2/6

WIRELESS ENGINEER

The Journal of Radio Research & Progress

Vol. XXII. SEPTEMBER 1945 No. 264

CONTENTS

Published on the sixth of each month
SUBSCRIPTIONS (Home and Abroad)
One Year 32/- 6 months 16/-
Telephone: WATerloo 3333 (35 lines)
Telegrams: Experiwyr Sedist London

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

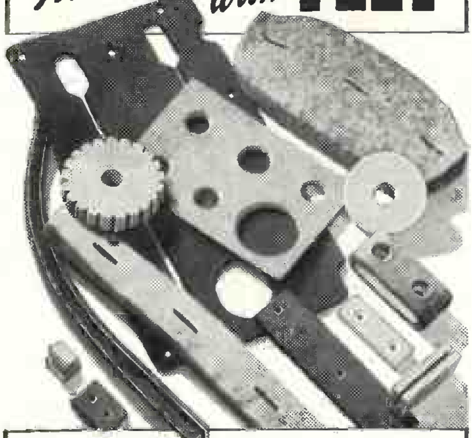
"OVER TO YOU"

FROM the skies to the tanks, from H.Q. to outpost "over to you" means comforting contact. Maybe just a routine "fix" for the navigator or, likely as not, vital instruction for a distant patrol. Millions of times a year the "over to you" has been spoken, and millions of times it has been Goodmans' equipment that responded. In every branch of the Services Goodmans' earphones, microphones and loudspeakers, as varied in their duties as in characteristics, play their part. In their designing and production has been builded vast new data and experience. With present tasks completed this enhanced knowledge will be applied to the no less formidable needs of peace. Goodmans eagerly and confidently await the "over to you."

GOODMANS
Loudspeakers

GOODMANS INDUSTRIES LTD. WEMBLEY. MIDDX.

Into Battle with FELT



Woollen & Hair Felts, Cloths. Furnishing, Mechanical, Surgical. Washers, Strips and Gaskets. Gas Meter Washers. Felt Cut and Turned. Waterproofing.

STERLING TEXTILE INDUSTRIES LTD.

STERLING WORKS, ALEXANDRA ROAD, PONDERS END
MIDDLESEX

'Phone: HOWARD 2214-5, 1755 'Grams: STERTEX, ENFIELD

MINIATURE or MIDGET

HIVAC LIMITED. Greenhill Crescent, Harrow on the Hill. Middx. Phone: HARROW 0895

C. R. Casson 7

BRITISH BSR THROUGHOUT

Standard Sine Wave Sources

TYPE LO.800A

This model is chosen as a Standard by most Departments.

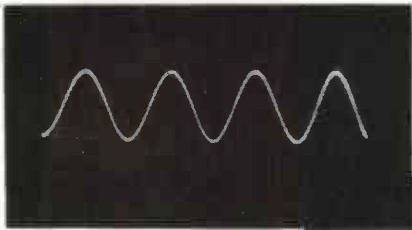
Stable, reliable and indispensable to all serious workers.

FREQUENCY RANGES (3 Models)
0–15,000 c.p.s.
0–25,000 c.p.s.
0–50,000 c.p.s.

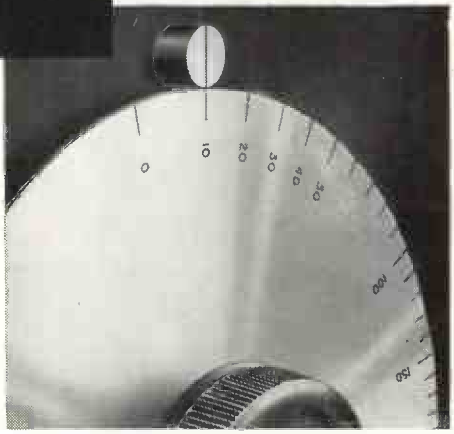
Three range Output Voltmeter incorporated—0–250, 0–50, and 0–10.

Four output impedances, 5,000, 1,000 600 and 15 ohms.

OUTPUT UP TO 5 WATTS.



10 CYCLES PER SECOND



TYPE LO.800A OSCILLATOR, a scale of which is illustrated together with an actual oscillogram of output voltage, gives good waveform even below 10 c.p.s. This necessitates a minimum "pull-in" between the two H.F. oscillators. Superlative design results in an almost perfect waveform from lowest to highest frequencies. Output voltage is constant to within a few per cent. over the frequency range.

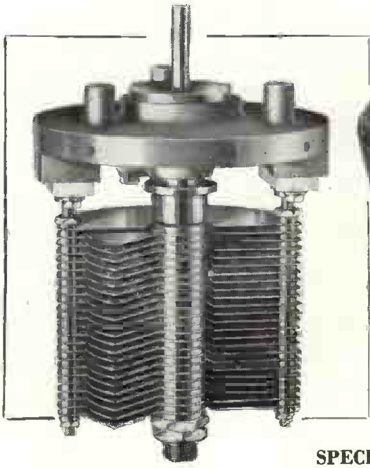
BIRMINGHAM SOUND REPRODUCERS LTD.,
CLAREMONT WORKS, OLD HILL, STAFFS.
'Phone: Cradley Heath 6212/3. 'Grams: Electronic, Old Hill.

VARIABLE AIR CONDENSER TYPE A-430

Our Type A-430 Variable Air Condensers have been standardised for many high-grade instruments, particularly when reasonable size and cost are important factors. Rugged construction, smooth even control and excellent electrical characteristics are reasons why these condensers are selected.

Type A-430 Condensers are supplied in metal boxes for bench use, or with cylindrical brass covers for panel mounting.

Bulletin B-236-B, giving full particulars of these instruments, will be supplied on request.



SPECIFICATION

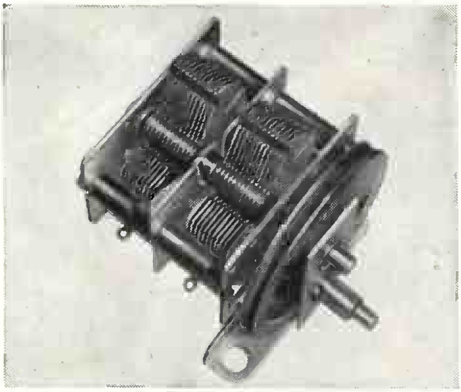
Main Casting. Gun Metal **Vanes.** Brass
Insulation. Frequentite **Bearing.** Large single cone
Drive. Direct, or 50 : 1 reduction—4½" silvered scale
Sizes. From 100 μμ F. to 1000 μμ F.

MUIRHEAD

MUIRHEAD & CO. LTD., ELMERS END, BECKENHAM, KENT.
TELEPHONE: BECKENHAM 0041-0042

FOR OVER 60 YEARS DESIGNERS & MAKERS OF PRECISION INSTRUMENTS

C.R.C.33



M.G.R.N. 1, 2 or 3 GANG CONDENSER

This is made in various capacities up to 540mmf. of Rigid construction, with smooth slow motion drive and with tropical finish. The Spindle is tapped 6 BA for attachment of pointer. An indicator can be driven by cord from the drum disc. Built in trimmers can be supplied if required.

REGISTERED TRADE MARK

JACKSON
BROS (LONDON) LIMITED
KINGSWAY · WADDON · SURREY
TELEPHONE: CROYDON 2754-5 TELEGRAMS: WALFILCO, PHONE, LONDON

LOOKING AHEAD

NOW is the time to start deciding who shall supply the Transformers and Chokes for your post-war product.

Why not let us have a rough idea of what you will want, and let us submit suggestions and prototypes ?

Installed in our new factory is the very latest in Coil Winding Machines, vacuum impregnating plant, test equipment, and everything necessary for the production of the finest transformers that are made.

Drop us a line and let us show you the latest developments. You are bound to be interested.

WODEN TRANSFORMER CO. LTD.
MOXLEY ROAD, BILSTON, STAFFS.
Telephone : BILSTON 41959-0

LARGE DEPT. FOR WIRELESS BOOKS.

FOYLES

FINEST STOCK IN THE WORLD OF NEW AND SECONDHAND BOOKS ON EVERY SUBJECT.
Quick Postal Service. **Books Bought.**
119-125, CHARING CROSS ROAD, LONDON, W.C.2.
Tel.: GERrard 5660 (16 lines). Open 9 a.m.—6 p.m., including Saturday.

Piezo QUARTZ CRYSTALS
for all applications.
Full details on request.

QUARTZ CRYSTAL CO., LTD.,
(*Phone : MALden 0334.*) 63-71, Kingston Rd., New Malden, SURREY.

TURNING AND MACHINING OF PLASTIC MATERIALS
SCREWS in bakelite fabric, **COIL FORMERS, BOBBINS, etc.,** built to specification.

KESSLERS (LONDON) **LTD.,**
201-203, STOKE NEWINGTON CHURCH STREET, LONDON, N.16

DUAL TESTOSCOPE

This new dual model indicates 2-30 volts and 100-750 volts.
Send for leaflet G.24 on "Testing."

RUNBAKEN·MANCHESTER·1

THE *Dainite* SERVICE.

With Fifty Years' experience of compounds and mouldings and an up-to-date plant will quote for your particular requirements in Moulded Rubber Parts.

The Old Grammar School, Market Harboro' Erected 1614.

THE HARBORO' RUBBER CO. LTD., MARKET HARBOROUGH

KING

ELECTRIC CHAIN PULLEY BLOCK

Write for booklet on lifting and shifting or separate catalogue of conveyors, cranes, and other mechanical handling equipment.

GEO. W. KING LTD.,
HARTFORD WORKS · HITCHIN · HERTS.
HITCHIN 960 · GLASGOW DOUGLAS 27989 · MANCHESTER CENTRAL 3947 · NEWCASTLE 24196

The MULLARD
all-glass technique
By a complete departure from the conventional form of valve construction, Mullard have effectively reduced the losses due to H.F. resistance, inductance and capacity effects within the valve itself and in the leads coming from the electrodes. The all-glass technique makes use of an almost flat circular glass pressing for the base of the valve, into which short pins are sealed, the electrodes being welded directly to the pins. By thus reducing the length of the lead-out connections, considerably improved efficiency at the higher radio frequencies has been achieved.
A DEVELOPMENT OF THE MULLARD LABORATORIES

WIRELESS ENGINEER

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

VOL. XXII SEPTEMBER, 1945 No. 264

EDITORIAL

Valve Equivalent Circuit Conventions and Negative Feedback

WE have recently received from Dr. Geoffrey Builder, of the D.S.I.R. of Australia, a communication entitled "Valve Equivalent Circuit Conventions," with the kindly suggestion that it might serve as material for editorial comment. It was prepared before the publication of Dr. Sturley's article in the May issue of *Wireless World* and our June editorial on the same subject. He refers to the different conventions and emphasises that "various papers on negative feedback have revealed a lack of uniformity in the form of the feedback equations, chiefly associated with confusion as to the proper choice of signs in the valve equivalent circuit." It is a coincidence that this paper was on its way to this country while this very point was being discussed in *Wireless World* and *Wireless Engineer*.

Dr. Builder appears to adopt a hybrid convention. We reproduce in Fig. 1 his equivalent circuit in which the valve is replaced by an a.c. generator with an e.m.f. of $-\mu de_g$ acting upwards, so that e.m.f.'s are referred to the clockwise direction around the circuit. The arrow suggests, however, that currents are referred to the opposite direction. If this is so, he is not quite correct in saying that "this is the equivalent circuit used by Terman and others," since Terman says definitely that "the signs are such that a positive value for I_r means a current flowing in opposition to the steady direct current," whereas Builder seems to regard the current as positive when it flows in the same direction as the steady current. If one assumes opposite directions as positive for current and voltage one must put a minus sign in Ohm's law and that is what Builder does when he writes $de_a = -Zdi_a$ for the voltage across the load Z. Whichever convention is adopted one must obtain Builder's formula

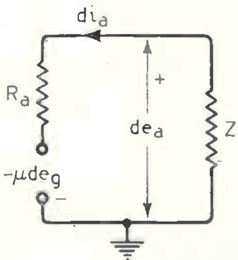


Fig. 1.

$$M = -\mu Z/(Z + R_a)$$

or its equivalent for the voltage gain of the stage.

Dr. Builder regards it as unfortunate that, whereas the actual amplification M of the stage is negative, the amplification factor μ of the valve should be conventionally regarded as positive. He is on dangerous ground, however, when he says that "like M, the amplification factor of a single valve as a matter of physical fact has a negative value"; that depends on the definition of amplification factor. He maintains that the conventional μ "hides the physical reality to an extent that may cause considerable confusion to the student of negative feedback equations."

To illustrate his point Builder considers the negative feedback stage shown in Fig. 2, in which the direct currents and voltages are omitted for simplicity. Although he states that "all voltages are referred to the common earth point shown," this presents some difficulties in the case of e_i.

It can be readily shown that

$$e_a = \frac{-\mu Z}{R_a + (1 + \beta\mu)Z} \cdot e_i$$

Hence, whereas without feedback $M = \frac{-\mu Z}{R_a + Z}$,

with negative feedback $M' = \frac{-\mu Z}{R_a + (1 + \beta\mu)Z}$.

Thus $M' = \frac{M}{1 - \beta M}$. Here M is negative and β positive, hence M' is negative and smaller than M.

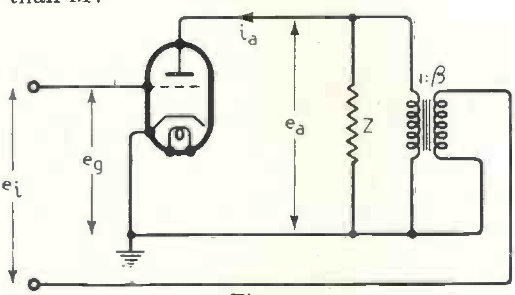


Fig. 2.

The effective value R_a' of the valve resistance in the equivalent circuit can be found as follows. The voltage e_a across the load impedance Z is

$$e_iM' = \frac{-e_i\mu Z}{R_a + (1 + \beta\mu)Z}$$

hence the current

$$i_a = \frac{\mu e_i}{R_a + (1 + \beta\mu)Z}$$

Dividing top and bottom by $(1 + \beta\mu)$ we have

$$i_a = \frac{\frac{\mu e_i}{1 + \beta\mu}}{\frac{R_a}{1 + \beta\mu} + Z}$$

Hence $R_a' = \frac{R_a}{(1 + \beta\mu)}$, and the effective e.m.f. of the generator is $\frac{\mu e_i}{(1 + \beta\mu)}$. The equivalent circuit is thus determined. In the above we have followed the hybrid convention as to sign of voltage and current.

Now Dr. Builder suggests that it would be preferable to define the amplification factor of the valve as $\mu' = (\delta e_a/\delta e_g)$ for i_a constant, which is, of course, negative and equal to $-\mu$. We should then have $M = \frac{\mu' Z}{R_a + Z}$ and also $R'_a = \frac{R_a}{1 - \beta\mu'}$, but the sign in $M' = \frac{M}{1 - \beta M}$ remains unchanged since this does not involve μ. The only advantage gained by this new definition of the amplification factor is that μ', M and M' are all negative—a doubtful advantage. Dr. Builder says, however, " Some confusion in regard to triode equivalent circuits and the equations for negative feedback might be relieved by the use of μ' as the amplification factor. The student would automatically and logically relate the negative values of amplification factor and actual amplification met with in the normal triode amplifier. The physical reality expressed in the negative value of the amplification factor for a single triode is a cogent argument for the use of μ' so defined. While the need of such a change is doubtful, it must not be overlooked that the student is usually in difficulty in obtaining a clear physical picture corresponding to the equivalent circuit. . . . It also seems desirable that the amplification factor μ' be used in negative feedback equations to obtain consistency of form in the equations and to simplify the interpretation of these equations when they are applied to multi-stage amplifiers."

Although we have explained Dr. Builder's point of view we must confess that we see little, if any, advantage in saying that the amplification of a valve is -20 rather than 20. If the load Z is a non-inductive resistance, each stage of the amplifier acts as a phase-inverter and one is justified in writing $M = -\mu Z/(R_a + Z)$ and regarding M as negative, but more generally one could write $M = \mu Z/(R_a + Z) \angle\theta$ in which the phase-angle θ is 180° if Z is non-reactive.

The discussion of this subject of the valve equivalent circuit has brought out quite clearly that almost every possible variant has been employed by different authors. Emrys Williams in his "Thermionic Valve Circuits" employs the positive convention and regards both currents and e.m.f.'s as positive when in the direction of the steady current. This is clearly shown in his Fig. 24 on p. 29 which we reproduce as Fig. 3 and by his formula for the voltage amplification

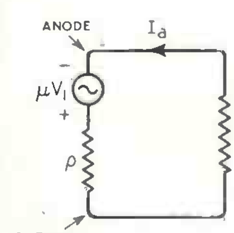


Fig. 3.

$(VA) = \mu R/(R + \rho)$. Terman, on the other hand, in his "Fundamentals of Radio," adopts the negative convention and regards

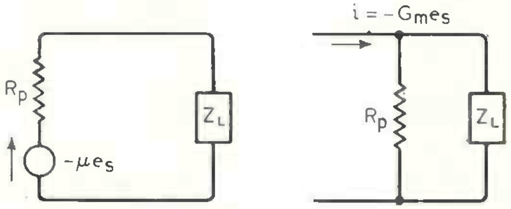


Fig. 4.

both currents and e.m.f.'s as positive when in the opposite direction to the steady current. In his Fig. 56 on p. 95, reproduced here as Fig. 4, he illustrates this both for the constant-voltage generator form and for the constant-current generator form, introducing an e.m.f. $-\mu e_s$ in the former and a current $-G_m e_s$ in the latter. The e.m.f. distributes itself between R_p and Z_L in series, whereas the current distributes itself between them in parallel. Then there is the hybrid convention employed by Builder and others to which we have referred above. Anyone who consistently uses one of these conventions will probably frown on the other two, but, after all, they are only conventions, and, if properly applied, any one of them will give correct results.

G. W. O. H.

RADIOLOCATION

Recent Security Release

On August 15th there was a general release of technical information on the developments which have taken place during the war in Radar technique. The applications of electromagnetic detection and ranging to offence and defence as well as to navigation have been wide and varied, and a new circuit technique has developed as a result of the demand for higher powers on shorter wavelengths.

Modern Radar equipment operates on centimetre wavelengths and relies on the magnetron for the generation of pulses of high peak power. Cavity resonators take the place of tuning inductances and condensers; "wiring" has given place to "plumbing," for energy is conveyed in hollow wave guides.

The accompanying illustration shows a centimetre-wave gun-laying equipment used in the Army for the control of anti-aircraft gunfire. Separate reflectors for transmission and reception are used and the high-frequency generator is mounted immediately behind the transmitting reflector. The dipole arrays are used in connection with the system for identifying friendly or hostile aircraft (I. F. F.).

LOSS-FREE TRANSMISSION LINES*

Some Limitations of Matching Systems

By R. Sibson, M.A.

1. Introductory

1.1. A LOSS-FREE transmission line has associated with it a constant, called the characteristic impedance, which is determined by the physical dimensions of the line and its dielectric ; this constant will be denoted by Z_0. The definitive property of Z_0 is here taken to be that if the line is terminated by a load Z_0 then the load will absorb any energy reaching it along the line without any reflection taking place. Thus a load Z_0 extracts the maximum possible power from a line of that characteristic impedance. In these circumstances the line is said to be matched or correctly terminated. For a loss-free line Z_0 is purely resistive.

1.2. It is often desirable in high-frequency work to match a line when the load is fixed and not equal to Z_0. When this is the case it may still prove possible to present to the main section of line a load equal to Z_0, by introducing a reactance or reactances in shunt across the line near the actual load. The power transmitted by the line is then completely absorbed by a compound load consisting of the actual load, the added reactance(s) and the length(s) of line joining them. Of these only the actual load can contain any resistive element, so that this will in fact absorb all the power concerned.

1.3. The determination of value and position for each of the added reactances can be performed by a graphical method using a circle diagram ; two systems using added reactances will be discussed later, in addition to one other matching system to which the circle diagram method also applies. In all three cases it will be shown that a match is not in general possible for all values of the actual load.

The succeeding discussion thus falls into two main divisions :—

(i) A simple approach to the circle diagram method as applied to loss-free lines, and

(ii) determination of the condition for a match to be possible, with a solution when this condition is satisfied, in each of the following cases :—

(*a*) Single stub (one added reactance, with its position variable).

(*b*) Double stub (two added reactances, in fixed positions).

(*c*) Double slug (two quarter-wave transformers, in variable positions).

2. Notation and Conventions

2.1. The more important elements of the notation used are collected here :—

Z_0 = characteristic impedance of line
Z_l = load impedance $= R_l + jX_l$
Z_{in} = input impedance of a length of line, loaded in any way $= R_{in} + jX_{in}$

It is convenient to measure all impedances in terms of Z_0, and we define, e.g., the "normalised" impedance Z_1 corresponding to the actual impedance Z_l by the relations

$$Z_1 = \frac{Z_l}{Z_0} = \frac{R_l}{Z_0} + j\frac{X_l}{Z_0} = x_1 + jy_1$$

Any admittance is defined by the relation $Y = 1/Z$, with corresponding suffixes, and admittances are "normalised" in terms of the characteristic admittance Y_0 $(= 1/Z_0)$ in the same way as impedances. Thus, for example,

$$Y_1 = \frac{Y_l}{Y_0} = \frac{1/Z_l}{1/Z_0} = \frac{Z_0}{Z_l} = \frac{1}{Z_1}$$

Henceforward the terms impedance and admittance will denote normalised quantities unless otherwise specified ; *Y's* and *Z's* with numerical suffixes will always denote normalised quantities.

Since $Z_1 = x_1 + jy_1$, Z_1 can be represented by a point whose co-ordinates are (x_1, y_1) on a cartesian diagram ; Y_1 can be similarly represented, but to maintain a distinction between points representing impedances and admittances, Greek letters will be used for the co-ordinates of the latter ; we shall write

$$Y_1 = \xi_1 + j\eta_1, \text{ etc.}$$

2.2. The conventions adopted for the circle

* MS. accepted by the Editor, April 1945.

diagram will be introduced as the method is developed.

3. Elementary Properties of Loss-free Lines

3.1. It will be of value to recall one or two simple formulæ connected with loss-free lines. A short-circuited length l of line, of characteristic impedance Z_0, fed with a purely sinusoidal signal of wavelength λ, has an actual input impedance Z_{in} given by

$$Z_{in} = jZ_0 \tan \frac{2\pi l}{\lambda}$$

The same line with open-circuit termination has

$$Z_{in} = -jZ_0 \cot \frac{2\pi l}{\lambda}$$

Now as l increases from 0 to $\lambda/4$, $2\pi l/\lambda$ increases from 0 to $\pi/2$; hence one or other of the above formulae takes up, for some value of l between 0 and $\lambda/4$, any value of reactance between $-j\infty$ and $+j\infty$. Thus such lengths of line can be used to provide the added reactances previously referred to. The lengths of line so used are called stubs.

3.2. For length $l = \lambda/4$, loaded with an actual impedance Z_l,

$$Z_{in} = Z_0^2/Z_l$$

Such a length of line, deliberately used to effect a transformation of impedance, is called a quarter-wave transformer, and two of these, of different characteristic impedance from the rest of the line, are used in the double-slug matching system.

For length $l = \lambda/2$ with the same load

$$Z_{in} = Z_l$$

Thus the introduction or removal of a length $\lambda/2$ of line at any point will not affect matching conditions; it is often used as a means of transferring a given impedance to another point.

4. Introduction to the Circle Diagram

4.1. All the simple formulae quoted in Section 3 are special cases of the general formula for the input impedance Z_{in} of any length l of loss-free line terminated by a load Z_l,

$$Z_{in} = Z_0 \frac{Z_l + jZ_0 \tan \frac{2\pi l}{\lambda}}{Z_0 + jZ_l \tan \frac{2\pi l}{\lambda}} \quad .. \quad (1)$$

If Z_l and Z_{in} are normalised by writing

$$\frac{Z_l}{Z_0} = Z_1 = x_1 + jy_1, \quad \frac{Z_{in}}{Z_0} = Z_2 = x_2 + jy_2,$$

equation (1) becomes

$$x_2 + jy_2 = \frac{x_1 + jy_1 + jt}{1 + jt\,(x_1 + jy_1)} \quad .. \quad (2)$$

where $t = \tan \frac{2\pi l}{\lambda}$.

Thus, if x_1, y_1, and t are given, equation (2) determines x_2 and y_2 algebraically, although the answers would be rather cumbersome. It will be shown, however, that if Z_1 and Z_2 are represented by the points (x_1, y_1) and (x_2, y_2) on a rectangular cartesian diagram, then (x_2, y_2) can be found by a simple graphical construction when (x_1, y_1) and t are given. It is an important point that the establishment of this construction depends only on the algebraic form of the original equation (1).

4.2. In equation (2), if any two of the quantities x_1, y_1, t are fixed and the third allowed to vary, then the point (x_2, y_2) describes a locus. We consider two particular cases of this :—

(i) Let x_1 be fixed and less than unity, and let y_1 be zero (i.e., make Z_l a resistance R_l less than Z_0), and let t vary; this will show how the input impedance varies with varying length of line, with a fixed resistive load. Equation (2) becomes

$$(1 + jx_1 t)(x_2 + jy_2) = x_1 + jt$$

Hence equating real and imaginary parts, we have

$$\left.\begin{array}{l} x_2 - x_1 y_2 t = x_1 \\ y_2 + x_1 x_2 t = t \end{array}\right\} \quad .. \quad .. \quad .. \quad (3)$$

The locus of (x_2, y_2) is obtained by eliminating t from equations (3); this gives, after slight rearrangement,

$$x_2^2 + y_2^2 - x_2(x_1 + 1/x_1) + 1 = 0 \quad (4)$$

Thus the locus of (x_2, y_2) is a circle, having as diameter the section of the x-axis between $(x_1, 0)$ and $(1/x_1, 0)$. (See Fig. 1.)

This is called a u-circle, because in the higher analysis of the method,* which is capable of dealing with lossy lines, the circle is identified by a parameter u_1 given by

$$u_1 = \tanh^{-1} x_1$$

The formulae of 3.2 show that

when $l = 0$, $\quad Z_2 = x_1$
when $l = \lambda/4$, $\quad Z_2 = 1/x_1$
when $l = \lambda/2$, $\quad Z_2 = x_1$

* J. C. Slater, "Microwave Transmission." McGraw Hill. Jackson and Huxley, *J.I.E.E.*, Part III, Sept., 1944. Jackson, "High Frequency Transmission Lines." Methuen.

Hence as l increases from 0 to $\lambda/2$, the point (x_2, y_2) moves right round the u-circle. We still have to find which way round it goes, and how far for any given value of l.

It is to be noted that no two u-circles intersect, and that any one surrounds the point M (1, 0), which represents the characteristic impedance Z_0 and is called the match point.

(ii) The other locus of (x_2, y_2) required is that described when l (i.e., t) is fixed, y_1 is zero, and x_1 varies between 0 and 1 : this gives the variation of Z_{in} for a fixed length of line with resistive load varying between 0 and Z_0. For this it is only necessary to revert to equations (3), and eliminate x_1 instead of t. This gives

$$x_2^2 + y_2^2 - y_2(t - 1/t) - 1 = 0 \quad \ldots \quad (5)$$

This is again a circle, having as diameter the section of the y-axis between the points (0, t) and (0, $-1/t$), and, for any value of t, passing through the points (± 1, 0). The centre of the circle is thus

$$\left\{0, \tfrac{1}{2}(t - 1/t)\right\} \equiv \left\{0, -\cot\frac{4\pi l}{\lambda}\right\}$$

and its radius is $\left|\operatorname{cosec}\dfrac{4\pi l}{\lambda}\right|$.

When $l = 0$, the centre is (0, $-\infty$), and as l increases to $\lambda/8$ it moves up to (0, 0) and so on to (0, $+\infty$) as l increases to $\lambda/4$. Thus starting from any value of $x_1 < 1$, the point

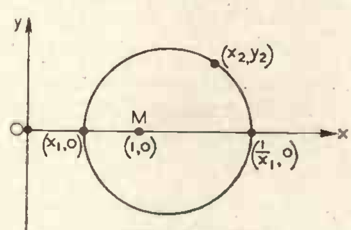


Fig. 1.

(x_2, y_2) will lie, for any value of $l < \lambda/4$, on the arc of the circle found above, which lies in the positive quadrant ; i.e., the arc MT_1 in Fig. 2. For, from the second of equations (3)

$$y_2 = t(1 - x_1 x_2) > 0$$

as long as $t > 0$, i.e., $l < \lambda/4$, since $x_2 < 1/x_1$*.

The circle T_1MT_2 is called a v-circle, as the higher analysis identifies it by the parameter $v = 2\pi l/\lambda$.

Thus it is now clear that in case (i), with fixed resistive load $R < Z_0$ and varying length of line, the point (x_2, y_2) moves clockwise round the u-circle as l increases. In Fig. 2 the arc MT_1 is associated with a length l of line, $< \lambda/4$, and starting from any point $(x_1, 0)$ on OM, the point (x_2, y_2) will finish on this arc when the length of line reaches the value l. An arc such as MT_1

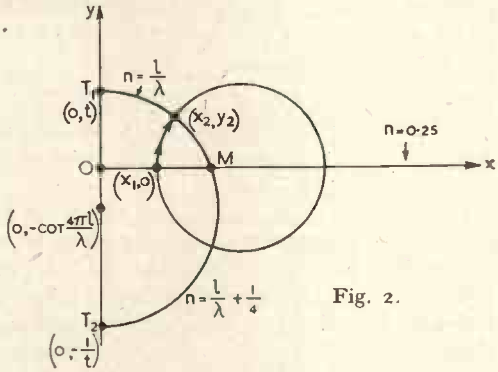


Fig. 2.

will be called a v-arc, and will be labelled with an index $n = l/\lambda$.

The significance of the arc MT_2 can be seen as follows :—

$$\cot\frac{4\pi}{\lambda}\left(l + \frac{\lambda}{4}\right) = \cot\left(\frac{4\pi l}{\lambda} + \pi\right) = \cot\frac{4\pi l}{\lambda}$$

Thus the v-circle has the same centre for lengths of line l and $l + \lambda/4$, and as the v-circle passes through M in any case, the circle is the same for these two lengths of line. Thus the arc MT_2 must be that associated with length $l + \lambda/4$ of line, and has index $n = l/\lambda + \frac{1}{4}$.

This apparently rather arbitrary subdivision of the v-circle arises from our restriction of x_1 to be less than unity : this arbitrariness will be seen to disappear in a later generalisation.

4.3. From the above the following rules arise for finding the input impedance Z_{in} of a length l ($< \lambda/2$) of line terminated by a resistance R_l ($< Z_0$) :—

(i) Plot the point $(R_l/Z_0, 0) \equiv (x_1, 0)$, and draw the u-circle through it.

(ii) Follow the u-circle clockwise until the v-arc having index $n = l/\lambda$ is encountered. The point of intersection is (x_2, y_2).

(iii) Then $Z_{in} = Z_0(x_2 + jy_2)$.

The following points may be noted :—

(i) OM is a v-arc, having $n = 0$.

(ii) The rest of the x-axis to the right of M is a v-arc, having $n = 0.25$.

* For this point I am indebted to my colleague, Mr. H. Melvin Melvin.

(iii) In some diagrams the values of n quoted in (i) and (ii) are reversed, but it will be seen later that this makes no difference to the method.

(iv) Geometrically the u- and v-circles form two orthogonal systems of coaxial circles.

(v) The y-axis is the limiting u-circle for $x_1 = 0$.

(vi) The v-arcs $n = 0.125$, $n = 0.375$ are arcs of the circle having centre O and radius unity.

4.4. A few simple examples may help to illustrate the above.

Example 1. Find the input impedance of a length $\lambda/8$ of line of characteristic impedance 600Ω, terminated by a resistance of 300Ω. (Fig. 3.)

Here $Z_1 = \dfrac{300}{600} = \dfrac{1}{2}$.

