. 524, p. 224.)

334. PHOTOGRAPHY IN THE INFRA-RED REGION OF THE SPECTRUM.—Mushkin. (*Journ. of Tech Phys.* [in Russian], No. 9, Vol. 10, 1940, pp. 771–778.)

The difficulties of focusing an infra-red camera are pointed out and a method is proposed for obviating them, based on the use of a photoelectron converter (Fig. 1), in which the image to be photographed is projected on an Ag-Cs_2O-Cs photocathode and the electrons so liberated produce a visible electron image on a silver anode covered with a layer of Zn_2SiO_4. For infra-red photography an infra-red filter is interposed between the image and the converter (Fig. 7). This method can also be used for a preliminary visual examination of documents for scientific and juridical purposes. The theory of the method is discussed, and a number of photographs of electron images taken with and without the infra-red filter are shown. Some other possible applications of the converter are also suggested.

335. PHOTOGRAPHY BY LUMINESCENT SCREENS IN THE EXTREME ULTRA-VIOLET [down to 230 A.U.].—Suga & Kamiyama. (*Journ. Opt. Soc. Am.*, Sept. 1941, Vol. 31, No. 9, pp. 592–593.)

336. DETERIORATION OF PHOTOGRAPHIC FILMS BEFORE DEVELOPMENT [Experiments showing that Cosmic Rays are Not a Major Factor].—Sproull. (*Journ. Applied Phys.*, Aug. 1941, Vol. 12, No. 8, p. 654.)

337. AN ELECTRONIC INTEGRATOR FOR COUNTING CIRCUIT CONTACTS [primarily for indicating Average Number of Relay Closures per Minute in Ultra-Violet Radiation Recorder, but applicable to Many Industrial Control Purposes].—Kenrick. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 33–35 and 74, 75.)

338. A NEW USE FOR X-RAYS IN INDUSTRY [Routine Inspection of Soldered Joints in Interior of Table Knives: Photographic or Visual Observation replaced by Pass-or-Reject Relay controlled by Ionisation of Air by the X-Rays].—Woods & Kenna. (*Electronics*, April 1941, Vol. 14, No. 4, pp. 29–31 and 89..91.)

"In continuous use for about a year with complete satisfaction," although the currents available are of the order of only 10^{-9} ampere.

339. PHYSIOLOGICAL EFFECTS OF ULTRA-SHORT-WAVE RADIATION.—(*Wireless World*, Nov. 1941, Vol. 47, No. 11, p. 293: letter.)

340. SYNCHRONISED VOLTAGES FOR BIOELECTRIC RESEARCH [for Action-Potential Impulses Too Short for Moving-Film as Time Base: Synchronised Stimulator & Time Base, for Double or Triple Recording].—Goldberg. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 30–32 and 82.)

341. AN A.C. OPERATED ELECTRONIC INDUCTORIUM [using Saw-Tooth Generator: Impulses 2–60 per Second].—Cullen. (*Science*, 29th Aug. 1941, Vol. 94, pp. 219–220.)

342. DESIGN CHART FOR R.F. HEAT-TREATMENT GENERATORS [for Condenser-Field Method: to avoid Disappointing Results due to Improper Coupling to Load].—Mittelman. (*Electronics*, Aug. 1941, Vol. 14, No. 8, pp. 51 and 52.)

Example: to determine the required voltage across 15″-square electrodes for a 70-ohm load to absorb 50 watts (at 6 m wavelength), with 1″ spacing on both sides.

343. MUSCULAR PARALYSIS CAUSED BY ELECTRIC CURRENTS [D.C. & up to 10 kc/s].—Dalziel & Lagen. (*Electronics*, March 1941, Vol. 14, No. 3, pp. 22–23.)

344. ELECTRON MICROSCOPES AND THEIR USES [with Photographic Examples].—Becker & Ahearn. (*Scientific Monthly*, Oct. 1941, pp. 309–324.)

345. OBSERVATIONS ON THE EFFECT OF SOUND AND SUPERSONIC WAVES ON THE PROTEIN OF THE TOBACCO-MOSAIC VIRUS [with help of Electron-Microscope]. — Kausche & others. (*Naturwiss.*, 19th Sept. 1941, Vol. 29, No. 38, pp. 573–574.)

346. A THREE-PHASE ELECTROCARDIOGRAPH MIXING CIRCUIT.—Jordan. (*See* 205.)

347. THE PRACTICAL VALUE OF RADIO-GEOLOGICAL INVESTIGATIONS. — Fritsch. (*Bull. Assoc. suisse des Élec.*, 20th June 1941, Vol. 32, No. 12, pp. 274–276: summary, in German, from *Funktech. Monatshefte*, No. 8, 1940, p. 117 onwards.)

348. EARTHING DEVICES TO WATER MAINS OR PIPES [Notice of Specification B.S. 951–1941].—British Standards Institution. (*Wireless Engineer*, May 1941, Vol. 18, No. 212, p. 197.)

349. SHOCK WAVES IN AIR, AND CHARACTERISTICS OF INSTRUMENTS FOR THEIR MEASUREMENT. —Thompson. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, p. 463.) From the Naval Proving Ground.

350. NOISE TREMOR DUE TO TRAFFIC, FROM AN ENGINEER'S POINT OF VIEW.—Bernhard. (*Journ. Acous. Soc. Am.*, Jan. 1941, Vol. 12, No. 3, pp. 338–347.)

351. CRYSTAL ELEMENTS [Development and Applications of "Bimorph" Rochelle-Salt Crystals for Acoustic & Industrial Purposes (Vibration, Pressure, Direct-Inking Oscillograph, etc.)].—Williams & Duffield. (*Communications*, Aug. 1941, Vol. 21, No. 8, pp. 8–10 and 34, 35.)

352. A GENERAL PURPOSE VIBRATION METER [with Piezoelectric Pick-Up: Range down to 2 c/s].—Scott. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 46–50.) General Radio Type 761-A.

353. BALL-BEARING NOISE AND VIBRATION [S.K.F. Investigations].—Buhl. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 51–53.)

354. A POWER-SYSTEM GOVERNOR SENSITIVE TO FREQUENCY AND LOAD [Balanced-Solenoid & Electronic System, primarily for Hydro-electric Generating Units].—Curtis. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 89–92.)

355. NEGATIVE DAMPING [Combination of Self-Excitation (produced by Series Capacitance in Armature Circuit) & Hunting] OF ELECTRICAL MACHINERY.—Concordia & Carter. (*Elec. Engineering*, March 1941, Vol. 60, No. 3, Transactions pp. 116–118.)