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WIRELESS ENGINEER

The Journal of Radio Research & Progress

Vol. XX JUNE 1943 No. 237

CONTENTS

Published on the first of each month

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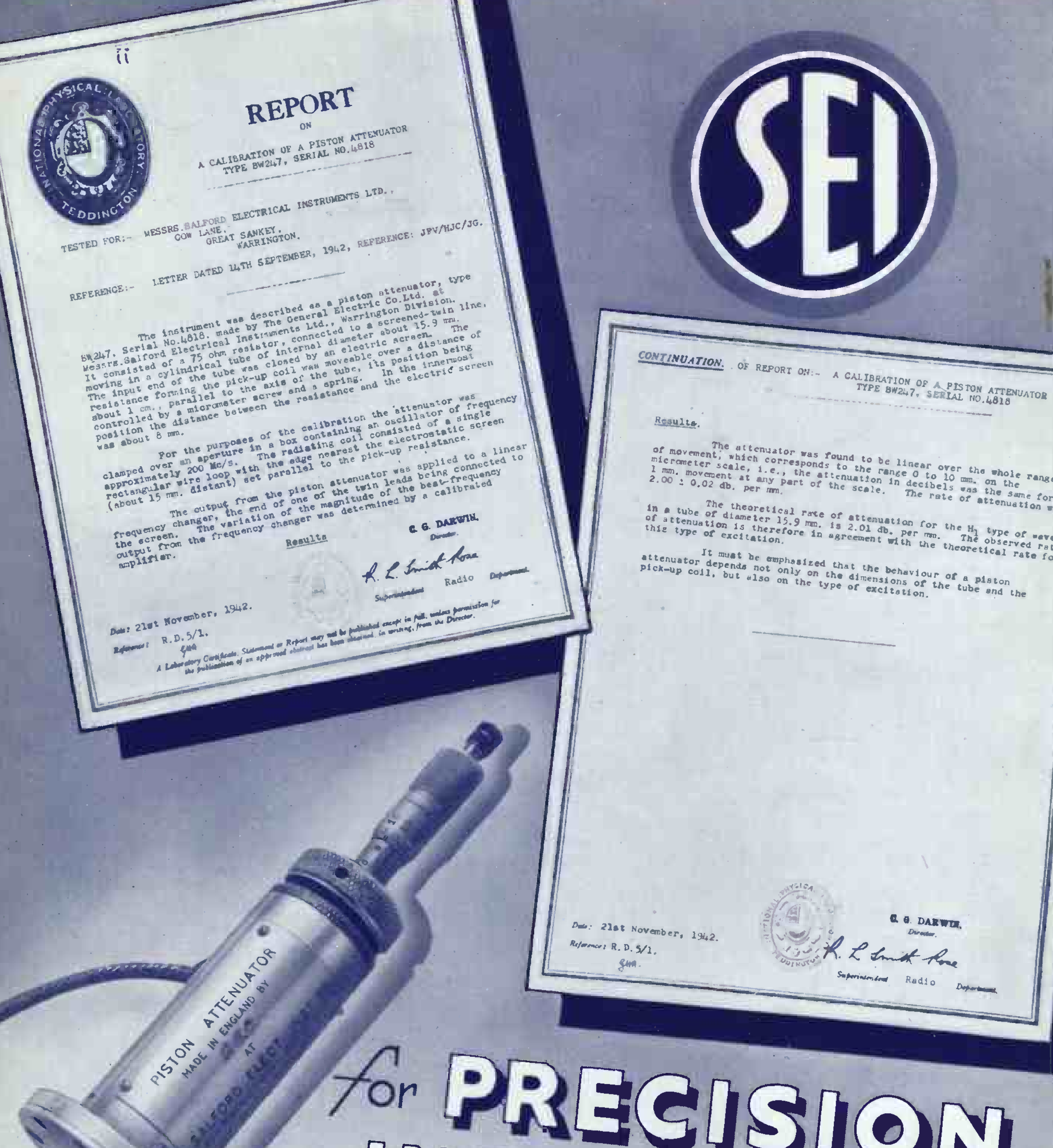

REPORT

ON

A CALIBRATION OF A PISTON ATTENUATOR
TYPE BW247, SERIAL NO.4818

TESTED FOR:- MESSRS. SALFORD ELECTRICAL INSTRUMENTS LTD.,
COW LANE,
GREAT SANKEY,
WARRINGTON.

REFERENCE:- LETTER DATED 14TH SEPTEMBER, 1942, REFERENCE: JFV/HJC/JG.

The instrument was described as a piston attenuator, type BW247. Serial No.4818. made by The General Electric Co.Ltd. at Messrs.Salford Electrical Instruments Ltd., Warrington Division. It consisted of a 75 ohm resistor, connected to a screened-twin line, moving in a cylindrical tube of internal diameter about 15.9 mm. The input end of the tube was closed by an electric screen. The resistance forming the pick-up coil was moveable over a distance of about 1 cm., parallel to the axis of the tube, its position being controlled by a micrometer screw and a spring. In the innermost position the distance between the resistance and the electric screen was about 8 mm.

For the purposes of the calibration the attenuator was clamped over an aperture in a box containing an oscillator of frequency approximately 200 Mc/s. The radiating coil consisted of a single rectangular wire loop with the edge nearest the electrostatic screen (about 15 mm. distant) set parallel to the pick-up resistance.

The output from the piston attenuator was applied to a linear frequency changer, the end of one of the twin leads being connected to the screen. The variation of the magnitude of the beat-frequency output from the frequency changer was determined by a calibrated amplifier.

Results

C. G. DARWIN, Director.

R. L. Smith Rose, Superintendent Radio Department.

Date: 21st November, 1942.
Reference: R.D.5/1.
GHA

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CONTINUATION. OF REPORT ON:- A CALIBRATION OF A PISTON ATTENUATOR TYPE BW247, SERIAL NO.4818

Results.

The attenuator was found to be linear over the whole range of movement, which corresponds to the range 0 to 10 mm. on the micrometer scale, i.e., the attenuation in decibels was the same for 1 mm. movement at any part of the scale. The rate of attenuation w
2.00 ± 0.02 db. per mm.

The theoretical rate of attenuation for the H_1 type of wave in a tube of diameter 15.9 mm. is 2.01 db. per mm. The observed rat of attenuation is therefore in agreement with the theoretical rate fo this type of excitation.

It must be emphasized that the behaviour of a piston attenuator depends not only on the dimensions of the tube and the pick-up coil, but also on the type of excitation.

Date: 21st November, 1942.
Reference: R.D.5/1.
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C. G. DARWIN, Director.

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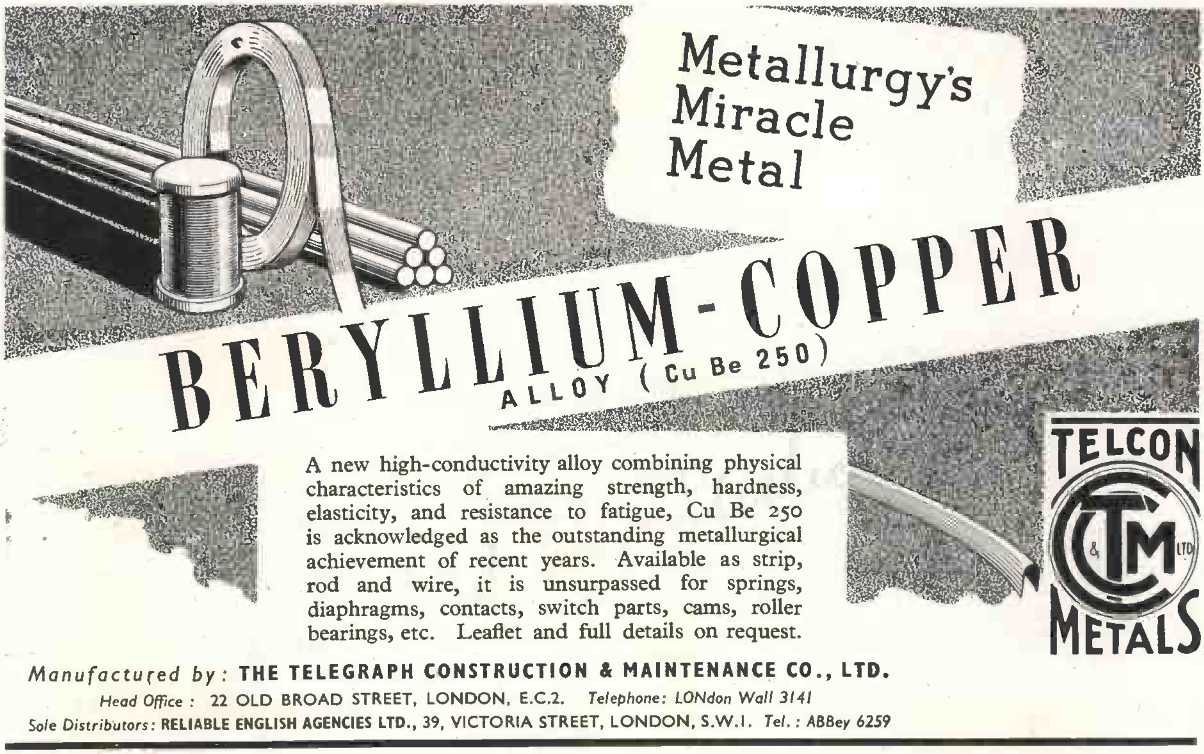
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electronic briefs: television
To produce a moving picture it becomes necessary to break down the action into a series of still pictures. Each still scene is flashed on the screen individually but done so rapidly that the human eye sees a smooth action. If the motion picture projector is slowed down the action becomes jerky. Each still picture is called a frame and the conventional movie projector flashes between 24 and 30 frames per second on the screen. Television is based upon the same principle but the problems involved are much more complex
Television, using the same basis for creating picture action as the movies, breaks down the picture or scene to be broadcast into a series of still pictures called frames. But each frame must also be broken down into approximately 200,000 tiny segments, each segment being broadcast separately and reassembled at the receiving end so rapidly that 30 frames can be flashed on the screen every second. Thus some 6,000,000 separate signals must be transmitted per second. Furthermore each of these signals starts as light, is converted into an electrical impulse, broadcast and then reconverted to light again. To make television talk, a conventional sound transmitter must be coordinated and synchronized with the picture broadcast.
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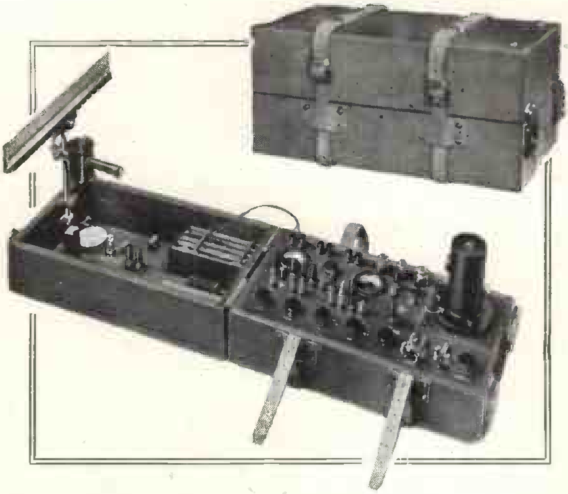

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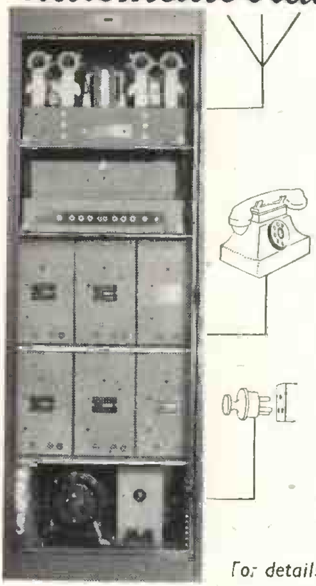

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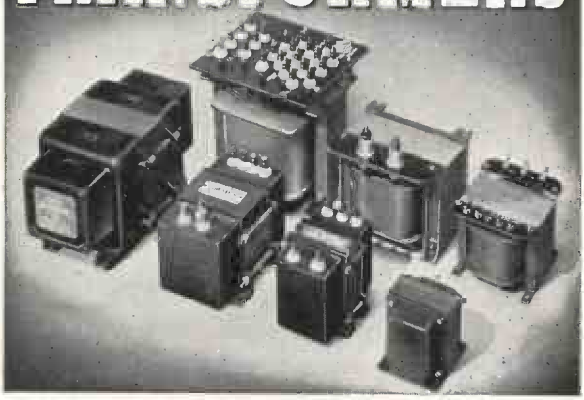

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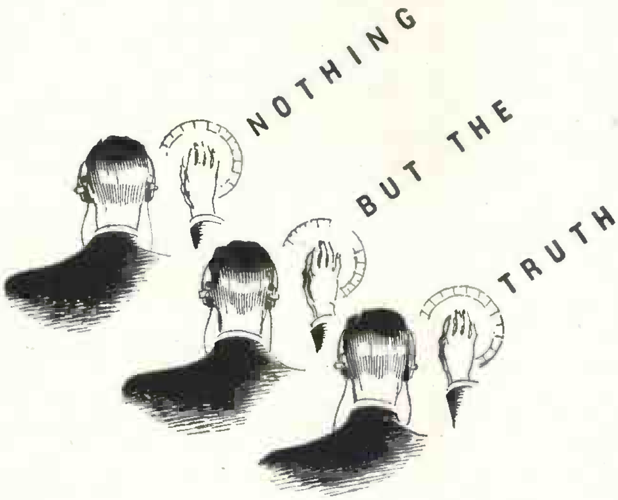

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WHY ERSIN MULTICORE

the Solder wire with 3 cores of non-corrosive ERSIN FLUX is preferred by the majority of firms manufacturing the best radio and electrical equipment under Government Contracts.

WHY THEY USE CORED SOLDER

Cored solder is in the form of a wire or tube containing one or more cores of flux. Its principal advantages over stick solder and a separate flux are:

(a) it obviates need for separate fluxing (b) if the correct proportion of flux is contained in cored solder wire the correct amount is automatically applied to the joint when the solder wire is melted. This is important in wartime when unskilled labour is employed.

WHY THEY PREFER MULTICORE SOLDER. 3 Cores—Easier Melting

Multicore Solder wire contains 3 cores of flux to ensure ffux continuity. In Multicore there is always sufficient proportion of flux to solder. If only two cores were filled with flux, satisfactory joints are obtained. In practice, the care with which Multicore Solder is made means that there are always 3 cores of flux evenly distributed over the cross section of the solder, so making thinner solder walls than single cored solder, thus giving more rapid melting and speeding up soldering.