Thus the starting point is X_1 $(\frac{1}{2}, 0)$ and from here we move clockwise round the u-circle until the v-arc having $n = \dfrac{\lambda/8}{\lambda} = 0.125$ is encountered at $X_2\,(x_2, y_2)$. From an actual set of diagrams, or a simple geometrical argument, we find that

$$(x_2, y_2) \equiv (0.8, 0.6), \quad \text{so that}$$
$$Z_{in} = Z_0\,(0.8 + 0.6j)\ \Omega$$
$$= (480 + 360j)\ \Omega$$

Example 2. Find the input impedance of a short-circuited $\lambda/8$ stub, having $Z_0 = 80\Omega$. Here $Z_1 = 0$, so that the starting point is the origin O, and the u-circle to be followed is the y-axis. Thus again the movement is

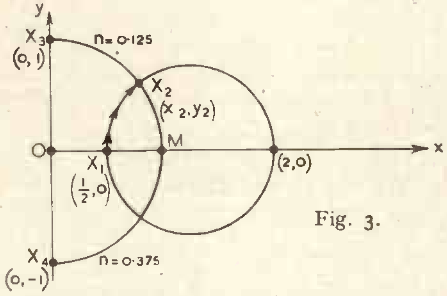


Fig. 3.

along this special case of a u-circle until the v-arc having $n = 0.125$ is encountered at X_3 (Fig. 3 again). Obviously $X_3 \equiv (0, 1)$, so that

$$Z_{in} = Z_0 \cdot (0 + j)$$
$$= 80j\ \Omega$$

Example 3. The general problem of finding the length of short-circuited stub to provide a given reactance presents no difficulty. Reversing the procedure of Ex. 2, we simply plot the normalised reactance on the y-axis, read off the value of n at that point, and multiply by λ, e.g., find the length of short-circuited stub required to give a reactance of $-80j\Omega$, with $Z_0 = 80\Omega$. Here the reactance is represented by $(0, -1)$; i.e., X_4 in Fig. 3. At X_4, $n = 0.375$. Hence the required reactance can be provided by a short-circuited stub $3\lambda/8$ long, or more conveniently by an open-circuited stub $\lambda/8$ long.

4.5. So far Z_{in} can only be found when Z_l is a pure resistance less than Z_0; we now proceed to extend the method to any value whatever of Z_l, as follows.

As before, let $Z_1 = Z_l/Z_0 = x_1 + jy_1$; plot (x_1, y_1), and draw the u-circle and

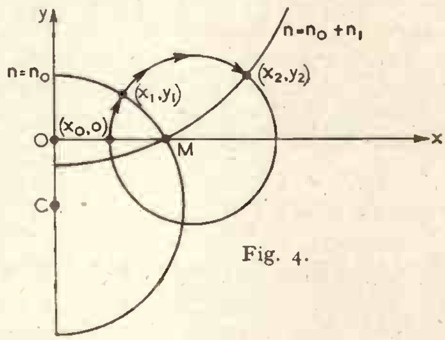


Fig. 4.

v-circle through it.* Read off the value n_0 of the index of the v-arc through (x_1, y_1). Note also the point $(x_0, 0)$ at which the u-circle through (x_1, y_1) cuts OM. (Fig. 4.)

Thus the load Z_l is the actual input impedance of a length l_0 $(= n_0\lambda)$ of line terminated by a resistance x_0Z_0, where $x_0Z_0 < Z_0$; this is illustrated diagrammatically in Fig. 5.

If we now attach the networks on each side of Fig. 5 to a length l_1 $(= n_1\lambda)$ of line we shall have the same input impedance Z_{in} in each case, as shown in Fig. 6.

The left-hand side of Fig. 6 is now the general case which we have not yet solved; but Fig. 6 shows it to be equivalent to a

* There are several constructions for the u-circle and v-circle through a given point (x_1, y_1): one is as follows. Bisect the line joining (x_1, y_1) to M at right angles. Let the bisector cut Oy at C (Fig. 4). Then C is the centre of the v-circle through (x_1, y_1). Draw the radius from C to (x_1, y_1), and a perpendicular to it through the latter point. The perpendicular cuts Ox at the centre of the u-circle through (x_1, y_1).

particular case which we can deal with. On the right-hand side of Fig. 6 Z_{in} is found by starting from $(x_0, 0)$ and proceeding clockwise round the u-circle until the v-arc having $n = (l_0 + l_1)/\lambda = n_0 + n_1$ is encountered at (x_2, y_2). (Fig. 4.) Then $Z_{in} = Z_0(x_2 + jy_2)$ as usual. But we could have reached (x_2, y_2) equally well by starting from (x_1, y_1) and going clockwise round the u-circle so as to increase the value of n from n_0 to $n_0 + n_1$, i.e., by an amount l_1/λ. The method is now general for any value of Z_l.

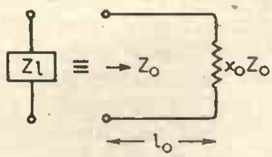


Fig. 5.

4.6. As a special case of the above, if $l_1 = \lambda/4$, $n_1 = 0.25$, and (x_2, y_2) is the other point of intersection of the u- and v-circles through (x_1, y_1). (Fig. 7.)

In Fig. 7 $Z_{in} = Z_0(x_2 + jy_2)$ is the input impedance of length $\lambda/4$ of line terminated by $Z_l = Z_0(x_1 + jy_1)$, and *vice versa*. But for length $\lambda/4$ of line

$$Z_{in} = Z_0^2/Z_l$$

or $Z_{in}/Z_0 = Z_0/Z_l$

or $Z_2 = 1/Z_1$

This result will be of use presently.

4.7. In stub-matching systems we are concerned with impedances in parallel, as stubs are connected across the main transmission line. In this case the corresponding admittances can be added algebraically, so that it is of value to show that the whole of the method as so far developed applies to admittances also.

Using the notation outlined in 2.1, we have at once that

$$Y_1 = 1/Z_1 = Z_2$$

as in 4.6, so that the point (x_2, y_2) of Fig. 7

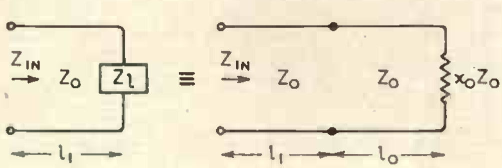


Fig. 6.

is identical with the point (ξ_1, η_1) where $Y_1 = \xi_1 + j\eta_1$. Thus the admittance point (ξ_1, η_1) corresponding to an impedance point (x_1, y_1) is the other point of intersection of the u- and v-circles through (x_1, y_1).

Also if we go back to equation (1) of 4.1, and rewrite this in terms of admittances we get

$$\frac{1}{Y_{in}} = \frac{1}{Y_0} \cdot \frac{1/Y_l + j\tan\frac{2\pi l}{\lambda}\Big/ Y_0}{1/Y_0 + j\tan\frac{2\pi l}{\lambda}\Big/ Y_l}$$

or $$Y_{in} = Y_0 \cdot \frac{Y_l + jY_0\tan\frac{2\pi l}{\lambda}}{Y_0 + jY_l\tan\frac{2\pi l}{\lambda}}$$

This is of exactly the same form as equation (1) with Y's replacing Z's everywhere. Thus the whole method applies to admittances also.

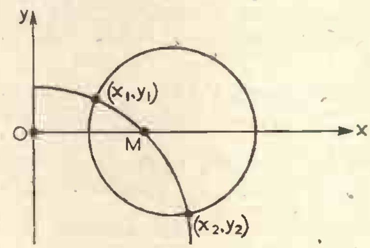


Fig. 7.

A small point worth noting here is that whereas inductive reactance is positive, inductive susceptance is negative; this arises directly from the general relation $Y = 1/Z$.

5. Matching Systems

The above discussion provides us with the technique for solving the particular problems mentioned in 1.3.

5.1. *The Single Stub System*

5.1.1. The length of the stub, which is taken to be short-circuited, and the distance of the stub from the load, are the variables. The line from stub to load and the stub itself have characteristic impedance Z_0; the rest of the line, to which the load Z_l is being matched, has characteristic impedance Z_0'.

5.1.2. The layout is thus as shown in Fig. 8, and we have to find l_1 and l_2 so that the line of characteristic impedance Z_0' is matched. The procedure is as follows:—

(i) Let $Z_l/Z_0 = Z_1 = x_1 + jy_1$, and plot (x_1, y_1).

(ii) Find the corresponding admittance point (ξ_1, η_1) as in 4.7.

(iii) The introduction of length l_1 of line involves a further movement round the u-circle on which both (ξ_1, η_1) and (x_1, y_1) lie, to a point (ξ_2, η_2); $\xi_2 + j\eta_2$ is then the input admittance of this length of line with the given load, and we have to combine with $\xi_2 + j\eta_2$ the susceptance provided by the

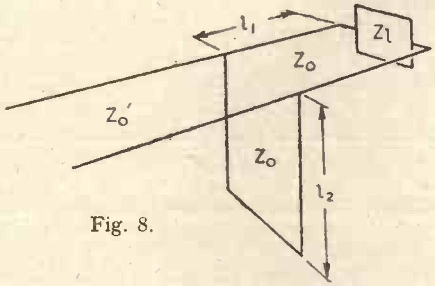


Fig. 8.

stub to complete the match. The last movement must therefore be to the point $(Y_0'/Y_0, 0)$ where $Y_0 = 1/Z_0$, $Y_0' = 1/Z_0'$.

Now the introduction of the susceptance of the stub is represented by a movement parallel to the η-axis, so that (ξ_2, η_2) must lie on the ordinate through $(Y_0'/Y_0, 0)$. Hence as long as the u-circle through (x_1, y_1) surrounds $(Y_0'/Y_0, 0)$, it is possible to find two points, either of which may be taken as (ξ_2, η_2), namely A and B in Fig. 9.

The distance and direction of movement from whichever point is chosen as (ξ_2, η_2) to $(Y_0'/Y_0, 0)$ determines the susceptance which the stub must provide, and hence determines its length l_2; it is perhaps simplest to convert the required susceptance to reactance first in obtaining l_2. Also the change in n in going clockwise from (ξ_1, η_1) to (ξ_2, η_2) round the u-circle fixes the length l_1 of line between the load and the stub.

We may note here that in Fig. 9 this movement will in any case involve crossing the line OM, at which n is discontinuous; but it is fairly easy to see that what we must do to reckon the increment in n is to split the movement into two parts, from (ξ_1, η_1) to

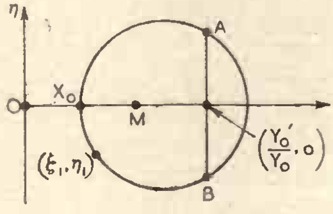


Fig. 9.

X_0 and from X_0 to A or B, taking n as increasing to a final value of 0.5 for the first part and as starting again from zero for the second. It will then be the sum of these two increments in n which we shall require.

5.1.3. In Section 5.1.2 we assumed that the u-circle through (x_1, y_1) surrounded the point $(Y_0'/Y_0, 0)$, and this is in fact the condition for a match to be possible. *The condition is better expressed by saying that (x_1, y_1) must lie outside the u-circle through $(Y_0'/Y_0, 0)$, which also passes through $(Z_0'/Z_0, 0)$*; this gives the condition in terms of the original data.

Thus the further away $(Z_0'/Z_0, 0)$ is from M, the more severe does the restriction on the value of Z_l become, while on the other hand if $Z_0' = Z_0$ there is no restriction at all, except that Z_l must not be purely reactive.

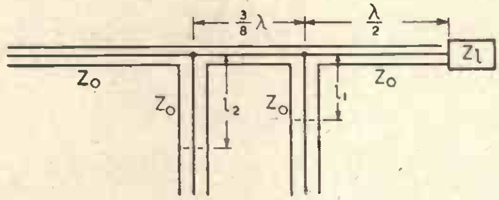


Fig. 10.

In general we can express the condition algebraically as follows. The u-circle through $(Z_0'/Z_0, 0)$ has as its equation

$$x^2 + y^2 - \left(\frac{Z_0'}{Z_0} + \frac{Z_0}{Z_0'}\right)x + 1 = 0$$

(*cf.* equation (4) of 4.2); and for $(x_1, y_1) \equiv \left(\frac{R_l}{Z_0}, \frac{X_l}{Z_0}\right)$ to lie outside this we require

$$R_l^2 + X_l^2 - \left(Z_0' + \frac{Z_0^2}{Z_0'}\right)R_l + Z_0^2 > 0$$

where $Z_l = R_l + jX_l$.

5.2. *The Double Stub System*

5.2.1. This system consists of two stubs each of adjustable length, attached to the main line at fixed points. The system is thus well suited mechanically for use on concentric line, whereas the single stub is more so for open twin line.

In this case the stubs and the main line are all taken to be of characteristic impedance Z_0, and the load is again Z_l. The separation of the first stub from the load is conventionally $\lambda/2$, so that the load impedance is transferred to the point of connection of the first stub. The distance between the stubs is usually $\frac{3\lambda}{8}$; this gives rise to a particular restriction on the range of values of Z_l for which a match is possible. An indication will be given in the Appendix of the effect on the restriction of varying the stub separation from $\frac{3\lambda}{8}$.

5.2.2. The layout is thus as shown in Fig. 10, and l_1 and l_2 have to be found. As the stubs are inevitably short-circuited in

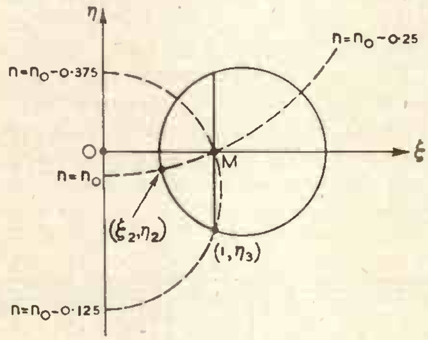


Fig. 11.

this case, each must have a range of variation of length from 0 to $\lambda/2$.

We have to consider the following sequence of operations:—

(i) Combination of Y_1 $(= Y_l/Y_0$, where $Y_l = 1/Z_l)$ with the susceptance provided by the first stub.

(ii) Transformation of the resulting admittance by the introduction of $\frac{3\lambda}{8}$ of line.

(iii) Completion of the match by combining with the result of (ii) the susceptance provided by the second stub.

Consideration of (iii) leads us to the fact that the point reached by (ii) must be on the ordinate through M.

Thus the admittance resulting from (i) must be such that when transformed by $\frac{3\lambda}{8}$ of line it gives an admittance whose conductive component is unity.

5.2.3. We proceed to prove a necessary lemma concerning such admittances.

Let the admittance at the end of (ii) be $1 + j\eta_3$, and that at the end of (i) $\xi_2 + j\eta_2$, as illustrated by Fig. 11.

Then we have, from the basic algebraic equation,

$$1 + j\eta_3 = \frac{\xi_2 + j\eta_2 + j\tan\frac{3\pi}{4}}{1 + (\xi_2 + j\eta_2)\,j\tan\frac{3\pi}{4}}$$

$$= \frac{\xi_2 + j(\eta_2 - 1)}{1 + \eta_2 - j\xi_2}$$

Equating real parts, we have

$$1 = \frac{\xi_2(1 + \eta_2) - \xi_2(\eta_2 - 1)}{(1 + \eta_2)^2 + \xi_2^2}$$

which can be written

$$(\xi_2 - 1)^2 + (\eta_2 + 1)^2 = 1$$

This represents a circle S, having centre $(+1, -1)$ and radius unity, and this is thus the locus of points representing admittances $\xi_2 + j\eta_2$ which satisfy the stated condition, namely, that at the end of $\frac{3\lambda}{8}$ of line they give input admittances with conductive component 1. We may note that S touches the ξ-axis at M, and the η-axis at $(0, -1)$.

The Appendix indicates the form of the locus for stub separation other than $\frac{3\lambda}{8}$.

5.2.4. At the end of (i) of 5.2.2, the point reached must, therefore, lie on S. Now (i) involves a movement from (ξ_1, η_1) where $Y_1 = \xi_1 + j\eta_1$, parallel to the η-axis; we thus have the following procedure, which can be used to build up Fig. 12 step by step:—

(i) Plot the point (ξ_1, η_1) representing the load admittance.

(ii) Combine with $\xi_1 + j\eta_1$ a susceptance sufficient to give a total admittance $\xi_2 + j\eta_2$, where (ξ_2, η_2) lies on S, and, of course,

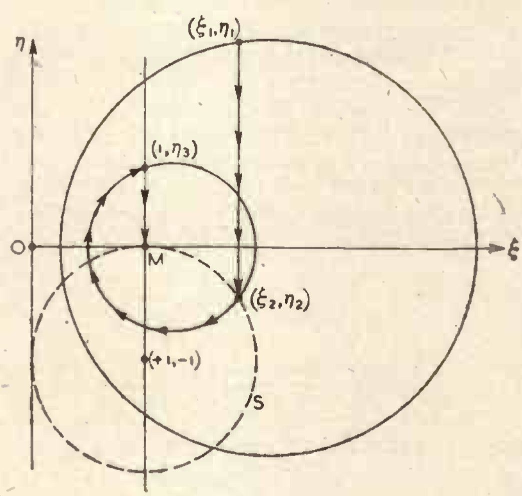


Fig. 12.

$\xi_1 = \xi_2$. We may note that once again, in Fig. 12, we have a choice of two solutions.

(iii) The introduction of $\frac{3\lambda}{8}$ of line now transforms (ξ_2, η_2) into a point $(1, \eta_3)$ on the ordinate through M, by the lemma proved in 5.2.3.

(iv) The addition of the susceptance of the second stub can now be made to transform $(1, \eta_3)$ into $(1, 0)$; i.e., M. The movements from (ξ_1, η_1) to (ξ_2, η_2), and from $(1, \eta_3)$ to M determine the susceptances required of the stubs, and hence their lengths.

5.2.5. The condition for a match to be possible is clearly that the ordinate through (ξ_1, η_1) shall intersect the circle S; i.e., we require $\xi_1 \leqslant 2$

or real part of $(1/Z_1) \leqslant 2$

where $Z_1 = Z_l/Z_0 = x_1 + jy_1$ as usual.

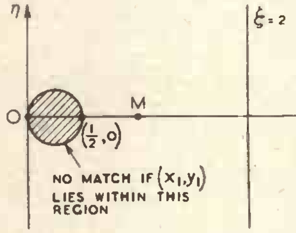


Fig. 13.

The condition becomes

$$x_1/(x_1^2 + y_1^2) \leqslant 2$$

or $\quad x_1^2 + y_1^2 \geqslant x_1/2$

or $\quad (x_1 - \tfrac{1}{4})^2 + y_1^2 \geqslant (\tfrac{1}{4})^2.$

This means that for a match (x_1, y_1) *must lie on or outside the circle having centre* $(\tfrac{1}{4}, 0)$ *and radius* $\tfrac{1}{4}$, *i.e., the circle on the line joining* O *to* $(\tfrac{1}{2}, 0)$ *as diameter.* See Fig. 13. The condition can be established equally well by a simple geometrical argument from the relation $Y_1 = 1/Z_1$.

If $Z_l = R_l + jX_l$, the condition becomes

$$R_l^2 + X_l^2 \geqslant \tfrac{1}{2} R_l Z_0.$$

5.3. *The Double Slug System*

5.3.1. This consists effectively of two sections of line, each $\lambda/4$ long, of different characteristic impedance from that of the line into which they are introduced, and of adjustable position along that line.

The system may comprise slugs $\lambda/4$ long riding on the inner conductor, or sleeves $\lambda/4$ long sliding inside the outer, or blocks of dielectric of electrical length $\lambda/4$, filling the space between inner and outer. An example of each is shown in section in Fig. 14.

5.3.2. The main lengths of line will be taken to have characteristic impedance Z_0, and the $\lambda/4$ sections Z_0'; from the previous paragraph it will be clear that in any case $Z_0' < Z_0$ and we shall write

$$Z_0' = \rho Z_0, \quad \text{where } 0 < \rho < 1.$$

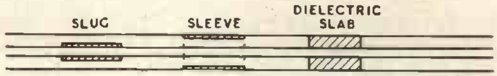


Fig. 14.

5.3.3. As a preliminary to attacking the complete problem, we may consider the impedance transformation effected by a $\lambda/4$ slug of characteristic impedance Z_0', as expressed in terms of movements on a circle diagram.

Let Z_l and Z_{in} be the actual load and input impedances of the slug. Then

$$Z_{in} = Z_0'^2/Z_l = \rho^2 Z_0^2/Z_l$$

so that $\quad Z_{in}/Z_0 = \rho^2/(Z_l/Z_0)$

or $\quad Z_2 = \rho^2/Z_1$

with the usual notation.

Hence to obtain Z_2 from Z_1 on a circle diagram, we must make the following movements :—

(i) Find the input impedance obtained by transforming Z_1 by $\lambda/4$ of line of characteristic impedance Z_0. This gives $1/Z_1$.

(ii) Scale down the resulting impedance in the ratio $\rho^2 : 1$; this gives ρ^2/Z_1, or Z_2.

5.3.4. We may now consider the complete problem as illustrated in Fig. 15, where the lengths of line l_1 and l_2 have to be found.

The impedance at D looking towards L must be 1; therefore the impedance at C looking towards L, Z_4, is given by

$$1 = \rho^2/Z_4 \quad \text{or} \quad Z_4 = \rho^2.$$

Thus the impedance Z_3 at B looking towards L must be somewhere on the u-circle through the point $(\rho^2, 0)$.

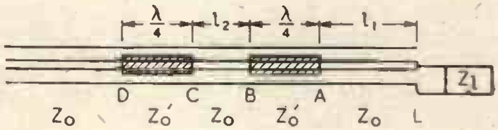


Fig. 15.

5.3.5. We therefore arrive at the following procedure :

(i) Represent Z_l by its normalised form $Z_1 = x_1 + jy_1$, and plot (x_1, y_1).

(ii) Draw the u-circle through (x_1, y_1), and also a circle S, having the origin as external centre of similitude with the u-circle, and scaled down in the ratio $\rho^2 : 1$ from the u-circle. Operations (i) and (ii) of 5.3.3, starting from any point of the u-circle, will thus always lead to a point on S.

(iii) Draw the u-circle through X_4 $(\rho^2, 0)$, which point represents Z_4, and let this u-circle cut S at X_3 and X_3'. Let the point corresponding to X_3 on the u-circle through X_1 (x_1, y_1) be X_2'. Let the v-circle through X_2' cut the same u-circle again at X_2. See Fig. 16.

(iv) The sequence of movements on the diagram is now as follows :—

(*a*) A suitable length of line l_1 transforms X_1 into X_2.

(*b*) The first slug transforms X_2 into X_3 via X_2', by the result of 5.3.3.

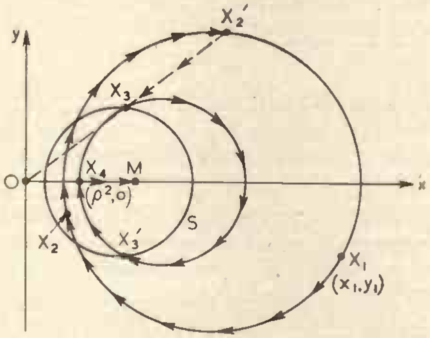


Fig. 16.

(*c*) A further length of line l_2 transforms X_3 into X_4.

(*d*) The second slug transforms X_4 into M [via $(1/\rho^2, 0)$ in strict accordance with 5.3.3 ; but this has not been shown diagrammatically in Fig. 16, as for simplicity the last step had already been worked out in 5.3.4.]

5.3.6. The success of the procedure clearly depends on whether or not the u-circle through X_1 is such that its scaled down version S intersects the u-circle through $(\rho^2, 0)$.

We observe first of all that since any u-circle encloses M, S must enclose $(\rho^2, 0)$. Hence the procedure can only fail if the circle S encloses the u-circle through $(\rho^2, 0)$ completely.

This requires that of the points of intersection of S with the x-axis, the one more remote from O must be at a point $(x_0, 0)$ where $x_0 > 1/\rho^2$. The corresponding u-circle will, therefore, cut the x-axis at a point $(x_0/\rho^2, 0)$ where now

$$x_0/\rho^2 > 1/\rho^4.$$

Thus for a match to be possible X_1 must lie on or within the u-circle through the points $(1/\rho^4, 0)$ and $(\rho^4, 0)$.

In particular, if Z_l is a pure resistance R_l we require

$$(Z_0'/Z_0)^4 \leqslant R_l/Z_0 \leqslant (Z_0/Z_0')^4.$$

Hence the smaller the value of ρ, i.e., the "fatter" the slug, the less stringent is the restriction on the value of Z_l.

6. Appendix

If in the double stub system, the separation of the stubs is other than $\frac{3\lambda}{8}$, then we have, in lieu of the first equation of 5.2.3,

$$1 + j\eta_3 = \frac{\xi_2 + j\eta_2 + jt}{1 + jt\,(\xi_2 + j\eta_2)}$$

where $t = \tan \frac{2\pi l}{\lambda}$, l being the new stub separation. Hence equating real parts

$$1 = \frac{\xi_2(1 - t\eta_2) + (\eta_2 + t)t\xi_2}{(1 - t\eta_2)^2 + t^2{\xi_2}^2}$$

or $\quad t^2{\xi_2}^2 + (t\eta_2 - 1)^2 - (t^2 + 1)\xi_2 = 0$

which represents a circle of centre

$$\left\{\frac{t^2+1}{2t^2}, \frac{1}{t}\right\} \text{ and radius } \frac{t^2+1}{2t^2}$$

This touches the y-axis at $(0, 1/t)$, and cuts the x-axis at M and $(1/t^2, 0)$. The tangent corresponding to $\xi = 2$ is now $\xi = (t^2 + 1)/t^2$, and the region of no match is inside the circle on the line joining O to $[t^2/(t^2 + 1), 0]$ as diameter.

Thus, values of stub separation exist for which the region of no match is either larger or smaller than that for separation $\frac{3\lambda}{8}$. The choice of $\frac{3\lambda}{8}$ as separation thus appears to be a compromise ; the conflicting factors are probably reduction of the region of no match on the one hand and facility of adjustment of the stubs to their correct positions on the other. It seems likely that as the region of no match becomes smaller, the stub adjustment becomes more critical, but a theoretical demonstration of this would require a further considerable discussion.

OSCILLOGRAPH FOR THE DIRECT MEASUREMENT OF FREQUENCY EMPLOYING A SIGNAL CONVERTER*

By P. Nagy, Dipl.Eng., and M. J. Goddard, M.Sc.

(*International Television Corporation*)

SUMMARY.—In previous publications[1, 2], the deflection-modulated cathode-ray valve—called the signal converter—was described comprehensively. The electron optical design, the reasons for its adoption and the performance of the converter were given. The television applications were treated in detail employing "pure signal conversion," while the use of the valve as a time-base generator was mentioned briefly.

The first part of this paper describes a mains driven oscillograph with calibrated time-base velocity for direct measurement of frequency, employing the signal converter as the time-base generator. The accuracy of reading is ±1 per cent. The circuit of the unconventional time-base valve, which greatly facilitated this development, is discussed in detail. All factors affecting the accuracy of frequency measurement are examined and the simple correction circuits for the elimination of the influence of mains variations, and the methods of circumventing the instability and ageing of circuit components are described. Precision oscillographs should replace conventional meters.

The second part of the paper deals with the theory of the signal converter as a time-base generator. Formulae are given for the determination of the circuit constants C, R_1, R_2, C_2. The theoretical results are verified by photographs. Almost any type of time base requirement can be satisfied by employing a signal converter.

PART I

DESCRIPTION OF THE OSCILLOGRAPH

TABLE OF CONTENTS

1. Introduction

THE usual method adopted for the measurement of the repetition-rate (frequency) of electrical phenomena is a comparative one. The unknown frequency is compared with a known standard; *e.g.*, the known frequency is applied to the X deflection plates of a C.R. tube and the unknown to the Y plates; by continuously changing the known frequency a stationary Lissajous pattern appears on the screen of the C.R. tube, whence the relation of the unknown to the known frequency may be determined. Or the known frequency may be applied to the grid of the C.R. tube, thus "marking" the time base.

Whichever method is employed a continuously variable calibrated signal generator is required. The accuracy of the frequency determination is the same as the accuracy of the signal generator. A good class heterodyne or C.R. oscillator or radio-frequency signal generator is accurate to ± 1 or 2 per cent.

The alternative solution is the calibration of the time-base velocity. When the time required for the spot to travel a predetermined distance on the C.R. tube screen is known, the frequency of the signal under examination may be read off directly on a calibrated transparent screen attached to the C.R. tube.

This latter method is employed in the oscillograph described in the following pages. The circuit and the factors affecting the accuracy of calibration and reading are described in detail.

2. The Time-Base Valve: the Signal Converter†

The time base of the oscillograph is generated by a single hard valve—the

* MS. accepted by the Editor May 1945.

† A comprehensive account of the signal converter may be found in *Wireless Engineer*, June 1943, Vol. XX, No. 237, pp. 273–299.

signal converter. It is a deflection-modulated cathode-ray valve which is capable of converting an arbitrary signal into its own time base. The operation of the converter is explained with the aid of the circuit of Fig. 1. By an electron optical system (G, A_1, A_2) the image of the elongated cathode K is sharply focused at the output electrode XY. By means of secondary

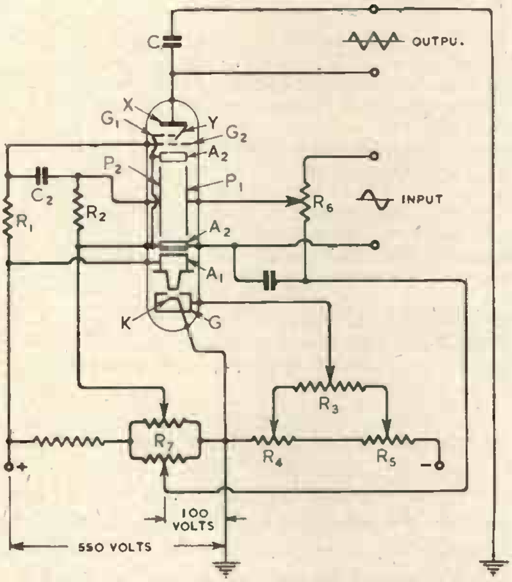


Fig. 1. *Schematic circuit of the signal converter as a time-base generator.*

electron emission and the auxiliary grids G_1 and G_2, the output electrode is divided into two parts, the "positive side" Y and the "negative side" X. When the image falls on the negative side, the output load C is charged in a negative sense by the beam current. The time-base output potential V after time T is

$$V = \frac{i_x T}{C}$$

where i_x is the charging current of the negative side ($i_x \simeq$ beam current). When the image falls on the positive side, a large number of secondary electrons is released from the surface Y and collected by G_2, thus charging C in a positive sense.

When an input signal is placed on the deflection plate P_1 it is converted into a linear time-base output potential across C, automatically synchronised with the input. Thus a part of one period of an arbitrary signal can be investigated on the screen of an oscillograph. C may represent the X plates of the C.R. tube. This mode of operation may be called "pure signal conversion."

To be able to observe several periods of a signal, the converter is used in a self-generator circuit by employing the resistors R_1 and R_2 and the condenser C_2. When the image of the converter is deflected from one side of the output electrode to the other, the current collected by the screen G_2 changes and so develops a transient signal across R_1 which is fed via C_2 to the deflection plate P_2 in a regenerative sense. With the aid of R_2, through which the signal leaks away, time-base oscillations are generated.

The output electrode current as a function of the deflection potential of the plate P_2 is given in Fig. 2; in the *constant current* region x the scan of the time base is produced and the image falls wholly on X; in the sloping part x-y the image falls partly on X and partly on Y; in the region y the image falls wholly on the positive side Y and produces the flyback of the time base. When the image is biased within the slope x-y the signal converter will oscillate.

In previous publications the generator type signal converter was only mentioned *; the simplicity of the circuit itself, the latitude permissible in the choice of the circuit constants R_1, R_2 and C_2 and the independence of the time-base output from changes of the S/P coefficient of the output electrode, justify a detailed treatment.

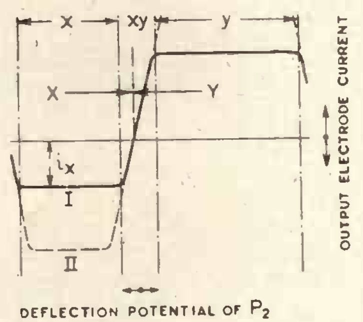


Fig. 2. *Output-deflection characteristic of signal converter in circuit conditions of Fig. 1. Curve I, i_x = 0.2 mA; curve II, i_x = 0.5 mA.*

The circuit of Fig. 1 with the quantitative relationship between the circuit constants and signal converter characteristics will be dealt with in detail in Part II of this paper.

* Ref. 1, page 292. Ref. 2, page 35.

3. The Converter Circuit and Time-Base Controls

After time T the time-base output potential $V = i_xT/C$. When the output load C is known and i_x is measured, the scanning velocity of the oscillograph V/T is defined. For some predetermined time-base output potential V, the oscillograph may be calibrated directly in frequency $1/T = f$.

In Fig. 1 all controls which are required for the frequency measurement are indicated (R_3, R_6, R_7).

The main frequency control (large centre dial on the oscillograph panel, see Fig. 4) is calibrated in cycles per second, from 5 to 60. This control alters the variable resistance R_3, changing the bias of the grid G and thus the beam current (*i.e.*, i_x when the image falls on the negative side X of the output electrode).

It is convenient to make i_x and the number of cycles per second correspond. For example :

5 c/s ; $i_x = 0.05$ mA,
30 c/s ; $i_x = 0.30$ mA,
60 c/s ; $i_x = 0.60$ mA.

Then the calibration of the main frequency dial can be checked with ease with the aid of a milliammeter connected to the output electrode of the converter (by placing the "multiply frequency" switch in the "calibrate" position, see Figs. 3 and 4). This is the main reason why i_x values between 0.05 and 0.6 mA are employed. Low charging currents of the order of 0.05 mA can be safely employed using the signal converter, see Appendix I. The two limiting points of the $i_x - V_g$ characteristic (Fig. 5) are set with the aid of the variable resistance controls R_4 and R_5.

To calibrate the main frequency control R_3 any two points, one at the lower and one at the higher end of the characteristic, may be adjusted, *e.g.*,

15 c/s ; $i_x = 0.15$ mA,
50 c/s ; $i_x = 0.50$ mA.

The value of the output load C is so selected as to give a convenient *datum deflection* (V) on the C.R. tube screen. The values which have been selected for i_x and T give $i_xT = 0.01$ milliamp sec. = constant ; then $C = 0.05$ microfarad gives $V = 200$ volts, which corresponds to the datum deflection of 3 ins. approx. on a tube of 5.25 ins. diameter.

It will be shown in Part II that the value of T/C_2R_2 should be within 0.5 and 3. In the oscillograph $T/C_2R_2 = 1.3$ for $V = 200$ volts. The scan period T is inversely proportional to i_x, because $T = CV/i_x$ where C and V are constants ; *i.e.*, when i_x is increased from 0.05 to 0.6 mA the scan period is reduced twelve fold ; so in order to keep T/C_2R_2 approximately constant and equal 1.3, R_2 is reduced in the same proportion, keeping C_2 constant.

Also the collector screen resistance R_1 must be similarly decreased, because the feed back potential is proportional to i_xR_1 and should be kept approximately constant (see Part II).

In order to produce satisfactory time-base oscillations the obvious solution is to couple with the spindle of R_3 two variable resistors R_1 and R_2. In the oscillograph two ten-pole switches are employed with a chain of small fixed resistors (0.1 watt dissipation), as shown in Fig. 3.

"*Multiply Frequency*" *Control.* The frequency reading of the main dial (R_3) is true when the "Multiply Frequency" control (two six-pole switches on common spindle, see Figs. 3 and 4) is in position 1 and so the output load C equals 0.05 μF. By placing this control in the 10, 100, 1000 and 2000 positions respectively, different output condensers (C = 5000 pF = 500 pF, = 50 pF, = 25 pF) and coupling condensers C_2 are switched into the circuit, thereby extending the calibration, from 5 to 120,000 c/s.

"*Time Base Amplitude, Image Position of Signal Converter*" *Control.* This control (see Figs. 3 and 4) alters the bias of the deflection plate P_1, by altering the tapping point of the potential divider R_7 (Fig. 1). Thus the image may be placed in any region of the converter characteristic. This control serves a fivefold purpose :

(1) By connecting a milliammeter to the output electrode ("Multiply Frequency" switch in "Calibrate" position) the output electrode-current/deflection-potential characteristic of the converter (Fig. 2) can be checked,* and as already mentioned ;

(2) the main frequency dial can be cali-

---

* The potential drop across R_7 is so chosen as to cover the useful part of this characteristic : $V_{P\,mean} \pm 20$ volts. The S/P coefficient of the output electrode may be checked by placing the image on X measuring i_x, reversing the polarity of the meter and shifting the image on Y measuring i_y ; then

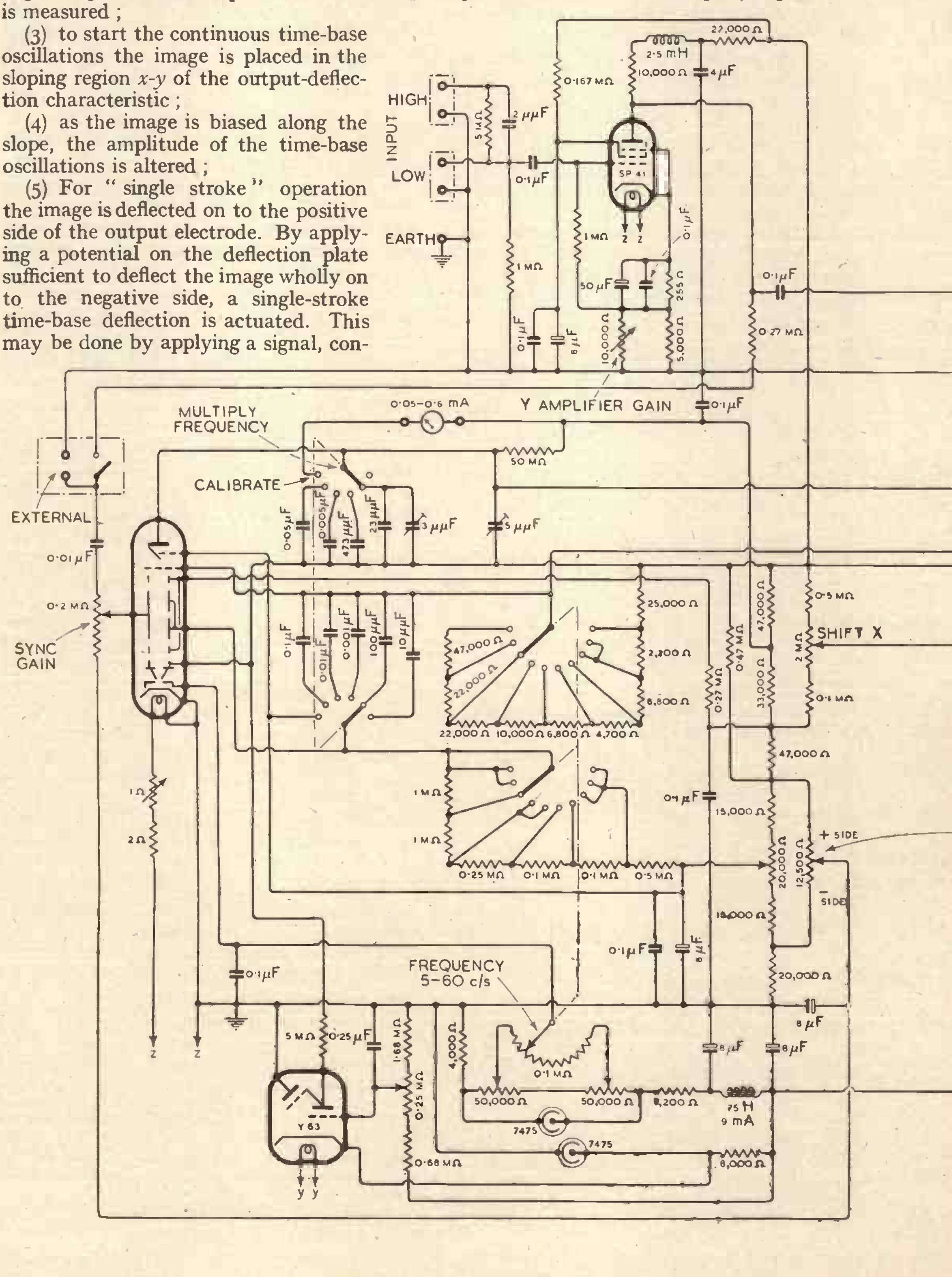
$$S/P = i_y/i_x + 1.$$

brated when the image is deflected on to the negative part of the output electrode and i_x is measured ;

(3) to start the continuous time-base oscillations the image is placed in the sloping region *x-y* of the output-deflection characteristic ;

(4) as the image is biased along the slope, the amplitude of the time-base oscillations is altered ;

(5) For " single stroke " operation the image is deflected on to the positive side of the output electrode. By applying a potential on the deflection plate sufficient to deflect the image wholly on to the negative side, a single-stroke time-base deflection is actuated. This may be done by applying a signal, conveniently via the " external " synchronising input terminal, on to the plate P_1.



"Sync. Gain" Control. To lock the time base a fraction of the useful signal is fed to the deflection plate P_1. The calibrated "Sync. Gain" control attenuates the amplitude of this signal by altering the potentiometer R_6 (see Figs. 1, 3 and 4). The sync. signal itself is fed to P_1 via R_6 either from the Y amplifier or externally, by applying the input signal to the terminals provided.

An increase in the amplitude of the sync. signal tends to reduce the amplitude of the time base. As the sync. signal amplitude is increased, the locking is always tighter and the amplitude of the time base is less. If the sync. signal amplitude is increased sufficiently the self-generator action is swamped, and "pure" signal converter action results.

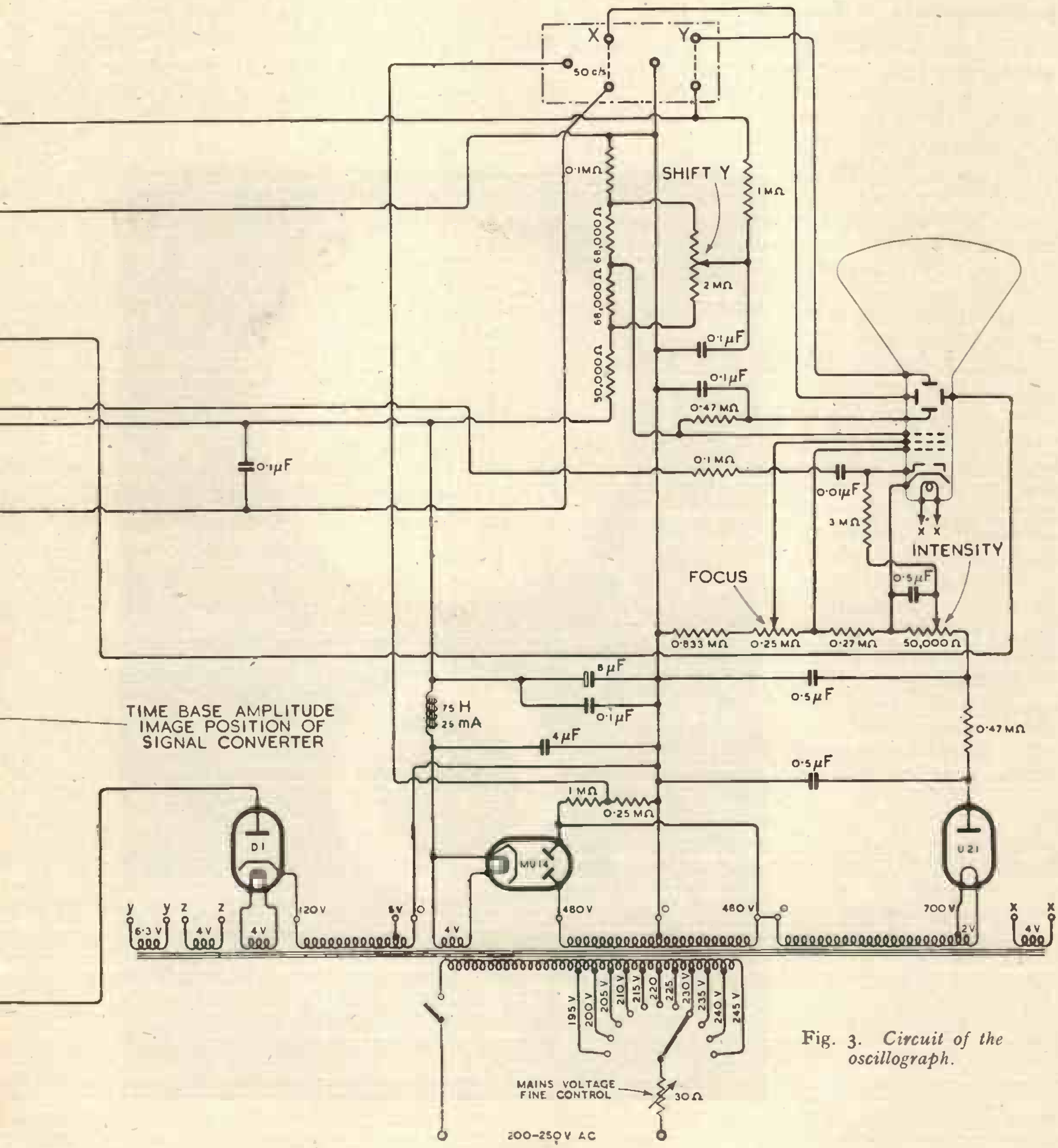


Fig. 3. *Circuit of the oscillograph.*

The changes of the time-base amplitude due to varying R_7 or R_6 do not affect the constancy of the time-base velocity.

The *fly-back* of the time base is blacked out by connecting the collector screen of the converter via a condenser to the grid of the C.R. tube. The scan to fly-back ratio is constant for all time-base velocities.

4. Measurement of Frequency

The C.R. tube is provided with a transparent calibrated screen, having three parallel riders and a red zero line (see Fig. 4). The position of the riders is indicated by the letters $4F$, $2F$ and F, corresponding to the time-base output potential $V/4$, $V/2$ and V (V = 200 volts). When the observed signal shows n complete cycles between the red zero line and the F rider, then the frequency of the signal is n times the frequency indicated by the main dial and the frequency multiplier. If only that number of cycles is counted which lies between the red zero line and the $4F$ or $2F$ rider—as may be more convenient—then the number of cycles counted must naturally be multiplied by 4 or 2 respectively. The start of the scan should be adjusted close to the red zero line.

5. Factors Affecting Accuracy of Frequency Reading.

The accuracy of frequency measurement is within 1 per cent.

While the method of measurement described is straightforward and more or less obvious, the accuracy of measurement and frequency calibration is influenced by a considerable number of factors, all of which must be carefully weighed when designing the oscillograph.

(*a*) Temperature and atmospheric conditions affect the output capacitance C. The time-base velocity is inversely proportional to C, $V/T = i_x/C$; therefore C must be accurate and remain constant within 1 per cent. Silvered mica or ceramic condensers are commercially obtainable with a tolerance of $\pm$ 1 per cent.; their temperature coefficient is small and the sealed type

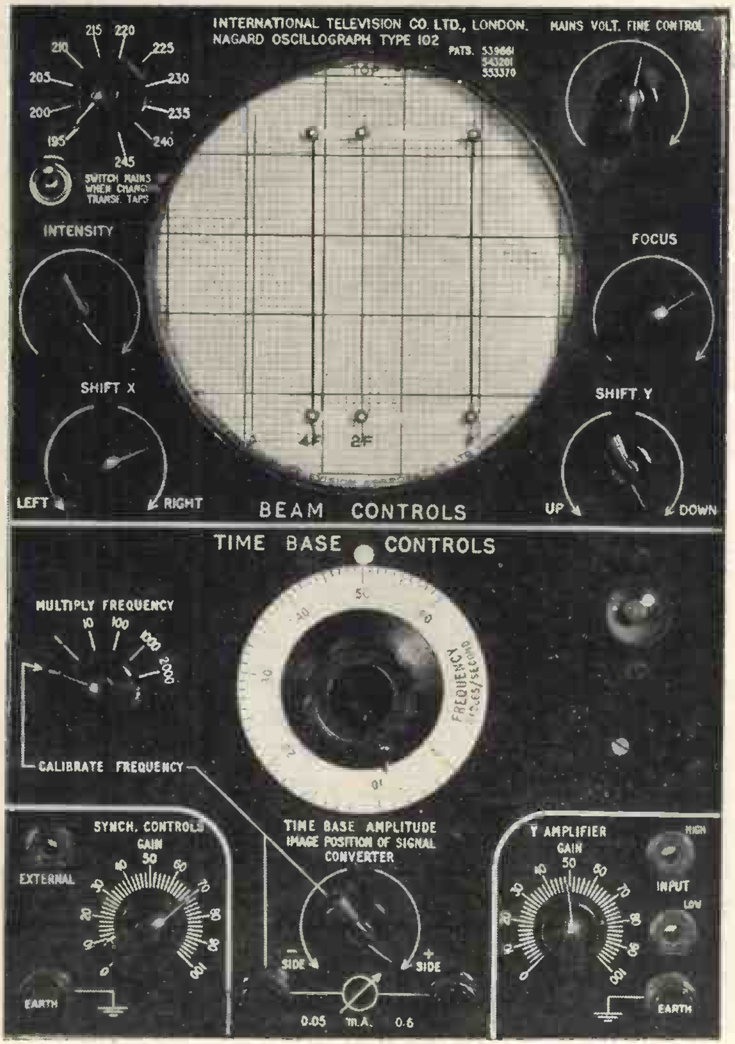


Fig. 4. *Panel of oscillograph.*

is not affected by atmospheric conditions.*

(*b*) There is an inherent error when the trace on the C.R. tube is read relative to the riders of the transparent calibrated screen. This error is due to the finite width of the trace and the riders, the distance between fluorescent screen and riders and the human element when adjusting the *n* complete cycles relative to the riders.

The diameter of the C.R. tube bulb and transparent screen is 133 mm., the distance between the *O* line and the *F* rider, *i.e.*, the distance corresponding to the datum time-base output amplitude *V*, is approximately 75 mm. utilising only the substantially flat part of the C.R. tube bulb. To permit 1 per cent. accuracy of reading the width of the trace and riders should be less than 75/100 = 0.75 mm.; the actual widths are approximately 0.4 mm. The distance between the trace and riders is of the order of 3 mm. Assuming a convenient viewing distance of 500 mm., it was found that an observer never deviates more than ± 40 mm. from the correct viewing position, corresponding to a maximum error in reading of 1/4 of a millimeter.† So the accuracy of reading is within that of the calibration.

When the position of the transparent screen relative to the axis of the time base (*X* deflection) is correct, *i.e.*, when the horizontal lines of the scale are accurately parallel and hence the riders perpendicular to the said axis, a single cycle can be adjusted with the required accuracy between the *O* and *F* riders. Lack of linearity of the *Y* amplifier does not affect the reading.

When a signal which contains a transient is under investigation it should be synchronised in such a phase that the transient coincides with the riders. For other signals, *e.g.*, sine waves, the steepest part of the curve should be adjusted to coincidence.

Often, however, it is more convenient to adjust and count the peaks of the waves; the required accuracy is then maintained if several (5—10) complete cycles are measured by reducing the time-base velocity, a procedure which is always possible. In this latter case, the adjustment of the calibrated screen relative to the time-base axis is not critical.

(*c*) When the scan of the time-base is truly linear (dV_0/dt = constant) the accuracy of the frequency reading is not affected by the position of the trace on the screen; *e.g.*, the start of the scan could be adjusted at the 2*F* rider and a reading taken between the 2*F* and *F* riders.

The constancy of the spot-velocity is influenced by the lack of constancy of the C.R. tube deflection sensitivity. This error varies in individual tubes; it does not affect, however, the accuracy of the frequency reading, being automatically eliminated if the position of the riders is set by the actual deflection corresponding to *V*/4, *V*/2 and *V*. For example, the riders are in the correct positions when 4 complete cycles of a known frequency (say, 50 c/s from the mains) are adjusted on the screen placing the main frequency dial in the appropriate position (12.5 c/s, or measuring $i_x = 0.125$ mA), then the first, second and fourth complete cycle determines the correct position of the riders, 4*F*, 2*F* and *F* respectively.

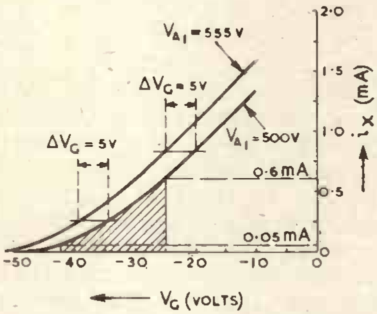


Fig. 5. *"Negative" output electrode current characteristics as function of grid bias for different first anode potentials.*

The charging current of the output load *C* is constant well within 1 per cent. for output electrode potentials from 250 to 530 volts (see Part II, Fig. 12, $i_x = f_2(V_0)$). The scan need not be linear; reading errors from this cause are entirely eliminated when the scan is adjusted to start at the *O* line.

The scan does not require readjustment, when the scanning velocity or amplitude of the time base is changed, if the output

* The temperature coefficient of linear expansion of mica is 3.10^{-6} per deg. C. The capacitance is proportional to the area and inversely proportional to the separation between the plates; hence the capacitance is directly proportional to the temperature coefficient. For 100 deg. C. change in temperature the capacitance change in a "good" condenser is less than 0.1 per cent., while in a "bad" mica condenser the change is of the order of 0.5 per cent.

† Conditions would be ideal if the calibrated scale were on the inside of the bulb.

electrode of the converter is directly coupled to the X deflection plate of the C.R. tube (see Fig. 3), because the scan always starts at the positive equilibrium potential of the output electrode, which is substantially constant (see Part II, Fig. 14).

A further advantage of the direct coupling is that the "Shift X" potential divider (Fig. 3) acts instantaneously; the annoying crawling effect—when a coupling condenser is charged exponentially via a resistance—is eliminated. Often preceding a frequency reading a number of fine adjustments—displacement of the trace along the X axis—are necessary, and this instantaneous response of the trace to the "Shift X" control is essential for easy reading.

(*d*) To facilitate quick reading, an unknown frequency should lock the time base in *any* position of the main frequency dial. The signal converter is very receptive to synchronisation; when the "Sync. Gain" control is increased sufficiently to produce tight locking, the frequency of the signal under investigation can be changed (even as much as a hundred fold) *without affecting* the tight locking of the stationary pattern on the screen. Usually it is also possible to change the phase of the locked pattern at the start of the scan by adjusting the "Time-Base Amplitude" control, *i.e.*, biasing the image within the slope *x-y*.

(*e*) The same calibrated engraved dial for controlling R_3 must be accurately adjustable by R_4 and R_5 for different converter supply potentials and for *any* converter having slightly differing $i_x - V_G$ characteristics. The beam-current/grid-voltage characteristic of the converter (Fig. 5) is space-charge limited and is similar to that of the triode. This characteristic is determined by the cathode-grid and grid-first-anode distances and the potentials of grid and first anode. The efficiency of the cathode, *i.e.*, the total cathode emission available, has only a slight effect on the characteristic.

When different potentials are applied to the first anode, the slope of the curve, di_x/dV_G, remains constant for some predetermined beam current value i_x, *i.e.*, the curve does not alter its shape, it is only shifted laterally, along the abscissa; hence the main frequency control R_3 can be calibrated independently of V_{A_1} by setting two limiting points with R_4 and R_5.

When employing the same calibrated dial (R_3) for a large number of signal converters, it was further found, that the cathode-grid, grid-anode distances can vary as much as 10 per cent., without materially affecting the accuracy of the calibration. Employing a large linear wire wound resistor (diameter 80 mm.) for R_3, the accuracy of calibration is well within 1 per cent.

(*f*) The deflection sensitivity of the C.R. tube must be constant, otherwise the riders require resetting. When the "Intensity" control of the C.R. tube is adjusted—altering the grid bias—the beam current is altered. The smoothing circuit of the C.R. tube supply consists of condensers and an ohmic resistance; the value of this resistance must be so chosen that the potential across the resistance chain supplying the first anode, second anode and grid bias potentials alters less than 2 per cent. when the beam current is altered between the limits of the well focused region. Then the deflection sensitivity alters less than 1 per cent., because the electron velocity and thus the deflection sensitivity is proportional to the square root of the accelerating potential.

The deflection sensitivity of the tube may be quickly checked by measuring a known frequency (50 c/s from the mains, available on the side panel of the oscillograph).

(*g*) In order to measure with greater accuracy than 1 per cent. the value of i_x should be measured after a frequency setting, by means of a sub-standard milliammeter as was described (place "Multiply Frequency" switch in "Calibrate" position and deflect image on to "negative side" of output electrode), and this value should be used as the measure of frequency in place of the reading on the main dial.

From sub-sections (*a*) to (*g*) it is apparent that the accuracy of frequency measurement is within 1 per cent. and that the calibration can be quickly and easily checked in every respect.

6. Accuracy of Frequency Measurement: Eliminating Influence of Mains Variations

In order to measure accurately it is essential to eliminate the effect of mains voltage variations. These would alter the beam current of the signal converter and the deflection sensitivity of the C.R. tube.

The first obvious solution is to stabilise the mains supply by using saturated transformers and chokes ; while good sine wave output is obtainable from such a combination,[3] the bulkiness of the control unit and the considerable stray 50 c/s fields make this choice very undesirable ; also control is insufficient for large mains variations.

The second obvious solution is to stabilise all the voltages which affect i_x and the deflection sensitivity of the C.R. tube by a triode-pentode combination or other means (barretters, etc.). In Fig. 6 is shown a circuit, which, for example, could be employed to stabilise the D.C. supply to the signal converter ; the operation of this and similar circuits has been fully described.[4]

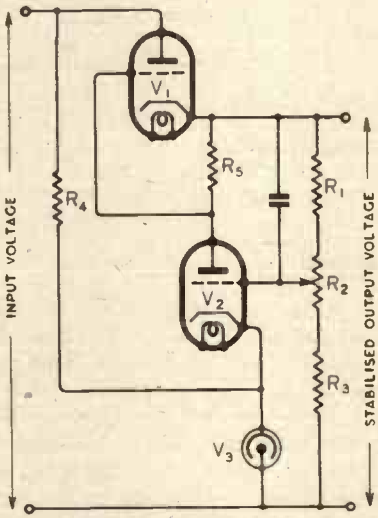


Fig. 6. *Mains voltage stabiliser circuit employing three valves.*

At least, three valves are required, a triode (V_1) across which the input potential changes are dropped, a control triode or pentode (V_2) which supplies the grid bias for V_1, and a gas-filled voltage stabiliser (V_3).

While this or similar circuits give a remarkably stable output voltage, it was not adopted for the following reasons :

(*a*) For 230-volt mains the wasteful potential drop across V_1 is of the order of 150 volts. The stabilising circuit should be effective for mains potentials from 195 to 260 volts. For the latter case the potential drop across V_1 rises to 250 volts. Thus the smoothing circuit of the rectifier must be designed for 550 + 250 = 800 volts, and electrolytic condensers cannot be employed. This, and the employment of three additional valves, results in an uneconomical and bulky solution.

(*b*) It would be necessary to employ a similar unit, using a further three valves, for the stabilisation of the C.R. tube supply ; this unit would be even bulkier than the former.

(*c*) A 15 per cent. change in the mains supply and thus in the signal converter heater voltage would alter the beam current of the converter, necessitating the employment of a barretter to stabilise the heater current.

A very much simpler and far more economical solution has been adopted to eliminate the effect of the mains voltage variations upon the accuracy of the frequency reading. This will be described.

Observations extending over a considerable period have shown that two distinct types of mains-disturbances have to be dealt with, namely : sudden surges due to switching on and off of nearby machinery resulting in small deviations of the mains potential, and a slow change of much greater magnitude (of the order of 5 or occasionally even 10 per cent.), due to the periodic daily decreasing and increasing demand.

The former type of disturbance changes only i_x ; its effect on the deflection sensitivity of the C.R. tube and other parts of the circuit is negligible, being within the calibration accuracy of the oscillograph. Particularly in the low beam current region (i_x = 0.05 mA) a 1 per cent. change of the grid voltage of the signal converter results in a much greater percentage change of i_x. For example :

$V_G = -45$ volts	..	$i_x = 0.05$ mA
$V_G = -44.5$ volts	..	$i_x = 0.06$ mA
Change $\cong 1$ %		Change $\cong 20$ %
$V_G = -27.5$ volts	..	$i_x = 0.6$ mA
$V_G = -27.2$ volts	..	$i_x = 0.615$ mA
Change $\cong 1$ %		Change $\cong 2.5$ %*

These beam current changes corresponding to the frequent mains surges considerably affect the time-base velocity, the steadiness of the time base and so the synchronisation.

* The corresponding change in the first anode potential tends to decrease this error, but the amount of correction is small relative to the magnitude of the error. If a variable "cathode" resistor could be used for R_3 (see Fig. 1) the error would be considerably less ; this is, however, not possible, because of difficulties of calibrating R_3 and because it requires adjustment of the second anode potential for changes of i_x to refocus the converter image.

The correcting circuit—shown in Figs. 3 and 7—is simple, consisting of two resistors R_1 and R_2 (dissipating 0.1 watt) and a small voltage stabiliser N (95 volts, consumption 4 mA). The circuit is based on the constancy of the amplification factor A of the converter gun system.

$$A = \frac{dV_{A_1}}{dV_G}, \text{ when } i_x = \text{constant.}$$

For some fixed i_x value the amplification factor is an absolute constant for all practical values of the first anode potential;* changes of heater voltage do not affect it. It is also substantially constant for i_x values between 0.05 and 0.6 mA.† From Fig. 5 A may be evaluated:

$$A \simeq \frac{\Delta V_{A_1}}{\Delta V_G} = \frac{55 \text{ volts}}{5 \text{ volts}} = 11.$$

It follows that if the mains potential alters, say, 10 per cent., the grid potential V_G must be shifted 5 volts relative to earth potential for all values of i_x; this is accomplished if the range of potentials stabilised by N is shifted *in toto* by 5 volts. Then the constancy of i_x is not affected by mains variations.

In Appendix II is shown that the amplification factor and the supply potential of the corrected grid-bias circuit ($V+V_1+V_2$) determine the resistance chain of the circuit, *i.e.*, V_1 and V_2:

$$\frac{V_2}{V_1} = \frac{R_2}{R_1} = \frac{V + V_1 + V_2}{V_{A_1}} A - 1.$$

$V+V_1+V_2$ must be so chosen that it lies safely above the "striking" potential of the neon stabiliser. For the actual circuit of the oscillograph, V striking = 130 volts, so a reasonable value is $V+V_1+V_2 = 137.5$ volts. Also $V_{A_1} = 550$ volts and $A = 11$; hence

$$\frac{V_2}{V_1} = \frac{137.5}{550} 11 - 1 = \frac{7}{4}.$$

Therefore $V_1 = 15.45$ volts and $V_2 = 27.05$ volts.

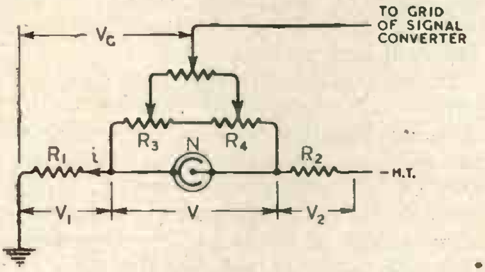


Fig. 7.

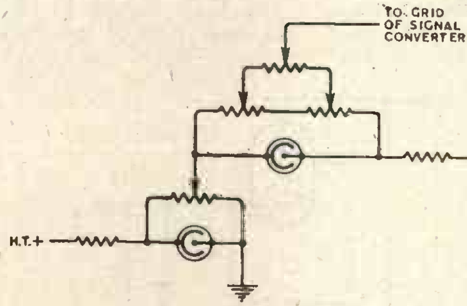


Fig. 8.

Correcting circuits for the stabilisation of the beam current of the signal converter.

Two more conditions must be satisfied. V_1 must be less than the grid bias for $i_{x\max}$ and $V_1 + V$ must be greater than the grid bias for $i_{x\min}$. The minimum and maximum i_x values employed in the oscillograph satisfy the conditions above calculated.

If high i_x values are employed and V_1 is greater than V_G for maximum i_x, other circuits, for example that of Fig. 8, can be used.

When the time constant of the smoothing circuit and load complex of the signal converter supply is identical to that of the grid voltage correction supply, then the supply potential and the bias changes are *in phase* and so the correction is instantaneous.