ERSIN FLUX

For soldering radio and electrical equipment non-corrosive flux should be employed. For this reason either pure resin is specified by Government Departments as the flux to be used, or the flux residue must be pure resin. Resin is a comparatively non-active flux and gives poor results on oxidised, dirty or "difficult" surfaces such as nickel. The flux in the cores of Multicore is "Ersin"—a pure, high-grade resin subjected to chemical process to increase its fluxing action without impairing its non-corrosive and protective properties. The activating agent added by this process is dissipated during the soldering operation and the flux residue is pure resin. Ersin Multicore Solder is approved by A.I.D., G.P.O., and other Ministries where resin cored solder is specified.

PRACTICAL SOLDERING TEST OF FLUXES

The illustration shows the result of a practical test made using nickel-plated spade tags and bare copper braid. The parts were heated in air to 250° C, and to identical specimens were applied ½" lengths of 14 S.W.G. 40/60 solder. To sample A, single cored solder with resin flux was applied. The solder fused only at point of contact without spreading. A dry joint resulted, having poor mechanical strength and high electrical resistance. To sample B, Ersin Multicore Solder was applied, and the solder spread evenly over both nickel and copper surfaces, giving a sound mechanical and electrical joint.

ECONOMY OF USING ERSIN MULTICORE SOLDER

The initial cost of Ersin Multicore Solder per lb. or per cwt. when compared with stick solder is greater. Ordinary solder involves only melting and casting, whereas high chemical skill is required for the manufacture of the Ersin flux and engineering skill for the Multicore Solder incorporating the 3 cores of Ersin Flux. However, for the majority of soldering processes in electrical and radio equipment Multicore Solder will show a considerable saving in cost, both in material and labour time, as compared either with stick solder or single cored solder. Cored solder ensures that the solder and flux are put just where they are required, and by choice of suitable gauge, economy in use of material is obtained. The quick wetting of the Ersin flux as compared with resin flux in single core resin solder ensures that with the correct temperature and reasonably clean surface, immediate alloying will be obtained, and no portions of solder will drop off the job and be wasted. Even an unskilled worker, provided with irons of correct temperature, is able to use every inch of Multicore Solder without waste.

ALLOYS

Soft solders are made in various alloys of tin and lead, the tin content usually being specified first, i.e. 40/60 alloy means an alloy containining 40% tin and 60% lead. The need for conserving tin has led the Government to restrict the proportion of tin in solders of all kinds. Thus, the highest tin content permitted for Government contracts without a special licence is 45/55 alloy. The radio and electrical industry previously used large quantities of 60/40 alloy, and lowering of tin content has meant that the melting point of the solder has risen. The chart below gives approximate melting points and recommended bit temperatures.

ALLOY Tin Lead	Equivalent B.S. Grade	Solidus C.°	Liquidus C.°	Recommended bit Temperature C.°
45/55	M	183°	227°	267°
40/60	C	183°	238°	278°
30/70	D	183°	257°	297°
18.5/81.5	N	187°	277°	317°

VIRGIN METALS—ANTIMONY FREE

The wider use of zinc plated components in radio and electrical equipment has made it advantageous to use solder which is antimony free, and thus Multicore Solder is now made from virgin metals to B.S. Specification 219/1942 but without the antimony content.

IMPORTANCE OF CORRECT GAUGE

Ersin Multicore Solder Wire is made in gauges from 10 S.W.G. (.128″—3.251 m/ms) to 22 S.W.G. (.028″—.711 m/ms). The choice of a suitable gauge for the majority of the soldering undertaken by a manufacturer results in considerable saving. Many firms previously using 14 S.W.G. have found they can save approximately 33⅓%, or even more by using 16 S.W.G. The table gives the approximate lengths per lb. in feet of Ersin Multicore Solder in a representative alloy, 40/60.

S.W.G.	10	13	14	16	18	22
Feet per lb.	23	44.5	58.9	92.1	163.5	481

CORRECT SOLDERING TECHNIQUE

Ersin Multicore Solder Wire should be applied simultaneously with the iron, to the component. By this means maximum efficiency will be obtained from the Ersin flux contained in the 3 cores of the Ersin Multicore Solder Wire. It should only be applied direct to the iron to tin it. The iron should not be used as a means of carrying the solder to the joints. When possible, the solder wire should be applied to the component and the bit placed on top, the solder should not be "pushed in" to the side of the bit.

ERSIN MULTICORE SOLDER WIRE is now restricted to firms on Government Contracts and other essential Home Civil requirements. Firms not yet using Multicore Solder are invited to write for fuller technical information and samples,

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WIRELESS ENGINEER

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

VOL. XX JUNE, 1943 No. 237

Editorial

The Optimum Conditions for Class C Operation

IN the February Editorial we considered the optimum conditions for Class A amplifiers. In the *Proceedings of the Institute of Radio Engineers* for November, 1942, there is an article by J. C. Frommer dealing with the same problem for Class C operation of triode oscillators. The problem is complicated by the introduction of another variable, viz., the fraction of the cycle during which the valve is conducting. With medium-size valves it is assumed that the cost of power consumption is negligible compared with the cost of the apparatus, and that, consequently, the optimum condition is not a question of efficiency but of getting the maximum possible output without endangering the valve. It is assumed therefore that the anode supply voltage V_a and the anode dissipation P_a are both maintained at their permissible limits as prescribed by the valve manufacturers. The two variables, the swing sV_a of the anode voltage and the peak value $\hat{\imath}_a$ of the anode current, must be associated with such a duration of current flow that the prescribed anode dissipation is just attained. The duration of current flow is expressed as $2\theta/2\pi$ of a cycle, and we can refer to 2θ as the angle of current flow. Taking as origin the moment of minimum anode voltage as in Fig. 1 it is seen that

$$v_a = V_a(1 - s\cos\omega t) \qquad (1)$$

$$v_g = -V_g + (V_g + \hat{v}_g)\cos\omega t \qquad (2)$$

It should be noted that V_g is the *negative* grid bias but that v_g is the extent to which

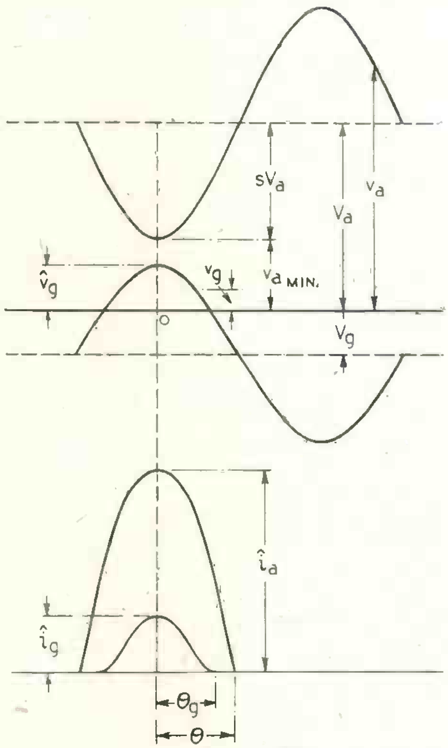

Fig. 1.

the grid is positive ; $\hat{v}_g$ is not the amplitude of the grid swing. The voltages are assumed to be sinusoidal, which will be approximately true, the tuned circuit keeping the harmonics to a relatively small value.

A basic current is that direct current I_r which at the steady anode voltage V_a would give the rated anode dissipation P_r. V_r is the anode voltage which would give this value of current with the grid connected to the cathode. For other values of anode and grid voltages

$$i_a = I_r\left(\frac{v_a + \mu v_g}{V_r}\right)^\alpha \quad \ldots \quad (3)$$

Owing to grid current the index α is less than 3/2 ; in subsequent numerical calculations Frommer puts $\alpha = 1$, thus simplifying the calculations very considerably. Substituting from (1) and (2)

$$\frac{i_a}{I_r} = \left(\frac{V_a - \mu V_g}{V_r} + \frac{\mu V_g + \mu \hat{v}_g - sV_a}{V_r}\cos \omega t\right)^\alpha \quad \ldots \quad (4)$$

Now $i_a = 0$ when $\omega t = \theta$, the cut-off angle ; hence putting

$$\frac{\mu V_g - V_a}{V_r} = u$$

we must have

$$\frac{i_a}{I_r} = \left(-u + \frac{u}{\cos\theta}\cos\omega t\right)^\alpha \quad \ldots \quad (5)$$

The anode current reaches its maximum value $\hat{i}_a$ when $\omega t = 0$; hence

$$\frac{\hat{i}_a}{I_r} = \left(-u + \frac{u}{\cos\theta}\right)^\alpha \quad \ldots \quad (6)$$

Dividing (5) by (6)

$$\frac{i_a}{\hat{i}_a} = \left(\frac{\cos\omega t - \cos\theta}{1 - \cos\theta}\right)^\alpha \quad \ldots \quad (7)$$

The mean value of the anode current

$$I_a = \frac{1}{2\pi}\int_{-\theta}^{+\theta} i_a d\omega t$$

$$= \hat{i}_a \frac{1}{2\pi}\int_{-\theta}^{+} \left(\frac{\cos\omega t - \cos\theta}{1 - \cos\theta}\right)^\alpha d\omega t$$

$$= \frac{\hat{i}_a}{\pi} F(\theta)_\alpha \quad \ldots \quad (8)$$

where $F(\theta)_\alpha$ is put for half the integral.

The input power

$$P_1 = V_a I_a = \frac{V_a \hat{i}_a}{\pi} F(\theta)_\alpha \quad \ldots \quad (9)$$

The output power

$$P_2 = \frac{1}{2\pi}\int_{-\theta}^{+\theta} (V_a - v_a) i_a \, d\omega t$$

which, on substituting for v_a and i_a from (1) and (7) becomes

$$P_2 = V_a \hat{i}_a s \frac{1}{2\pi}\int_{-\theta}^{+\theta} \left(\frac{\cos\omega t - \cos\theta}{1 - \cos\theta}\right)^\alpha \cos\omega t \, d\omega t$$

$$= \frac{V_a \hat{i}_a s}{\pi} G(\theta)_\alpha \quad \ldots \quad (10)$$

where $G(\theta)_\alpha$ is put for half the integral.

Substituting for $\hat{i}_a$ from (8) we have

$$P_2 = sV_a I_a \frac{G(\theta)_\alpha}{F(\theta)_\alpha} \quad \ldots \quad (11)$$

The anode dissipation is the difference between the input and the output ; hence

$$P_a = P_1 - P_2 = V_a I_a \left(1 - s\frac{G(\theta)_\alpha}{F(\theta)_\alpha}\right) \quad \ldots \quad (12)$$

and this has to be made equal to the prescribed value P_r.

Putting p for the ratio of the output power to the plate dissipation, we have

$$p = \frac{P_2}{P_a} = \frac{s\dfrac{G(\theta)_\alpha}{F(\theta)_\alpha}}{1 - s\dfrac{G(\theta)_\alpha}{F(\theta)_\alpha}} \quad \ldots \quad (13)$$

$$\therefore \quad s = \frac{p}{1 + p}\cdot\frac{F(\theta)_\alpha}{G(\theta)_\alpha} \quad \ldots \quad (14)$$

Since, by definition, $I_r = P_r/V_a$, we have from (8)

$$\frac{\hat{i}_a}{I_r} = \frac{\pi}{F(\theta)_\alpha}\cdot\frac{V_a I_a}{P_r} \quad \ldots \quad (15)$$

and since from (11) and (14)

$$\frac{V_a I_a}{P_r} = \frac{P_2}{P_r}\cdot\frac{1}{s}\cdot\frac{F(\theta)_\alpha}{G(\theta)_\alpha} = \frac{p}{s}\,\frac{F(\theta)_\alpha}{G(\theta)_\alpha} = 1 + p \quad \ldots \quad (16)$$

(15) may be written

$$\frac{\hat{i}_a}{I_r} = \frac{\pi}{F(\theta)_\alpha}\cdot(1 + p) \quad \ldots \quad (17)$$

In Fig. 2 these calculated values of $\hat{i}_a/I_r$ are plotted as ordinates, the abscissae being $1 - s = v_{a\,min.}/V_a$ obtained from (14).

On the assumption that $\alpha = 1$

$$F(\theta)_\alpha = \tfrac{1}{2}\int_{-\theta}^{+\theta} \frac{\cos\omega t - \cos\theta}{1 - \cos\theta}\, d\omega t = \frac{\sin\theta - \theta\cos\theta}{1 - \cos\theta}$$

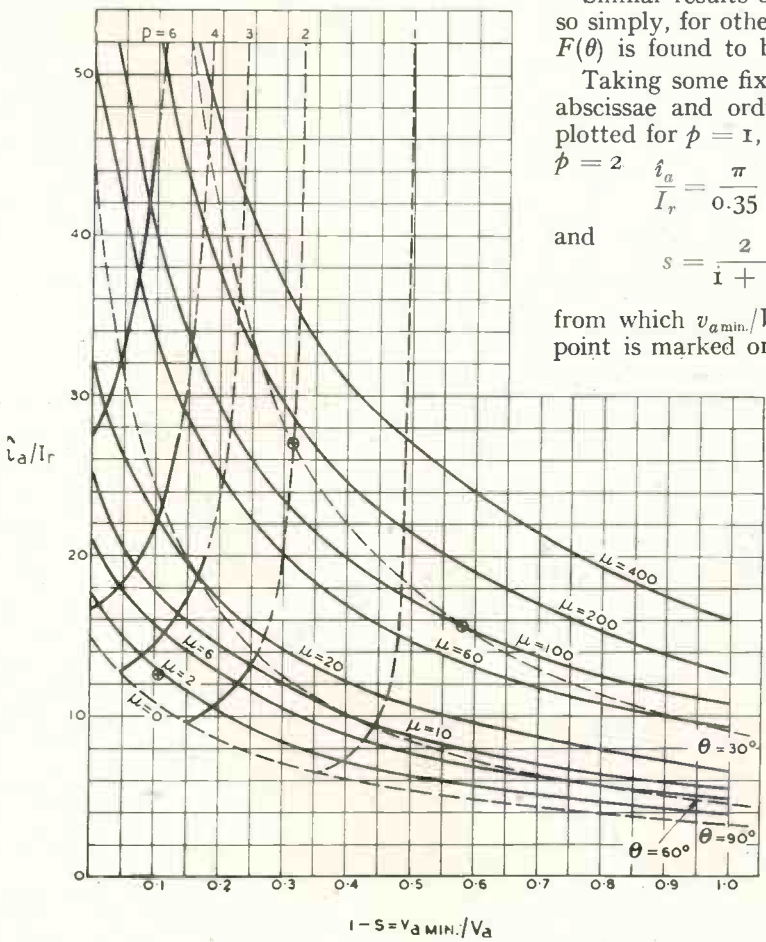

Fig. 2.

and

$$G(\theta)_\alpha = \tfrac{1}{2}\int_{-\theta}^{+\theta} \frac{\cos^2\omega t - \cos\theta\cos\omega t}{1 - \cos\theta}\, d\omega t$$

$$= \frac{\theta - \sin\theta\cos\theta}{2(1 - \cos\theta)}$$

These formulae give the following values :

$\theta =$	30°	60°	90°
$F(\theta)$	0.35	0.68	1.00
$G(\theta)$	0.34	0.61	0.79

$F(\theta)$ is very nearly proportional to θ and can be put equal to 0.64θ, where θ is in radians, with sufficient accuracy for all practical purposes.