The slow mains voltage changes are checked and controlled with the aid of an electron-beam visual indicator, sensitive to less than 0.25 per cent. mains variation. The correct input to the mains transformer for standard mains voltages is applied by connecting the appropriate tap on the transformer primary (5 volt steps from 195 to 245 volts are provided) and by adjusting the "Mains Voltage Fine Control" variable resistance (see Figs. 3 and 4). When the visual indicator is uniformly illuminated, the adjustment of the mains potential is correct (see Fig. 9).

As the accuracy of frequency measurement depends on the reliability of the visual

* Disregarding the effect of space charge close to the cathode the amplification factor is determined by the ratio of cathode-grid and cathode-first anode capacitances.

† A decrease of the amplification factor occurs only at very low i_x values; *e.g.*, at $i_x = 0.005$ mA the decrease of A is of the order of 5 per cent.

indicator circuit, this is described (see Figs. 3 and 10). The electron beam visual indicator consists of two parts: a conventional triode (K, G_3, A), loaded with the anode load R_1, and the electron beam "triode"; the anode of this latter is the fluorescent target T, its grid G_4 is connected within the valve to cathode potential and it has a second "grid" —in the form of a knife edge—which is connected within the valve to the anode A.

Fig. 9 (*above*). *The illuminated target of the visual mains voltage indicator.*

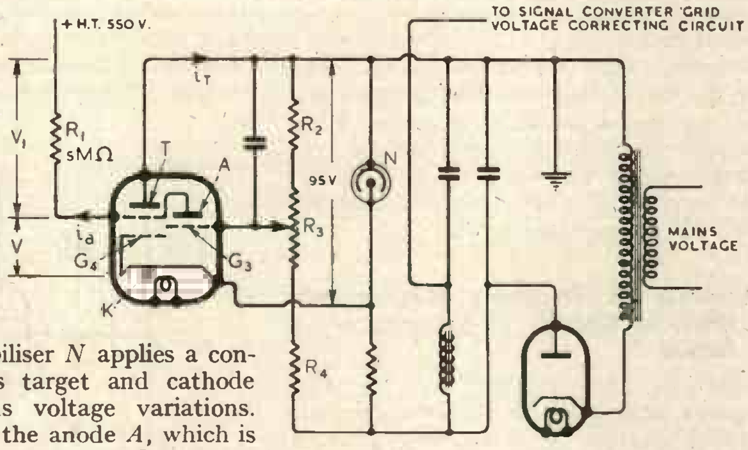


Fig. 10 (*right*). *Circuit of the electron beam visual mains voltage indicator.*

The neon voltage stabiliser N applies a constant potential across target and cathode independent of mains voltage variations. For some potential of the anode A, which is close to that of the target, the fluorescent target is uniformly covered by electrons; for potentials more positive or negative a white or dark cone appears, as indicated in Fig. 9. The bias of the grid G_3 is sensitive and proportional to variations of the mains voltage; it is set by adjusting R_3 to give uniform target illumination while the mains input is correct.

It is essential that the visual indicator be sensitive to less than 1 per cent. mains variation and that changes in its characteristic and in the circuit components do not affect the voltage indication.

(1) The sensitivity of the mains voltage indicator is proportional to the amplification factor ($\Delta V_A/\Delta V_{G_3}$) of the amplifier triode section;* it also depends on the angular displacement of the fluorescent image as function of the anode potential changes.

In the circuit of Fig. 10, 0.25 per cent. change of the mains potential ($\Delta V_{G_3} \simeq 0.3$ volt) results in a distinct change of the fluorescent image.†

(2) When low anode current i_a (*i.e.*, large bias V_{G_3}) is employed, the constancy of i_a is unaffected by the ageing of the valve, as i_a is a small fraction of the total cathode emission available.

The target current i_T is sensitive to ageing, because the grid G_4 is at cathode potential: errors from this source are, however, eliminated by stabilising the target potential.

(3) The grid bias potential V_{G_3}, once set, must remain constant. Errors due to ageing of the resistors, and changes of temperature are eliminated if the potential divider resistance chain is built up of the same type of resistors having the same dissipation. Uniform changes in R_2, R_3 and R_4 will then not affect the potential division.

(4) If the anode load R_1 is much greater than the internal resistance R of the triode, large variations in R_1 due to ageing or temperature have only a negligible effect upon the anode potential.

* The effective amplification a is approximately equal to the amplification factor μ because the load R_1 (5 megohms) is much greater than the internal resistance R of the triode ($R \simeq 50{,}000$ ohms)

$$a = \mu \frac{R_1}{R + R_1} \qquad R_1 \simeq 100\,R$$

$$\therefore \quad a \simeq \mu$$

† The commercial electron-beam tuning indicators have a "variable mu" characteristic, *i.e.*, for low anode currents the amplification factor is considerably reduced; for sensitive voltage measurement applications constant amplification factor characteristic would be preferable, as high load and hence low anode current values considerably improve the stability of the circuit (see (4) and also (2)).

It can be shown that

$$\frac{\Delta V_1}{V_1} = \frac{\Delta R_1}{R_1} \cdot \frac{R}{R + R_1 + \Delta R_1}$$

where $\Delta R_1/R_1$ represents the percentage change in the load resistance and $\Delta V_1/V_1$ the resulting anode potential change.

For example, if $R_1 \simeq 100\,R$

and $\Delta R_1 = \frac{10}{100} R_1$

$$\frac{\Delta V_1}{V_1} = \frac{10}{100} \cdot \frac{R_1/100}{\frac{R_1}{100} + R_1 + \frac{10}{100} R_1} = \frac{1}{1110}$$

i.e., for a 10 per cent. change in R_1 the change in V_1 is less than one part in a thousand. When V_1 is 500 volts the change in anode potential (ΔV_1) is 0.45 volt, which is immaterial.

Provided that the reference potential given by the voltage stabiliser remains constant, the visual indicator employed in the above simple circuit is as reliable for comparative voltage measurements as any first-grade moving-coil voltmeter, it occupies less space and is more economical.

7. Accuracy of Frequency Measurement: Effect of Stability of Components and Ageing

Whenever the accuracy of frequency measurement depends on the accuracy of the potential division of some resistor chain, the chain is composed of resistors of the same type, under-rated, and of equal dissipation, so that temperature changes or ageing do not affect the "potential division" of the chain, although the current through it may be affected. As already mentioned the voltage divider resistors employed for the biasing of the grid G_3 of the visual indicator follow this principle. This is also the case in Fig. 7 for resistors R_1 and R_2 and for R_3 and R_4; likewise for the bleeder circuit resistor chain of the C.R. tube supply, although this is much less critical.

Changes in other components will not effect the accuracy of calibration.

The internal resistance of the rectifiers is so low in comparison with their loads, that as long as the rectifier is capable of giving any emission the D.C. supply potentials remain substantially constant.

Certain reference voltages must be kept constant to preserve the calibration. These are determined by the neon stabilisers. Unfortunately some stabilisers age slowly. Thus it is essential to check the calibration of the visual mains voltage indicator occasionally, say, every three months.

8. The Y Amplifier: H.F. Corrected Linear Attenuator

The unknown signals must be amplified by the Y amplifier without distortion and the input impedance of the amplifier must be so great that the circuit to which it is applied is unaffected.

The amplifier and attenuator are high- and low-frequency corrected.

In the circuit shown in Fig. 3 the amplification is attenuated by variable "negative feedback." For input signals above ½ volt the application of negative feedback results in a very high input impedance and tends to eliminate the effect of the input capacitance so that the high-frequency response is good.

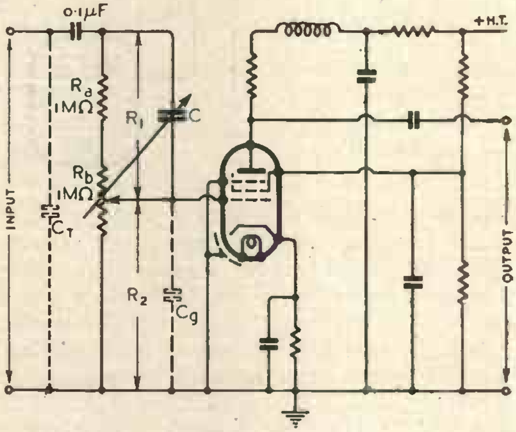


Fig. 11. *Circuit of the Y amplifier and linear input voltage attenuator.*

For certain applications an alternative input attenuator and amplifier circuit is employed, as shown in Fig. 11. Here the attenuating effect at the high frequencies of the capacitance C_g is eliminated by a variable condenser C coupled with the attenuator R_b in such a manner that $R_1/R_2 = C_g/C$, *i.e.*, the capacitive potential division is the same as that of the ohmic resistances.

It can be shown that

$$\frac{R_1}{R_2} = \frac{R_a + R_b\,(1 - D)}{D R_b}$$

where D = fraction utilised of total available grid input signal.

Or for the convenient case, when $R_a = R_b$, $R_1/R_2 = C_g/C = (2 - D)/D$. Then for maximum signal input $C = C_g$. The actual form of C may be readily calculated from above formula; in the solution adopted the movable plate is a tapering spiraloid. C is represented by two metal laminæ fixed to insulating plates which are attached respectively to the stationary case and rotating spindle of the variable resistance R_b.

The advantage of the circuit of Fig. 11 is that the linear attenuator R_b can be readily calibrated while the input impedance can be quite high (2 megohms, with parallel capacitance changing from 5 to 1 pF); the input impedance is, however, higher in the attenuator circuit employing negative feedback. A cathode-follower input stage is the ideal.

9. Future Aspects

In industry, where electrical quantities are measured, most of the A.C. measuring instruments are suitable only at the 50 c/s mains frequency.

The electronic art will spread to all branches of industry. For both research and production, electronic controlling and checking devices will be increasingly employed, whether or not the particular industry is specialising in electrical apparatus.

These devices will use electrical signals extending over a wide range of frequencies. An instrument will be required which is capable of measuring potential and current at these frequencies, and of determining the frequencies themselves, with the same accuracy as, say, a first grade universal multi-range moving-coil ampere-voltmeter. It should be compact, simple, and the accuracy independent of mains variations. These requirements can be hardly fulfilled by an oscillograph using commercially available C.R. tubes and conventional valves; but solutions can be visualised by which they would be fulfilled, employing special calibrated C.R. tubes, etc.

The oscillograph is, in many respects, a measuring device superior to conventional meters; its input impedence can be made very high; it will register not only r.m.s. and peak values, but give a complete picture of the changes during the whole period of recurrent and non-recurrent phenomena. There is no real reason—merely some difficulties and snags—why it should not be made to register absolute quantities with the same accuracy as other conventional meters.

(To be concluded.)

APPENDIX I

The low negative output electrode current $i_x = 0.05$ mA employed would destroy the linearity of the time base output of a conventional circuit.

The output electrode is directly connected to the deflection plate of the C.R. tube and is "floating," *i.e.*, it is not connected to any supply potential. The output load is a pure capacitance, C. Ohmic leaks parallel to C are minute and can be neglected. The deflection plate of the C.R. tube may collect electrons or ions, this "leak" is, however, of much higher order of magnitude than 2 megohms.

When a "leak" is across the output load C

$$V = i_x R(1 - e^{-t/CR})$$

If the exponential term is expanded as an infinite series this expression reduces to

$$V = \frac{i_x t}{C}\left[1 - \tfrac{1}{2}\frac{t}{CR} + \tfrac{1}{6}\left(\frac{t}{CR}\right)^2 \ldots\right]$$

Provided T/CR is small compared with unity the third and subsequent terms are negligible, T/CR being the maximum value of t/CR.

The second term then represents the deviation from linearity of the scan due to the "leak" R across C.

$$V = \frac{i_x T}{C} \quad \therefore \quad \tfrac{1}{2}\frac{T}{CR} = \frac{V}{2i_x R}$$

For $i_x = 0.05$ mA and the required datum output $V = 200$ volts $\tfrac{1}{2}\frac{V}{i_x}$ corresponds to a resistance of $\tfrac{1}{2}\frac{200}{0.05} = 2$ megohms, so if the "leak" R is say 200 megohms, the lack of linearity $\tfrac{1}{2}\,T/CR$ is 1 per cent.

APPENDIX II

$V + V_1 + V_2$ and V_{A_1} change in proportion:

$$V + V_1 + V_2 = kV_{A_1}$$

and $\quad \Delta(V + V_1 + V_2) = k\Delta V_{A_1}$

Since $\Delta V = 0$, this becomes:

$$\Delta V_1 + \Delta V_2 = \frac{V + V_1 + V_2}{V_{A_1}}\Delta V_A \quad \ldots \quad (1)$$

But $\quad A = \frac{\Delta V_{A_1}}{\Delta V_G}$ and $\Delta V_G = \Delta V_1$

$\therefore \quad \Delta V_{A_1} = A\Delta V_1$

Substitute in (1):

$$\Delta V_2 = \Delta V_1\left[\frac{V + V_1 + V_2}{V_{A_1}}A - 1\right]$$

But $\quad V_1 = iR_1$ and $V_2 = iR_2$

$\therefore \quad \Delta V_1 = R_1\Delta i$ and $\Delta V_2 = R_2\Delta i$

$$\therefore \quad \frac{V_2}{V_1} = \frac{R_2}{R_1} = \frac{\Delta V_2}{\Delta V_1} = \frac{V + V_1 + V_2}{V_{A_1}}A - 1$$

REFERENCES

[1] The Signal Converter. New thermionic discharge tube for the production of the time base deflection potentials of a C.R. tube, P. Nagy and M. J. Goddard, *Wireless Engineer*, June 1943, Vol. 20, pp. 273–299.

[2] The Signal Converter and Its Application to Television, P. Nagy, *Journal of the Television Society*, Vol. 4, No. 2, pp. 26–36.

[3] The "Stabilistor," A. H. B. Walker, *Wireless World*, Nov. 1944.

[4] Electronic Voltage Regulators, Livingston Hogg, *Wireless World*, Nov., Dec. 1943. Also Lindenhovius, Rinia, *Philips Technical Review*, Vol. 6 No. 2, 1941.

CORRESPONDENCE

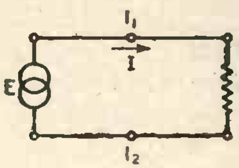
Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

A "Strange" Convention ?

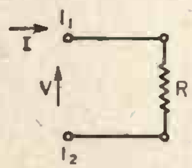
To the Editor, "Wireless Engineer"

SIR,—An Editorial in the July 1945 issue of *Wireless Engineer* criticises the convention adopted in my paper in *The Marconi Review*, No. 77. This same convention, however, has escaped your editorial wrath nearer home[1, 2]. The least that can be said about its merits is that it is self-consistent, it does not involve the user in lengthy explanations which are confused by errors of draughtsmanship, and it has been used before[3]. The derivation of this convention may be simply described.

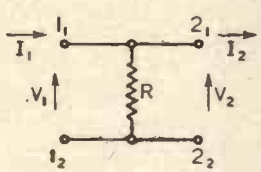
Consider a mesh (a) consisting of a generator E and a load R. The current flowing in the mesh, I, is given arbitrarily the clockwise direction shown by the arrow. It is convenient to attach to the generator E an arrow pointing upwards, that is, in the same direction as the current arrow. This is the convention you would apparently prefer. If now we wish to discuss the properties of the network R, we scratch out the generator, leaving the network of (b). The current arrow I remains from left to right, and we insert a voltage arrow V which



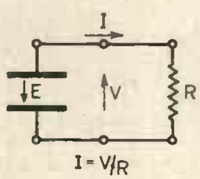
(a)



(b)



(c)



(d)

is intended to close the mesh. We can then say that, as the two arrows are both for clockwise rotation, $V = IR$.

When R becomes a four-terminal network, (c), we must use arrows also for the output voltages and currents. The sense chosen for these is that sense which will represent a clockwise path round a succeeding mesh. If this is done, tandem interconnection corresponds to a straightforward matrix multiplication without manipulation of signs. (*Loc. cit.* (1) equation A.6).

The editorial electric balls present two problems, a circuit problem and a field problem. I do not see that any difficulty is caused if the circuit is drawn in the form of (d).

H. JEFFERSON.

London, S.W.1.

[As a matter of fact it was the article in *Wireless Engineer* last December that first introduced us to this strange convention, but we regarded it then as a personal idiosyncrasy of the author. It was when we were told that it was being employed at an educational institution that we felt that something should be done about it. We are indebted to Mr. Jefferson for calling attention to the article by Strecker and Feldkeller in 1929 for it is very enlightening. After pointing out that the voltages and currents set up in the network fed by the terminals 1 and 2 depend only on the tension V_1 between them, whatever the source of power, they say "Wir können dann über die Art wie die Spannung V_1 aufrechterhalten wird frei verfügen und nehmen an dass die Spannung V_1 durch eine an das Klemmenpaar (1, 2) aufgelegte elektromotorische Kraft V_1 mit verschwindendem inneren Widerstand erzeugt wird," or in English "We are then free to maintain the tension V_1 in any way we please, and we assume that the tension V_1 is produced by a source of electromotive force V_1 with a negligibly small internal resistance connected between the terminals." Hence, although they use the same symbol for both tension and electromotive force they make it quite clear that the arrow represents not the tension but the electromotive force which, in the absence of the real source of supply, would produce the same potential difference between the terminals. In the presence of the actual source of supply this postulated source of e.m.f. would supply no current because its e.m.f. would be exactly counterbalanced by the p.d. between the terminals. Hence, so far as the p.d. can be said to have a direction, it is exactly equal and opposite to the e.m.f. shown by the arrow. As Mr. Jefferson says, such a convention is self-consistent ; if one realises that the arrow always indicates the direction of the e.m.f. which would exactly counterbalance the p.d., one will always obtain correct results.

Mr. Jefferson seems to be vague about his arrows. He says "It is convenient to attach to the generator E an arrow pointing upwards. . . . This is the convention you would apparently prefer." It is surely not a matter of convenience or convention ; the e.m.f. E of the generator in his Fig. (a) can only be represented by an upward pointing arrow. Similarly later he "inserts a voltage arrow V which is intended to close the mesh" presumably meaning thereby a fictitious generator of e.m.f. indicated by the arrow V as is so clearly explained by Strecker and Feldkeller.—G. W. O. H.]

---

[1] *Wireless Engineer*, December 1944, Vol. XXI, p. 564.

[2] *Wireless Engineer*, August 1945, Vol. XXII, p. 384.

[3] *E.N.T.*, 1929, Vol. 6, No. 3, p. 93.

WIRELESS PATENTS

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

RECEIVING CIRCUITS AND APPARATUS

567 134.—Automatic volume-control system for operation over a wide range of frequencies and for responding rapidly to large and sudden changes of amplitude.

Standard Telephones and Cables Ltd. (assignees of L. P. Tuckerman). Convention date (U.S.A.) 18th August, 1942.

567 468.—Adjustable coupling device for pretuning the I.F. circuits of a supersonic set comprising two coaxial coils and a powdered-iron core.

Johnson Laboratories Inc. (assignees of F. N. Jacob). Convention date (U.S.A.) 16th May, 1942.

TELEVISION CIRCUITS AND APPARATUS

567 475.—Scanning device in which the light path from a lamp to the photo-sensitive surface is confined to a V-shaped transparent plastic element.

Standard Telephones and Cables Ltd. (assignees of P. M. Rainey). Convention date (U.S.A.) 27th August, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

567 264.—Earthing system comprising a series-parallel set of electrolytic resistances and an automatic switch for preventing overload.

The British Thomson-Houston Co. Ltd. and C. J. Errol. Application date 24th May, 1943.

567 287.—Slot-and-cover arrangement to allow for the introduction and adjustment of a probe along the length of a coaxial transmission line or hollow wave guide.

The General Electric Co. Ltd. and E. M. Hickin. Application date 13th February, 1942.

567 334.—Portable equipment for transmitting either radio or light signals, at will, to facilitate the location of persons lost on land or sea.

Bendix Aviation Corporation. Convention date (U.S.A.) 10th July, 1942.

567 352.—Relay circuit for safeguarding the amplifiers of a wireless transmitter from casual voltage surges.

Standard Telephones and Cables Ltd. (assignees of J. O. Weldon). Convention date (U.S.A.) 23rd June, 1942.

567 407.—Adjustable click device associated with an indicator scale for selecting one or other of the various harmonics of a master oscillator.

The General Electric Co. Ltd.; N. R. Bligh; J. B. L. Foot; and E. F. Foreman. Application date 16th June, 1943.

567 426.—Construction of a rugged condenser of the interleaved type suitable for the wireless equipment used in a military tank or similar vehicle.

Philips Lamps Ltd. and R. G. D. Holmes. Application date 11th March, 1943.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

567 441.—The use of selected sensitive coatings for the photo-electric cathode and the secondary-emission electrodes of an electron multiplier, iconoscope, or image dissector.

Cinema-Television Ltd. and A. Sommer. Application date 20th July, 1943.

567 462.—Electrode construction and assembly designed to prevent over heating in a wireless transmitter valve.

A. R. J. Ramsay (communicated by Eitel-McCullough, Inc.). Application date 11th May, 1943.

SUBSIDIARY APPARATUS AND MATERIALS

566 970.—Construction and arrangement of the input and output transformer elements of a balanced-bridge circuit for operation over a wide range of frequencies. (Divided out of 566 945.)

C. G. Mayo. Application date 19th February, 1943.

566 986.—Construction of a high-voltage trimming condenser comprising metal-coated ceramic plates.

R. F. Oxley. Application date 17th June, 1943.

567 015.—Busbar terminal arrangement to avoid strain on the elements of a number of parallel-connected retifier units.

Standard Telephones and Cables Ltd.; E. A. Richards; and L. J. Ellison. Application date 15th July, 1943.

567 016.—Means for ensuring correct contact pressure between the adjacent discs or elements of a metal rectifier unit.

Standard Telephones and Cables Ltd. and E. A. Richards. Application date 15th July, 1943.

567 017.—Wide-range variable-resistance device assembled from standardised components.

The Plessy Co. Ltd. Convention date (U.S.A.) 12th November, 1942.

567 112.—Apparatus for recording and aggregating a number of different electric impulses.

Bell Punch Co. Ltd. and R. Milburn. Application date 11th May, 1943.

567 161.—Electrode arrangement for a "container-condenser" as used for measuring the permittivity or power factor of a dielectric.

Marconi Instruments Ltd. and C. F. Brocklesby. Application date 26th July, 1943.

567 165.—Method of stacking and clamping the interleaved layers of conducting and insulating sheets of a high-voltage condenser.

Dubilier Condenser Co. (1925) Ltd., and R. J. Tungay. Application date 27th July, 1943.

567 209.—Electron-discharge device for regulating the current supply for spot welding in accordance with a saw-toothed control voltage.

Westinghouse Electric International Co. Convention date (U.S.A.) 21st May, 1942.

567 280.—Bridge circuit for testing solids, liquids, or gases by utilising the ionising effect of X-rays.

The British Thomson-Houston Co. Ltd. (communicated by the General Electric Co.). Application date 25th October, 1943.

ABSTRACTS AND REFERENCES

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

Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title, while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

PROPAGATION OF WAVES

2877. A SUMMARY AND INTERPRETATION OF ULTRA-HIGH-FREQUENCY WAVE-PROPAGATION DATA COLLECTED BY THE LATE ROSS A. HULL.—A. W. Friend. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 358-373.)

Author's summary :—" An analysis of portions of the data recorded by Hull indicates that, with certain extensions and minor variations, his theories were leading toward the now apparently correct solution of the ultra-high-frequency propagation problems. It was indicated that propagation far beyond the horizon was produced by refraction or reflection in the tropospheric strata.

" Calculations of radius of ray-curvature have been made from data provided by the United States Weather Bureau, from stations near the propagation terminals points. It is indicated that radii of curvature less than the radius of the earth are coincident with conditions favourable to the propagation of strong signals over this path extending far beyond the horizon.

" A simple equation is given for calculating the radius of ray-curvature. It is concluded that more accurate meteorological data with finer structure characteristics should make possible more precise calculation of propagation conditions. It also appears that certain meteorological conditions may be assumed when various propagation conditions are encountered."

2878. RADAR TECHNIQUES, PART III : CHARGES, FIELDS AND WAVES [Transmission-Line Waves, Radiated Fields, and Reflection at Normal Incidence].—C. B. DeSoto. (*QST*, June 1945, Vol. 29, No. 6, pp. 44-49.) For previous parts *see* 2650 of August.

2879. THE RADAR EQUATION.—" D. G. F." (*Electronics*, April 1945, Vol. 18, No. 4, pp. 92–94.)

An equation is derived from fundamental considerations, connecting the radiated power, receiver sensitivity, and distance and size of the reflecting object. It is shown that the maximum range is proportional to the fourth root of the product of the transmitter power, the transmitting-antenna gain, the receiving-antenna absorption area, the target reflecting area, and the inverse of the minimum detectable received power. This is developed for the radar case of a single dipole radiator and circular reflector, to give the range in terms of pulse length, wavelength, and receiver noise-factor.

2880. PROPAGATION, ACCORDING TO GEOMETRICAL OPTICS, OF A MONOCHROMATIC LUMINOUS WAVE IN AN ISOTROPIC HETEROGENEOUS MEDIUM.—F. Odone. (*Nuovo Cimento* [Turin], May/July 1942, Vol. 19, No. 5/7, p. 157 onwards.)

A summary of this 12-page paper is given in *Physik. Berichte*, No. 20, Vol. 24, 1943, pp. 1323–1324. By an isotropic heterogeneous medium is meant a medium composed of a succession of different media each of which is homogeneous in itself. The treatment is in two parts : (i) analytical, on Fermat's principle, and (ii) geometrical (laws of refraction), including the derivation of a formula, $-\,di = \zeta + \Delta$, which is said by the writer to be probably new. It determines the change suffered by the propagation angle ζ as one passes along the ray from one point to another point infinitely near to the first, whatever the shape of the surfaces of equal refraction may be : ζ is the angle between two successive tangents, and Δ the angle between grad n and grad $(n + dn)$. If the surfaces of equal refraction are plane and parallel, then $n \sin i$ is a constant ; if they are concentric spherical surfaces, then $nr \sin i$ is a constant (derivation of Bouger's formula : *see* V. Bouasse, " Optique géométrique," p. 272.)

2881. REFLECTION OF ELECTROMAGNETIC WAVES BY MEDIA WHOSE OPTICAL CONSTANTS VARY IN A CONTINUOUS FASHION.—C. Mihul,

(*Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1323.)

Cf. 407 & 3843 of 1938. "The problem of the mechanism of the reflection of electromagnetic waves by a medium whose optical constants vary according to a continuous law has not yet been finally solved. The same problem is presented in connection with the oscillations of transmitting and receiving aerials and the reflection of short (and especially ultra-short) waves by the ground. The moisture of this frequently varies with the depth, and on the amount of moisture depend the dielectric constant of the ground and its electrical conductivity.

"This position is usually dealt with by assuming certain well-defined electrical properties for the ground, and introducing, between ground and atmosphere, an intermediate layer which similarly possesses definite electrical properties differing, however, from those of the atmosphere and of the ground. By this assumption the problem becomes one of reflection at an intermediate layer with parallel bounding surfaces.

"In reality, however, the changes of the constants involved are continuous: the writer has therefore set himself to calculate, by the Fresnel laws, the reflection of electromagnetic waves for the case of a medium whose optical constants vary continuously. First comes the calculation of the reflecting power of a medium on the assumption that the dielectric constant and the conductivity both vary continuously; then, on the same assumption, the calculation of the reflection of electromagnetic waves by the ionosphere is carried out." The full paper appears in a publication from Jassy University.

2882. The Formation of the Abnormal-E Layer of the Ionosphere.—K. Rawer. (*Naturwiss.*, No. 36, Vol. 28, 1940, p. 577 onwards: short summary in *Physik. Berichte*, No. 13, Vol. 24, 1943, p. 923.)

"Since it is difficult to explain the formation of the abnormal-E layer by corpuscular rays, the following ionisation process is suggested: the O_2 molecules dissociated during the day are recombining continually—even during the night—in triple collision; by this process $O(^1S)$ atoms are formed, and these for their part recombine by double collision and produce O_2 and e; that is, ionisation. In this way, on the one hand, the nocturnal residual ionisation of the E layer can be explained.

"Since, on the other hand, violent winds (and therefore pressure fluctuations) obviously occur at these heights, and since the above-described mechanism is strongly dependent on pressure, very high ion densities may be produced at different points, such as are observed in the abnormal-E layer. A numerical estimate leads to the right order of magnitude for the ionisation."

2883. The Electrical Conductivity of an Ionized Gas in a Magnetic Field, with Applications To the Solar Atmosphere and the Ionosphere.—T. G. Cowling. (*Proc. Roy Soc.*, Series A, 18th June 1945, Vol. 183, No. 995, pp. 453–479.)

Author's summary:—"The methods of Chapman and Enskog are used to discuss conduction of electricity and diffusion currents in an ionized gas with several constituents, in a transverse magnetic field. The free-path formula for the conductivity is compared with that derived by the exact methods. The two formulæ are identical in form if a correction is applied to the usual free-path method; this correction robs the method of much of its simplicity. The uncorrected free-path method, however, gives correct results for the electron contribution to the conductivity in all practical cases; and for the ion contribution if a large number of neutral molecules are present—e.g. in the earth's upper atmosphere, about 5×10^5 times the number of ions (of both signs).

"Numerical values are given for the conductivity in the sun's outer layers and in the earth's upper atmosphere. Mechanical forces due to currents induced in moving material are shown to be very important in the sun, and in the F-layer of the earth's atmosphere. The solar results are used to discuss the motion of solar prominences and eruptions. In the earth's atmosphere, the observed collision frequencies of electrons are shown to imply upper limits for ion-densities in the E and F layers. The integral conductivities of the E and F layers are estimated, and it is shown that, on the dynamo theory of the lunar variation of the earth's magnetic field, tidal oscillations in these layers must be between 100 and 1000 times as great as those at the ground. Diamagnetism and drift currents are shown to make negligible contributions to the lunar and solar variations of the earth's magnetic field.

"In an Appendix, the applicability of Boltzmann's equation to strongly ionized gases is discussed."

2884. A Newly Discovered Periodicity of 16 Months in the Sun's Wave Radiation.—C. G. Abbot. (*Science*, 11th May 1945, Vol. 101, No. 2628, pp, 483–484.)

Analysis previously reported showed that the monthly mean value of the solar constant over a long period of time contains 14 periodicities all of which are approximately aliquot parts of 273 months. The amplitude of the component having a periodicity of 136½ months (11-year cycle) is very small. and in re-examination of the results to confirm this observation a further component period of 16 months has been discovered. "I now set the initial dates of maximum and minimum for the 16-month periodicity at October 1920, and May 1921, respectively. The amplitude is 0.12 per cent of the solar constant."

2885. Remarks on the Zodiacal-Light Problem [Defence of the Writer's "Two Ring-Shaped Dust Accumulations" Hypothesis: the Importance of the Night-Vision Peculiarities of the Observer: etc.].—C. Hoffmeister. (*Physik. Berichte*, No. 22, Vol. 24, 1943, pp. 1455–1456: from *Astron. Nachr.*, Dec. 1942).

2886. On the Propagation of Luminous Energy in Anisotropic Media.—L. de Broglie. (*Comptes Rendus* [Paris], 3rd/31st Aug. 1942, Vol. 215, No. 5/9, p. 153 onwards: short summary in *Physik. Berichte*, No. 14, Vol. 24, 1943, pp. 975–976.)

"The general picture of the classical theory of light propagation in anistropic bodies, in particular the concept of the light ray which forms a certain angle with the normal to the wave front, and the concept of the light velocity along such a light ray, assumes a monochromatic plane wave with constant amplitude. This is unsatisfactory, since such a wave does not exist.

"The writer therefore, as an addition to the methods which lead from 'wave optics' to 'geometrical optics,' develops the above concepts without the assumptions previously made, and derives the formula for the light velocity, without explicit use of the Poynting vector and the envelope of the wave planes."

2887. ON THE ABSORPTION, IN THE SOLAR SPECTRUM, BY WATER VAPOUR [Survey of Potsdam Observatory Programme: Discussion of Various Workers' Results: Apparatus: the Atmospheric Extinction Curve and the Question of the Constancy of the Exponent in the $\lambda^{-1.3}$ Relation].—O. Hoelper. (*Meteorol. Zeitschr.*, Feb. 1943, Vol. 60, No. 2, p. 37 onwards: summary in *Physik. Berichte*, No. 19, Vol. 24, 1943, pp. 1283–1284.)