Similar results could be obtained, but not so simply, for other values of α. If $\alpha = 1.5$, $F(\theta)$ is found to be approximately 0.57θ.

Taking some fixed value of θ, say 30° the abscissae and ordinates are calculated and plotted for $p = 1, 2, 3$, etc. For example, if $p = 2$

$$\frac{\hat{\imath}_a}{I_r} = \frac{\pi}{0.35}(1 + 2) = 27$$

and

$$s = \frac{2}{1 + 2}\cdot\frac{0.35}{0.34} = 0.69$$

from which $v_{a\,\min.}/V_a = 1 - s = 0.31$. This point is marked on the curves.

On joining all the points referring to $\theta = 30°$ on the various p curves, we get the dotted curve marked $\theta = 30°$. Similarly for other values of θ.

On joining all the points referring to $p = 2$ on the various θ curves we get the curve marked $p = 2$. Similarly for other values of p.

The u curves can now be drawn. For any value of u the value of $\hat{\imath}_a/I_r$ is calculated from (6) ; this gives the ordinate on the corresponding θ curve. For example if $\theta = 30°$ and $u = 100$

$$\frac{\hat{\imath}_a}{I_r} = \left(-u + \frac{u}{\cos\theta}\right) = -100 + \frac{100}{\sqrt{3}/2} = 15.5$$

This point is also marked on the curve in Fig. 2.

Determination of Grid Circuit Constants

Since u denotes $\dfrac{\mu V_g - V_a}{V_r}$ we have

$$V_g = \frac{uV_r + V_a}{\mu} \quad \ldots \quad \ldots \quad (18)$$

Grid current only flows when v_g is positive, and if the cut-off angle of the grid current be θ_g as shown in Fig. 1 we have

$$(V_g + \hat{v}_g) \cos \theta_g = V_g \quad \ldots \quad \ldots \quad (19)$$

from which

$$\frac{V_g}{\hat{v}_g} = \frac{\cos \theta_g}{1 - \cos \theta_g} \quad \ldots \quad \ldots \quad \ldots \quad (20)$$

Substituting from (2) we have

$$v_g = V_g \frac{\cos \omega t - \cos \theta_g}{\cos \theta_g} \quad \ldots \quad \ldots \quad (21)$$

and therefore

$$v_g/\hat{v}_g = \frac{\cos \omega t - \cos \theta_g}{1 - \cos \theta_g} \quad \ldots \quad \ldots \quad (22)$$

If we assume that the grid current varies as the βth power of the grid voltage

$$\frac{i_g}{\hat{i}_g} = \left(\frac{\cos \omega t - \cos \theta_g}{1 - \cos \theta_g}\right)^\beta \quad \ldots \quad \ldots \quad (23)$$

For the mean grid current we have

$$I_g = \frac{1}{2\pi}\int_{-\theta g}^{+\theta g} i_g d\omega t = \frac{1}{2\pi}\hat{i}_g \int_{-\theta g}^{+\theta g} \left(\frac{\cos \omega t - \cos \theta_g}{1 - \cos \theta_g)}\right)^\beta d\omega t$$

$$= \frac{1}{\pi}\hat{i}_g F(\theta_g)_\beta \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

The grid power consumption

$$P_g = \frac{1}{2\pi}\int_{-\theta g}^{+\theta g} v_g i_g dt \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

$$= \frac{1}{\pi}\hat{v}_g \hat{i}_g F(\theta_g)_{\beta + 1} \quad \ldots \quad \ldots \quad (26)$$

The grid leak resistor must have a value

$$R_l = \frac{V_g}{I_g} = \frac{\hat{v}_g}{\hat{i}_g} \cdot \frac{\cos \theta_g}{1 - \cos \theta_g} \cdot \frac{\pi}{F(\theta_g)_\beta} \quad (27)$$

If alternating current is barred from the grid leak circuit by a reactor, the power lost in the grid leak will be

$$P_{l\,(\mathrm{d.c.})} = V_g I_g = \hat{v}_g \hat{i}_g \cdot \frac{\cos \theta_g}{1 - \cos \theta_g} \cdot \frac{F(\theta_g)_\beta}{\pi} \quad \ldots \quad \ldots \quad (28)$$

If no reactor is employed there will be additional loss of power in the grid leak due to the superposed alternating current, viz.,

$$P_{l\,(\mathrm{a.c.})} = \frac{(V_g + \hat{v}_g)^2}{2R_g},$$

which, from (19), may be written

$$P_{l\,(\mathrm{a.c.})} = \left(\frac{V_g}{\cos \theta_g}\right)^2 \frac{I_g}{2V_g} = \frac{V_g I_g}{2\,(\cos \theta_g)^2} \quad (29)$$

In Fig. 3 five grid ratios are plotted as ordinates, the abscissae being θ_g as shown at the top. The scale of $V_g/\hat{v}_g$ at the base is obtained from (20).

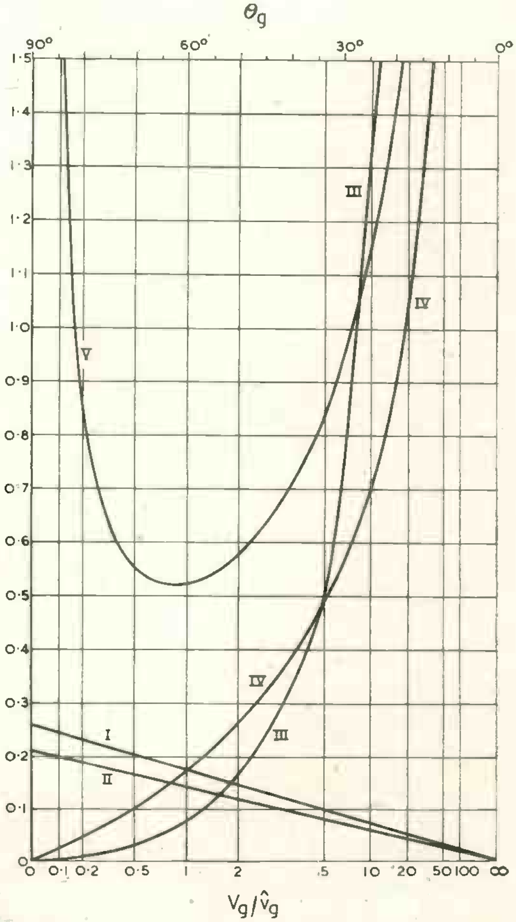

Fig. 3.

The five curves in Fig. 3 refer to the following ratios

I. $I_g/\hat{i}_g$ from (24).

II. $P_g/\hat{i}_g\hat{v}_g$ from (26).

III. $\dfrac{R_l}{100\, \hat{v}_g/\hat{i}_g}$ from (27)

IV. $P_{l\,(\mathrm{d.c.})}/\hat{i}_g\hat{v}_g$ from (28).

V. $\dfrac{P_{l\,(\mathrm{d.c.})} + P_{l\,(\mathrm{a.c.})}}{\hat{i}_g\hat{v}_g}$ from (28) and (29).

In evaluating $F(\theta_g)_\beta$ Frommer assumed that $\beta = 2$, i.e., that the grid current is proportional to the square of the positive grid voltage; this is based on a paper by W. G. Wagener (*Proc. I.R.E.*, Jan., 1937, pp. 51 and 60).

On this assumption

$$F(\theta_g)_\beta = \frac{1}{2}\int_{-\theta g}^{+\theta g}\left(\frac{\cos \omega t - \cos \theta_g}{1 - \cos \theta_g}\right)^2 d\omega t$$

$$= \frac{\theta_g(1 + 2\cos^2 \theta_g) - 1.5 \sin 2\theta_g}{2(1 - \cos \theta_g)^2}$$

On evaluating this for various values of θ_g between 0 and 90° and plotting it, the resulting curve is found to differ very little from a straight line through the origin, and, consequently, to an accuracy more than sufficient for all practical purposes,

$$F(\theta_g)_2 = 0.51\ \theta_g$$

where θ_g is in radians. $F(\theta)_2$ is thus equal to 0.79 $F(\theta)_1$ for the same value of θ.

Formula (26) involves $F(\theta_g)_{\beta+1}$, i.e.,

$$F(\theta_g)_3 = \frac{1}{2}\int_{-\theta}^{+\theta}\left(\frac{\cos \omega t - \cos \theta_g}{1 - \cos \theta_g}\right)^3 d\omega t$$

This is also found to give a curve which differs very little from a straight line through the origin for values of θ_g up to 90°, and one can put

$$F(\theta_g)_3 = 0.43\ \theta_g$$

where θ_g is in radians.

An Example

In the original paper Frommer takes as an example of the application of the curves, a triode (Taylor T40) with a thoriated cathode for 2.5 amperes at 7.5 volts. Its amplification factor μ is 25, its continuous rated anode voltage V_a, 1,250 volts, and its rated anode dissipation P_r, 40 watts. For the basic current we have

$$I_r = \frac{P_r}{V_a} = \frac{40}{1250} = 32 \text{ mA.}$$

From the static characteristics of the valve one finds that with $V_g = 0$, an anode voltage of 600 is required to give this current; hence $V_r = 600$.

If the permissible peak cathode current is not given by the makers of the valve, a value must be allotted to it. It is recommended that this should be 8, 30, or 100 milliamperes per watt of heating power, depending on whether the cathode is of pure tungsten, thoriated or oxide-coated. In the present case the cathode is thoriated and the heating power is 18.75 watts; the peak cathode current may therefore be taken as $18.75 \times 30 = 563$ mA.

The peak current occurs when the grid voltage is a maximum and the anode voltage a minimum (Fig. 1), and it is assumed that the limiting condition is that these voltages are equal, i.e., $\hat{v}_g = v_{a\,\text{min.}}$ It is necessary to have static characteristics of the valve giving the anode and grid currents for various values of v_a with the grid connected to the anode. One then finds the voltage for which $i_a + 2\,i_g$ is equal to the permissible peak cathode current. Twice i_g is taken as an approximate allowance for the non-uniformity of the current due to the proximity of the grid wires to the cathode. If the grid wires are close together this figure may be taken less than 2. In the present example, it was found that when $v_a = v_g = 130$ volts, $i_a = 400$ mA and $i_g = 85$ mA, and therefore $i_a + 2i_g = 570$ mA.

The ratio $\frac{V_{a\,\text{min.}}}{V_a} = \frac{130}{1250} = 0.104$ and the ratio $\frac{\hat{i}_a}{I_r} = \frac{400}{32} = 12.5$.

These are the abscissae and ordinates of Fig. 2 from which we find that $u = 1.7$ and $p = 2.7$; the point is marked in Fig. 2.

The grid bias can now be found from (18), and the output from (13).

$$V_g = \frac{uV_r + V_a}{\mu} = \frac{(1.7 \times 600) + 1250}{25}$$

$$= 91 \text{ volts.}$$

The output $P_2 = pP_r = 2.7 \times 40 = 108$ watts.

$$\hat{i}_g\hat{v}_g = 0.085 \times 130 = 11 \text{ watts, and}$$

$$\hat{v}_g/\hat{i}_g = 130/0.085 = 1530 \text{ ohms.}$$

The remaining grid circuit values can now be obtained from Fig. 3, the relevant abscissa of which is

$$V_g/\hat{v}_g = 91/130 = 0.7$$

or, since

$$\cos \theta_g = \frac{V_g}{V_g + \hat{v}_g} = \frac{91}{221} = 0.412,$$

$$\theta_g = 65.7^\circ.$$

From curve I

$$\frac{I_g}{\hat{i}_g} = 0.2 \text{ and } I_g = 85 \times 0.2 = 17 \text{ mA.}$$

From curve II

$$\frac{P_g}{\hat{i}_g \hat{v}_g} = 0.16 \text{ and } P_g = 11 \times 0.16 = 1.76 \text{ watts.}$$

From curve III

$$\frac{R_l}{100\, \hat{v}_g/\hat{i}_g} = 0.4$$

and

$$R_l = 100 \times 1530 \times 0.4 = 6120 \text{ ohms.}$$

But as the curve cannot be relied upon at such low values unless plotted accurately on a large scale, the grid leak resistor is better calculated from the formula

$$R_l = \frac{V_g}{I_g} = \frac{91}{0.017} = 5350 \text{ ohms.}$$

From curve IV

$$P_{l(\text{d.c.})}/\hat{i}_g \hat{v}_g = 0.13$$

and

$$P_{l(\text{d.c.})} = 11 \times 0.13 = 1.43 \text{ watts.}$$

If the grid leak resistor carries alternating current then from curve V

$$\frac{P_{l(\text{d.c.})} + P_{l(\text{a.c.})}}{\hat{i}_g \hat{v}_g} = 0.52$$

and

$$P_{l(\text{d.c.})} + P_{l(\text{a.c.})} = 11 \times 0.52 = 5.7 \text{ watts}$$

Since $V_a = 1250$ and $v_{a\,\text{min.}} = 130$, the amplitude of the anode a.c. voltage is 1120. We have seen that the output power P_2 is 108 watts and this must be equal to $\frac{V^2}{R}$ where R is the effective resistance of the load in the anode circuit ; hence

$$R = \frac{1120^2}{2 \times 108} = 5800 \text{ ohms.}$$

The amplitude of the grid a.c. voltage is $V_g + \hat{v}_g = 91 + 130 = 221$ volts ; hence

$$\frac{\text{grid a.c. voltage}}{\text{anode a.c. voltage}} = \frac{221}{1120} = 0.197$$

which is an important ratio in designing the necessary feed-back if the valve is to operate as an oscillator.