2888. REMARKS ON THE RESULTS OF EXTINCTION MEASUREMENTS ON LIGHT CARRIED OUT BY V. GUTH & F. LINK.—F. Linke. (*Meteorol. Zeitschr.*, April 1943, Vol. 60, No. 4, p. 140 onwards: summary in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1284.)

2889. STUDY OF COSMIC-RAY AIR SHOWERS WITH THE METHOD OF COINCIDENT BURSTS IN TWO UNSHIELDED IONISATION CHAMBERS.—L. G. Lewis. (*Phys. Review*, 1st/15th April 1945, Vol. 67, No. 7/8, pp. 228–237.)

Author's summary:—"A study of these sets of curves reveals the presence of many high density cosmic-ray air showers of heretofore unsuspectedly small lateral spread. These showers cannot originate at the top of the atmosphere but must be a secondary phenomenon."

2890. THEORETICAL CALCULATIONS ON EXTENSIVE ATMOSPHERIC COSMIC-RAY SHOWERS.—L. Wolfenstein. (*Phys. Review*, 1st/15th April 1945, Vol. 17, Nos. 7/8, pp. 238–247.)

Author's summary:—"Large cosmic-ray showers in air investigated with ionisation chambers and coincidence counters, have been explained hitherto as originating from primary electrons of very high energy. . . . It is pointed out that the large number of narrow showers of high energy must originate much nearer to the chamber than the top of the atmosphere if they are to be explained by the cascade theory. It is concluded that the assumption of primary electrons is of little help in explaining the results." (*See* 2889 above.)

2891. REFLECTOR EFFICIENCY [Use of Mirrors in collecting Electromagnetic Energy as in Cosmic Static Experiments (*see* 336 of 1943): Effect of Cavity Size].—G. Reber. (*Electronic Industries*, July 1944, Vol. 3, No. 7, pp. 101..216.)

2892. "WHAT ARE COSMIC RAYS?" [Book Review].—P. Auger. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 432, 434.)

2893. EXTENSION OF THE LYMAN–BIRGE–HOPFIELD BAND SYSTEM OF THE NITROGEN MOLECULE [including an Investigation of the Influence of Temperature on These Bands].—Renée Herman & L. Herman. (*Comptes Rendus* [Paris], 3rd/31st Aug. 1942, Vol. 215, No. 5/9, p. 133 onwards: short summary in *Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1433.) For other Notes reporting this series of researches *see*, for example, 3786 of 1944 and 718/9 of March.

2894. ON THE NATURE OF CERTAIN BANDS IN THE SPECTRUM OF ACTIVE NITROGEN.—A. W. Jakowlewa. (*Physik. Berichte*, No. 15, Vol. 24, 1943, p. 1051.)

2895. THE ATMOSPHERIC OZONE AT HIGH LATITUDES [including Curves showing the Latitude-Dependence in January, April, July, & October].—F. W. P. Götz. (Summary in *Physik. Berichte*, No. 13, Vol. 24, 1943, pp. 930–931.)

2896. THE TEMPERATURE-DEPENDENCE OF THE REFRACTIVE INDEX, AND THE COMBINED SCATTERING OF SECOND ORDER.—L. M. Lewin. (*Physik. Berichte*, No. 15, Vol. 24, 1943, p. 1051.)

Short abstract of a Russian paper in which the author "derives an equation for the temperature-dependence of the refractive index for constant density, and investigates its relation to the ratio of the intensity of the Rayleigh radiation and the Raman scattering of second order."

2897. THE VARIATION OF THE VERTICAL TEMPERATURE GRADIENT WITH CERTAIN TYPES OF CHANGES OF STATE OF ARBITRARY FLUIDS [in Meteorology & Hydrology].—F. Morán. (*Physik. Berichte*, No. 13, Vol. 24, 1943, pp. 931–932.)

2898. RADIATIVE COOLING IN THE LOWER ATMOSPHERE.—W. M. Elsasser. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 931: from *Monthly Weather Review*, No. 7, 1940.) For a book review *see* 2643 of 1943.

2899. AIR-MASS CLIMATOLOGY, A POINT AT ISSUE BETWEEN GEOGRAPHERS AND METEOROLOGISTS.—F. Linke. (Short summary in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1284.)

2900. AEROLOGICAL ESTIMATION OF THE WATER CONTENT OF CLOUDS [and the Development of an Approximate Formula $W = 0.64 e_m(t).(1 - f)$ [g/m^3], where e_m is the Saturation Pressure at Temperature t and f the Relative Humidity of the Surrounding Air].—H. Ertel. (*Meteorol. Zeitschr.*, Feb. 1943, Vol. 60, No. 2, p. 64 onwards.)

A short summary is given in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1282. For other work by this writer *see* 2644 of 1943.

2901. THE RÔLE OF THE ENERGY LAW IN METEOROLOGY AND GEOPHYSICS.—A. Schmauss. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 921.)

2902. STATISTICAL PROGNOSIS [Description of Writer's Experiences in Weather Forecasting by Comparison with Similar Meteorological Conditions in the Past].—K. Wegener. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 941.)

2903. The Moon's Phases and the Course of Precipitation Phenomena.—Z. Berkes. (*Meteorol. Zeitschr.*, Dec. 1942, Vol. 59, No. 12, p. 402 onwards.)

A short summary is given in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1280. "The introduction discusses the effect of lunar gravitation; it includes the statement 'In the ionosphere the effect is, in comparison, much more important; for instance, the moon produces a wave of 2 km amplitude in the height of the *E* layer.' The writer then discusses the results of various investigations pointing to 'true moon effects,' such as those of Angot, Schuster, and others (frequency of rain, of thunderstorms), and investigates whether the records of precipitation in Budapest from 1887 to 1942 show any sign of the 29½-day synodic period. He concludes that there is an indubitable connection between lunar phase and precipitation."

2904. The Problem of the Cause of Terrestrial Magnetism [Final Survey of the Writer's Researches, including Many Experimental Tests].—Q. Majorana. (*Physik. Berichte*, No. 19, Vol. 24, 1943, pp. 1275–1277: a long abstract.)

2905. On the Impulsion Moment of an Electromagnetic Wave.—Humblet. (*See* 3100.)

2906. On the Propagation of Sound in the Atmosphere, taking Gravity and Thermal Gradient into Account.—C. Cattaneo. (*Nuovo Cimento*, Aug./Oct. 1942, Vol. 19, No. 8, p. 230 onwards: summary in *Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1456.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2907. Curious Applications of the Control of a Current of Mobile Electric Charges in the Atmosphere.—P. Toulon. (*Physik. Berichte*, No. 13, Vol. 24, 1943, pp. 925–926.)

Abstract of a summary in *Journ. de Phys. et le Radium*, No. 2, 1941. "So far as can be seen from the very short report, the writer sets out to prove that by a suitable combination of a sharp point maintained at high potential (such as is used for the measurement of the atmospheric vertical current), a grid, and a plate-shaped electrode, the well-known relationships of the current/voltage behaviour in a triode valve can be reproduced even at atmospheric pressure. The current values are naturally much smaller here (of the order of 50 to 100 μA)." *See* also 1363 of 1942.

PROPERTIES OF CIRCUITS

2908. Electric Cavity Resonators and Their Application in Ultra-Short-Wave Amplifier Engineering [Swiss Thesis, in German: Book Review].—A. De Quervain. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, p. 417.)

2909. Capacitance, Inductance, and Characteristic Impedance of Multi-Wire Double [Go-and-Return] Bird-Cage Systems.—Freudenhammer. (*See* 2962.)

2910. Note on Impedance Matching of Shunt-Fed Half-Wave Dipole.—Glinski. (*See* 2963.)

2911. An Improved Antenna Coupling Circuit for 30–40 Mc/s [Permeability-Tuned Pi-Type of Antenna Coupling gives Higher Gain than Tuned-Secondary Transformer].—H. J. Kayner. (*Communications*, March 1945, Vol. 25, No. 3, pp. 38..69.)

2912. Aerial Coupling Circuits. Part IV—R.F. Transformer Coupling [Analysis and Graphs for Voltage Gain, Selectivity and Reflected Capacitance].—S. W. Amos. (*Electronic Eng:g.*, May 1945, Vol. 17, No. 207, pp. 505–508.)

2913. Graphical Representation of Bridge Circuits [Simple Method of determining Voltages, Currents, & Resistances].—V. Wendt. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, pp. 156–157.)

2914. Selecting Coax Cable [Most Economical Type for given Application: Power Ratings: Mechanical Considerations: Power Loss].—V. J. Andrew. (*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 84..158.)

2915. Design of L–C Phase-Shift Networks [Graphs for Filter-Type Networks for High Power, giving Voltage and Current Ratings when using Finite-Q Coils].—R. W. Woods. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 144–146.)

2916. Paper on a Single-Phase-Fed Phase-Shifter for Measuring and Other Purposes [with Advantages over Previous Types].—Beindorf. (*See* 3019.)

2917. The Phase-Shift Generator.—Hildebrandt. (*See* 2991.)

2918. Linear Single-Stage Valve Circuits.—N. R. Campbell, V. J. Francis, & E. G. James. (*Wireless Engineer*, July 1945, Vol. 22, No. 262, pp. 333–338.)

Formulae are developed "that permit an important class of linear single-stage valve circuit problems to be solved. . . ." Even in complicated circuits "no element need be ignored." The circuit is treated as a multi-terminal network. "The properties of such a network are completely defined by a set of simultaneous equations, whose constant terms are made up of the imposed e.m.f.s and certain impedances associated with them. The solution . . . can then be stated in terms of the determinant of these equations and the co-factors of its elements together with the constant terms. The individual impedances are contained in the elements of the determinant; the formulae relating the elements to the impedances turn out to be very simple."

2919 Method of Stabilising the Action of a Valve Amplifier with respect to Variations of the Heating Current [Compensation obtained by making a Variation of Heating-Current Voltage produce an Automatic Adjustment of the Grid Bias].—E. Cotton. (*Journ. de Phys. et le Radium*, April/June 1941, Vol. 2, No. 2, p. 79 onwards: summary in *Physik. Berichte*, No. 15, Vol. 24, 1943, pp. 1053–1054.)

2920. BALANCED AMPLIFIER CIRCUITS.—E.M.I. Laboratories. (*Electronic Eng:g*, July 1945, Vol. 17, No. 209, p. 610.)

An improved "paraphase" push-pull circuit in which D.C. and/or A.C. stabilisation is obtained by the introduction of negative feedback between anode and grid of paraphase valve.

2921. THE FREQUENCY RESPONSE OF R.C. COUPLED AMPLIFIERS [Data Sheets giving Frequency Response, Time Delay, & Phase Angle].—K. R. Sturley. (*Electronic Eng:g*, July 1945, Vol. 17, No. 209, pp. 593–596.) The curves are based on the articles by the same author referred to in 1756 of June.

2922. AN ANALYSIS OF THE HIGH FREQUENCY OPERATION OF THE CATHODE FOLLOWER.—C. N. Jeffery. (*A. W. A. Tech. Review*, [Australia] March 1945, Vol. 6, No. 6, pp. 311–323.)

"The cathode follower circuit may be safely employed at high frequencies provided certain limitations are imposed on the impedances connected to both the input and output terminals, these limitations becoming more restrictive as the frequency rises.

"The following requirements are generally demanded of a cathode follower working at high frequencies. (The significant factor is in brackets): (i) A low output impedance is required for connection to a concentric cable or low-impedance network — (g_m high). (ii) The output impedance should not be affected by the connection to the input of a wide variety of generators — (C_{gk} low). (iii) Freedom from oscillation if the cathode impedance becomes capacitive due to disconnection of the load. This demands a high value of negative shunting resistance — ($g_m/C_{ke}C_{gk}$ high). (iv) A high input resistance when the output is correctly terminated — (g_m/C^2_{gk} high).

"Thus a tentative figure of merit is $g_m/C_{ke}C^2_{gk}$. Applying this figure to the ideal values assumed in this discussion the triode connection is approximately 50 per cent. better than the pentode case.

"The above discussion of figure of merit has disregarded input capacitance and is only applicable to the case where the generator impedance is a tuned circuit incorporating such capacitance. If, on the other hand, the input capacitance has to be low, then the factor $1/C_{ga}$ should be considered."

In the above, g_m, C_{ke} and C_{gk} are mutual conductance, and cathode-earth and cathode-grid capacitances respectively.

2923. USING CATHODE COUPLING [Cathode Follower Applications at Low and High Frequencies: Basic Circuit Characteristics].—W. Muller. (*Electronic Industries*, August 1944, Vol. 3, No. 8, pp. 106..196.)

2924. CATHODE-FOLLOWERS AND LOW-IMPEDANCE PLATE-LOADED AMPLIFIERS [Anode-Loaded Amplifier used as Low-Impedance Coupling Stage has many of the Characteristics of a Cathode-Follower, together with Decoupling and Phase-Reversal Features, not given by Cathode-Follower].—S. Moskowitz. (*Communications*, March 1945, Vol. 25, No. 3, pp. 51–94.)

"It should therefore be kept in mind that in many applications, the advantages of the cathode-follower over the plate-loaded amplifier may be debatable."

2925. CATHODE-FOLLOWER CIRCUITS. [Principles of Operation and Review of Some Recent Applications.]—H. M. Greenwood. (*QST*, June 1945, Vol. 29, No. 6, pp. 11–18 and 88.)

2926. UNWANTED NEGATIVE FEEDBACK THROUGH DEFECTIVE CONDENSERS [with Special Reference to L.F. Amplifiers].—Sternke. (*See* 2948.)

2927. COUNTER-MODULATION [sometimes spoken of as "Negative Feedback from L.F. to H.F. Stages"].—Brück. (*See* 2949.)

2928. LOW-FREQUENCY AMPLIFICATION—Part VII. INCREASING LOW FREQUENCY RESPONSE [Analysis and Graphs for the Frequency Response and Phase Distortion of L.F. Correcting Circuits.].—K. R. Sturley. (*Electronic Eng:g*, May 1945, Vol. 17, No. 207, pp. 510–513.) *See* 1756 of June for previous part.

2929. SINGLE CRYSTAL FILTERS.—K. R. Sturley. (*Wireless Engineer*, July 1945, Vol. 22, No. 262, pp. 322–332.)

Author's summary:—"This article shows that generalised selectivity curves can be constructed for two identical tuned circuits coupled by a single fully neutralised crystal, and also for the condition arising when the two formerly identical tuned circuits are mistuned an equal amount in opposite directions from the crystal frequency. Increased selectivity due to mistuning is accompanied by reduced amplification at the crystal frequency (generalised curves are given to estimate this loss), and the appearance of secondary humps at the resonant frequencies of the mistuned circuits with loss of selectivity at the "skirts" of the curves. At frequencies very much off-tune from the crystal resonant frequency mistuning has little effect. Numerical examples are given to illustrate the method of using the generalised curves."

2930. CRYSTAL FILTERS [Part I: Introduction to the Lattice Section: Part II: Reactance Circuits and Lattice Filters].—R. L. Corke. (*P.O. Elec. Eng. Journ.*, Jan. 1945, Vol. 37, Part 4, pp. 113–115; April 1945, Vol. 38, Part 1, pp. 7–10.)

Formulæ for simple lattice and equivalent ladder forms. Lattice networks give greater design freedom and are the basis of most crystal filter circuits. The total number of critical frequencies is one more than the number of elements in the circuit. Part II explains application of Forster's Theorem to the calculation of the impedance of a filter network at any frequency from a knowledge of the critical frequencies.

2931. A NOTE ON THE ALIGNMENT OF THREE-ELEMENT BAND-PASS FILTERS.—J. G. Downes. (*A. W. A. Tech. Review* [Australia], March 1945, Vol. 6, No. 6, pp. 325–335.)

Author's abstract:—"A simple procedure, similar to that used in the alignment of tuned circuits in amplifiers, is described for the adjustment of a common type of three-element band-pass filter, and the procedure is justified mathematically. Also, the similarity of a section of the filter to a pair of coupled circuits is noted, and the idea of 'sufficiency of coupling' discussed in relation to the filter section."

In a section dealing with the comparison of a filter-section with a pair of coupled circuits, it is pointed out that "the filter section, when terminated in a fixed resistance R_0, exhibits, although over-coupled at the mid-frequency ω_0, a 'singled-peaked' frequency response curve; *i.e.*, there is only one frequency at which maximum power transfer is obtained. It is sometimes thought, in connection with coupled circuits, that a 'double-peaked' response (maximum power transfer at two frequencies) always occurs with over-coupling; the present analysis shows this to be not necessarily true." (R_0 is the mid-band characteristic impedance.)

2932. Filter Analysis and Design [Discussion of Simple Filter Networks Operating Under Ideal Conditions].—C. E. Skroder. (*Communications*, March 1945, Vol. 25, No. 3, pp. 72..88; April, No. 4, pp. 62..65.)

2933. Designing Filters for Specific Jobs, Part II [Formulæ for Determining Characteristics of Low-pass and High-pass Units].—A. H. Halloran. (*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 102–106.) Part I appeared in the April issue.

2934. The Calculation of the Self-Inductance of Single-Layer Cylindrical Coils [Objections to Use of Nagaoka's Formula for Calculation of Coil to provide a Given Inductance (Necessity for Trial-&-Error Process): Development of Improved Version giving Simplified Working and Any Desired Degree of Accuracy].—G. Welytschko. (*Arch. f. Elektrot.*, 30th Nov. 1943, Vol. 37, No. 11, pp. 520–533.)

The four quantities involved in the Nagaoka formula, L, N, d, and K_1, are reduced to three mutually independent quantities L/d, n, and W. Instead of the usual Nagaoka form $L = N^2dK_1$ (where in the factor $K_1 = f(l/d)$ the coil-length l is unknown, so that one has to work with assumed values of N and l/d) the new formula takes the shape $L = n^2dW$, of which the one component n^2d is usually decided on right at the beginning (n is the number of turns on a length equal to the mean coil diameter d) while the second component W depends only on the ratio l/d. "Through this artifice all the difficulties disappear." The series and tables for exact calculation and for approximate formulae are given, together with nomograms for quick approximations, and enable the required coil to be calculated with any desired accuracy.

The transformation can be carried out as follows, starting from the most usual simplified Nagaoka form:

$L = N^2dK_1 = n^2l^2K_1/d$ (since $n = Nd/l$) $= n^2dK_1l^2/d^2$ $= n^2dK_1 \cot^2\alpha$ (since coil-factor $\cot\alpha = l/d$).

Now Nagaoka's $K_1 = (4\pi/3)[\{K + (\tan^2\alpha - 1)E\}/\sin\alpha - \tan^2\alpha] = 4\pi/3 \tan^2\alpha\,[\{K + (\tan^2\alpha - 1)E\}/\sin\alpha\tan^2\alpha - 1] = \tan^2\alpha \,.\, W$.

Hence $L = n^2d \,.\, K_1\cot^2\alpha = n^2d \,.\, \tan^2\alpha \,.\, W \,.\, \cot^2\alpha = n^2dW$.

2935. Graphical Solution of Bandspread Problems [Graphical Determination of the Values of Fixed and Variable Capacitance for any Degree of Bandspread].—V. S. Buccicone. (*QST*, June 1945, Vol. 29, No. 6, pp. 42–43.)

2936. Behaviour of Resistors at Radio Frequencies [Equivalent Series Resistance, Inductance, Reactance at Frequencies below Resonant Frequency].—R. G. Anthes. (*Electronic Industries*, Sept. 1944, Vol. 3, No. 9, pp. 86–88.)

2937. Correction to "The Magnetic Field Strength and Self-Induction in Plane-Parallel Circular Plates traversed Radially by Alternating Current" [1544 of 1944].—H. H. Wolff. (*Arch. f. Elektrot.*, 30th Nov. 1943, Vol. 37, No. 11, p. 554.)

2938. Correspondence on "Polyphase Systems applied to R.F."—Knoebel & others: Bickmore. (*See* 2966.)

2939. Simplification of Complex Switching Analysis.—Byron. (*See* 3082.)

TRANSMISSION

2940. On the Problem of Grid Modulation in Magnetrons.—H. H. Klinger. (*Funktech. Monatshefte*, Feb./March 1943, No. 2/3, p. 32.)

Müller (677 of 1942) obtained satisfactory results with grid modulation so long as oscillations of the tangential path-time type ($n > 2$) were involved, but found that distortion occurred in the case of radial path-time oscillations. It is oscillations of the latter type, however, which are specially important for the generation of the shortest waves. The present writer has found that the magnetron arrangement with inhomogeneous field, suggested by Rice (4006 of 1936) allows a satisfactory grid modulation to be obtained. The writer concludes: "the application of grid modulation to the magnetron lying in an inhomogeneous magnetic field gives, according to my results, the possibility of a direct modulation of the magnetron generator in the region of very short waves, whereby, by a simultaneous action on grid and anode, a frequency-stabilising effect can be obtained similar to that already carried out for the Barkhausen-Kurz oscillator." For previous work *see* 2323 & 2325 of 1942, 736 of 1943, and 1434 of May.

2941. Marine Voice-Code Set.—(*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 100..146.)

A water-tight lifeboat transmitter-receiver weighing about 150 lbs., which has a range up to 1000 miles and provides for automatic operation on 500 kc/s and 8.28 Mc/s. A 300-ft. aerial can be supported either by kite or balloon, a cylinder of helium being supplied to inflate the latter, or an inverted-V mast aerial may be used. Power is furnished by hand cranking and automatic operation is controlled by motor driven cams.

2942. Multi-Channel Army Communications Set [Used during Invasion of France: Installed in Four Hours: Provides for Code, Voice, Teleprinter, and for use as Automatic Repeater]. — (*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 90..182.)

2943. A Note on a Phase Modulator Principle.—R. A. Wooding, Jr. (*Proc. I.R.E.*, Australia, April 1945, Vol. 5, No. 8, pp. 13–16 and 24.)

Author's summary:—" A method of producing 'quasi phase-modulation' is given. It is shown that when two carrier waves, out of phase by a fixed angle (frequencies identical) and modulated in opposition, are combined, their resultant is a carrier whose sidebands have a resultant at 90 degrees to the carrier. A practical circuit for producing this condition, together with some aspects of design, is discussed."

2944. External-Anode Triodes; Characteristics and Applications: Parts III & IV.—Ebel. (*See* 2971.)

RECEPTION

2945. An "Anti-Squealer" for Superregenerative Receivers [Pre-selector to Eliminate Radiation from, and Reduce Antenna Effects in, Superregenerative Receivers].—P. S. Rand. (*QST*, June 1945, Vol. 29, No. 6, pp. 23–25 and 86.)

2946. An Improved Antenna Coupling Circuit for 30–40 Mc/s [Permeability-Tuned Pi-Type of Antenna Coupling gives Higher Gain than Tuned Secondary Transformer].—H. J. Kayner. (*Communications*, March 1945, Vol. 25, No. 3, pp. 38..69.)

2947. Some Developments in Crystal-Controlled Diversity Receivers.—H. A. Ross & L. K. Curran. (*A.W.A. Tech. Review* [Australia], March 1945, Vol. 6, No. 6, pp. 337–349.) A description of two equipments for the range 5 Mc/s–20 Mc/s.

2948. Unwanted Negative Feedback through Defective Condensers.—K. Sternke. (*Funktech. Monatshefte*, Feb./March 1943, No. 2/3, pp. 28–31.)

This is the paper referred to in 1520 of 1944. " In the mains [smoothing] unit wet electrolytic condensers are frequently used. These have many advantages over the dry type, but their use is limited by the fact that they have to be mounted upright to prevent leakage of the liquid. Consequently, for decoupling in l.f. amplifiers dry electrolytics are used almost exclusively. . . .

" It is often found that these condensers lose their capacitance. The obvious causes of this are the heating produced in service and too large an a.c. component. This result, which is not obtained with ordinary paper condensers, is probably to be attributed exclusively to changes due to the electrolyte. The nature of the changes in the electrolytic condenser is, however, of less interest than the effect of the capacitance loss on the circuit. . . ." This is investigated in the present paper, with special reference to l.f. amplifier circuits. The calculations are confirmed by experiment. The case where the loss of capacitance occurs in the cathode-circuit condenser is first considered, then the case where the screen-grid condenser is concerned. Serious losses of amplification are found.

2949. Counter-Modulation.—L. Brück. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, pp. 149–151.)

" Counter-modulation is the term given to the process by which an already modulated oscillation is again modulated, in a modulator stage, with the same frequency in such a way that the oscillation leaves this modulator stage with a smaller depth of modulation than it possessed on the input side. Thus counter-modulation diminishes the modulation amplitude and in this respect has a resemblance to negative feedback. For this reason it is occasionally spoken of as 'negative feedback from l.f. stage to h.f. stage.' But it is not a negative feedback as we know the latter with its good properties in the l.f. stages of broadcast receivers. Particularly in respect to the reduction of non-linear distortion is the behaviour of counter-modulation quite different. The present paper deals only with counter-modulation for amplitude-modulated oscillations."

As to what may be expected from counter-modulation, it has been suggested that by making it suitably dependent on frequency, the frequency characteristic of a receiver can be improved by its use (D.R.P. 642 761): such frequency-dependent counter-modulation has been suggested for the reduction of non-linear distortion in receivers (Sturm, 2097 of 1937: " as will be shown here, however, this last proposal must be regarded with caution": Fig. 3 shows how counter-modulation may produce non-linear distortion, increasing with the depth of modulation). " Above all, it may be expected that [by the use of counter-modulation] the diode distortions can be avoided which occur when the a.c. loading is smaller than the d.c. loading of a diode, and which set in only from a definite depth of modulation onwards. (Fig. 4)."

Another effect is deduced from the curves of Figs. 2 & 3: namely that the diminution of modulation depth produced by counter-modulation is greater for large values of carrier-wave than for small, so that a volume-controlling action occurs which reinforces the already present automatic fading regulation and may produce over-regulation.

2950. Frequency Conversion Circuit Development: Part I [Historical Survey of Frequency Conversion Circuits used with Superheterodyne Receivers, and their Development in Relation to Multi-Grid Valves].—H. Stockman. (*Communications*, April 1945, Vol. 25, No. 4, pp. 46..92.)

2951. F.M. Detector Circuit of Wide Adaptability [Reid Discriminator Circuit: Used successfully at Frequencies from 460 kc/s to 50 Mc/s: Simple Adjustment of Cross-over Frequency and Peak-to-Peak Separation].—J. Gelzer. (*Electronic Industries*, July 1944, Vol. 3, No. 7, pp. 92–94.)

2952. Receiver with 2 Mc/s I.F.—H. Kees. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 129–131.)

Describes a high quality receiver for local stations in the range 100–1750 kc/s (*i.e.* the " intermediate " frequency is higher than the signal frequency). The only tuning control is in the local oscillator circuit, which requires a frequency coverage of less than two-to-one. A low-pass filter is used between the aerial and first detector. Application of high intermediate frequencies in f.m. and communication receivers is also discussed.

2953. REDUCING RADIO NOISE.—C. Wasmansdorff. (*Electronic Industries*, July 1944, Vol. 3, No. 7, pp. 80..180.)

"An analysis of various methods that may be used to help in the elimination of man-made and natural interference." The importance of an electrostatic screen in the input circuit of a receiver is stressed and a method of measurement and establishment of a figure of merit for receivers is given. The use of "noise antennae" is discussed and circuit arrangements are given for the five common methods of noise reduction, namely, limitation, cancellation, counter modulation, blanking out, and variation of gain.

2954. MULTI-CHANNEL ARMY COMMUNICATIONS SET.—(*See* 2942.)

2955. MARINE VOICE-CODE SET.—(*See* 2941.)

2956. GRAPHICAL SOLUTION OF BANDSPREAD PROBLEMS [Graphical Determination of the Values of Fixed and Variable Capacitance for any Degree of Bandspread].—V. S. Buccicone. (*QST*, June 1945, Vol. 29, No. 6, pp. 42–43.)

2957. CATHODE-FOLLOWERS AND LOW-IMPEDANCE PLATE-LOADED AMPLIFIERS.—Moskowitz. (*See* 2924.)

2958. CAPTURED ENEMY RADIO EQUIPMENT.—(*QST*, June 1945, Vol. 29, No. 6, pp. 32–33 and 90.)

2959. INTERFERENCE FROM FLUORESCENT LIGHTING.—Pugh. (*See* 3253.)

AERIALS AND AERIAL SYSTEMS

2960. A COAXIAL ANTENNA FOR 112 Mc/s.—R. H. Parker. (*QST*, June 1945, Vol. 29, No. 6, pp. 40–41 and 90.)

Details of a coaxial transmission-line and coupling system suitable for a half-wave antenna for mobile operation at 112 Mc/s.

2961. DESIGN OF BROAD-BAND AIRCRAFT ANTENNA SYSTEMS [Measurement of Aircraft Antenna Impedances: Use of Reactance Networks to Increase Antenna Bandwidth: Selection and Design of Broad-Band Antennas].—F. D. Bennett, P. D. Coleman & A. S. Meier. (*Communications*, March 1945, Vol. 25, No. 3, pp. 46..90.) Digest of paper presented at I.R.E. Winter Meeting.

2962. CAPACITANCE, INDUCTANCE, AND CHARACTERISTIC IMPEDANCE OF MULTI-WIRE DOUBLE [Go-and-Return] BIRD-CAGE SYSTEMS.—K. Freudenhammer. (*Arch. f. Elektrot.*, 30th Nov. 1943, Vol. 37, No. 11, pp. 534–541.)

Author's summary:—"The exact formulae for C, L, and Z of multi-wire cage systems are complicated and involved even for a few wires in each cage. The exact formulae for the two-wire double cage are obtained, taking into account the effect of the ground; from the result, the formulae for C, L, and Z of the four-wire cage are derived without taking the ground effect into consideration. Next, approximate formulae for double cages with an arbitrary number of wires are obtained, the effect of the ground being again neglected.

"The formulae are very simple and clear, and a comparison of the results of calculation using the exact formulae and the approximate, which has been carried out for four-wire cages, shows that the approximate solution gives errors below 1 per cent. if the ratio cage-spacing/cage-radius, D/R, is kept greater than 5 and the ratio cage-radius/wire-radius greater than 10.

"The influence of the ground is allowed for by a correcting term which depends only on the ratio cage-spacing/ground-distance, D/H. The calculation of the characteristic impedance of a two-wire double cage, taking ground effect into account, by the approximate method gives very good agreement with the accurate values. The approximate formulae can be solved in terms of the cage radius, so that for a given spacing between cages, given number of wires, and given C, L, or Z, the necessary cage radius R can be determined quickly." For cages with more than 4 wires the accuracy of the approximate formulae increases, since for $n \to \infty$ they merge into the exact formulae.

2963. NOTE ON IMPEDANCE MATCHING OF SHUNT-FED HALF-WAVE DIPOLE.—G. Glinski. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 408–410.)

Author's summary:—"The formula for the spacing between feeding points of the shunt-fed, horizontal, half-wave dipole is obtained. The spacing is found to be a function of radiation resistance and characteristic impedance of the dipole, and of the characteristic impedance of the feeding line. Curves are calculated showing that the assumption of equal dipole and feeder-line characteristic impedance may lead to considerable error in the calculation of the spacing of feeding points."

2964. A DUMMY DIPOLE NETWORK.—G. W. O. H. (*Wireless Engineer*, July 1945, Vol. 22, No. 262, pp. 313–315: Editorial.)

The work of Salinger (2568 of 1944) is discussed. Salinger suggests a circuit comprising an inductance shunted by a resistance, this combination being connected in series with a condenser, and the whole being shunted with another condenser. By suitably adjusting the values of these components the output impedance seen across the second condenser can be made to simulate quite accurately the theoretical impedance characteristic of a dipole of specified diameter and length, over a wide frequency range. At resonance, however, the dummy network shows a resistive impedance which varies with the ratio of diameter to length. "This raises the interesting point whether the radiation resistance of an aerial of given length decreases as its diameter is increased, and, if so, to what extent, and why."

2965. MUTUAL AND SELF-IMPEDANCE FOR COLLINEAR ANTENNAS.—C. W. Harrison. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 398–408.)

Author's summary:—"In Part I a two-element collinear array, consisting of identical centre-driven antennas of finite radius, is discussed as a boundary-value problem. A formulation is given for the distribution of current when the antennas are driven symmetrically and anti-symmetrically. From these data the impedance properties of the array may be deduced.

"In Part II a simplified, but much less rigorous investigation of the same problem is presented. The more important results include curves and tables for mutual and self-impedance."

The author concludes :—" Calculations based on the equations of Part I should give results in quantitative agreement with measured values for mutual and self impedance " and in connection with two identical centre-driven antennas arranged in echelon and parallel to each other :—" The importance of the present analysis is that it is easily extended to include this case. However, certain integrals are encountered in the theoretical development which have not as yet been sufficiently well tabulated to warrant a discussion of this more general problem at the present time."

2966. CORRESPONDENCE ON "POLYPHASE SYSTEMS APPLIED TO R.F." [2561 of August: Scheme for Automatic Rotation of Radiation Pattern of Two-Element Array, and "Ionoscan" Arrangement, are Both stated to be Unsound].—H. W. Knoebel & others: R. W. Bickmore. (*QST*, June 1945, Vol. 29, No. 6, pp. 55–57.)

VALVES AND THERMIONICS

2967. ACORN TUBE TECHNICS [Production Methods to Ensure long Filament Life and Stable Characteristics].—L. G. Pacent. (*Electronic Industries*, Sept. 1944, Vol. 3, No. 9, p. 94.. 220.)

2968. ULTRA-SHORT-WAVE GENERATOR WITH PHASE-FOCUSING: III [Mathematical Representation of the Excitation Conditions in the Klystron].—F. Lüdi. (*Helvet. Phys. Acta*, 12th April 1943, Vol. 16, No. 2, p. 136 onwards: short summary in *Physik. Berichte*, No. 21, Vol. 24, 1943, p. 1382.)

Ending with calculations of the optimum dimensions and working conditions of a system for a 6 cm. wave.

2969. THE RADIAL PATH-TIME OSCILLATION IN THE MAGNETRON [Survey of Its Mechanism, based on Original Experiments: with Special Attention to the Optimum Inclination of the Magnetic Field].—H. H. Klinger. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, pp. 165–166.)

2970. ON THE PROBLEM OF GRID MODULATION IN MAGNETRONS.—Klinger. (*See* 2940.)

2971. EXTERNAL-ANODE TRIODES: CHARACTERISTICS AND APPLICATIONS: PARTS III & IV [Importance of Proper Operation and Maintenance in Prolonging Valve Life: Working Temperatures must be Controlled by Efficient Cooling Systems: Design Considerations for Applications in Class C, Class B R–F and A–F Amplifiers, and High-Power Oscillators].—A. J. Ebel. (*Communications*, March 1945, Vol. 25, No. 3, pp. 62 and 94..97, & April 1945, pp. 52..106.) *See* 2228 of July for previous parts.

2972. THE "UNIT VALVE" SERIES [Types A–F: with Photographs, Diagrams, & Details].—R. Kretzmann. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, pp. 157–160.) Following on the paper dealt with in 3261 of 1942.

2973. DEFLECTION BEAM TUBES.—P. Glass. (*Electronic Industries*, August 1944, Vol. 3, No. 8, pp. 90..206.)

Industrial applications and use in d.c. negative feedback circuits of electron beam tubes in which the fluorescent screen is "replaced by one or more target electrodes whose object it is to intercept a varying amount of beam electrons whenever the beam is deflected from its normal position in accordance with an applied signal."

2974. VALVE TESTING [Rapid Determination of Amplification Factor and Anode Impedance under Operating Conditions].—F. E. Planer. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 176.)

By measuring the change in a.c. output voltage when a known value of capacitance is shunted across the anode-load resistance of a resistance-coupled valve, knowing also the value of this resistance and the frequency, it is possible to calculate the amplification factor and anode impedance of the valve. The principle may be applied to the rapid checking of the characteristics of the valves in built-up apparatus.

2975. STATIONARY ELECTRON SWARMS IN ELECTROMAGNETIC FIELDS.—D. Gabor. (*Proc. Roy. Soc., Series A*, 18th June 1945, Vol. 183, No. 995, pp. 436–453.)

Author's summary :—" Electron clouds rotating in axially symmetric magnetic fields have been known for a long time, but the agreement between theory and experiment is still very unsatisfactory. The discrepancy appears to be due to the interaction of electrons. Before approaching this difficult problem it is desirable to possess a more complete theory of stationary swarms without interaction. In the present paper the distribution density is calculated on the basis of classical statistical mechanics. It is shown that electrons injected at any point with very small initial velocities will distribute themselves with a density inversely proportional to the distance from the axis, in a certain annular space. Only the limits of this space, not the distribution inside it, will be dependent on the electric or magnetic fields. The uniform or nearly uniform distributions calculated by previous authors are singular solutions, inconsistent with any degree of statistical disorder. Other laws of density distribution can be realised by simultaneous injection of electrons at several points. These offer a possibility to realise dispersing electron lenses and corrected electron optical systems. It is shown that the ring current produced by the rotating electron cloud can reduce the magnetic field at the axis very considerably in devices of practicable dimensions. It appears also possible to produce clouds of free electrons with densities sufficient for observable optical effects.

2976. A SPACE CHARGE PROBLEM: ITS APPLICATION TO CATHODE-RAY TUBE DESIGN.—H. Moss. (*Wireless Engineer*, July 1945, Vol. 22, No. 262, pp. 316–321.)

Author's summary :—" A solution is obtained for the problem of a focused electron beam of circular symmetry emerging from an anode hole and moving subsequently in a region of constant axial field. This problem is an extension of the simpler one first treated by Watson, and later more fully by Thompson and Headrick (*see* 136 of 1941), in which the electron beam is moving in a region free from external fields. Several numerical examples of the two solutions are compared with particular reference to cathode-ray tubes using post acceleration."

2977. THE ELECTRON OPTICS OF MASS SPECTROGRAPHS AND VELOCITY FOCUSING DEVICES.—Hutter. (*See* 3034.)

2978. ON THE EXPERIMENTAL SOLUTION OF PLANE POTENTIAL PROBLEMS BY ELECTRIC DIPOLE FIELDS [in the Electrolytic Trough].—K. Schmidt. (*Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1249.)

The abstract mentions that in some cases conformal representation and the hodograph process is used; also that by using the principle of superposition more complex flows were built up from elementary fields. "Edges" can be represented experimentally by semiconductors or by a series of individual electrodes connected to each other by adjustable resistances: it is in such problems that the experimental method is of special value owing to the complications of calculation.

2979. FREQUENCY CONVERSION CIRCUIT DEVELOPMENT: PART I [Historical Survey of Frequency Conversion Circuits used with Superheterodyne Receivers, and their Development in Relation to Multi-Grid Valves].—H. Stockman. (*Communications*, April 1945, Vol. 25, No. 4, pp. 46..92.)

2980. A THEOREM OF LARMOR AND ITS IMPORTANCE FOR ELECTRONS IN MAGNETIC FIELDS.—Brillouin. (*See* 3101.)

2981. "SEEING THE INVISIBLE" [A Popular Account of the Electron Microscope: Book Review].—G. G. Hawley. (*Electronics*, Feb. 1945, Vol. 18, No. 2, p. 408.)

DIRECTIONAL WIRELESS

2982. "RADIO DIRECTION FINDERS" [Book Review].—D. S. Bond. (*Electronics*, Oct. 1944, Vol. 17, No. 10, p. 320 and 322.)

2983. RADAR TECHNIQUES, PART III: CHARGES, FIELDS AND WAVES [Transmission-Line Waves, Radiated Fields, and Reflection at Normal Incidence].—C. B. DeSoto. (*QST*, June 1945, Vol. 29, No. 6, pp. 44–49.) For previous parts *see* 2650 of August.

ACOUSTICS AND AUDIO-FREQUENCIES

2984. ON THE PROPAGATION OF SOUND IN THE ATMOSPHERE, TAKING GRAVITY AND THERMAL GRADIENT INTO ACCOUNT.—C. Cattaneo. (*Nuovo Cimento*, Aug./Oct. 1942, Vol. 19, No. 8, p. 230 onwards: summary in *Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1456.)

2985. ON THE INTERPRETATION OF THE LOCUS CURVES OF SOUND-ABSORBING MATERIALS [of Elastic & Porous Types: Treatment by Application of an Acoustic Four-Terminal-Network Theory].—C. Zwikker. (*Physik. Berichte*, No. 13, Vol. 24, 1943, pp. 914–915: from *Akust. Zeitschr.*, No. 1, 1943.)

2986. THE PIEZOELECTRIC EFFECT OF THE ROCHELLE SALT CRYSTAL KH_2 PO_4.—W. Bantle & Ch. Caflisch. (*Helvet. Phys. Acta*, 30th June 1943, Vol. 16, No. 3, p. 235, onwards.)

A long summary of this 16-page paper is given in *Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1320. For other summaries *see* 3184 of 1944 and back reference.

2987. THE LOW-FREQUENCY POWER AMPLIFIER.—K. Steimel. (*Telefunken-Röhre*, Feb. 1943, No. 27/28, p. 7 onwards: summary in *Physik. Berichte*, No. 24, Vol. 24, 1943, pp. 1559–1560.)

This is the paper referred to in 3180 of 1944. "In amplifiers with asymmetrical modulation of the output valve (type AB amplifiers) the usual method of measuring the non-linear-distortion factor, with one sinusoidal continuous note, provides no real basis for the modulation relations in practical service (speech and music); it is therefore suggested that the distortion measurement should be carried out as a combination-tone measurement with two sine-voltages of equal amplitudes and independent frequencies. . . ." An expression for the distortion coefficient in these conditions is given. "The measurements show that the cathode resistance for the automatic grid-biasing must be made larger than the usual choice. The influence of the cathode bridging condenser on 'contrast' and transient processes is discussed."

2988. THE FREQUENCY RESPONSE OF R.C. COUPLED AMPLIFIERS.—Sturley. (*See* 2921.)

2989. A BRIDGE STABILISED RESISTANCE-CAPACITANCE OSCILLATOR.—F. G. Clifford. (*Electronic Eng:g*, June 1945, Vol. 17, No. 208, pp. 560–564.)

"A description is given of an amplitude stabilised resistance-capacitance oscillator of the now well-known bridge stabilised type. The conditions for maximum frequency stability are indicated and the results of tests on a model oscillator are given. Suggestions for other uses of the amplitude stabilising circuit are briefly outlined."

The model described has 3 ranges:—25–400 c/s; 265–4500 c/s; 2.65–40 kc/s: Output power approximately constant at 6 mW, and output impedance approximately 600 ohms resistive from 50 c/s to 30 kc/s: Maximum harmonic content 0.2% for second and 0.18% for third at 6 mW: Frequency stability at 1000 c/s over 70 hours $\pm$ 0.08 c/s: A change of mains supply voltage from 200 to 240 volts produces less than 0.05 db change of output level and less than 0.2 c/s change of frequency at 1000 c/s.

2990. NOTE-GENERATOR WITHOUT ANODE BATTERY [Triode B409 in Retroaction Connection, using a 1:5 L.F. Transformer: Two-

Octave Range by Variation of Heating Voltage].—V. Jörgensen. (Short summary in *Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1333.)

2991. THE PHASE-SHIFT GENERATOR [covering the Whole Range 16–20 000 c/s: Its Advantages over the Heterodyne Type of Note-Generator]. — R. Hildebrandt. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, pp. 161–164.) *Cf.*, for example, 1854/5 of 1943.

2992. ON THE THEORY OF THE DIFFRACTION OF A PLANE SOUND WAVE AT A SPHERE.—L. Schwarz. (*Physik. Berichte*, No. 21, Vol. 24, 1943, p. 1380: from *Akust. Zeitschr.*, May 1943.)

2993. RESONANCE DATA OF THE VOWEL RESONATORS [Oscillographic Investigation of Speech & Singing].—T. von Tarnoczy. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 919: from *Akust. Zeitschr.*, No. 1, 1943.)

2994. THE SURVEYING OF THE FINE STRUCTURE OF ACOUSTIC RESONANCES WITH THE HOT-WIRE SOUND-METER.—A. Loebenstein. (*Helvet. Phys. Acta*, 1st March 1943, Vol. 16, No. 1, p. 91 onwards.)

A short summary of this 8-page paper is given in *Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1332. The fine structure of the resonance curves of cylindrical resonators, found by Zickendraht (3030 of 1942), is checked with a hot-wire instrument: good agreement is found. "The natural frequencies which emerge show a similarity, not yet explained, to the plane radial air-vibrations calculated by Rayleigh for cylindrical resonators."

2995. ON THE THEORY OF THE PIANO HAMMER AND THE PIANO STRING [and the Effect of the Nature of the Hammer Covering].—R. Mertens. (Short summary in *Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1435.)

2996. AN ELECTRONIC MUSICAL INSTRUMENT.—W. Saraga. (*Electronic Eng:g*, July 1945, Vol. 17, No. 209, pp. 601–603.)

Describes a single-note instrument designed to eliminate certain disadvantages of Theremin's "Aetherophon," such as lack of support for hand, dependence of pitch on position of whole body, and difficulty of producing linear pitch scale. A photo-electric cell is used as the playing manual "because the geometrical relations of light beams and light and shadow which determine the amount of light falling on the cell when the hand of the player is in a certain position are much simpler, and much easier to control, than the geometrical relations of electrostatic fields which determine hand capacitance in a certain position of the hand."

2997. ELECTRONIC SOUND EFFECTS [Equipment for the Production of Sounds by Purely Electronic Means: Distant Shell Burst: Local Shell Burst with Whine: Local Machine Gun: Distant Machine Gun: Tank: Aeroplane: Motor Cycle, etc.].—P. D. Saw. (*Electronic Eng:g*, July 1945, Vol. 17, No. 209, pp. 580–584.)

2998. THE EFFECT OF SUPERSONIC WAVES ON THE MAGNETIC BEHAVIOUR OF NICKEL: I & II.—G. Schmid & U. Jetter. (*Physik. Berichte*, No. 24, Vol. 24, 1943, pp. 1557–1558 & 1558–1559.)

2999. NEW DEVELOPMENTS IN THE USE OF SUPERSONIC WAVES IN CHEMISTRY [Survey].—G. Schmid. (*Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1333: from *Chemie*, 1943.)

PHOTOTELEGRAPHY AND TELEVISION

3000. TELEVISION — PAST AND FUTURE.—H. L. Kirke. (*Nature*, 26th May 1945, Vol. 155, No. 3943, pp. 621–623.)

Summary of lecture to the Royal Institution. The general requirements and features of modern television practice are discussed. Properties of the terminal apparatus and methods of programme distribution are briefly described. The relation between definition and system band-width in monochrome and colour transmissions, and its implications, are considered.

3001. TELEVISION STANDARDS [Quality of Television Image Not Entirely Decided by Number of Scanning Lines: Effective Resolution of Television Receivers Reduced by Inadequate Focusing and Increase of Spot Size with Brightness].—O. J. Russell. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 177–178.)

"It appears fairly certain that a perfect 405-line image would be adequate for all purposes and would even approach the maximum necessary for home use. It may therefore be a little premature to abandon all interest in the present standards. . . ."

3002. TELEVISION AFTER THE WAR [Synopsis of Recommendations of Hankey Television Committee].—(*Nature*, 26th May 1945, Vol. 155, No. 3943, pp. 615–617: leading article.)

3003. V.H.F. NETWORK FOR TELEVISION RELAY.—(*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 86..162.)

"Perhaps the foremost problem in the development of commercial television for domestic use is the one concerning network programs. The cost of staging a television program is considerably greater than that of a corresponding sound program and it becomes necessary and desirable, therefore, to chain together many cities for the same program . . ." Details are given of a multiple relay television network connecting Washington D.C. and Philadelphia in four jumps, frequencies of 210 Mc/s and 236 Mc/s being used for alternate jumps.

3004. TRANSMISSION OF COLOUR PICTURES BY FACSIMILE [Under a Finch Telecommunications Patent Three-Colour Separation Films can be Transmitted or Received, and then Recombined by Usual Photographic Methods].—(*Electronics*, April 1945, Vol. 18, No. 4, pp. 236, 240, 244.)

3005. A TELEVISION STUDIO INSTALLATION DESIGNED FOR RESEARCH AND INSTRUCTION.—A. Preisman. (*Communications*, March 1945, Vol. 25, No. 3, pp. 33..61 & April, No. 4, pp. 48..76.)

3006. The Television Camera with Image-Converter Storage-Type Pick-Up Tube.—J. Günther. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, Supplement pp. 37–40.)

3007. Cathode Ray Tubes and their Applications.—Christaldi. (*See* 3029.)

3008. The Influence of Illumination on the Fatigue of Photo-Electric Cells [Causes of Fatigue Effect and Figures for Maximum Safe Illumination for Cells of Various Types are Suggested].—A. Sommer. (*Electronic Eng:g*, May 1945, Vol. 17, No. 207, p. 504.)

MEASUREMENTS AND STANDARDS

3009. S.H.F. Power Measuring.—H. G. Shea. (*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 79..142.)

The problems arising in the accurate measurement of power in wave guides at frequencies above 1000 Mc/s are outlined and the use of thermistors as power-sensitive elements is described. The elimination of standing waves is stressed and details are given of the slotted line probe method of detecting them.

3010. A Frequency Meter with Self-Contained Standard Oscillator [enables Experimenter of Moderate Means to measure Radio Frequencies up to 30 Mc/s., or Higher with an accuracy of approx. 1 part in 10^4].—G. P. Anderson. (*Electronic Eng:g*, May 1945, Vol. 17, No. 207, pp. 500–503.)

3011. Frequency Range Extension [Frequency (of 800 c/s Supplies) Measured by using Multivibrator to Divide Frequency to a Value falling within Range of Vibrating Reed Indicators: Extension to 2600 c/s Possible].—(*Electronic Industries*, August 1944, Vol. 3, No. 8, p. 117.)

3012. Test-Set for Quartz Crystals [Oscillator suitable for Rapid Testing of a Wide Variety of Crystal Types under Appropriate Conditions].—W. E. McNatt. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 113–115.)

3013. Voltmeter for High Frequencies [for Direct Measurement, without Interposition of Connecting Leads: based on Optical Double Refraction produced by Heating of Transparent Dielectric such as Glass].—H. Straubel. (*Funktech. Monatshefte*, Nov./Dec. 1942, No. 11/12, p. 168.) D.R.P. 704 178. *See* also 1117 & 1446 of 1942.

3014. An Electrostatic Voltmeter of High Precision.—B. H. Schultz. (*Physica*, July 1943, Vol. 10, No. 7, p. 471 onwards: summary in *Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1421.)

Distinguished by special symmetry of design. The moving vane is suspended by a quartz fibre; thus "there is no heating by the h.f. currents and no change in the torsion modulus. The capacitance amounts to 12–15 cms. By changing the segments two ranges of 75 to 450 volts are provided. The variation of sensitivity in one month is up to 0.2 per thousand. Between 9° and 20° C. there is no detectable influence of temperature. With a charge up to 75 volts there is no trace of any spontaneous deflection drop over a period of two hours."

3015. Calibration of a Field-Strength Measuring Set for Wavelengths from 200 to 600 Metres.—E. Eckel. (*Funktech. Monatshefte*, Feb./March 1943, No. 2/3, pp. 32–36.)

The usual calibration method depends on the use of a standard signal generator whose frame aerial produces a calculable magnetic field which in its turn produces a calculable e.m.f. in the frame aerial of the field-strength measuring set. "This method, however, is too inexact owing to uncontrollable external influences (distortion of magnetic field by metallic objects, etc.)."

The calibration method here described "is based on the assumption that equally large e.m.f.s applied at a certain point (the middle of the frame aerial) will produce equally large resonance voltages at the terminals of the frame: Fig. 3. The chief aim in this method must be the production of an accurately definable voltage. If, for instance, the test voltage is composed of an ohmic and an inductive component, then it will be dependent, through change in its inductive component, on every change of frequency. This change is as a rule not calculable, because of uncontrollable influences, so that no definable voltage results. In the present method the generation of the test voltage is accomplished by the use of a double-walled tube (Fig. 4.)." The coaxial tubes are insulated from each other at one end, conductively connected at the other. Two voltages can be taken off: the one (ohmic voltage) depends only on the value of transmitting current, the other (inductive voltage) on the transmitting current and on its frequency. "All external uncontrollable influences are thus completely excluded." The two voltages can be calculated by means of the formulae here derived.

The apparatus is described: the way the test voltage is applied to the mid-point of the frame aerial of the apparatus under test is shown in Fig. 11. The method "gives flawless results."

3016. Natural Limit of Measuring Radiation with a Bolometer.—J. M. W. Milatz & H. A. van der Velden. (*Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1432.)

Summary of the *Physica* paper referred to in 857 of March. "Dahlke & Hettner came to the conclusion that this limit is governed by the fluctuations in the temperature of the bolometer; the present writers consider that the Brownian motion of the electrons in the resistance, and (if an amplifier is used) the noise of the first valve (thermal agitation and shot effect), must also be taken into account.

"Bauer included in his calculations other fluctuations besides those of the temperature, but he neglected the influence (occurring in a.c. amplification) of the frequency spectrum of the temperature fluctuations. The writers develop, for the first time, an expression for this frequency spectrum. It is shown that it is possible so to choose the bolometer current that the signal/noise ratio is an optimum."

3017. On a New Method for the Measurement of Very Small Quantities of Electricity.—G. Hoffmann. (*Physik. Berichte*, No. 24, Vol. 24, 1943, p. 1544.)

"In electrometry with thermionic valves the observational limit is determined by the difficulty of constructing completely satisfactory amplifying arrangements for direct potentials. The limit is about 1000 electric elementary quanta (*e*). According, however, to Johnson & Johnson's investigations, 100*e* must be detectable. To make the measurement more precise, it is an obvious step to use a periodically opening contact in order to modulate the direct potential, and then to amplify the alternating potential. Contacts, however, lead to difficulties for low potentials.

"The writer therefore suggests the conversion to alternating potential by an oscillating condenser. An electro-magnetically maintained tuning-fork carries, near its ends, insulated metal pieces with slightly convex, polished insertions of platinum-iridium, which are brought by the vibrations almost into contact. Such a 'near-contact' has a capacitance of about 1 cm. . . . If this method of measurement proves successful, a whole series of problems, particularly in nuclear physics, will be able to be investigated with heightened accuracy."

3018. AN IMPEDANCE METER ON THE DIFFERENTIAL SUBSTITUTION PRINCIPLE [for Frequencies 30–300 Mc/s: suitable for the Measurement of Complex Resistances whose Reactive Components are due to Capacitances of 0–100 pF or Corresponding Inductances, and whose Active Components lie between 50 Ohms & 50 Kilohms]. — A. Klemt. (*Funktech. Monatshefte*, Feb./March 1943, No. 2/3, pp. 36–39.) The paper referred to in 1643 of 1944.

3019. SINGLE-PHASE-FED PHASE-SHIFTER FOR MEASURING [and Other] PURPOSES, COMPOSED OF A THREE-PHASE TRANSFORMER AND A THREE-PHASE "VOLTAGE SEPARATOR."— W. Beindorf. (*Arch. f. Elektrot.*, 30th Nov. 1943, Vol. 37, No. 11, pp. 542–554.)

Single-phase-fed phase-shifting devices have hitherto been of three types: the "resistance" phase-shifter, the "bridge" phase-shifter, and the "rotating-field" device. The two first have the defects of a narrow range (at most $\pm 90°$), a change of phase angle not even approximately proportional to the change in the regulating resistance, and the dependence of the phase angle on the load resistance. The third type (field coils at right angles, fed with currents with 90° phase difference, and central rotatable coil) has been used not only for measuring purposes but also for many communication-technique applications (receiving arrangement for rotating beacons, synchronisation control for impulse-system phototelegraphy, etc.). It gives a continuous phase adjustment from 0° to 360°, but the 90° phase displacement of the two exciter currents requires for its production a special circuit of chokes, capacitances, and resistances, which has to be adjustable.

"It is thus evident that the need exists for a phase-shifter which shall be continuously adjustable over 360°, fed with single-phase current, as free as possible from sliding-contact resistances, and readily introduced between two amplifier stages." The combination here described, with its theoretical diagram shown in Fig. 10, is based on Fortescue's well-known analysis of an asymmetrical three-phase system into one single-phase system and two symmetrical three-phase systems of opposite phase-sequence. The theory of the arrangement is confirmed by tests on an experimental model (pp. 551–553), built up from commercial resistances, paper condensers, and a rotating transformer with an armature having three windings at 120°.

3020. THE CALCULATION OF THE SELF-INDUCTANCE OF SINGLE-LAYER CYLINDRICAL COILS.— Welytschko. (*See* 2934.)

3021. A DIELECTRIC-CONSTANT METER.—F. C. Alexander. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 116–119.)

The article gives a general survey of dielectric constant measurements at radio frequencies up to 100 Mc/s., and describes in detail a simple and inexpensive apparatus for laboratory or industrial measurements to an accuracy of 1 per cent. The change of plate current of a crystal oscillator on tuning through its natural frequency is used as a resonance detector. The oscillator operates at 7 Mc/s., and is a 6E5 "magic-eye" tube, which gives a direct indication of plate current.

3022. MEASUREMENTS OF THE DIELECTRIC CONSTANT OF SOME NON-POLAR GASES (H_2, D_2, He, O_2, and Air) AND CO BETWEEN ROOM TEMPERATURES AND 20° ABS.—A. van Itterbeek & J. Spaepen. (*Physica*, March 1943, Vol. 10, No. 3, p. 173 onwards: summary in *Physik. Berichte*, No. 20, Vol. 24, 1943, pp. 1319–1320.) For the improved electrostatic method used, *see* 3468 of 1943.

3023. A CHANGE OF CAPACITANCE METHOD FOR THE MEASUREMENT OF MECHANICAL DISPLACEMENTS [Heterodyne Oscillator in which Variation of Displacement Causes Change of Beat Note: Frequency-Amplitude Converter Produces from Mixer Output a Direct Voltage proportional to Capacity Change].— E. Bradshaw. (*Journ. of Scient. Instr.*, June 1945, Vol. 22, No. 6, pp. 112–114.)

3024. THE PIEZOELECTRIC EFFECT OF THE ROCHELLE SALT CRYSTAL KH_2PO_4.—Bantle & Caflisch. (*See* 2986.)

3025. CORRECTIONS TO THE NAUEN ONOGO AND COINCIDENCE SIGNALS, THE COINCIDENCE SIGNALS OF BORDEAUX AND RUGBY, AND THE SHORT-WAVE COINCIDENCE SIGNALS OF NAUEN, BORDEAUX, AND MONTE GRANDE, JULY/AUGUST AND SEPT./OCT. 1942.— (*Astron. Nachrichten*, Oct./Nov. & Dec. 1942, Vol. 273, Nos. 2 & 3, pp. 104 & 159.) Mentioned in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1273.

SUBSIDIARY APPARATUS AND MATERIALS

3026. DEFLECTION SENSITIVITY OF PARALLEL-WIRE LINES IN CATHODE-RAY OSCILLOGRAPHS.— H. G. Rudenberg. (*Journ. Applied Phys.*, May 1945, Vol. 16, No. 5, pp. 279–284.) *See* 1553 of May.

3027. A SPACE CHARGE PROBLEM: ITS APPLICATION TO CATHODE-RAY TUBE DESIGN.— Moss. (*See* 2976.)

3028. INDUSTRIAL OSCILLOGRAPH FOR IMPULSE TESTING [for Observation or Photographing of Single High-Voltage Transients: Continuously Evacuated]. — O. Ackermann. (*Electronics*, May 1945, Vol. 18, No. 5, pp. 154..180.)

3029. CATHODE-RAY TUBES AND THEIR APPLICATIONS.—P. S. Christaldi. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 373–381.)

Author's summary :—" A joint service-industry programme of standardisation and specification of cathode-ray tubes has resulted in improvements in performance as well as in uniformity of production and has laid the foundation for more intelligent design of electronic equipment using these tubes. Much progress has been made recently in both techniques and designs of cathode-ray tubes and circuits. Both brightness and resolution of the fluorescent spot have been improved. New intensifier-type tubes have been developed for high accelerating potentials with high deflection sensitivities, considerably extending the range of visual observation and photographic recording of cathode-ray traces.

" Better response of deflection amplifiers to transient or pulse signals has been attained, together with improvements in linear time-base circuits for presenting such signals on scales measured in microseconds rather than milliseconds, and in timing circuits for calibrating them. Signal and sweep-delay circuits have been developed to facilitate viewing certain types of patterns. New techniques have suggested new applications of cathode-ray equipment in many fields of laboratory, military, and industrial measurement. Mechanical devices can be tested readily for vibration, balance, and speed ; electrical circuits and components may be inspected ; optical problems may be studied, as by the cathode-ray spectrograph ; and the non-destructive testing of many metals can be accomplished.

" It is expected that the improved cathode-ray tubes and techniques developed during the past few years, many of which have not yet been publicly described, will be applied to laboratory and production equipment as well as to television transmission and reception."

3030. THE IMAGE FORMATION IN CATHODE-RAY TUBES AND THE RELATION OF FLUORESCENT SPOT SIZE AND FINAL ANODE VOLTAGE.—G. Liebmann. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 381–389.)

Author's summary : — " A new equivalent-optical system consisting of three lenses is proposed to represent the electron-optical system of a cathode-ray-tube gun. The image formation by these lenses is discussed. It is concluded that the fluorescent spot is an image of the cathode and that its size is almost independent of the value of the final anode voltage E_A if lens errors can be disregarded. The solid angle of the electron beam proceeding from the second lens to the main focusing lens, contracts in inverse proportion to the final accelerating voltage, as expressed by the formula r^2E_A = constant, r being the radius af the electron beam. Measurements on a number of cathode-ray tubes of widely different design confirm these predictions. The new theory is compared critically with the earlier ' cross-over ' theory which led to different predictions. Some applications of the new conception to practical cathode-ray-tube design are briefly discussed."

3031. " LUMINESCENCE OF LIQUIDS & SOLIDS AND ITS PRACTICAL APPLICATION " [Book Review].—P. Pringsheim & M. Vogel. (*Journ. Applied Physics*, April 1945, Vol. 16, No. 4, p. 259.)

3032. SPECIMEN STAGE FOR THE ELECTRON MICROSCOPE [Use of Gauze supporting Collodion Film to hold Specimen : Assembly in Cartridge Form : Stage Mounting : Avoiding Vibration].—P. C. Smith, R. G. Picard, & F. E. Runge. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 234–258.)

3033. " SEEING THE INVISIBLE " [A Popular Account of the Electron Microscope : Book Review].—G. G. Hawley. (*Electronics*, February 1945, Vol. 18, No. 2, p. 408.)

3034. THE ELECTRON OPTICS OF MASS SPECTROGRAPHS AND VELOCITY FOCUSING DEVICES.—R. G. E. Hutter. (*Phys. Review*, 1st/15th April 1945, Vol. 67, Nos. 7/8, pp. 248–253.)

Author's summary :—" The well-known results of the theory of mass spectrometers and velocity focusing devices are derived again by a different method which is simpler than the ones previously used and which brings out more clearly the electron optical nature of the deflecting and focusing properties of the fields employed in these types of instruments."

3035. ELECTRONIC PROBLEMS INVOLVED IN THE PRACTICAL APPLICATION OF MASS SPECTROMETER.—J. H. Hipple, J. Grove & W. M. Hickam. (*Review Scient. Instr.*, April 1945, Vol. 16, No. 4, p. 69.)

3036. STATIONARY ELECTRON SWARMS IN ELECTROMAGNETIC FIELDS.—Gabor. (*See* 2975.)

3037. SPECTROSCOPIC INVESTIGATION OF THE EFFECT OF MAGNETIC FIELD ON ELECTRICAL DISCHARGE IN GASES.—S. B. Kulkarni. (*Current Science* [Bangalore], Oct. 1944, Vol. 13, No. 10, pp. 254–255.)

3038. VACUUM-TIGHT CERAMIC/GLASS JOINTS.—H. Vatter. (*Feinmech. Präzision*, 1943 : short summary in *Physik. Berichte*, No. 23, Vol. 24, 1943, p. 1460.)