Frommer draws attention to the fact that the valve may be so designed that the permissible cathode emission is either exceptionally small or exceptionally large for the rated anode dissipation. In the former case the operating point would fall below the $u = 0$, $\theta = 90°$ curve in Fig. 2 and, although a slightly higher output could be obtained by increasing θ to about 120°, it is not considered desirable ; in such a case the point on the $u = 0$ curve is taken, and the anode dissipation correspondingly reduced below the rated value.

If the permissible cathode emission is exceptionally high the operating point on Fig. 2 will fall in the region in which the p curves are shown dotted. Instead of determining the point on the $v_a = v_g$ characteristic for which $i_a + 2i_g$ is equal to the permissible peak current, the $v_a = v_g$ characteristic should be drawn on Fig. 2, the co-ordinates being, of course, v_a/V_a and i_a/I_r, and the point found where a p curve just touches it. Lower values of p cut the characteristic, and higher values miss it entirely ; the one that just touches it gives the operating point and the value of p for maximum output. The peak cathode current will be smaller than the permissible maximum, but the output will be greater than would be obtained with the greater cathode current.

G. W. O. H.

The Signal Converter*

New Thermionic Discharge Tube for the Production of the Time Base Deflection Potentials of a Cathode-Ray Tube

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Summary.—The purpose of this paper is to show that the signal converter is an ideal electronic device for the production and synchronisation of the time base deflection potentials of a cathode-ray tube. With the aid of the signal converter the accuracy of synchronisation in television and cathode-ray oscillograph circuits is greatly enhanced. In television time-base circuits the separation of the synchronising signal from the picture signal and the separation of the frame synchronising signal from the line synchronising signal is avoided and the complete television signal is automatically "converted" into the line and frame scans. In contradistinction to known time-base circuits (using gas-filled relays or standard hard valves) the output of the signal converter is not triangular (saw-tooth) but trapezoidal; this trapezoidal output potential has inherent advantages over the triangular wave form; its significance is most apparent when considering the accurate synchronisation of a manifold interlaced television picture.

It is further shown that the signal converter (Nagard Type I) is capable of delivering substantially linear deflection potentials of the order of 1,000 volts with a beam current of less than a milliampere at a deflection frequency of 100 000 cycles per second and using an input potential of the order of a few volts only. Time-base frequencies of the order of 50 megacycles per second may be attained, using the signal converter principle.

The basic principles of conventional time-base circuits are discussed and compared with those of the signal converter.

Different electronic solutions to achieve the conversion of a signal into its own time base are dealt with. The electron optical design of the Nagard Type I converter and the reasons for its adoption as the best apparent solution are described in detail and the performance of the same is given on the basis of characteristic curves and oscillograms.

CONTENTS

1. Introduction

THE signal converter is a deflection modulated cathode-ray valve; i.e., a valve which has similar dimensions to an ordinary radio valve, but in constructional principles is similar to a cathode-ray tube and in which the input signals are applied to deflection plates, instead of to a grid. It was designed to simplify and improve the principles which hitherto have been employed for the production and synchronisation of the time-base deflection potentials of a cathode-ray tube, as employed in the television and oscillograph technique for the visual observation of electrical phenomena. While there are other uses for this tube, such as scientific research applications, etc., this paper is mainly concerned with the applica-

* MS. accepted by the Editor, March, 1943.

tion of the tube in television and cathode-ray oscillograph technique.

In a conventional valve the electrodes are cylindrical and are built up in a concentric manner, the cathode in the centre of the system and the grid, auxiliary grids and anode surrounding each other in turn. The electrodes of a deflection-modulated cathode-ray valve, however, follow each other in a similar fashion to the electrode system of a cathode-ray tube. In contradistinction to a conventional intensity-modulated valve the current drawn from the cathode of the deflection-modulated cathode-ray valve may be kept constant during modulation. The image of the cathode (or the "crossover" near the cathode) is sharply focused at an output electrode and the input signals are placed on a pair of deflection plates; the movement of the image due to the potential changes on the deflection plates results in a changing output potential.

During the authors' investigations which were conducted to clarify the possibilities and limitations of deflection-modulated valves as amplifiers, frequency changers, etc.,[1] it was realised that one of the most significant applications of these valves is the signal converter[2] which is capable of converting and amplifying any arbitrary signal into its own time-base deflection signal.

It was also found that deflection-modulated cathode-ray valves are in many respects inherently superior to conventional valves, especially so when used as amplifiers, frequency changers, etc., at ultra-high frequencies.

It is of interest to note that as early as 1906[3] deflection-modulated valves were designed for the amplification of electrical signals. Lack of understanding of electron optical principles and absence of knowledge of the laws of secondary electron emission were, however, insurmountable barriers, and thus thermionic discharge tubes developed on the lines of conventional intensity modulation.

2. Basic Principles of Conventional Time-Base Circuits.*

Time-base circuits were evolved as a direct result of the development of the cathode-ray tube. For the visual observation of electrical phenomena the cathode-ray tube is an ideal device, as the electron beam, which records the shape and amplitude of the electrical signals on the fluorescent screen, has no inertia within the range of frequencies in general use. To be able to observe the shape of electrical signals without distortion it is necessary to give the electron beam a deflection which is linearly proportional to time. This is achieved by applying a linearly increasing potential on a pair of deflection plates or a linearly increasing current through a pair of deflection coils. The signals which have to be reproduced on the screen of the cathode-ray tube are either placed on another pair of deflection means (plates or coils) to deflect the beam at right angles to the time-base deflection while the beam current remains constant, or are applied to the grid of the cathode-ray tube to modulate the intensity of the beam current. The first method provides a two-dimensional picture of the amplitude variations of a signal; it is used in the cathode-ray oscillograph. The second method provides a picture of the amplitude variations of the signal in terms of light intensity; it is used for television pictures, where the complete picture is "scanned" by two time bases at right angles to each other, the line and frame time bases.

A time base need not necessarily be linear. For certain applications sinusoidal (particularly in high frequency investigations), circular or even spiral time bases may be preferred[4]; the linear time base is, however, the most important.

As the dimensions of the screen of a cathode-ray tube are limited, and as in most cases it is essential to produce a visually observable image, and nearly all electrical phenomena are periodic, the time base deflection is interrupted periodically; the result is a saw-tooth wave-form as shown in Fig. 1*b*. Thus the electrical signals are split up into sections, each occurring within a given time period. The signals during each time period should be of the same form, thus overlapping each other to produce a stationary image on the screen. This requires that the frequency of the time-base oscillation should be an exact and constant

* A complete account of the most important time-base circuits will be found in a paper by O. S. Puckle, see Bibliography.

submultiple of the periodic frequency of the signals. The best way to achieve this is by locking or synchronising the time-base oscillations with the signals.

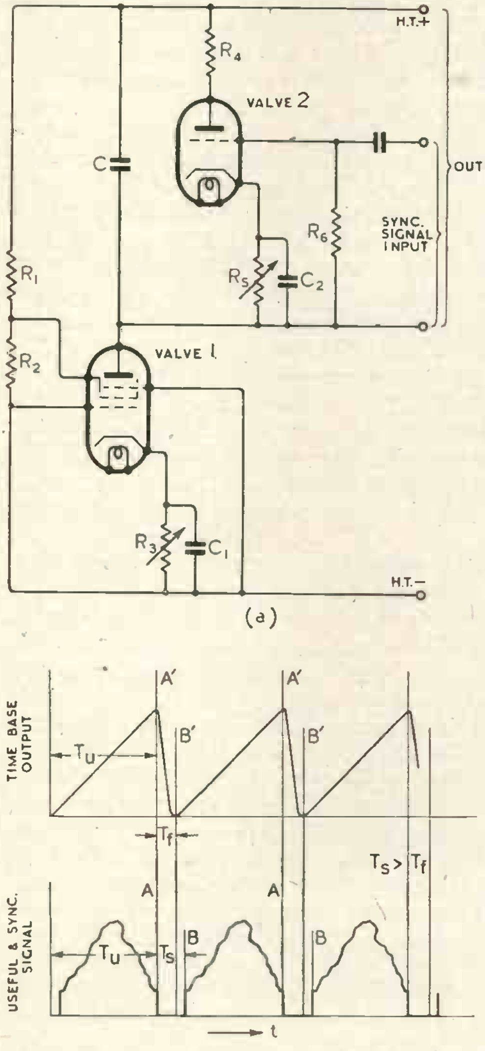

Fig. 1.—*Circuit of a conventional time base (a) and the relation between the time-base output and the sync. signal (b).*

For the investigation of transient phenomena "single stroke" linear deflection is used. These images are, however, seldom observable visually, but they can be investigated photographically.

In what follows it is not intended to discuss the different types of time-base circuits in detail and to analyse their comparative merits and disadvantages, but rather to point out with the aid of a prototype the basic principles which are common to all time bases at present employed in practice.

These principles may be conveniently discussed in connection with Fig. 1*a*, which shows an advanced version of a circuit using a gas-filled relay.

There are two ways of producing a linear time-base trace, namely, by using a condenser or an inductance. In the former case a constant charging current builds up a linearly increasing potential, while in the latter case a constant d.c. potential across a pure inductance results in a linearly increasing current. Most of the time bases employed to-day are of the capacitive type, because it is very much simpler and more economical to deal with condensers, especially when a large range of time-base frequencies is dealt with, as, for example, in cathode-ray oscillographs.

Every time-base circuit may be divided into two distinct parts, namely, that which controls the time-base trace (Valve 1, R_1, R_2, R_3, C_1 in Fig. 1) and that which effects the fly-back motion (Valve 2, R_4, R_5, R_6, C_2).

In Fig. 1 the condenser C is charged via a pentode (Valve 1). When the potential across C reaches the critical ionisation potential of the gas-filled relay (Valve 2) the condenser discharges through Valve 2, and the whole charging and discharging cycle starts again; the resulting time-base output potential across C is shown in Fig. 1*b*. The resistance R_3 controls the grid bias and thus the anode current of the pentode, i.e., R_3 regulates the steady charging current of the condenser C and thus the frequency of the time base. R_4 controls the rapidity of the discharge of C through the gas-filled relay. R_5 defines the bias and thus the ionisation potential of the gas-filled relay, i.e., it controls the amplitude of the time-base output potential. The synchronising signals are applied to the grid of the gas-discharge valve.

It should be noted that the circuit of Fig. 1*a*, as indeed all time-base circuits hitherto known, is a saw-tooth *generator* locked by a synchronising signal. While it may sound strange to those conversant with the art, it is nevertheless possible to imagine, perhaps more easily by the uninitiated, the signal under examination to be transformed or converted into its own time-base potential variation. To those who are not too accustomed to conventional technique this solution would appeal because thereby the necessity of synchronisation is altogether eliminated. In contradistinction to conventional circuits, the signal converter is capable of converting any arbitrary signal into its own time base.

To be able to form an opinion about the efficiency of a time-base circuit the following points should be considered :

1. Linearity of time-base potential.
2. Maximum limiting frequency.
3. Power supply necessary.
4. Maximum output potential ; ratio of supply potential to maximum output potential.
5. The accuracy, ease and stability of synchronisation.

(1) The linearity of the time base depends on the constancy of the current charging the condenser (C in Fig. 1) across which the time-base potential variations are produced. The basic circuit consists of a constant source of potential, which charges the condenser via a current-limiting component; this component is either a resistance or a hard valve—the latter is superior. When a resistance is used, as the potential across the condenser increases, the charging current decreases in accordance with the well-known exponential function

$$i = i_0\, e^{-t/CR},$$

so that only a limited section of the exponential curve may be regarded as a reasonable approximation to a straight line, thus only a small part (about 20 per cent.) of the potential of the source may be usefully employed for the time-base potential variations. This last condition is more favourable when the ohmic resistance is replaced by a high-frequency pentode. This solution, however, also lacks perfection ; for example, in Fig. 1*a*, as C charges up, the anode potential of the pentode decreases, resulting in a corresponding decrease of the anode current. This reduction of the anode current occurs in all high-frequency pentodes built on conventional lines, as the internal resistance of such valves is of the order of a few megohms and cannot conveniently be made higher. When the potential variations across C are of the order of a few hundred volts the lack of constancy of the anode current is of the order of 5 to 10 per cent.

From the above it is apparent that a valve wherein the reaction between output and input systems is eliminated, i.e., a valve having an internal resistance approaching infinity, would approach the ideal condition in which the charging current is constant. To eliminate the lack of constancy of the charging current when a resistance or high frequency pentode is used, correcting circuits have been developed ; these are, however, of considerable complexity and only approximate to the ideal solution.

(2) The maximum frequency which is attainable in a gas-filled triode time base is limited by the particular conditions prevailing in a gas-filled valve[5]; the practical limit with gas-filled triodes is at 50 000 c/s ; using complex circuits, however, frequencies of the order of 1 Mc/s have been reached.[6]

The highest frequency attainable when employing hard standard radio valves is of the order of 500 000 c/s, while using powerful amplifiers " scanning speeds " of 600 volts/10^{-7} sec. and saw-tooth frequencies of 14 Mc/s have been reached[7, 8, 9, 10]. Here the limitation is due to the finite values of the inter-electrode and circuit capacitances and due to the large currents necessary for the increased charging, and especially discharging, speed to attain these high frequencies. The above frequency limits are quoted from the latest literature on the subject, some of which fails to specify the saw-tooth output potentials at which these frequency limits are reached. When comparing the frequency limitation of time-base circuits one should bear in mind that the highest frequency attainable is inversely proportional to the maximum amplitudes of the output potential of the time base ; thus when specifying the maximum frequency of different circuits the output potential should be given. The best specification is the maximum scanning speed, i.e., the maximum rate of charging of C in volts per microsecond.

To extend the frequency range of hard-valve time bases it would be possible to generate a saw-tooth signal of small amplitude and use an amplifier; this, however, would be most impracticable, as a saw-tooth signal is rich in higher harmonics and thus at frequencies of the order of several megacycles per second only small resistance values could be employed as anode loads, and these in turn would require the use of very powerful valves.

(3) The addition of an amplifying stage to a saw-tooth generator means a great wastage of power. In the circuit of Fig. 1 the least wastage of power would be attained when C is represented only by the unavoidable capacitance of the deflection plates of the cathode-ray tube.

If one could limit the capacitance of the deflection plates of a cathode-ray tube and of the components associated with the time-base circuit to a few micro-microfarads, the power required for the deflection would be very small. A cathode-ray tube may be compared to an "ideal relay" or to a "voltage amplifier" in contradistinction to the output stage of a sound amplifier requiring "watts." As the deflection plates of a cathode-ray tube represent a pure capacitive load, the time-base generator should employ only this capacitance as a load and should avoid the use of any resistive loads parallel to it. In the signal converter this condition can be fulfilled.

(4) As already mentioned when considering point 1, in time bases employing a resistor to control the current charging the condenser only 20 per cent. of the supply potential can be usefully gained for the saw-tooth output. Replacing this resistance by a high-frequency pentode enables the gain ratio of saw-tooth to output potential to be raised considerably, as the anode-current/anode-voltage characteristics of a pentode may be used up to the "knick" of the curves. The gain ratio of the signal converter is above 90 per cent.

(5) The circuit of Fig. 1*a* is synchronised in the following manner: as the potential across C rises and approaches the critical discharge potential of the gas-filled triode the synchronising signal, which is applied to the grid of V_1, is in such a phase as to reduce slightly the critical discharge potential and thus the synchronising signal will initiate the discharge.

In Fig. 1*b* the useful time-base trace T_u is controlled by the synchronising signal T_s. But note that the start A of the synchronising signal initiates the *discharge* of the gas-filled triode; this discharge is "out of control"; that is, the rapid discharge of the condenser C continues until the potential across the gas-filled triode drops to such an extent that the discharge extinguishes itself. At this moment B', that is when the fly-back period is terminated, the scan starts automatically. In other words, the synchronising signal controls only in an indirect fashion the start of the useful scan T_u. While the above description may appear unnecessarily detailed and obvious, it is of significance to realise that the time base is synchronised at the start of the fly-back period T_f. *Not* the scan but the fly-back is synchronised. To achieve accurate synchronisation of the useful signal component it is essential to keep the scan and fly-back time intervals constant relative to each other. Obviously the fly-back is only a necessary means which interrupts the continuous useful scan and in most applications this means is made invisible by biasing the grid of the C.R. tube negative during the synchronising pulses T_s.

It would be a superior and more stable type of synchronisation if also the start B' of the useful scan could be controlled, but unfortunately all the conventional time-base circuits employ the former kind of synchronisation. While this serves the purpose in a number of applications, in some important uses (television, etc.) it introduces unnecessary complexity of the synchronising signal generation.

Apart from the accuracy of synchronisation, which has been hinted at above and which will be dealt with later in greater detail, being of considerable significance, the ease and stability of synchronisation should also be considered when judging the merits of a time-base circuit.

The smaller the signal amplitudes sufficient for the satisfactory synchronisation of the time base, the better. For example, in the signal converter "tight" synchronisation is achieved with amplitudes of the order of a fraction of a volt.

The stability of synchronisation may be affected by the influence of mains variations or changes of temperature, etc. For example, the use of a saturated diode as the charging valve in Fig. 1 was superseded by a high-frequency pentode, as being less sensitive to the variations of the mains. Or again, the fly-back interval is affected in a gas-filled triode time base by changes of temperature ; temperature has an influence on ionisation and thus on the critical discharge potential.

The authors have endeavoured to present in this section the principle of a conventional time-base circuit based on a prototype ; it would, however, assist the reader to study the bibliographical references, for he could thus more fully appreciate the basic difference between the principle of conventional time-base circuits and that of the signal converter.

3. The Signal Converter Principle

In the circuit of Fig. 1 the condenser C is charged by the anode current of the high-frequency pentode and is discharged by the gas-filled triode. To be more accurate, that plate of the condenser which is in contact with the anode of the high-frequency pentode is charged in a negative direction by the pentode and in a positive direction by the gas-filled triode. Since both these valves—indeed all " valves " having thermionic cathodes, as, in fact, their name implies—conduct current in only *one* direction, it is essential that *two separate* valves should be employed for the charging and discharging.

It is apparent that if an electronic discharge " valve " could be made to conduct current in both directions, similarly to an a.c. component, the charging and discharging of the condenser C could be accomplished by a single valve.

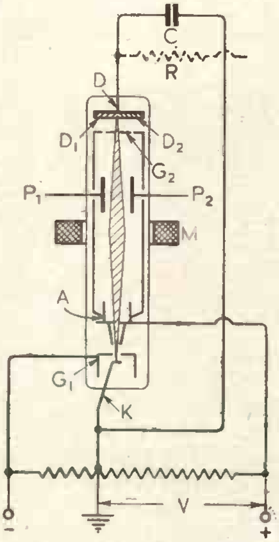

Fig. 2.—*Deflection-modulated cathode-ray valve suitable for the " conversion " of signals.*

This is the basic principle of the signal converter, which thus marks a fundamental development in thermionic valve technique.

With the aid of a valve shown in Fig. 2, for example, the condenser C may be charged in a positive or negative sense. The valve consists of a cathode K, an electron optical focusing system : G_1, A, M, G_2, a pair of deflection plates P_1, P_2, and an output electrode D. The image of the cathode K is focused with the aid of the grid G_1, the anode A and the magnetic focusing coil M into a narrow spot or line at the output electrode. The output electrode is divided into two parts : D_1 and D_2. The part D_1 consists of, or is coated with, a conductive material which has a secondary electron coefficient smaller than unity, D_2 consists of, or is coated with, a material which has a secondary electron coefficient larger than unity ; thus when the electron image is deflected by an alternating potential placed across the deflection plates P_1, P_2, so as to fall in turn wholly on the part D_1 and wholly on the part D_2 of the output electrode, the current flowing to the condenser C will change its direction. With the aid of secondary electron emission a " hard " discharge valve may be thus transformed into an " a.c. component."

To facilitate the understanding of the above and following subject matter of this paper it is desirable to deal with secondary-electron emission in general, and in particular with the charging up or equilibrium potential of a secondary emissive surface when bombarded by primary electrons of different velocities.

4. Secondary Emission

Any surface, metal, semiconductor or insulator will emit secondary electrons when struck by primary electrons. The secondary current (at constant primary electron velocities) is proportional to the primary current. This is true within wide limits. Measurements ranging from very low to high primary current densities show the secondary-emission coefficient to be constant ; the highest primary current densities used by the authors were of the order of 100 milliamperes per square centimetre.*

* It is difficult to deal with such highly concentrated beams due to space charge effects ; carefully designed electrodes situated as close as possible to the secondary emissive surface will, however, almost eliminate the negative field due to the high concentration of electrons.

The secondary-emission coefficient, i.e., the ratio of secondary to primary electrons, as function of the primary electron velocities is the characteristic curve of a secondary emissive surface ; it gives all the information required regarding the charging up potential

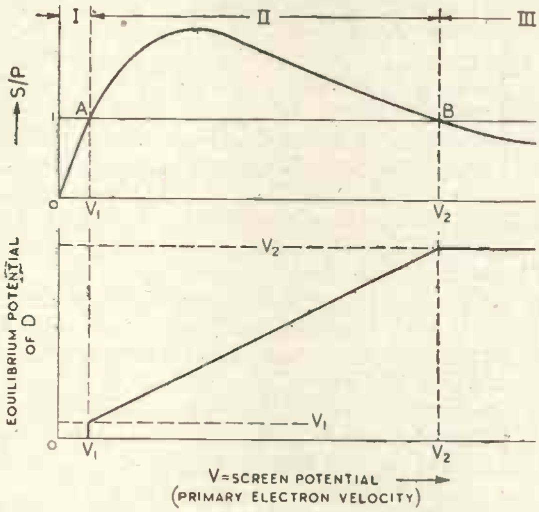

Fig. 3.—*The S/P characteristic (a) and the equilibrium potential (b) of a typical secondary emissive surface.*

of the secondary emissive surface.[11] In Fig. 3*a* is seen a typical characteristic. In Fig. 4 the secondary emissive layer *D* is bombarded by electrons emitted from the cathode *C*, having a " velocity " *V* volts.† The screen grid *G* and the anode *F* are at the same potential *V*. The equilibrium potential of the layer *D* (see Fig. 3*b*), when the primary electron velocities are increased from zero upwards, show three sharply defined ranges, indicated by I, II and III in Fig. 3.

Range I. For velocities between zero and V_1 the secondary-emission coefficient is smaller than one, i.e., more electrons reach than leave the surface *D* and it charges negatively. The accumulation of the negative charge is, however, limited ; when the potential of the cathode is reached the primary electrons are not attracted any more by a positive potential and cannot travel as far as *D*. Thus in Range I the potential of *D* is equal to the potential of the cathode.‡

When the " velocity " of the primary electrons is exactly V_1 volts the secondary-emission coefficient is equal to one, the number of electrons reaching and leaving

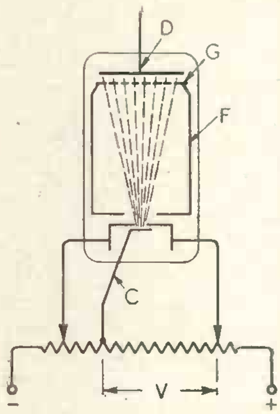

Fig. 4.—*Thermionic device for the investigation of the equilibrium potential of a " floating " output electrode.*

the surface *D* is the same and the potential of *D* " is and remains " V_1 ; in this statement and during the following discussion referring to Ranges II and III it is assumed that the potential of *D* must be equal to or higher than V_1 at the start of the electron bombardment. Point *A* of the S/P curve is a critical point ; the potential of the bombarded surface *D* is not in stable equilibrium, i.e., the slightest potential change of the anode close to V_1 in the negative direction will result in a sudden jump of the potential of *D* from V_1 to cathode potential.

At this juncture the importance of the influence of the initial potential of the bombarded surface *D* should be emphasised. If at the start of the bombardment *D* is at

† The accelerating voltage to which an electron is subjected is a measure of the velocity of the electron.

‡ The equilibrium potential will be very nearly equal to the cathode potential ; due to the initial velocity of the electrons it has the tendency to become a fraction of a volt more negative than the potential of the cathode, the effect of the initial velocity of the primary electrons is, however, mostly counterbalanced by the effect of space charge resulting in an equilibrium potential which is slightly positive relative to cathode.

cathode potential this cannot be increased whatever may be the potential of the accelerating electrodes F and G. All primaries are slowed down almost to zero velocity (cathode potential) just before reaching the secondary emissive surface and thus the conditions of Range I prevail and the equilibrium potentials of Ranges II and III in Fig. 3*b* could not be attained.*

Range II. At the primary electron velocities ranging from V_1 to V_2, the secondary emission coefficient is higher than one. If the potential of the surface D is more negative than the potential of G and F, all the secondary electrons are collected by G and F.† More electrons will leave than reach the surface D, which thus charges in a positive sense. The potential of D increases until it is equal to the potential of G, when some of the secondary electrons return to D, and a condition of equilibrium is reached, at which the number of secondaries leaving D and collected by G and F is equal to the number of primary electrons reaching D. This equilibrium potential is equal or very close to the potential of G, since secondary electrons have low initial velocities of the order of a few volts.

If the potential of the surface D is initially more positive than the potential of G and F, the secondary electrons are all returned to D, which, therefore, charges in a negative sense until the above-mentioned equilibrium potential is reached.

Fig. 3*b* shows the equilibrium potential of the surface D as function of the primary electron velocities.[11]

Range III. When the anode potential increases above V_2 the potential of D remains constant at V_2; in Range III the secondary electron emission coefficient is lower than one. When the initial potential of D is higher than V_2, but lower than the anode potential, then all the secondaries are collected by G and F, but more primaries reach D than there are secondaries and thus D charges negatively until, at the point B, S/P is equal to unity and the emissive surface is again at an equilibrium potential.

When the initial potential of D is higher than the anode potential all electrons, primaries and secondaries, are collected by D charging it negatively until the point B is reached again.

In the above it was shown that the respective positive and negative charging efficiency and the equilibrium potential of a conductive secondary emissive surface is defined by the velocity of the primary electrons bombarding it. When high charging efficiency is required caesium-caesium oxide, barium-barium oxide, magnesium, beryllium, etc.,[12, 13, 14] layers may be used with a maximum normal S/P of 6 to 12. In the case of most of the efficient secondary emissive surfaces the critical potential V_1 is of the order of 50 volts, while V_2 is above 2,000 volts. The maximum S/P is at voltages of the order of 300 to 600 volts. The S/P characteristic is independent of the temperature of the layer.[12, 15] It is very critical to the direction of the incident electrons. S/P is smallest when the path of the electrons is normal to the secondary

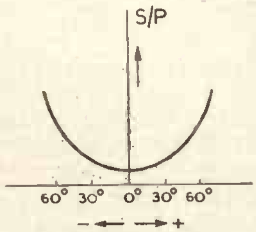

Fig. 5.—*Relation between the secondary emission coefficient and the angle of incidence of the primary electrons.*

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* Taking the arrangement of Fig. 4 it is useful to examine what the potential of the electrode D is likely to be before the start of the bombardment. The secondary emissive surface D is a "floating electrode", let the resistance between D and the other electrodes be infinite (unavoidable leakage to G and F is not taken into account). It is well known that when an electron discharge takes place in good vacuum the gas molecules are ionised. (The positive ion current is proportional to the electron current and the pressure.) If there is no electron current some minute ionisation of the molecules may still take place in a positive electrostatic field, e.g. in the space surrounded by G and F. Then the positive ions tend to charge D to the same potential as that of G. Secondary electron emission due to the ion current and the electrostatic influence of the screen grid G has the same effect on D.

If there is any leakage between D and G, D again acquires the potential of G. Whichever effect should prevail the tendency is to keep the potential of the secondary emissive surface positive and equal to the anode potential. Thus if it is desired to investigate the equilibrium potential of the secondary emissive surface in Range II the anode potential should be present before the heater of the cathode is switched on; only then will the primary electrons reaching the surface D acquire velocities equal to or higher than V_1.

† This is true in all three ranges as long as the screen grid is kept at a more positive potential than the bombarded secondary emissive surface.

emissive surface. S/P increases as the angle of incidence increases,[16, 12] as shown in Fig. 5.

The physics of the secondary emissive layers is a much too complex subject to discuss here with any completeness; the above considerations relate specifically to the subject matter of the deflection-modulated cathode-ray valve.