3039. IMPORTANCE AND PROGRESS IN THE UTILISATION OF WIND POWER IN DENMARK.—D. Stein. (Long summary in *Rassegna d. Stampa Tecnica Tedesca* [Rome], Nov./Dec. 1942, Electrotechnics Section pp. 385–395 & 399–403.) For other recent work *see* 940 & 2617/8 of 1943.

3040. POSITIVE AND NEGATIVE POWER SUPPLIES.—E. M. I. Laboratories. (*Electronic Eng:g*, June 1945, Vol. 17, No. 208, p. 559.)

A means is described for providing, in addition to the usual positive anode supply voltage, a comparable negative voltage, both voltages being stabilised. Economy is achieved by using a conventional stabilising circuit with the voltage drop across the regulating valve used for one of the supplies.

3041. A 700 kV Direct-Current Electrostatic Generator [of van de Graaff Type, for Output Current of 1 mA and Over: Dimensions reduced to a Minimum].—J. F. Smee. (*Journ. I.E.E.*, Part I, Nov. 1944, Vol. 91, No. 47, pp. 422–431.)

3042. A New Rectifier Unit [Selenium Type Rectifier having Smoothed Output and suitable for use with Floating Battery at Small Telephone Exchange].—S. D. Chapman. (*P.O. Elec. Eng. Journ.*, Jan. 1945, Vol. 37, Part 3, pp. 118–119.)

3043. Stability of Low-Pressure Mercury Arcs as a Function of Current.—R. Copeland & W. H. Sparing. (*Journ. Applied Phys.*, May 1945, Vol. 16, No. 5, pp. 302–308.)

Among other results, " there is much evidence to show that the extinction of the arc depends upon uncontrolled circumstances in the neighbourhood of the cathode spot, and there was a spectacular increase in arc stability when the cathode spot was anchored at a tungsten film."

3044. Plastics in High Frequency Insulation.—P. I. Smith. (*Electronic Eng:g*, May 1945, Vol. 17, No. 207, pp. 515–516.)

3045. Fabricating Plastics: New Uses of Plastics for Electronic Components require Careful Evaluation of Published Characteristics.—(*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 86–87 and 132.) With table of properties of various types.

3046. " Natural and Synthetic High Polymers" [Book Review].—K. H. Meyer. (*Journ. Applied Physics*, April 1945, Vol. 16, No. 4, pp. 258–259.)

English translation (by L. E. R. Picken) of German text book: " A Text Book and Reference Book for Chemists and Biologists."

3047. Surface - Leakage Investigations on Moulding Materials [P.-T.R. Methods & Equipment, and a New " Dipping " Method].—Physikalisch - Technische Reichsanstalt. (*Physik. Berichte*, No. 18, Vol. 24, 1943, p. 1224: from *Kunststoffe*, No. 1, 1943.) *Cf.* 206 of 1943.

3048. " Chemie und Technologie der künstlichen Harze " [Synthetic Resins: Book Review].—J. Scheiber. (*Zeitschr. V.D.I.*, 16th Oct. 1943, Vol. 87, No. 41/42, p. 672.) An enthusiastic review.

3049. Shape of Large Molecules in Plastics determined [by Two New Instruments employing Scattering of Light].—P. M. Doty. (*Sci. News Letter*, 27th Jan. 1945, Vol. 47, No. 4, p. 57.) From the Polytechnic Institute of Brooklyn.

3050. Ultra - Violet - Absorbing Plastic [with High Transmission of Visible Light: by Treatment of Plastic with an Azine].—Polaroid Corporation. (*Review Scient. Instr.*, March 1945, Vol. 16, No. 3, p. 61.)

3051. The Physical Properties of Glass: II—The Density of Silicate Glasses [and Some New Formulae applicable to a Large Number of Glasses].—J. M. Stevels. (*Physik. Berichte*, No. 18, Vol. 24, 1943, p. 1208.)

3052. Characteristics of Chlorinated Impregnants in Direct-Current Paper Capacitors.—L. J. Berberich, C. V. Fields & R. E. Marbury. (*Proc. I.R.E.*, June 1945, Vol. 33, No.6, pp. 389–397.)

Authors' summary:—" Direct-current capacitors of the impregnated-paper type play an important role in electronic equipment required by the Armed Services. In some of these applications good performance is required over very wide temperature ranges. A new chlorinated-hydrocarbon composition which maintains reasonable capacitance constancy over a wide temperature range is described. The properties of this liquid are compared with conventional chlorinated impregnants. Since some alternating voltages usually accompany the direct voltages applied to capacitors, the alternating-current behaviour over wide temperature and frequency ranges is described for capacitors impregnated with three different liquids. The effect of voltage and temperature on the resistance of capacitors is discussed. Considerable attention is devoted to the life behaviour of capacitors impregnated with chlorinated liquids under direct-current stresses at high temperatures. A life-testing procedure is described which has yielded very satisfactory results on capacitors of varying sizes and ratings. A means for prolonging the life of capacitors impregnated with chlorinated impregnants involving the addition of stabilisers is discussed. Data showing effect of a number of stabilisers are presented. Finally, some data are presented showing the effect of voltage on the life of direct-current capacitors."

3053. On the Thermal Expansion of Insulating Paper.—A. Wallraff. (*Arch. f. Elektrot.*, 30th Sept. 1943, Vol. 37, No. 9, pp. 458–462.) A summary was dealt with in 1174 of April.

3054. Electronic Vulcanization [R.F. Heating very Suitable for Treatment of Rubber: Much Quicker than Steam Heating].—B.F. Goodrich Company. (*Review Scient. Instr.*, April 1945, Vol. 16, No. 4, p. 101.)

3055. Molecular Requirements for Synthetic Rubbers.—W. O. Baker. (*Bell Lab. Record*, April 1945, Vol. 23, No. 4, pp. 97–100.)

3056. Synthetic Rubber Now Stands on Its Own Merits [Some Advantages of Synthetic over Natural Rubber].—(*Sci. News Letter*, 3rd March 1945, Vol. 47, No. 9, p. 136.)

3057. Evaluating Insulating Varnishes.—K. N. Mathes. (*Gen. Elec. Review*, May 1945, Vol. 48, No. 5, pp. 20–28.)

3058. On Permanent Charges in Solid Dielectrics: I. Dielectric Absorption and Temperature Effects in Carnauba Wax.—B. Gross & L. F. Denard. (*Phys. Review*, 1st/15th April 1945, Vol. 67, Nos. 7/8, pp. 253–259.)

Authors' summary:—" The influence of the temperature upon dielectric absorption is studied for carnauba wax. Isothermic and non-isothermic current-time curves are measured. It is shown that a considerable part of the absorbed charge can be 'frozen in,' if the temperature is reduced to a value sufficiently inferior to that prevailing during the charging period before the system is short-circuited. The 'frozen' charge dissipates extremely slowly, if the temperature is kept low, but it is liberated rapidly if the temperature is raised again."

3059. THE IMPORTANCE OF STEATITE FOR HIGH FREQUENCY INSULATION.—J. G. Gleason. (*Proc. I.R.E.*, Australia, April 1945, Vol. 5, No. 8, pp. 2–12.)

Contains useful relative data, and a section on special points to be borne in mind in designing die-pressed ceramic items. A short bibliography is appended.

3060. FACTORS INFLUENCING THE MAGNETIC BEHAVIOUR OF SILICON-IRON TRANSFORMER SHEET.—V. Montoro. (*Physik. Berichte*, No. 21, Vol. 24, 1943, p. 1373.) Report on a metallographic and spectrographic investigation.

3061. PERMANENT MAGNETS [the New Ductile Materials and Their Applications].—General Electric Company. (*Terr. Mag. & Atmos. Elec.*, March 1945, Vol. 50, No. 1, pp. 80–81.) Taken from the paper mentioned in 1596 of May.

3062. THE FIELD OF PERMANENT MAGNETS [including Design for Best Results: Survey of Researches in Laboratory of Stuttgart Engineering College].—F. Emde. (*Physik. Berichte*, No. 20, Vol. 24, 1943, p. 1287.)

3063. IRON–SILICON ALLOY OF HIGH INITIAL PERMEABILITY [as Substitute for Iron–Nickel Alloys].—F. Pawlek. (*Zeitschr. V.D.I* 4th Sept. 1943, Vol. 87, No. 35/36, pp. 572–573: summary only.) For another summary *see* 2332 of 1944.

3064. INFLUENCE OF VARIOUS ALLOY ADDITIONS ON THE PROPERTIES OF CHROMIUM-CONTAINING PERMANENT-MAGNET STEELS.—H. Krainer & F. Raidl. (*Physik. Berichte*, No. 15, Vol. 24, 1943, p. 1054.)

3065. CALCULATION OF MAGNETIC LENSES WITH GIVEN SHAPE OF FIELD.—N. Svartholm. (*Physik. Berichte*, No. 15, Vol. 24, 1943, pp. 1028–1029.)

The field equation assumed is

$$H(z) = H_0/\{1 + (z/a)^2\}^\mu,$$

where μ is "any whole or half number equal to or greater than unity." For the case where $\mu = 1$ *see*, for example, Marton & Hutter, 1296 & 2943 of 1944.

3066. ELECTRONIC MAGNETISER ["Controlled Half-Cycle Capacitor-Discharge Circuit speeds up the Precision Treatment of Magnets"].—H. J. Hague. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 96 and 190, 191.) From the Westinghouse Company.

3067. HYSTERESIS OF INVERSE MAGNETOSTRICTION.—A. Herpin. (*Comptes Rendus* [Paris], Nov. 1943, Vol. 217, p. 475 onwards.) Mentioned in *Review Scient. Instr.*, March 1945. For previous work by this writer *see* 177/8 of January.

3068. MAGNETISM IN RELATION TO STRUCTURE [Report on Discussion].—C. V. Raman & others. (*Current Science* [Bangalore], Jan. 1945, Vol. 14, No. 1, p. 16.)

3069. THE ANTIFERROMAGNETISM OF THE FERROUS IONS: MAGNETIC SUSCEPTIBILITY AT LOW TEMPERATURES OF THE IRON PROTOXIDE FeO.—H. Bizette & Belling Tsaï. (*Comptes Rendus* [Paris], 4th/26th Oct. 1943, Vol. 217, No. 14/17, pp. 390–392.)

3070. MAGNETIC SUSCEPTIBILITY AT LOW TEMPERATURES OF SOLID SOLUTIONS MnO–MgO and FeO–MgO.—H. Bizette. (*Comptes Rendus* [Paris], Nov. 1943, Vol. 217, p. 444 onwards.) Mentioned in *Review Scient. Instr.*, March 1945.

3071. MAGNETIC ALTERNATING AND ROTATIONAL HYSTERESIS: ANALYTICAL REPRESENTATION AND NUMERICAL CONNECTION [Former Tacit Assumption that the Relation between Field Strength & Induction is the Same for the Two Phenomena is Incorrect for Materials with High Values of Hysteresis: etc.].—H. E. Jaeschke. (*Arch. f. Elektrot.*, 30th Sept. 1943, Vol. 37, No. 9, pp. 413–443.)

3072. THE VALIDITY OF THE POLE FIGURE [for determining Preferred Orientations in (*e.g.*) Cold-Rolled & Annealed Silicon Steel].—B. F. Decker. (*Journ. Applied Phys.*, May 1945, Vol. 16, No. 5, pp. 309–310.)

3073. ON CERTAIN NON-LINEAR PHENOMENA APPEARING ON THE SUPERPOSITION OF MUTUALLY PERPENDICULAR MAGNETIC FIELDS.—G. Gorelik. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, p. 383: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS*, Série Physique, 1944.)

3074. PARAMETRIC VIBRATIONS OF AN IRON BODY IN A VARYING MAGNETIC FIELD.—S. Rytov. (*Journ. of Phys.* [USSR], No. 6, Vol. 8, 1944, p. 383: in English, summary only: in full in Nos. 1–4, *Bull. de l'Ac. des Sci. de l'URSS*, Série Physique, 1944.)

3075. ON APPARENT MAGNETISATION [Theoretical & Experimental Investigation of the Apparent Demagnetisation of a Magnetised Ferromagnetic Cylinder by a 50 c/s Field gradually Reduced to Zero: Considerable Magnetisation remains in the Interior, owing to Skin Effect].—V. K. Arkadiev & L. A. Yurovsky. (*Comptes Rendus* (*Doklady, de l'Ac. des Sci. de l'URSS*, 10th April 1944) Vol. 43, No. 1, pp. 10–13: in English.)

The residual induction was measured from time to time as the diameter of the cylinder was reduced by etching with aqua regia.

3076. THE EFFECT OF SUPERSONIC WAVES ON THE MAGNETIC BEHAVIOUR OF NICKEL: I & II.—G. Schmid & U. Jetter. (*Physik. Berichte*, No. 24, Vol. 24, 1943, pp. 1557–1558 & 1558–1559.)

3077. CABLE SPLICING AND RECONDITIONING [Reconditioning Recovered Cable so that Maximum Amount may be Used: "Unidiameter" Joints enable Short Lengths to be Pieced Together].—L. C. Langford. (*P.O. Elec. Eng. Journ.*, April 1945, Vol. 38, Part I, pp. 22–24.)

3078. LOCATION OF LINE FAULTS [Pulse Technique Gives, on Oscilloscope, Location and Nature of Transmission Line Faults].—M. A. Honnell. (*Electronics*, Nov. 1944, Vol. 17. No. 11, pp. 110–113.)

3079. AERIAL CABLE LINES [Part 2. Stayed Poles and Methods of Erecting the cable].—P. R. Gerry. (*P.O. Elec. Eng. Journ.*, Oct. 1944, Vol. 37, Part 3.) Part 1 appeared in the July issue.

3080. CONSTANT SPEED IMPULSE MOTORS.—H. T. Mitchell & T. Pilking. (*P.O. Elec. Eng. Journ.*, Jan. 1945, Vol. 37, Part 4, pp. 109–112.)

A drum rotating at 1 rev./min. was required to operate unattended for 7 days with an accuracy of ± 10 revolutions during this period. Two constant speed impulse motors are described. The first, manufactured in U.S.A., is controlled by a centrifugal governor. The second, designed by the authors, uses as speed control a differential gear associated with a balance wheel and escapement.

3081. COLD CATHODE COUNTER CONTROL [Cold Cathode Tubes do nor require Maintenance of Stable Cathode Temperature or involve Delay after switching on: Particularly Suitable for Reliable use in Photo-Cell Operation of Relays].—L. Atkinson. (*Electronic Eng:g*, June 1945, Vol. 17. No. 208, pp. 553–555.)

3082. SIMPLIFICATION OF COMPLEX SWITCHING ANALYSIS.—M. Byron. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 413–414: a long letter.)

"This paper outlines a method whereby the designing of complex switching arrangements may be resolved into the least possible number of switches in a fraction of the time ordinarily required." The procedure used is first to suppose that the switching operation has to be carried out using only single-pole, single-throw switches: then rules are given which enable superfluous switches to be eliminated. An example is given of the method applied to a complicated two-way problem. (Letter apparently abridged before publication: e.g. Fig. 4b mentioned in text is not included.)

3083. A DELAYED-ACTION LEVER-TYPE KEY [Key when Depressed returns to Normal Position Slowly under action of Clock Spring and Centrifugal Governor: Delay up to Seven Seconds].—W. H. Blois & J. M. Fleming. (*P. O. Elec. Eng. Journ.*, April 1945, Vol. 38, Part I, pp. 16–18.)

3084. RESISTANCE OF CARBON TO CARBON CONTACT [Resistance for Pressures up to 30 000 gm per sq. cm: Time Lag of up to 24 hours on Increasing Pressure].—W. B. Pietenpol & F. C. Walz. (*Phys. Review*, 1st/15th March 1945, Vol. 67, Nos. 5/6, p. 201: Abstract only.)

3085. FLAMEPROOF TELEPHONE APPARATUS [Describes Types of Apparatus available and Details of Installation and Maintenance].—C. W. Arnold. (*P.O. Elec. Eng. Journ.*, Oct. 1944, Vol. 37, Part 3, pp. 81–85.)

3086. DISTRIBUTION OF THE SPEAKING CLOCK SERVICE.—J. M. Ridd. (*P.O. Elec. Eng. Journ.*, Jan. 1945, Vol. 37, Part 4, pp. 101–104.)

3087. THE INFLUENCE OF TEMPERATURE ON THE VOLTAGE AND OUTPUT OF DRY BATTERIES [and the Incorrectness of the Japanese Formula].—C. Drotschmann. (*Physik. Berichte*, No. 15, Vol. 24, 1943, p. 1042.)

3088. THE TESTING OF BRUSHES FOR LIFE AND PERFORMANCE UNDER VARIOUS ALTITUDE CONDITIONS, *and* ALTITUDE RATING OF ELECTRIC APPARATUS.—C. J. Herman: P. Lebenbaum, Jr. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, Transactions pp. 929–933: pp. 955–960.) Summaries were referred to in 1170 of April.

3089. THE DESIGN OF POWER AMPLIFIERS FOR OPERATING INK RECORDERS.—D. Robinson. (*Electronic Eng:g*, May 1945, Vol. 17, No. 207, pp. 493–497.)

3090. A CHUCK FOR GLASS TUBING [Grip on the Glass Obtained by Wrapping Steel Wires Tightly round it—Suitable for Bent or Slightly Non-Circular Tubing].—J. M. Somerville. (*Journ. of Scient. Instr.*, June 1945, Vol. 22, No. 6, pp. 114–115.)

3091. A COMPACT SOURCE PROJECTION LAMP [Small 250 W Mercury Vapour Lamp for use in Optical Projection Instruments and Scientific Apparatus].—H. K. Bourne. (*Journ of Scient. Instr.*, June 1945, Vol. 22, No. 6, pp. 107–110.)

3092. STEPPING RELAY MECHANISM [Type 82 Rotary Relay Stepping Unit operating Shaft Extension through 360° in 12 Progressive Steps: D.C.-Operated].—Price Brothers. (*Review Scient. Instr.*, March 1945, Vol. 16, No. 3, p. 60.)

STATIONS, DESIGN AND OPERATION

3093. A FIVE-CHANNEL CARRIER TELEPHONE SYSTEM FOR THE SERVICES.—L. S. Crutch. (*P.O. Elec. Eng. Journ.*, April 1945, Vol. 38, Part I, pp. 1–7.)

Describes the adaptation of the P.O. Carrier System No. 4 to meet Service requirements. The system uses a voice-frequency channel and five carrier channels up to 16 kc/s, with a band pass of 300–2600 c/s. As modified it is designed to work with loaded field-quad cable or army aerial lines. In the latter case frequencies up to 32 kc/s are used. The signalling system is a sensitive valve operated type so that range shall not be limited by an increase of line attenuation under working conditions. With 4-wire working on cables, repeaters are necessary every 40 miles. Power supply is from a.c. mains or 12 v accumulators, for field use.

The apparatus is more compact and robust than the standard P.O. equipment and is designed to operate in extreme climatic conditions. Large numbers of these units have been in use since 1941.

3094. A Simple Automatic Relaying System for WERS [Separated Antennas and Sufficient Difference in Frequency permit Simultaneous Operation of Transmitter and Receiver for Automatic Relaying of Messages].—N. H. McCoy. (*QST*, June 1945, Vol. 29, No. 6, pp. 34–35.

3095. A 1000 kW Diesel Generating Installation [Provision for safeguarding a Large Radio Station against Failure of Power Supply: Details of the Fullagar Engine Principle].—L. L. Hall & P. J. Rattue. (*P.O. Elec. Eng. Journ.*, Oct. 1944, Vol. 37, Part 3, pp. 75–80.)

3096. Post-war Fire Radio Service [New F.C.C. Rules: Mutual Aid System: Present Wire Facilities: Frequencies: Equipment].—(*Electronic Industries*, Sept. 1944, Vol. 3, No. 9, pp. 98–101.)

3097. A 50 kW. F.M. Transmitter.—P. B. Laeser. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 100–105.)

This 45 Mc/s., transmitter, which has been in use for several years, incorporates a phase shift modulator designed to ensure a centre carrier stability of 300 c/s, and to avoid other deficiencies of earlier types. The first oscillator operates at 190 kc/s, frequency multiplication to 15 Mc/s being obtained in the modulators. This is converted by mixing with the output of a 1 Mc/s crystal oscillator to give a 1 Mc/s signal, frequency modulated with a deviation of 2 kc/s. Frequency multiplication gives a deviation of 75 kc/s at the carrier frequency. The audio response is from 50–15 000 c/s and embodies "100 μs pre-emphasis." Distortion is less than 1.5%. Details of the 250 watt and 3 kW. amplifiers, and of the station layout are also included.

3098. WERS Expanded.—(*QST*, June 1945, Vol. 29, No. 6, pp. 19–21.)

F.C.C. regulations amended so that WERS stations can now operate in an emergency involving public safety: New networks may be established and existing licences renewed even though the Citizens Defence Corps, or equivalent civilian defence organisations, are no longer active in the area. Further amendments allow for co-operation with United States Weather Bureau in their flood and storm-warning emergency radio network.

3099. A Report on the F.C.C. Frequency Allocation Hearing.—(*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 92–97.)

A review of Docket 6651 which records an exhaustive enquiry by the Federal Communications Commission into the future needs of various services in the radio spectrum from 10 kc/s to 30 000 Mc/s (30 000 metres to 1 cm.).

GENERAL PHYSICAL ARTICLES

3100. On the Impulsion Moment of an Electromagnetic Wave.—J. Humblet. (*Physica*, July 1943, Vol. 10, No. 7, p. 585 onwards: in French: short summary in *Physik. Berichte*, No. 24, Vol. 24, 1943, p. 1559.)

"The writer investigates the analysis of the rotational moment of electromagnetic radiation into three components. The first two have the form of a path-moment and a spin-moment. The third component can be represented as a surface integral, and may be omitted if the potentials, as in meson theory, are defined unequivocally . . . The general considerations are applied to electric dipole-radiation and plane electromagnetic waves. In the latter case the fact that the rotational moment cannot be defined unequivocally is without practical importance."

3101. A Theorem of Larmor and its Importance for Electrons in Magnetic Fields.—L. Brillouin. (*Phys. Review*, 1st/15th April, 1945, Vol. 67, Nos. 7/8, pp. 260–266.)

Author's summary:—"The importance of a well-known theorem, originally due to Larmor, is emphasised. It enables a definition of "momentum" and "moment of momentum" for electrons in a magnetic field, hence the possibility of writing the conservation of these quantities when the geometry of the structure is convenient. As typical examples of the method, two special cases are discussed: a plane electron beam and a cylindrical electron beam with longitudinal magnetic field. In both cases it is found that the space-charge density of the beam is entirely controlled by the magnetic field and that the maximum current is obtained for a suitable optimum magnetic field."

3102. On the Scattering of Electrons in the Cascade Showers.—S. Belenky. (*Journ. of Phys.* [of USSR], No. 6, Vol. 8, 1944, pp. 347–357.)

3103. Unification of the Physical Fields.—F. R. Saxby. (*Nature*, 19th May 1945, Vol. 155, No. 3942, pp. 609–610.)

3104. The Equation of Waves in *n*-Dimensional Space having Constant Curvature: Solution of the Cauchy Problem.—M. Olevsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 10th Jan. 1945, Vol. 46, No. 1, pp. 3–6: in French.)

3105. The Electrophysics of Gases [Theoretical & Experimental Treatise].—W. Bartholomeyczyk & G. Mierdel. (*Physik. Berichte*, No. 24, Vol. 24, 1943, p. 1542.)

3106. The Rôle of the Energy Law in Meteorology and Geophysics.—A. Schmauss. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 921.)

MISCELLANEOUS

3107. Zeros of Bessel Functions.—D. B. Smith & others. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 240..248.) From the paper dealt with in 3663 of 1944.

3108. Tables of Bessel Functions.—(*Nature*, 19th May 1945, Vol. 155, No. 3942, p. 603.)

A "Guide to Tables of Bessel Functions" by Profs. H. Bateman and R. C. Archibald has been published by the U.S. National Research Council in the journal "Mathematical Tables and other

Aids to Computation." It contains lists of tables and graphs with their authors, information concerning errors in the tables and an alphabetical bibliography.

3109. HYPERBOLIC FUNCTIONS [Parallel between the Relationship of These Functions to the Equilateral Hyperbola and That of the Trigonometric Functions to the Circle].—W. H. Minor. (*QST*, June 1945, Vol. 29, No. 6, pp. 30–31.)

3110. LAPLACE TRANSFORMS FOR THE ELECTRONIC ENGINEER.—G. J. Wheeler. (*Electronics*, February 1945, Vol. 18, No. 2, pp. 304–314.)

3111. "MODERN OPERATIONAL MATHEMATICS IN ENGINEERING" [Book Review].—R. C. Churchill. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 370, 372.)

3112. AN ASYMPTOTIC METHOD FOR SOLVING CERTAIN CLASSES OF DIFFERENTIAL EQUATIONS HAVING VARIABLE COEFFICIENTS.—I. Shtokalo. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 20th Jan. 1945, Vol. 46, No. 2, pp. 51–52 : in French.)

3113. THE ESTIMATION OF ERROR FOR THE ITERATION METHOD OF SOLVING LINEAR EQUATION SYSTEMS [Influence of the Gaussian Transformation on the Convergence], *and* ON THE CONVERGENCE OF THE NEWTON APPROXIMATION PROCESS FOR EQUATION SYSTEMS.—L. Collatz : F. Rehbock. (*Physik. Berichte*, No. 15, Vol. 24, 1943, p. 1009 : p. 1010.)

3114. DIFFERENTIAL ANALYSER APPLICATIONS [Brief Outline of some Typical Problems that have been Solved by Use of Differential Analyser, to illustrate its Adaptability].—F. J. Maginniss. (*Gen. Elec. Review*, May 1945, Vol. 48, No. 5, pp. 20–28.)

3115. THE HARMONIC ANALYSIS OF DISTORTED SINE-WAVES.—R. C. de Holzer. (*Electronic Eng:g.*, June 1945, Vol. 17, No. 208, pp. 556–558 and July 1945, No. 209, pp. 606–608.)

Author's Abstract :—" 1. A table is given for the calculation of the first and third harmonics from two measured ordinates . . . 2. Formulae are derived which make it possible without measuring more ordinates, and without any calculation, to read in a diagram the odd harmonics up to the seventh . . . 3. In cases where even harmonics are present a simple method is given for such calculations up to the fourth harmonic."

3116. ON THE EXPERIMENTAL SOLUTION OF PLANE POTENTIAL PROBLEMS BY ELECTRIC DIPOLE FIELDS [in the Electrolytic Trough].—Schmidt. (*See* 2978.)

3117. THE WATSON SCIENTIFIC COMPUTING LABORATORY AT COLUMBIA UNIVERSITY [Recently Established by the International Business Machines Corporation].—(*Science*, 16th Feb. 1945, Vol. 101, No. 2616, pp. 168–169.)

3118. "ELEMENTARY STATISTICS" [Examination and Assessment of Measurements : Their Variations and Correlation : Quality Control : Book Review].—H. Levy & E. E. Preidel. (*Engineering*, 6th April 1945, Vol. 159, No. 4134, p. 263.)

3119. MODERN STATISTICAL METHODS IN INDUSTRY [Review of "Sampling Inspection Tables" (1250 of April) & "Regression Analysis of Production Costs and Factory Operations"].—H. F. Dodge & H. G. Romig : P. Lyle. (*Nature*, 14th April 1945, Vol. 155, No. 3937, pp. 438–439.)

"The most encouraging feature of Mr. Lyle's book is that it is written, not by a statistician, but by a practical industrialist who has proved the value of regression analysis in his own field . . ."

3120. INVERSE STATISTICAL VARIATES [Correspondence on "A Labour-Saving Method of Sampling," 1249 of April].—M. C. K. Tweedie : J. B. S. Haldane. (*Nature*, 14th April 1945, Vol. 155, No. 3937, p. 453.)

Haldane's reply begins : " Mr. Tweedie's demonstration of the relation between the seminvariant-generating (or cumulant-generating) functions of two sets of related distributions is of great interest. . . ." Based on it, Tweedie's general theory of the effect of Brownian motion on the times taken by colloid particles to travel a fixed distance under electrophoresis or convection will be published elsewhere, but one result is discussed here.

3121. "QUALITY THROUGH STATISTICS" [Book Review].—A. S. Wharton. (*Wireless Engineer*, June 1945, Vol. 22, No. 261, pp. 281–282.)

3122. THE SELECTION OF FACTORS IN STATISTICAL INVESTIGATIONS.—G. Walker. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 922.)

3123. UNDERWRITERS' LABORATORIES FIFTIETH ANNIVERSARY [and Some Notes on Its Development & Work].—Underwriters' Laboratories, Inc. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 264, 266.)

3124. METHOD OF JUDGING A VERY SLIGHT CORRELATION BETWEEN TWO STATISTICAL SERIES [by an Extension of the Lexis Dispersion Theory].—H. Gebelein. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 890.)

3125. CONTRIBUTION TO THE DETERMINATION OF THE EQUATION OF THE MOST PLAUSIBLE STRAIGHT LINE OF AN ERROR-CONTAINING SERIES OF POINTS.—H. Wolf. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 891.)

3126. REMARK ON THE HARMONIC ANALYSIS OF SMOOTHED SERIES OF OBSERVATIONS.—F. Baur. (*Physik. Berichte*, No. 13, Vol. 24, 1943, p. 922.) For Baur's work on meteorology *see* 1897 of 1942 and 1378 of 1943.

3127. PARABOLIC GRAPH PAPER FOR SQUARE-LAW FUNCTIONS.—A. Leen. (*Electronics*, February 1945, Vol. 18, No. 2, pp. 314 and 315.)

3128. GRAPHICAL SYMBOLS [Inter-Services Radio Circuit Symbols Committee's List].—*Wireless World*, June 1945, Vol. 51, No. 6, p. 189.)

A small selection is illustrated. A larger selection was published in *Electronic Eng:g* for June 1945.

3129. CIRCUIT DIAGRAMS.—L. H. Bainbridge-Bell. (*Electronic Eng:g*, June 1945, Vol. 17, No. 208, pp. 546–548.)

Suggests rules for laying out diagrams to show the operation of the circuit as clearly as possible. Components should be shown in their functional rather than their physical position and connections should be capable of being readily followed by eye. The passage from cause to effect should be from left to right; high potential points should be higher on the paper than low potential points. The "bridge" symbol for non-contact crossings is recommended.

3130. "ELECTRICAL DRAFTING" [Book Review: Use of Symbols: Preparation of Circuit and Schematic Diagrams].—D. W. Van Gieson. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, p. 349.)

3131. "ALIGNMENT CHARTS, CONSTRUCTION AND USE" [Book Review].—M. Kraitchik. (*Electronics*, February 1945, Vol. 18, No. 2, p. 402.)

3132. "LEHRBUCH DER DRAHTLOSEN NACHRICHTENTECHNIK" [Vol. I—Foundations and Mathematical Technique of H.F. Engineering (H. Möller): Vol. II—Radiation, Propagation, & Reception of Electromagnetic Waves (L. Bergmann & H. Lassen): Book Review].—N. von Korschenewski & W. T. Runge. (*Funktech. Monatshefte*, Feb./March 1943, No. 2/3, pp. 39–40.)

3133. BRITISH EMPIRE SCIENTIFIC CONFERENCE [Prof. A. V. Hill's address on Conference to be Called in London by the Royal Society early in 1946].—(*Nature*, 31st March 1945, Vol. 155, No. 3935, pp. 373–375.)

3134. COMMITTEES, DIVISIONS, PUBLICATIONS, ETC. [of Council for Sci. & Ind. Res. Australia —as at January 1945].—(Supplement to *Journal of the Council of Sci. & Ind. Res.* [Australia], Feb. 1945, Vol. 18, No. 1.)

3135. THE DESIRABILITY OF A NEW OVER-ALL PHYSICS ORGANISATION TO CONSOLIDATE THE MANY EXISTING SOCIETIES: THE ADVANTAGE OF CONSOLIDATION OF MEETINGS. —E. A. Boettner. (*Review Scient. Instr.*, Feb. 1945, Vol. 16, No. 2, p. 39.) For Wildhack's proposal and arguments *see* 1283 of April.

3136. THE QUESTION OF THE ADEQUACY OF EXISTING PHYSICS SOCIETIES: SUPPORT FOR THE REORGANISATION PROPOSALS OF HARNWELL AND WILDHACK [1283 of April & Back References].—P. H. Miller, Jr., & others. (*Review Scient. Instr.*, March 1945, Vol. 16, No. 3, pp. 58–59.)