5. Different Electronic Solutions to Convert a Signal into its own Time Base.

Perhaps the simplest way to divide a floating output electrode into a "negative" and a "positive" part is the electronic solution which has been described in Section 3 and shown in Fig. 2. Here the negative half

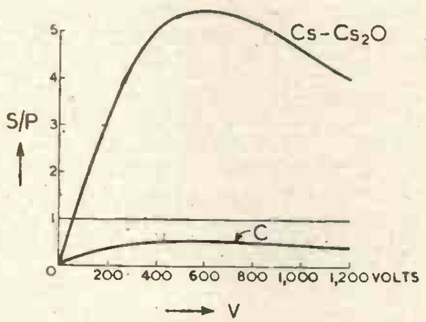


Fig. 6.—*The S/P characteristic of Cs — Cs_2O and C.*

has a secondary electron emission coefficient less and the positive half more than unity.

During the charging and discharging process the screen G_2 is kept more positive than the output electrode; all the secondary electrons, from the negative and positive half of the output electrode, are collected by this screen. For example, the negative half may be constituted by a carbon coating and the positive half by a Cs — Cs_2O surface which is known to be one of the best secondary electron emitters. The S/P characteristic of carbon and Cs — Cs_2O are shown in Fig. 6.

When the electron beam falls on the carbon half all the conditions of Range I prevail. As a matter of fact, Ranges II and III have no significance for carbon; always more electrons will reach the surface than leave it, so that the tendency of the output electrode is to reach the potential of the cathode.

When the beam falls on the Cs — Cs_2O half, assuming that the primary electron velocities are kept within Range II of the Cs — Cs_2O characteristic, the output electrode loses more electrons than it gains and it charges positively.

As long as the potential of the output electrode changes between the characteristic points *A* and *B* of the S/P characteristic (see Fig. 3), the proper operation of the device is ensured. It is, however, hardly possible to fulfil this condition in practice; this and other disadvantages make the adoption of this solution undesirable; these disadvantages are as follows:

(a) If—during the operation of the device—the potential of the output electrode decreases below the critical potential V_1 (see Fig. 3) of the Cs — Cs_2O surface the "positive" half would also charge in a "negative" direction because in Range I S/P is smaller than one, the output electrode would "stick" to the potential of the cathode and the converter would cease to function. This "choking" can hardly be avoided. The floating output electrode is loaded by a condenser. It can be biased to a safe potential above V_1 only with the aid of a resistance (e.g., *R* in Fig. 2); to make the biasing really effective the value of *R* should be of the order of the capacitance of *C*; this, however, would be hardly possible as by employing such an additional resistive load the linearity of the rise of the time-base potential would be destroyed.

(b) The charging efficiency of the negative half would be low; only a fraction of the total beam current could charge the output electrode negatively. The reason for this is that it is very difficult to produce a surface with a secondary emission coefficient lower than 0.5. Carbon Black has one of the lowest known secondary emission coefficients and its average S/P is still of the order of 0.5. It is also very difficult to obtain uniform results when trying to produce layers with low secondary emission; impurities increase the secondary emission.

(c) It is essential that the scanning part of the time-base potential should be linear; as may be seen from the S/P characteristics neither the charging of the positive nor that of the negative half can be kept constant due to the changing S/P values as function of the output electrode potential.

The choking of the valve may be eliminated by using for the negative and positive half of the output electrode surfaces with greatly differing critical potentials V_2. For example, for the negative half molybdenum and for the positive half platinum may be employed. The respective S/P curves are shown in Fig. 7. The molybdenum surface is employed

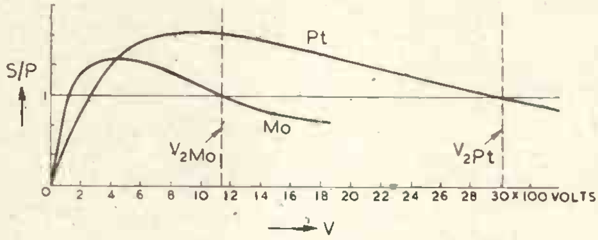


Fig. 7.—*The S/P characteristic of Pt and Mo.*

in Range III, and the platinum surface in Range II.

The potential of the output electrode can change between the critical potentials V_2 of the *Mo* and *Pt* surfaces. The critical potential of the *Mo* surface is of the order of 1200 volts; this is inconveniently high and it is difficult to find substances with lower critical potentials V_2. The useless d.c. potential V_{2Mo} and the inefficiency of the negative half cycle make the use of this solution rather unattractive, and the non-linearity of the charging remains.

The disadvantages of the above solutions are eliminated by using a simpler and more efficient principle and one which has been adopted for the signal converter. This principle will now be described in detail.

6. The Electronic Principle adopted for the Signal Converter

A schematic representation of the electron optical design and the circuit of the signal converter is given in Fig. 8. Here the drawing of the signal converter approximates closely to the actual electrode design (Fig. 12), as may be judged from the photograph of the signal converter shown in Fig. 9. In contradistinction to conventional cathode-ray tube design, where the electrodes of the electron lenses have rotational symmetry and circular apertures, the electrodes of the signal converter lack rotational symmetry and have rectangular apertures. The resulting electron lenses correspond to cylindrical lenses in optics; a more detailed discussion of this is given in Section 7. The plane of Fig. 8 is a cross-section of the signal converter in the direction in which the rectangular apertures are smallest; they may be visualised as being elongated in a plane perpendicular to the plane of the drawing. The cylindrical optical system has been adopted to increase the total beam current available to any required value, and that this is possible while retaining sharp focusing is of real significance in deflection modulated cathode-ray valves. Sharp definition of the electron image is only required in one dimension, so that the cathode and the line electron image may be elongated indefinitely in the other dimension.

The electrons emitted from the indirectly-heated cathode K are drawn by the first anode A_1 through the potential barrier of the negative grid G and are concentrated into a line (cross over) close to the opening of the grid. The electrons then entering the first anode form a narrow divergent beam which in turn is focused into a sharp line image at the tip of the member Y by the lens formed by the first and second anodes A_1 and A_2.

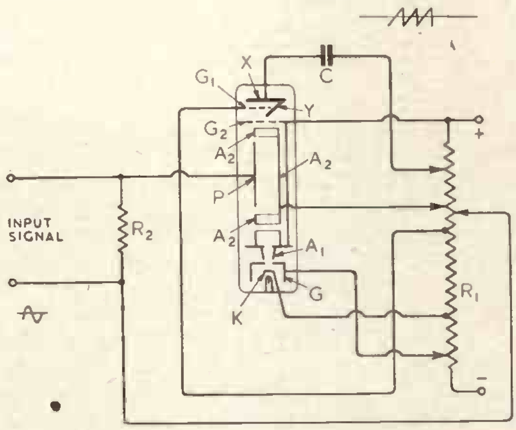


Fig. 8.—*Circuit of a signal converter.*

Within the second anode system is the deflection plate P, which may be regarded as an integral part of the second anode system itself. By applying input signals across the resistances R_2 to the plate P the electron image may be deflected across the output electrode $X - Y$.

For specific purposes the output electrode may be divided into the "positive" and "negative" parts in various ways; the system adopted for the signal converter is

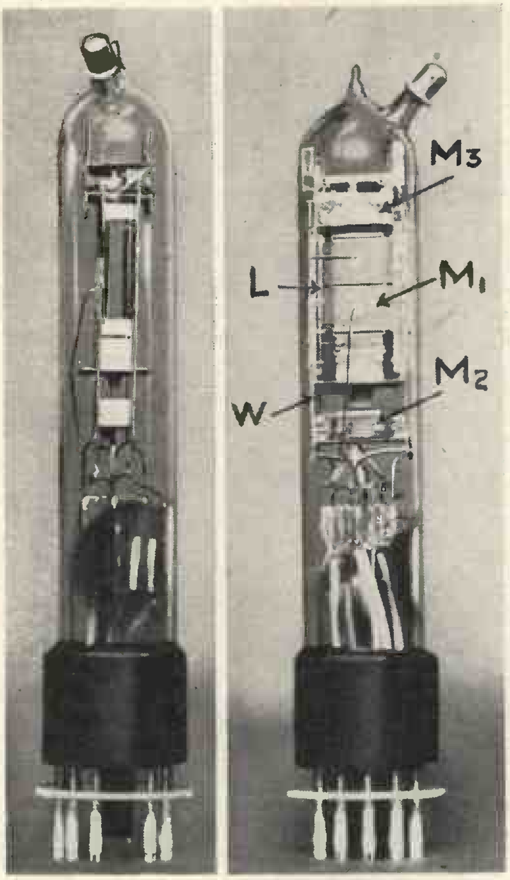


Fig. 9.—*The Nagard converter Type I.*

that shown in Fig. 8, employing the screens G_1 and G_2 in association with an output electrode consisting of members X and Y. Using this output electrode system eliminates choking of the valve and inefficiency and lack of constancy of the charging of the negative part.

In contradistinction to the solutions mentioned in Section 5, *both parts*, X and Y, consist of, or are coated with, a substance of high secondary electron emission.

When the electron image falls on the member Y, the positive part, the output electrode is charged according to the condition of Range II (see Fig. 3 and Section 4); secondary electrons are emitted from Y and are collected by the screen grid G_2, which is at first anode potential. Disregarding the effect of space-charge, it can be assumed that all the secondary electrons are collected by the screen grid as long as it is at a more positive potential than the output electrode. In Range II the secondary emission coefficient is greater than unity; thus the output electrode charges in a positive sense. If the electron image remains sufficiently long on the member Y, the potential of the output electrode rises to the equilibrium potential, which is near the potential of the screen G_2. The load of the signal converter is the pure capacitance C; then the potential V of the output electrode is determined by the charging current i, the charging time t, and the capacitance:

$$V = it/C.$$

Assuming that the *total* beam current i_b falls on the member Y, the effective charging current i is equal to the current emitted, which is the product of the beam current and the secondary emission coefficient, less the incident beam current, or

$$i = i_b\,(\mathrm{S/P} - 1).$$

The charging potential of the output electrode as a function of time is shown in Fig. 10; it should be noted that the potential is proportional to the charging time alone if the beam current and the secondary emission coefficient remain constant.

When the electron image falls on the member X, the negative part, the secondaries which are emitted are prevented from leaving the neighbourhood of the output electrode by the electrostatic field of the suppressor screen G_1, and are made to return to the output electrode, thus charging it in a negative sense. If the image remains sufficiently long on X, the potential of the output electrode reaches a value near the potential of the auxiliary electrode G_1. Here equilibrium is again attained between the electrons reaching and those leaving the output electrode (see Fig. 10, curve 2) provided that S/P is greater than unity, to achieve which the potential of G_1 is kept within Range II.

The operation of the valve depends on the output electrode always having an S/P greater than unity. S/P falls below unity if the velocity of the primaries falls below some minimum value, which is the critical potential

V_1 (Fig. 3). The primary electrons must never have a velocity less than this minimum, otherwise the potential of the output electrode will fall to cathode potential and "stick" there, choking the amplification of the signal converter. It is for this reason that G_1 is given a positive bias potential.

The suppressor screen G_1 also ensures that cathode, and secondaries may reach it, having passed through G_2, but as is explained in greater detail in Section 7, this may be avoided by applying a sufficiently large potential difference between P and G_2.

When now an alternating potential is applied to the deflection plate, the electron image is made to oscillate between the

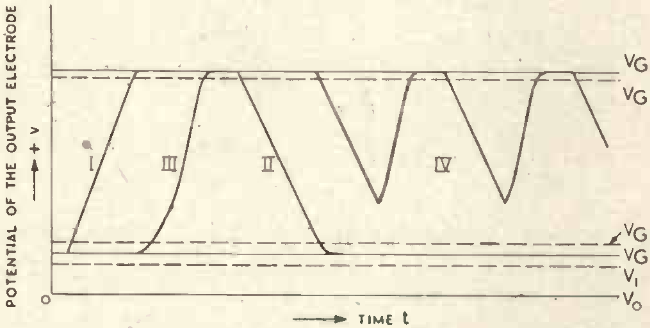


Fig. 10.—The "output" of a converter. The relation between the equilibrium potentials V_{G1}, V_{G2} and the output. Curve I, i_b and S/P = constant; curve II, i_b = constant, S/P = constant or variable; curve III, i_b = constant, S/P = variable; curve IV, combination of curves II and III. V_{G2} = potential of screen G_2: V_{G+} = potential when some of the secondaries start to return to the output electrode: V_{G-} = potential when the suppressor screen starts to collect some of the secondaries: V_{G1} = potential of suppressor screen G_1: V_1 = "critical potential" of the secondary emissive surface of the output electrode: V_0 = potential of the cathode.

the charging current of the negative part of the output electrode is independent of S/P and is equal to the beam current at all potentials of the output electrode. It is assumed that the total beam current will pass through G_1, a condition which can easily be fulfilled.

The positive bias of the suppressor screen does not limit the amplitude of the time-base output appreciably; the critical potential V_1 of most of the efficient secondary emitters is of the order of only 50 volts.

The screen G_2 serves not only to collect secondaries liberated from the positive part Y of the output electrode, but also to screen the body of the valve from the electrostatic fields produced by the potentials of the output electrode and the suppressor screen. The screening of the body of the valve from the potentials of the output electrode eliminates feed-back between the output electrode and the input members of the valve. The impedance of the valve is thus very high.

It is important that the deflection plate P should not collect primary or secondary electrons of any kind, i.e., it should act in the same way as an ideal control grid which is biased negatively relative to the cathode. The deflection plate is positive relative to positive and negative parts of the output electrode, and an amplified and converted signal, a time-base signal, is produced on the output electrode. The width of the image is made very small compared with the amplitude of the deflection so that during the oscillations it falls entirely on one or the other portion of the output electrode throughout substantially the whole of the deflection cycle; the time during which it falls partly on one portion and partly on the other is negligible. During the time that it falls on Y, the output electrode charges positively in an approximately linear function of time, and during the time it falls on X, the output electrode charges negatively in a substantially linear function of time (see Fig. 10). The result is that, whatever the form of the input signal, the output is a saw-tooth or trapeze-shaped signal. The potential of the output electrode may alternate between the potentials of the screens G_1 and G_2; whether it will reach both these extreme potentials depends on the value of the beam current and the times of charging and discharging. Theoretically the image could oscillate at such a high frequency that the output electrode does not reach either of the limiting potentials. In the circuit of Fig. 8, however, the mean potential of such an output saw-tooth signal would be unstable. Stable working would require that the image should oscillate about the " ideal symmetrical position " in which the charging of X and Y is equal; if the charging *efficiency* of X and Y is equal, this position is that in which half the image falls on Y and half on X. The slightest displacement of the mean position of the image towards the member Y would charge the output electrode to the potential of the screen grid, while the slightest displacement towards the member X would charge it to the potential of the suppressor screen. To avoid such instability the time-base signal should commence and terminate on one of the limiting potentials in each cycle.

It is advantageous that the image should fall on the negative part of the output electrode during the scan period and on the positive part during the fly-back period. The advantages are twofold. First, the charging of the part of the output electrode on which the electron image falls during the scan period must be constant at all potentials, for only then is the change of the output potential a direct linear function of the charging time. As already mentioned, the suppressor screen ensures that the charging current of the negative part is equal to the beam current, which is constant, and is independent of the potential of the output electrode. Secondly, the charging efficiency during the fly-back period should be much higher than during the scan period; this condition is satisfied if S/P of the positive part is high. The secondary emission need not be constant; what really matters is that the fly-back should be as fast as possible, as the output electrode must reach the potential of G_2 in a time interval which is shorter than the fly-back period. In these conditions the start of the scan coincides with the potential of the screen grid, the time-base output is trapeze-shaped and the most negative value of the scan is advantageously more positive than the suppressor screen (see curve 4 of Fig. 10).

If the actions of the respective parts of the output electrode are interchanged and the phase of the input signal reversed so that the image falls on the positive part during the scan period and on the negative part during the fly-back period, the charging efficiency of the latter could be increased by using the output electrode system shown in Fig. 20 (see Section 10). It would be necessary, however, to correct for the changing S/P characteristic of the positive part, as this is a non-linear function of the primary velocities, and to select a substance with a low secondary emission coefficient.

The charging efficiencies of the X and Y parts of the output electrode of Fig. 8 may be adjusted relative to each other by other means than the choice of the secondary emission coefficient of the positive part. For example, the negative charging efficiency may be reduced by shaping the member X or by blocking out part of the image falling on X. Also the synchronising signals (Fig. 1*b*) may be applied to the grid of the valve controlling the intensity of the beam, and thus the fly-back may be made as fast as desired.

7. Design and Construction of the Signal Converter

As has been pointed out in Section 6, the electron image formed in the region of the output electrode requires definition only in the direction of the deflection. In the direction normal to the deflection the electron image can be elongated. Accordingly, in order to provide a higher beam current, a cathode is employed which is elongated into the form of a long, narrow strip, and a " cylindrical " electron-optical system is employed.

The term " cylindrical " is here applied to electron lenses whose behaviour is analogous to that of cylindrical lenses in optics, i.e., their focusing action is in one dimension only. In electron optics a true cylindrical lens is provided by an electrostatic field which is symmetrical about one axis but is uniform in one direction normal to that axis. Such a field is obtained when a difference of potential exists between electrodes which are provided with apertures of infinite length. This is impossible in practice, but a close approximation is obtained to this condition when electrodes are employed having long, narrow apertures. A system of this type is used to focus the electrons from the elongated cathode into a line image in the region of the output electrode. The fact that the apertures are of finite length provides a residual focusing action in the direction parallel to the line of the cathode, which is useful in preventing the electron beam from diverging unduly in that direction.

There is considerable literature available concerning "spherical" electron-optical systems, but literature concerning cylindrical electron-optical systems is scanty. The behaviour of cylindrical systems is, however, very similar to that of spherical systems. It can be shown that, for paraxial electrons, the power of a cylindrical electron lens is exactly double that of the spherical lens which has the same axial distribution of potential.* A cylindrical electron lens consisting of a configuration of rectangular apertures with certain cross-sections and a certain distribution of potentials does not necessarily have the same axial distribution of potential as a spherical electron lens consisting of the same configuration of circular apertures with the same axial cross-sections and distribution of potentials, but in practice a sufficiently good approximation can usually be obtained by assuming that the axial distribution of potential is the same in both. In this case it is possible to calculate cylindrical lenses in accordance with known formulae for spherical lenses,[17] provided that the focal length of a given spherical lens *is halved* for the corresponding cylindrical lens. This procedure has been found to give surprisingly accurate results in practice.

Since a long, narrow cathode is required, an obvious solution would be to use a tungsten or thoriated tungsten wire, directly heated. It has been found, however, that the magnetic field produced even when a thin wire is employed is sufficient to produce appreciable deflection of the beam. Consequently, when an a.c. source is used to heat the wire, a signal is obtained on the output electrode corresponding to the a.c. supply.

In order to avoid this, an indirectly heated cathode is employed, which has the additional advantage of providing a more efficient cathode. A convenient form of indirectly-heated cathode is shown in Fig. 11. In Fig. 11*a* is shown a section at right angles to the length of the cathode and in Fig. 11*b* a section along the length of the cathode. The cathode consists of a flattened nickel tube *N*, of which the upper surface is slightly concave in cross-section. Along the centre of this depression is deposited a layer of barium strontium carbonate, which is decomposed and activated in accordance with known technique. The tungsten heater within the nickel tube is insulated with ceramic material. This heater has a configuration resembling a capital *M*, so that the magnetic field produced by the heater current is virtually annulled. The cathode is firmly fixed on a ceramic support *S* (see Fig. 11*b*).

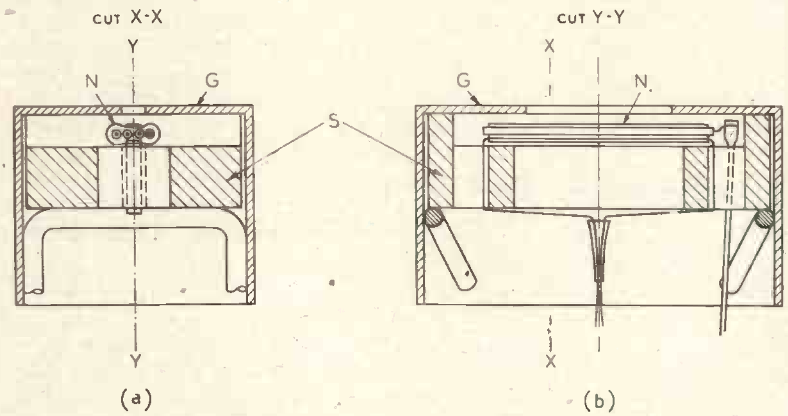


Fig. 11.—*Construction of the indirectly-heated cathode assembly.*

The cathode assembly fits into the box-shaped grid *G*, which has a narrow aperture at the top. The cathode-grid separation is very accurately established by two raised rims at the ends of the ceramic support *S* (Fig. 11*b*).

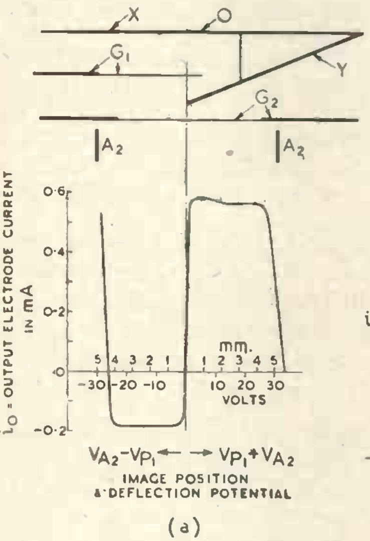
Electron-optical calculations cannot advantageously be applied to determining the best configuration of the lenses constituted by the potentials between the cathode and the grid and between the grid and first anode, owing to the large effects of space-charge. In practice the cathode is placed as near the grid as is considered expedient,

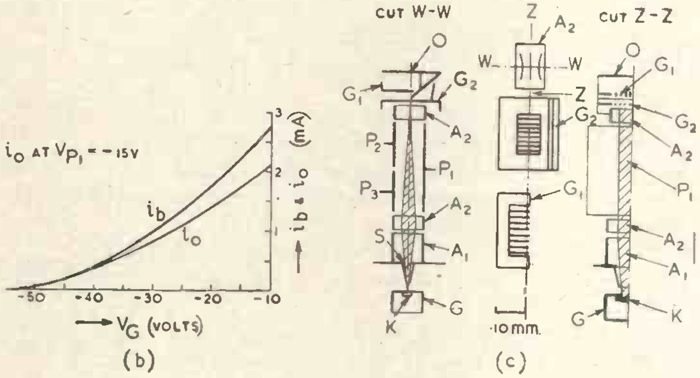
* See Appendix.

having regard to avoiding the danger of short-circuits, in order to obtain a large beam current ; the best value of the separation between grid and first anode is determined by experiment.

In designing a signal converter, it is desirable to keep the maximum supply potential low. In order, however, to obtain a concentrated electron beam, the first anode requires a reasonably high potential. This suggests that the first anode should be given the maximum available potential. On the other hand, in order to obtain large deflection sensitivity, the deflection plate should operate in a region of low potential. The deflection plate is most conveniently incorporated with the second anode. Both these factors, therefore, indicate that a departure should be made from orthodox cathode-ray tube design and that the second anode should be given a lower potential than the first anode. The actual configuration and relative potentials of the first and second anodes are determined on the basis of known electron-optical principles, as described above. In order to enhance the deflection sensitivity, the deflection plate should be made as large as possible. It can occupy almost the whole region between the first anode and the screen grid (see Fig. 12c).

As mentioned in Section 6, it is important that electrons should not reach the deflection plate. Stray primary electrons can be prevented from reaching the deflection plate by a suitable stop (aperture) in the first anode (*S* in Fig. 12*c*). A number of secondary electrons from the output electrode may pass through the screen grid. Most of these are slow, and so are unable to reach the deflection plate when this is slightly negative relative to the screen grid. A few fast secondaries from the output electrode, and also from the screen grid, may, however, reach the deflection plate, but if this is sufficiently negative relative to the screen grid, these fast secondary electrons also fail to reach it. This is another very good reason for making the second anode less positive than the first anode.





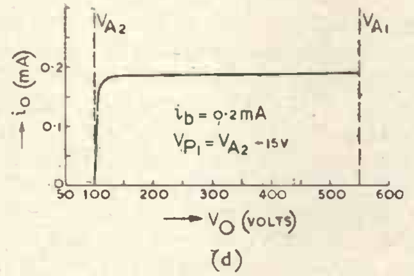


Fig. 12.—*Characteristic curves and the electrode design of the Type I converter. In (a)* V_{A_1} = 550 *volts* : V_{A_2} = 100 *volts* : V_O = 400 *volts* : $V_{P_2} = V_{P_3} = V_{A_2}$: i_o = 0.2 *mA*.

The screens G_1 and G_2 (Figs. 8 and 12) consist of parallel wires or ribbons which are perpendicular to the line of the electron image. A parallel wire system has a lens effect only in a plane which is perpendicular to the wires, so that the only effect of the screens is to break the continuous image up into a dotted line, while the sharpness of the line is not affected; changes in the potential of the output electrode cause changes in the gaps between the dots. The fact that the image is in the form of a dotted line instead of a continuous line is immaterial. Also the constancy of the beam current is not affected by G_2, since an equal number of electrons is stopped at all positions of the beam. The suppressor screen G_1 does not intercept electrons. The negative potential of the ribbons of the suppressor grid produces a focusing action on the electrons which causes them to pass through the apertures between the ribbons without striking them.

The changing potential of the output electrode does not affect the focus of the electron beam at the tip of the output electrode. It produces a deflection on the beam when the latter is not falling at the tip of the output electrode, but this deflection does not affect the operation of the signal converter.

In order to deal with high frequencies and to eliminate the possibility of "feed-back" between output and input, the connection of the output electrode is at the top of the converter (Fig. 9).

The various electrodes of the signal converter can conveniently be supported on mica plates. For this purpose the grid and first and second anodes are all made with the same rectangular cross-section. Tags are punched on each electrode, which fit into corresponding holes punched in the mica plates (Fig. 9). The first and second anode and deflection plates are supported by one pair of mica plates M_1, while the cathode-grid assembly is supported by a separate pair of small mica plates M_2. The mica plates are fixed to support strips L which are welded to wires W supported from the pinch of the valve. The output electrode and the screens are similarly supported from a third pair of mica plates M_3, and secured to the ends of the wires W.

The output electrode is coated with a secondary emissive material—developed after considerable difficulties—which is capable of withstanding a primary beam current density of the order of 100 mA/cm² at 1000 volts and will give a maximum S/P of the order of 6.

8. Practical Example. The Electrical Data of the Nagard Type I Signal Converter

As an example of the quantities involved in a signal converter the following calculation is given. The following assumptions are made:

- the required output time-base voltage $V = 300$ volts;
- the duration of the fly-back period is small in comparison with the scan period;
- the capacitance of the output electrode and the deflection plate of the C.R. tube and connecting leads $= C = 10\ \mu\mu\mathrm{F}$;
- the scan frequency $f = 10\,000$ c/s; and
- the effective charging current of the negative part of the output electrode is equal to the beam current.

Then the beam current is given by:

$$i_b = CVf = 0.03 \text{ milliamperes.}$$

This minute current is still further reduced if the frequency is smaller; for example, for a 50-cycle time base the beam current necessary is less than a microampere.

The smallest deflection necessary to produce an undistorted time-base output is theoretically equal to the beam width at the output electrode, but for safety it should be about three times that amount. Thus if the beam width is 0.2 mm, the input voltage should produce a deflection of about 0.6 mm. Assuming a deflection sensitivity of 5 mm/volt, this would require a minimum input amplitude of 0.12 volt. In this case the signal converter, as well as converting the input signal into a saw-tooth or trapeze-shaped time base, also produces an amplification of 2500 times.*

At this stage it should be noted that the input signal may increase during reception, say a hundred fold (deflection of image 60 mm) without affecting the constancy of the time-base output. As long as the electron image falls on the output electrode, and during the respective scan and time-base

* The amplification factor of a conventional valve is a constant, and is substantially independent of the amplitude of the signal. This, however, is not the case with the signal converter; the amplitude of the output signal is always the same, whatever the amplitude or shape of the input signal. Hence it would be better to speak of the "conversion factor" rather than the "amplification."

periods falls on the respective positive and negative parts, the time-base output is constant.

While in the above example the deflection sensitivity of 5 mm/volt is not considered an optimum case, as the employment of second anode, i.e., deflection plate mean potentials close to the potential of the cathode, would make possible the attainment of even higher deflection sensitivities, it was felt that for practical purposes a sensibility* of ½ to 1 image-width/volt was quite sufficient ; thus in the Type I and II signal converters a second anode potential of the order of 100 volts is employed. This potential is also conveniently chosen as the potential of the suppressor screen G_1, being higher than the critical potential V_1 (Fig. 3 and Sections 4 and 6) of the secondary emissive surface of the output electrode and low enough to be chosen as the negative limiting potential of the time-base output, thus G_1 can be connected within the valve to the members of the second anode.