3137. WHITHER AMERICAN PHYSICS? [and the Formation of Divisions in the American Physical Society: the Two Dangers ("Balkanization" & Over-Emphasis on Applied Physics) and Their Avoidance].—F. Seitz. (*Review Scient. Instr.*, Feb. 1945, Vol. 16, No. 2, pp. 39–42.)

3138. THE SIGNIFICANCE, TO THE INDUSTRIAL PHYSICIST, OF THE FORMATION OF DIVISIONS WITHIN THE AMERICAN PHYSICAL SOCIETY. —M. Muskat. (*Review Scient. Instr.*, Feb. 1945, Vol. 16, No. 2, pp. 38–39.)

3139. THE NEW DIVISION OF HIGH-POLYMER PHYSICS.—American Physical Society. (*Scient. Monthly*, Jan. 1945, Vol. 60, No. 1, pp. 71–72.)

3140. COMMUTATION OF ANNUAL SUBSCRIPTIONS [1286 of April: the Practical Objection is the Forfeiting of the Power to Resign].—R. Edgeworth-Johnstone: J. H. Unna. (*Nature*, 17th Feb. 1945, Vol. 155, No. 3929, p. 207.)

3141. SCIENTIFIC RESEARCH AND INDUSTRY IN U.S.A.—Sir J. C. Ghosh. (*Current Science*, April 1945, Vol. 14, No. 4, pp. 90–93.)

3142. SCIENTIFIC RESEARCH IN AUSTRALIA [Review of 17th Annual Report of Council for Sci. & Ind. Res. in Australia].—(*Engineering*, 20th April 1945, Vol. 159, No. 4316, pp. 303–304; to be continued.)

3143. THE CHALLENGE OF SCIENTIFIC RUSSIAN.—J. Chaitkin. (*Scient. Monthly*, April 1945, Vol. 60, No. 4, pp. 301–306.)

"There is no doubt that proficiency in the use of Russian as a medium of conversation or writing can be attained only by long practice and study. . . Learning to read and understand Russian scientific writing is an entirely different matter." The writer asks for a more widespread learning of scientific Russian, and gives an interesting brief account of it.

3144. SOVIET ELECTRONIC PLANT [report of speech by R. C. Ellis, Director of Radio & Radar Division of W.P.B. to R.M.A. Conference Chicago].—(*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 296–298.)

3145. RADIO IN RUSSIA [Impressions of Director of Radio and Radar Division, War Production Board while visiting Russia at invitation of Govt. of U.S.S.R. Prewar situation: Lack of standardisation: Evacuation to Siberia: Working conditions: Tube production: Enthusiasm of workers: Comparison with American practice: Factory morale].—R. C. Ellis. (*Electronic Industries*, July 1944, Vol. 3, No. 7, pp. 76..190.)

3146. SCIENTIFIC RESEARCH IN INDIA [Summary of Report of Recent Tour: Scientific and Industrial Research as Part of Indian Post-War Reconstruction: Coordination with Corresponding Activities in Britain].—A. V. Hill. (*Nature*, 5th May 1945. Vol. 155, pp. 525–529 & pp. 532–535.)

3147. SCIENTIFIC AND INDUSTRIAL RESEARCH IN INDIA.—V. S. Swaminathan. (*Scient. Monthly*, April 1945, Vol. 60, No. 4, pp. 307–310.)

3148. SCIENTIFIC EDUCATION AND RESEARCH IN RELATION TO NATIONAL WELFARE: PARTS II AND III.—(*Sci. & Culture* [Calcutta], March and April 1945, Vol. 10, Nos. 9 and 10, pp. 357–362, 405–412.) *See* 2420 of July.

3149. THE SCIENTISTS' POST-WAR PROBLEMS [Full Employment, Rehabilitation & Retraining, Standards of Living, International Collaboration: Article based on the Second National Wartime Conference].—H. Grundfest. (*Scient. Monthly*, Feb. 1945, Vol. 60, No. 2, pp. 130–140.)

3150. RESEARCH AFTER THE WAR [Report of a Symposium held under the Auspices of the American Association for the Advancement of Science on Need for a National Policy for Research].—L. K. Frank. (*Science*, 27th April 1945, Vol. 101, No. 2626, pp. 433–434.)

3151. THE AUTONOMY OF SCIENCE [and the Dangers of State Control: Lysenko *versus* Mendelism & Cytogenetics: Levy's "Science must be Marshalled for the People": etc.].—M. Polanyi. (*Scient. Monthly*, Feb. 1945, Vol. 60, No. 2, pp. 141–150.) *See* also March issue, No. 3, p. 202.

3152. "PRODIGAL GENIUS: THE LIFE OF NIKOLA TESLA" [Book Review].—J. O'Neill. (*Electronics*, May 1945, Vol. 18, No. 5, p. 392.)

3153. "RADIO'S 100 MEN OF SCIENCE" [Book Review: Account of Pioneers in the Radio Art].—O. E. Dunlap. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 373–374.)

3154. "PHILOSOPHY AND THE PHYSICISTS" [Criticism of the Philosophical Views of Eddington and Jeans: Book Notice].—L. Susan Stebbing. (*Journ. of Scient. Instr.*, April 1945, Vol. 22, No. 4, p. 78.)

3155. THE ENGINEER'S PLACE IN THE MODERN WORLD.—I. S. Coggeshall. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp. 283 and 284.)

3156. THE ENGINEER AND HIS FUTURE.—C. A. Powel. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp. 284 and 285.)

3157. THE ENGINEER'S PLACE IN THE SCHEME OF THINGS [His Education and Training: Responsibilities of Government, Industry and Individual].—R. H. Herrick, J. E. Hobson, J. E. Brown & A. B. Bronwell. (*Proc. I.R.E.*, May 1945, Vol. 33, No. 5, pp. 286–290.)

3158. THE PROFESSIONAL ENGINEERS' APPOINTMENTS BUREAU.—(*Journ. I.E.E.*, Part I, Dec. 1944, Vol. 91, No. 48, p. 443.) *See* also 1661 of May.

3159. THE ORGANISATION OF THE ENGINEERING PROFESSION.—W. Kidd. (*Journ. I.E.E.*, Part I, Feb. 1945, Vol. 92, No. 50, pp. 85–88.) Abridgment of Chairman's Address, North-Western Centre.

3160. EDUCATION AND TRAINING FOR ENGINEERS: SECOND REPORT—PART-TIME FURTHER EDUCATION AT TECHNICAL COLLEGES, INCLUDING COURSES FOR THOSE RETURNING FROM THE SERVICES.—I. E. E. Committee. (*Journ. I.E.E.*, Part I, Feb. 1945, Vol. 92. No. 50, pp. 56–68.) A review of the first Report was dealt with in 291 of 1944.

3161. SELECTION OF STAFF BY MEANS OF INTELLIGENCE AND APTITUDE TESTS.—R. C. Woods & A. S. MacDonald. (*Journ. I.EE.*, Part I, April 1944, Vol. 91, No. 40, pp. 148–157.) From Ericsson Telephones, Ltd. For a Discussion see *ibid.*, Sept. 1944, No. 45, pp. 354–355.

3162. THE IMPENDING SCARCITY OF SCIENTIFIC PERSONNEL.—M. H. Trytten. (*Scient. Monthly*, Jan. 1945, Vol. 60, No. 1, pp. 37–47.) By the director of the Office of Scientific Personnel of the National Research Council. *Cf.* Compton, 3164, below.

3163. THE ORGANISATION OF EXPERIMENTAL RESEARCH.—W. G. Radley. (*Journ. I.E.E.*, Part I, Jan. 1945, Vol. 92, No. 49, pp. 27–32.) Summaries were dealt with in 1122 of April.

3164. SCIENCE AND OUR NATION'S FUTURE.—A. H. Compton. (*Science*, 2nd March 1945, Vol. 101, No. 2618, pp. 207–209.)

"It takes at least six years for a capable eighteen-year-old to train himself for effective scientific research. Even if we should start now to resume such training, it will thus be at least six years before a normal supply of young professionals will again be available to our laboratories . . ."

3165. SCIENCE TALENT WINNERS [and Some of the Easier Test Questions in the Preliminary Round].—Westinghouse Company. (*Sci. News Letter*, 3rd Feb. 1945, Vol. 47, No. 5, pp. 69–70 and 72, 73, 76.) *Cf.* 2417 of July.

3166. "SUBJECT HEADINGS IN PHYSICS" [Book Review].—M. J. Voigt. (*Review Scient. Instr.*, April 1945, Vol. 16, No. 4, p. 86.)

3167. SCHOOL PHYSICS [School Certificate Standard: Book Review].—T. M. Yarwood. (*Nature*, 31st March 1945, Vol. 155, No. 3935, p. 378.)

3168. "REPORT OF THE CAMBRIDGE JOINT ADVISORY COMMITTEE FOR MATHEMATICS" [Syllabus for Examination taken by Sixth Form Pupils: Review].—(*Wireless Engineer*, June 1945, Vol. 22, No. 261, p. 201.)

3169. UNIVERSITY REFORM IN BRITAIN [Deprecation of Past Tendency to Isolationism].—R. Priestley. (*Nature*, 31st March 1945, Vol. 155, No. 3935, pp. 383–385.)

"The National Union of Students has recently discussed the subject, and has issued a report, the chief characteristic of which is its entire reasonableness."

3170. AN OBSTACLE TO A SCIENCE OF EDUCATION.—P. F. Brandwein: C. I. Glicksberg. (*Scient. Monthly*, Jan. 1945, Vol. 60, No. 1, pp. 81–83.)

Letter prompted by Glicksberg's assertion that "all science teaching, particularly on the secondary school level, must be 'impure', applied, humanly practical and significant . . . its scope is the entire universe, all of human life. . . ."

3171. Selection and Training of Students for Industrial Research [Discussion of whether Colleges should Contribute More to the Development of the Personal Qualities Required in Graduates Selected for Industrial Research].—A. W. Hull. (*Science*, 16th Feb. 1945, Vol. 101, No. 2616, pp. 157–160.)

3172. Looking Forward in Engineering Education [Need for Broad Interests, Practical Training and Avoidance of Over-Specialization].—D. D. Israel. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 353–354.)

3173. Engineering Training for Industry.—F. J. Gaffney. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, pp. 355–357.)

The qualities and capabilities which should be expected of an engineering graduate by industry are discussed. Of these qualities the ability to work with other people is the most neglected. Other essential qualities are a thorough knowledge of the basic principles of physics, a facility with mathematics and the ability to express ideas with clarity.

3174. Research in the Engineering and Technical Service, Signal Corps [In six parts: The Chief Signal Officer's Organisation for Research & Development—Maj. Gen. G. L. Van Densen: Laboratories of the Signals Corps Grand Signal Agency—Col. V. A. Conrad: The Signal Corps Aircraft Radio Laboratory—Col. W. L. Bayer: The Signal Corps Pictorial Engineering & Research Laboratory—Lt. G. Owen: The Signal Corps Standards Agency—Col. G. C. Irwin: Research and Development of Signal Equipment—Col. R. W. Raynsford: describes the activities of the research and development laboratories of the U.S. Signal Corps during the war].—(*Journ. Applied Phys.*, April 1945, Vol. 16, No. 4, pp 244–256.)

3175. Army Signal Training and Equipment.—(*Engineering*, 13th & 20th April 1945, Vol. 159, Nos. 4315 & 4316, pp. 298, 305–306.)

3176. "Marine Radio Manual" [Book Review].—M. H. Strichartz (Edited by). (*Electronics*, February 1945, Vol. 18, No. 2, p. 402.)

3177. Aviation Radio [Book Review].—H. W. Roberts. (*Proc. I.R.E.*, June 1945, Vol. 33, No. 6, p. 418.)

3178. "Alternating Currents Simplified" [Book Review].—G. W. Stubbings. (*Electrician*, May 25th 1945, Vol. 134, No. 3495, p. 472.)

3179. Radio Textbooks [Plea for Co-Operative Effort].—T. Roddam. (*Wireless World*, June 1945, Vol. 51, No. 6, pp. 186–187.)

Gresham's Law for books—"Every bad book bought means one guinea less for buying good books. . . ."

3180. Mould Preventive for Book Bindings.—D. C. Hetherington. (*Science*, 2nd March 1945, Vol. 101, No. 2618, p. 223.)

3181. Monthly Commentary: Wireless Contributions to Victory [and the Need now for Free Publication of Information still under Security Ban].—Wireless World. (*Wireless World*, June 1945, Vol. 51, No. 6, p. 161.)

3182. Electrical Progress and Development [includes References to War-time Developments in Frequency-Modulated Communication Equipment for the Services, Progress in Cable-Design and the Improvement of Alloys for Electrical Contacts].—H. W. Richardson. (*G.E.C. Journal*, Feb. 1945, Vol. 13, No. 3, pp. 109–142.)

3183. Progress in Engineering Knowledge during 1944: Materials, Design, Application.—P. L. Alger & J. Stokley. (*Gen. Elec. Review*, Feb. 1945, Vol. 48, No. 2, pp. 9–51: Bibliography pp. 55–61.)

3184. Specialised War-Time Scientific Collaboration [with New Zealand: Ionosphere Recording Stations set up].—I. E. Coop. (*Journ. Roy. Soc. Arts*, Feb. 16, 1945. p. 142.)

3185. Research Board for National Security [Its Origin, Functions, & Composition].—K. T. Compton. (*Science*, 2nd March 1945, Vol. 101, No. 2618, pp. 226–228.)

3186. Facts and Figures on Production in the Canadian Radar and Electronics Industry.—C. D. Howe. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 260, 262.) Excerpts from speech in Canadian House of Commons.

3187. Chicago War Production Conference [Development of the "Handy Talkie": Army Experiences with Radio Equipment: Tropical Problems (Outstanding Complaint concerns Rapid Growth of Fungus): Mass Production of Precision Equipment: Packing & Shipping: Excessive Secrecy: etc.].—(*Electronics*, May 1944, Vol. 17, No. 5, pp. 272..282.)

3188. Possibilities for 1948 [Estimated Distribution of the Total Exports of Electrical & Electronic Goods, on Assumption of Total of $195 000 000].—(*Electronics*, May 1944, Vol. 17, No. 5, p. 256.)

3189. Robot Radio Stations Forecast Weather [Meteorological Information Broadcast from Secret Locations: Servicing only Required at Intervals of Several Months].—(*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 198 and 202.)

3190. D.C. Saturable Reactors for Control Purposes: Design Factors [Core Design: Calculating Core Loss: Nickel-Iron Alloys & Silicon Steels: Wound *versus* Cut Cores: etc.].—H. Holubow. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 76–79.)

3191. A Continuous-Control Servo System.—J. T. McNamey. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 118–125.)

Mechanical angular displacements are converted to electrical phase shifts in one arm of a bridge. A second arm of the bridge at a remote point has similar phase shifts induced which can be used to operate mechanical displacements in the load.

3192. REMOTE CONTROL OF A TELEPRINTER BROADCAST SWITCH-BOARD [Equipment uses Standard Automatic Telephone Apparatus and incorporates an example of Revertive Signalling].—C. G. Grant & J. H. Collins. (*P.O. Elec. Eng. Journ.*, Oct. 1944, Vol. 37, Part 3, pp. 86–89.)

3193. FACTORY SHORT CUTS: IDEAS, METHODS, GADGETS AND NEW PRODUCTS ARE HELPING WIN THE BATTLE OF RADIO-ELECTRONIC PRODUCTION.—(*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, pp. 88–89: photographs & captions.) *See* also issue for March 1945, Vol. 4, No. 3, pp. 96, 97 (including a capacitor-plate straightening technique), and many other issues.

3194. ELECTRONIC TOOLS IN CHEMICAL RESEARCH.—R. H. Osborn & L. W. Beck. (*Electronic Industries*, Feb. 1945, Vol. 4, No. 2, pp. 82–85 and 142, 148.) From the Hercules Powder Company.

3195. ELECTRONIC MOTOR CONTROL [Development of Completely packaged Drives operating from A–C Power and giving Stepless Control of D–C Motors over wide Speed Ranges].—B. J. Dalton. (*Gen. Elec. Review*, May 1945, Vol. 48, No. 5, pp. 12–17.)

3196. A SIMPLE STROBOSCOPE FOR MOVING MACHINERY [using a Neon Lamp for the Flashing Element].—R. C. Paine. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 154..168.)

3197. ELECTRONIC BOTTLE INSPECTION [Modified & Faster System with Number of Photocells mounted on Roller Chain which is driven by Teeth on Outside Edge of Revolving Turret carrying Bottles of Coca-Cola, etc.], —S. R. Winters. (*Electronics*, May 1944. Vol. 17, No. 5, pp. 156, 159.)

3198. PHOTOELECTRIC-TUBE SMOKE SENSING: TYPICAL APPLICATIONS OF PHOTOELECTRIC DEVICES AND ASSOCIATED TUBE CIRCUITS FOR PROTECTION AND COMBUSTION CONTROL.—G. Sonbergh. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 98–100 and 194, 195.) *Cf.* 993 of March.

3199. SMOKE-DENSITY INDICATOR AND RECORDER FOR INDUSTRIAL PLANTS.—Brooke Engineering Company. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 148..152.)

3200. ELECTRONIC MERCURY-VAPOUR DETECTOR [for Safeguarding the Health of Employees in Various Industries].—General Electric Company. (*Electronic Industries*, March 1945, Vol. 4, No. 3, p. 106.) An ultra-violet lamp and phototube combination.

3201. LABORATORY OVEN TEMPERATURE CONTROL [Movement of Mercury in Oven Thermometer Alters Oscillator Tuning: Variation in Oscillator Plate Current operates Relay Controlling Oven Heaters].—W. B. R. Agnew. (*Electronics*, Oct. 1944, Vol. 17, No. 10, pp. 108–109.)

3202. ELECTRONIC TEMPERATURE CONTROL IN AIRCRAFT.—Minneapolis-Honeywell Regulator Company. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 147–148.)

3203. ELECTRONIC MAIL SORTING [and the Enormous Amount of Human Effort which could be saved by a System using Photoelectric Equipment].—W. C. White. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 192..200.) From the Electronics Laboratory, General Electric Company.

3204. HOPPER CONTROL FOR ORE CRUSHER [to keep Machines operating at Load corresponding to Highest Efficiency: Two Methods in Use, Microphone/Amplifier/Relay & Wattmeter/Phototube Combinations].—(*Electronics*, Feb. 1945, Vol. 18, No. 2, p. 146.)

3205. ELECTRONIC WIDTH-GAUGE FOR STRIP MATERIALS [such as Cinematograph Film: Readings reproducible within 0.002 mm: Lever/Capacitance-Change System].—S. C. Coroniti & H. S. Baldwin. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 196..212: from *Journ. Soc. Mot. Pic. Eng.*)

3206. ELECTRONIC AREA CALCULATOR [for measuring Size of Leather Hides, Pattern Layouts in Textile Industry, etc.: Scanning Beam, Photoelectric Equipment, & High-Speed Counter].—Stockton Profile Gauge Corporation. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 146, 148.)

3207. ELECTRONIC TEST SET FOR CALIBRATION AND ROUTINE CHECKING OF WIRE-TYPE STRAIN GAUGES.—E. H. Heinemann. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 146..150.)

"It is possible to hold gauges to better than 0.20% of the value of the standard resistors . . . without sacrificing quantity of production."

3208. STRAIN-GAUGE AMPLIFIER [Multistage Amplifier enables a Magnetic Oscillograph to be used with an Electric Gauge to Record Dynamic and Transient Quantities].—N. G. Branson. (*Gen. Elec. Review*, April 1945, Vol. 48, No. 4, pp. 55–58.)

3209. MICRODENSITOMETER WITH D.C. AMPLIFIER [for Rapid Measurement of Turbidity of Small Amounts (1 cc) of Solutions: primarily for Biological Work in Study of Animal Relationships: Other Applications].—S. R. Winters. (*Electronics*, July 1944, Vol. 17, No. 7, pp. 224..236.)

3210. ELECTRONIC ENGINE-PRESSURE INDICATOR [using a Quartz Crystal Unit Inserted into the Engine Head: A Wide-Band Oscilloscope Reproduces the Pressure Pattern].—J. W. Head. (*Electronics*, Jan. 1945, Vol. 18, No. 1, pp. 132–135.)

3211. GASKET PRESSURE METER: ELECTRONIC "SEALOMETER" AIDS RESEARCH AND DEVELOPMENT OF PIPE COUPLINGS, CLAMPS, AND REPAIR SLEEVES [for Gas or Liquid

Pipelines].—G. H. Pfefferle. (*Electronic Industries*, March 1945, Vol. 4, No. 3, pp. 102–103.)

3212. PRINCIPLES OF MAGNETIC CRACK DETECTION [Practical Treatise on Apparatus and Process: Book Review].—H. B. Swift. (*Nature*, 31st March 1945, Vol. 155, No. 3935, p. 378.)

3213. MOBILE TESTING OF RAILROAD RAILS [by Rail-Fissure Detector Cars].—Sperry Rail Service. (*Electronics*, Feb. 1945, Vol. 18, No. 2, p. 146.) Moving at a speed of 6–9 miles per hour. *Cf.* 253 of 1941.

3214. VIBRATION MEASUREMENT WITH ELECTRICAL DEVICES [including Rochelle-Salt and Moving Coil Types].—W. G. Schilling. (*Physik. Berichte*, No. 23, Vol. 24, 1943, p. 1460.)

3215. TUBES MEASURE CLOUD CEILINGS FOR PILOTS [by Projecting Pulses of Mercury Light Upwards and Detecting the Reflected Pulses].—(*Electronics*, Dec. 1944, Vol. 17, No. 12, p. 194.)

3216. REMOTE WATER-STAGE INDICATORS [Depth Data automatically Recorded at Headquarters by Radio or Line Signals controlled by Float Mechanism near Dam].—M. E. Kennedy. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 130–132.)

3217. RIVER LEVEL AUTOMATICALLY RECORDED BY RADIO [System at Phœnix, Arizona].—Leupold & Stevens Company. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 152..156.) Especially valuable during flood seasons, when the previously used telephone lines are often out of action.

3218. INVESTIGATION OF BORE-HOLES BY MEANS OF NEUTRONS: A NEW GEOLOGICAL METHOD BASED ON NUCLEAR PHYSICS.—B. Pontecorvo. (Short summary in *Physik. Berichte*, No. 19, Vol. 24, 1943, p. 1284.) From *Oil Gas Journ.*, 1941.

3219. ANALYSIS AND INTERPRETATION OF GEOMAGNETIC ANOMALIES [in Geophysical Exploration by Magnetic Methods].—E. H. Vestine & N. Davids. (*Terr. Mag. & Atmos. Elec.*, March 1945, Vol. 50, No. 1, pp. 1–36.) With 31 literature references.

3220. PRECISE MEASUREMENTS OF DEEP ELECTRICAL ANOMALIES [by a Method eliminating the Effects of Superficial Inhomogeneities in Resistivity].—T. S. West & C. C. Beacham. (*Terr. Mag. & Atmos. Elec.*, March 1945, Vol. 50, No. 1, p. 46: summary only, from *Geophysics*, 1944.)

3221. A PHOTOELECTRIC GALVANOMETER AMPLIFIER [primarily for Spectroscopic Analysis of Hydrocarbons, under Industrial Conditions: Mechanical Vibration countered by Negative Feedback: Readings on the One-Microvolt Range can be duplicated within $\pm$ 0.75%].—G. Asset. (*Electronics*, Feb. 1945, Vol. 18, No. 2, pp. 126–129.)

3222. THE ULTRAMICROMETER [Optical Type, taking Advantage of the Fact that the Separating Power of the Human Eye is Several Times as High for Short Lines as for Points].—H. I. Gramatzki. (*Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1429.)

Primarily for astronomical purposes, such as the measurement of the effective wavelength with an accuracy within $1.0\mu\mu$ (white stars) or $3.4\mu\mu$ (red stars). For the use of the term "ultramicrometer" in connection with electrical devices (capacitance-change or other principle) *see* many past abstracts, for example those given in the Subject Index for 1936, under "Miscellaneous."

3223. HIGH FREQUENCY AVIATION IGNITION SYSTEM [Impulse-Type Frequency Converter: Reduces Effect of Dirt on Plugs: Increased Reliability at High Altitudes].—(*Electronic Industries*, June 1945, Vol. 4, No. 6, p. 106.)

3224. ELECTRONIC IGNITION SYSTEMS [Promises Solutions to Problems of Cross-firing, Maintaining Spark Intensity at High Speed, and Reducing Sensitivity to Secondary Loading from Deposits on Plugs].—G. V. Eltgroth. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 106–112.)

The article states the shortcomings of the conventional ignition system, and describes several circuits using gas and hard tubes to operate on 6 volts or higher.

A plug assembly is described in which the spark-produced transients are confined to the plug itself, and interference reflected into the distributor line can be filtered out.

3225. "PHYSICAL FOUNDATIONS OF RADIOLOGY" [Book Review].—O. Glasser & others. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 353, 354.) An enthusiastic review.

3226. "ELECTRO-BIOLOGIE" ["The Effect of the Electric Current on the Complete Organism in Plants, Animals, & Man, and Its Pharmocological Influence": Book Review].—Fe. Scheminzky, Fr. Scheminzky, & F. Bukatsch. (*Physik. Berichte*, No. 21, Vol. 24, 1943, p. 1349.) For a paper by the first writer, on "Current Effect and Fine Structure in the Central Nervous System," see *ibid.*, p. 1395.

3227. ELECTRICAL MEASUREMENTS OF NERVOUS ACTIVITY.—W. S. McCulloch. (*Electronics*, July 1944, Vol. 17, No. 7, p. 198: summary of Radio Club lecture.)

3228. ELECTRONIC STIMULATORS [For Medical and Physiological Purposes: Early Methods: Electronic Methods: Essential Requirements: Effect of Load: Practical Design using Power Multivibrator provides Pulses of Variable Amplitude, Frequency, and Duration].—W. G. Walter & A. E. Ritchie. (*Electronic Eng:g*, July 1945, Vol. 17, No. 209, pp. 585..608.)

3229. ELECTRONIC DETECTION OF DECEPTION ["Pathometer" Measures and Records Change of Electrical Resistance of Subject's

Skin during Questioning].—J. F. Kubis. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 192–212.)

3230. CONFERENCE ON X-RAY ANALYSIS [Need for Correcting X-Ray Wavelengths: New Methods in Diffraction Technique: Laboratory Equipment: Interpretation of Patterns by Optical Principles: Analysis in Future: Need for Efficient Publication and International Cooperation: Exhibition]. —A. M. B. Parker, A. R. Stokes & A. J. C. Wilson. (*Nature*, 26th May 1945, Vol. 155, No. 3943, pp. 643–645.)

3231. BULL'S EYE BY X-RAY [Notes on Two New Tubes build for "Precision & Enormous Penetrating Power": with Special Attention to the Machlett Tube with Electron Focusing analogous to That of Electron Microscope, and Gold-Disc Target, etc.].—Machlett Laboratories. (*Journ. Applied Phys.*, May 1945, Vol. 16, No. 5, p. 314.)

3232. CHEMICAL ANALYSIS BY X-RAY ABSORPTION [Checking Chemical Composition of Solids, Liquids, and Gasses, by Quick Routine Measurements].—H. A. Liebhafsky & E. H. Winslow. (*Gen. Elec. Review*, April 1945, Vol. 48, No. 4, pp. 36–39.)

3233. MOBILE INDUSTRIAL X-RAY UNIT [Compact Two Million Volt Unit with Permanently Evacuated Tube].—E. E. Charlton & W. F. Westendorp. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 128–133.)

3234. 2 000 000-VOLT X-RAY TUBE [Enabling Exposure Times in Industrial X-Ray Photography to be Substantially Reduced].—(*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 198–206.)

3235. VERY RAPID LIGHT-SOURCE FOR PHOTOGRAPHY [10 C.P. for about 1/1000th Second: Explosion of (*e.g.*) Hexogen in Argon Atmosphere].—H. Muraour & others. (*Physik. Berichte*, No. 18, Vol. 24, 1943, p. 1215.)

3236. CONTRIBUTION TO HIGH-FREQUENCY SPARK CINEMATOGRAPHY.—Eckert & Eitz. (*Physik. Berichte*, No. 22, Vol. 24, 1943, p. 1433: short summary only.)

"In a further development of a 1911 arrangement due to Schatte, an apparatus is described which, using a comparatively weak source of energy, allows short-time series of sparks to be produced with frequencies up to 80 kc/s. The h.f. circuit is impulsed by a storage capacitance; deionisation is produced by blowing the spark gap with pressures up to 15 atmospheres."

3237. SPEED METER FOR CAMERA SHUTTERS [measuring Effective Speed, Not the Total Open Time: Compact Unit suitable for Counter Use in Camera Stores].—C. J. Penther. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 164..172.)

3238. ON THE USE OF THE LINEAR AMPLIFIER FOR THE MEASUREMENT OF THE IONISATION BY SINGLE PARTICLES.—S. A. Wytzes & G. J. van der Maas. (*Physica*, June 1943, Vol. 10, No. 6, p. 419 onwards: in English.) A very short summary is given in *Physik. Berichte*, No. 23, Vol. 24, 1943, p. 1478.

3239. GEIGER COUNTER SPECTROMETER FOR INDUSTRIAL RESEARCH.—H. Friedman. (*Electronics*, April 1945, Vol. 18, No. 4, pp. 132–137.)

3240. THE MECHANISM OF THE GEIGER–MÜLLER COUNTER: II [Behaviour of Alcohol Vapour added to the Filling]: III [Suitability of a Gas as Filling].—A. Nawijn & J. de Jong: A. Nawijn & D. Mulder. (*Physica*, July 1943, Vol. 10, No. 7, pp. 513, & 531 onwards: short summaries in *Physik. Berichte*, No. 23, Vol. 24, 1943, pp. 1478–1479 & 1479.)

3241. INDUSTRIAL CONTROL [Chicago Conference on Induction and Dielectric Heating].—(*Electronics*, March 1945, Vol. 18, No. 3, pp. 148–150, 152..176.)

3242. AUTOMATIC TUNING SYSTEM FOR PREHEATING PLASTICS.—R. W. Gilbert. (*Electronics*, Dec. 1944, Vol. 17, No. 12, pp. 106–109.)

The plastic forms the dielectric of the condenser of a circuit which is tuned to the frequency of the high-frequency generator. Methods are given for keeping the circuit in tune when the dielectric constant of the plastic changes during the heating process.

3243. MERCURY ARC HEATING FREQUENCY CONVERTER [Mercury Pool Unit supplying 100 kW. or more at Frequencies required for Efficient Induction Heating].—S. R. Durand. (*Electronic Industries*, June 1945, Vol. 4, No. 6, pp. 74..154.)

3244. H.F. HEATING OSCILLATORS [Circuit Choice: Power Requirements: Cooling: Output Coupling: Mechanical Considerations].—W. C. Rudd. (*Electronic Industries*, July 1944, Vol. 3, No. 7, pp. 96..204.)

3245. ELECTRONIC GLUEING OF SHOE SOLES [saving Long Period of Drying under Pressure].—G. Hart, Jr., & E. E. Winkley. (*Electronics*, May 1944, Vol. 17, No. 5, pp. 180, 184.) Adopted by the United Shoe Machinery Corporation.

3246. CURVED ELECTRODES IMPROVE PLASTICS PREHEATING.—Airtronics Mfg. Company. (*Electronic Industries*, Dec. 1944, Vol. 3, No. 12, p. 224.)

3247. HIGH-FREQUENCY MOULDING OF GLASS [Products now used for Radar & Other Instruments: after the War, "Electronic Glassware" will be employed for Electric Toasters, Cooking Utensils, etc.].—(*Sci. News Letter*, 24th March 1945, Vol. 47, No. 12, p. 192: paragraph only.)

3248. ELECTRONIC HEATING IN TEXTILE INDUSTRY [Resin-Impregnated Fabrics cured in Roll Form: Eliminates Curled Selvage].—(*Electronics*, November 1944, Vol. 17, No. 11, p. 144.)

3249. "HIGH FREQUENCY INDUCTION HEATING" [Book Review].—F. W. Curtis. (*Electronics*, May 1945, Vol. 18, No. 5, p. 394.)

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