The Type I and II converters are almost identical in construction, the only difference being the form of the screen G_2 and suppressor screen G_1. Type I was developed for the use in C.R. oscillographs and Type II for television purposes. In the former the fast fly-back is of secondary importance, but it is desirable to reach high scanning frequencies of the order of a few hundred thousand cycles ; thus the total available beam current is made to fall on the negative half of the output electrode, and the active part of the screens G_1 and G_2 consists of parallel wires and ribbons arranged in a manner to represent the least obstruction in the path of the image falling on both the negative and positive parts of the output electrode. These screens are shown in Fig. 12*c*. In Type II the highest scanning frequencies are of the order of 10 000 c/s and thus a fraction of the available total beam current is sufficient for the time-base output ; it is, however, important that the fly-back period be a fraction of the period of the synchronising signal and to achieve this, i.e., to make the ratio of positive charging and negative discharging currents as high as necessary, the greater part of the image is blocked out when falling on the negative part of the output electrode.

The data available from the curves and drawings of Fig. 12 should give a complete picture of the capabilities of the Type I signal converter.

Fig. 12*a* shows the output electrode current i_0 as a function of the image position and deflection potential ; to indicate the position of the image in relation to the output electrode system, the latter is also shown schematically. The beam current and output electrode current of the negative part as a function of the grid voltage is shown in Fig. 12*b*.

Fig. 12*c* is a full-scale drawing of the electrode system, showing the two sections through the main planes of symmetry, and the plan view of the second anode, and screens G_1 and G_2.

The output electrode current i_0 of the negative part as a function of the potential V_0 of the output electrode is shown in Fig. 12*d*.

Note in Fig. 12*a* that the minimum safe input voltage is of the order of 5, and the maximum safe input voltage of the order of 50 ; the maximum output time-base peak-to-peak amplitude is equal to 450 volts ($V_{A_1} - V_{A_2} = 550 - 100 = 450$ volts) when the first anode potential is 550 volts. Naturally a doubling of the first and second anode potentials would result in a corresponding increase of the maximum time-base output, input signal acceptance and grid voltage/beam-current characteristic (Fig. 12*b*). The important feature of Fig. 12*a* is the constancy of the output-electrode current during the negative half of the deflection characteristic. The secondary electron emission coefficient of the positive half is of the order of 4 and is not constant along the output electrode ; variations of S/P may and will occur in individual valves without affecting their efficiency.

The useful range of the grid-voltage/beam-current characteristic is within 0.02 and 1.0 milliampere. The sharp focusing of the image above 1.0 milliampere deteriorates and the use of beam currents below 20 microamperes is not advisable due to leakage troubles which may interfere with the linearity of the scan. The negative charging

* Deflection sensibility : defl. sensitivity measured in units of image-width instead of millimetres. Above example : image-width 0.2 mm, defl. sensitivity = 5 mm/volt, defl. sensibility, 25 image-width/volt.

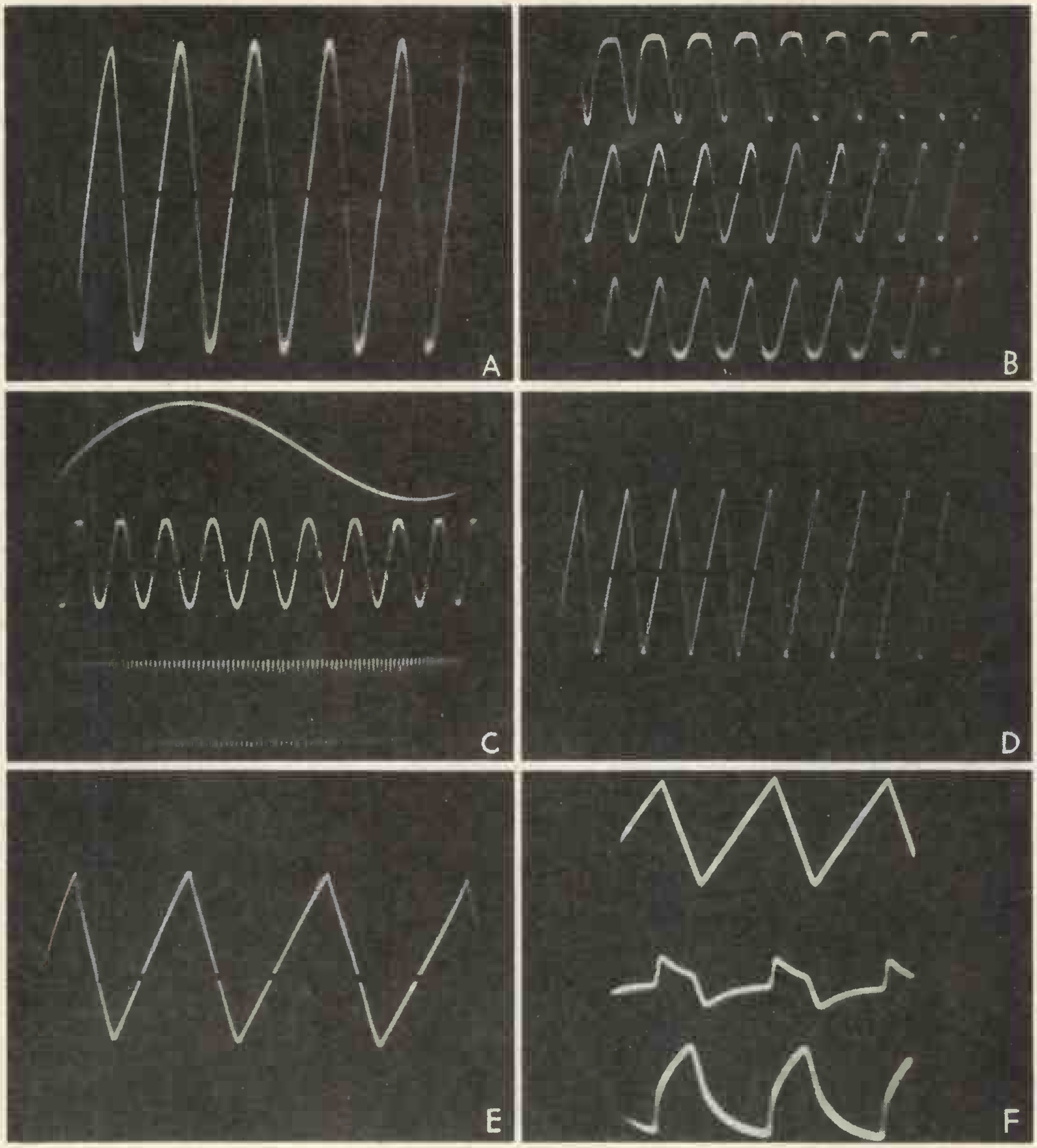


Fig. 13.—*Characteristic oscillograms of a "pure" converter (A, B, C), and a converter used as a generator (D, E, F).*

current of the output electrode is somewhat less than the beam current, as some of the primary electrons are stopped by the aperture of the first anode (*S* in Fig. 12*c*) ; this effect increases with the intensity of the electron beam and is a common shortcoming of electron guns.

The main considerations regarding the construction of the electrode system have been dealt with in Section 7, and this should be studied in conjunction with Fig. 12*c*. Note the (approximate) path of the beam. Three deflection plates, P_1, P_2, P_3, are employed to simplify the arrangements of the input, biasing and feed-back circuits; these remarks are elaborated in Section 9 dealing with the signal converter as a generator used in cathode-ray oscillographs. The distortion of the image when deflected is shown within the plane of the second anode; the aberrations are due to the "field lens" formed by the screen G_2 and the second anode system; these aberrations are, however, of no significance as at the edge of the member Y no distortion occurs and only at this central position is it necessary to have a well-defined and distortionless image to achieve the quick reversal of the output electrode current.

It should be noted that the negative output electrode current (Fig. 12*d*) is substantially independent of the variations of the potential of the output electrode.

It is further found in practice that the members of the second anode, the deflection plates and the suppressor screen, do not collect any current within the useful range of deflection.

The photographs of Figs. 13A and B show oscillograms of the output signal of a "well-aged" converter (continuously working for over 300 hours) employing sinusoidal input ($f = 5{,}000$ c/s, $V_{input} = 5$ volts r.m.s.). The oscillogram of the input signal is given in Fig. 13C.

In Fig. 13A the beam current and the bias of the input deflection plate is adjusted to give an output signal which just reaches the equilibrium potentials V_{G_1} and V_{G_2} (note lack of sharpness of the tips of the "saw-teeth").

In Fig. 13B, in addition to the repetition of 13A (centre oscillogram) the output of the converter is shown when the deflection plate is biased towards the positive Y (top oscillogram) and negative X (bottom oscillogram) part of the output electrode; the flat tops and bases correspond to the respective equilibrium potentials V_{G_1} and V_{G_2}. It should be pointed out that the amplitudes of the oscillograms were reduced by capacitive potential division, in order to produce on the screen of the cathode-ray tube convenient sized curves suitable for photography.

Figs. 13D, E and F show the output of the signal converter when used as a time-base generator (see Section 9).

To summarise the main points of this Section:

Very small power is needed to produce time-base potentials of several hundred volts amplitude.

The scan is substantially linear.

Input signals of the order of a few volts are sufficient to produce an undistorted time-base output. "Conversion factor" of several thousands.

The influence of the output electrode potential on the negative output electrode current is negligible.

9. The Signal Converter as a Linear Time-Base Generator. Cathode-ray Oscillograph using a Signal Converter

Previously, especially in Sections 3 and 6, chief emphasis was laid on the signal conversion, i.e., that an arbitrary signal may be converted into its own time base. While this is of major significance in television, and is also of importance in certain oscillograph applications, where the investigation of a part only of each complete cycle is sufficient, for most oscillographic investigations it is required to view several complete cycles of the signal. For this purpose the signal converter is used in a self-generator circuit.

Fig. 14 shows a self-generator circuit of which the mode of operation is particularly easy to visualise. Time-base output potentials of the form shown in Fig. 14*d* are generated across the output condenser C and are synchronised by the input signals (Fig. 14*b*) applied to the deflection plate P_1. C may be only the capacitance of the deflection plates of the cathode-ray tube. The operation of the circuit is as follows. The electron image is so adjusted that it falls on the negative part X of the output electrode,* across which it oscillates under the influence of the input signals applied to P_1, as shown in Fig. 14*c*. The output electrode thus charges negatively, thereby producing the "scan" of the time base, as shown in Fig. 14*d*. A fraction of the negative potential thus imparted to the output electrode is fed through the variable condenser C_2 on to the deflection plate P_2. This causes the electron image to move progressively across the negative part of the output electrode towards

* This assumption is made for the sake of clarity of the description; the beam may fall on either of the two halves X and Y at the start of the oscillations.

the positive portion Y, as seen in Fig. 14c. When this deflection is sufficient, the electron image reaches the part Y of the output electrode; in Fig. 14c this occurs at the end of the fourth cycle. The negative charging of the output electrode then ceases im-

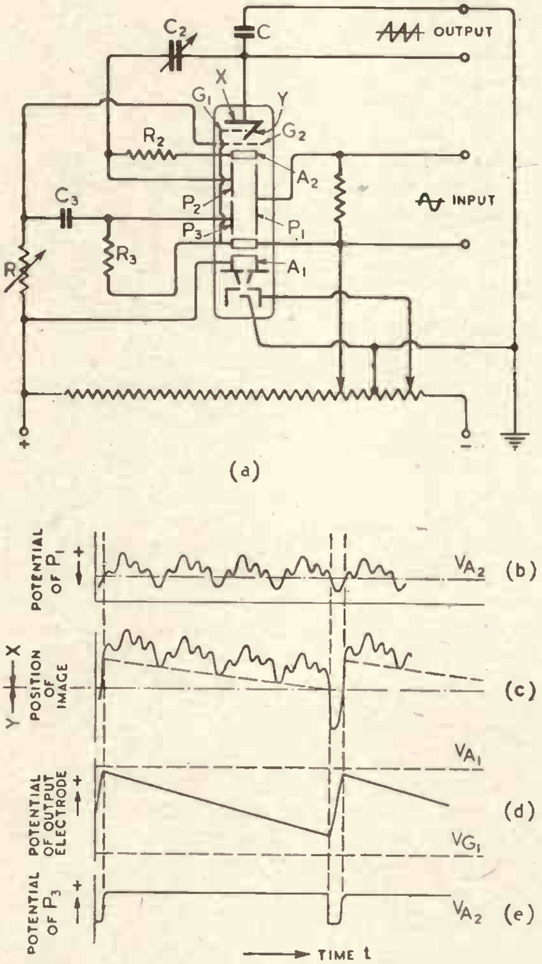


Fig. 14.—*The circuit* (*a*) *and the mode of operation* (*b, c, d, e*) *of a converter when employed in a cathode-ray oscillograph.*

mediately, and the output electrode begins to charge rapidly in a positive sense, thereby producing the fly-back portion of the time base. This would result in the electron image being deflected back on to the negative half X (actually—disregarding the effect of the time constant C_2R_2—the beam would tend to settle down into the symmetrical position in which the charging of X and Y is equal and opposite), but when the electron image begins to fall on Y, numerous secondary electrons are emitted which are collected by the screen G_2; this causes a fall of potential across the resistance R which is imparted to the deflection plate P_3 via C_3, thereby deflecting the electron image further on to the positive part Y. This negative signal due to the screen current remains substantially constant until either the output electrode reaches the potential of the screen G_2 or the beam leaves the part Y due to the increasingly positive potential of P_2; the potential of P_3 is shown in Fig. 14e. When this potential "kick" on P_3 ceases, the electron image is "kicked back" on to the negative part X, and the whole process is repeated from the start. The authors prefer to call G_2 the "kicking screen"; it contributes the essential factor in the production of the oscillations. Briefly, the image moves slowly towards the part Y, when it reaches Y then G_2 kicks the image over to, say, the centre of Y, the image then slowly returns towards the edge of Y, and when G_2 stops collecting current it kicks the image back on to the member X.

It was found that C_2 is not essential; the slow return of the image may be controlled by the time constant of C_3R_3.

The oscillations produced are extremely well defined, the "kicks" being very fast, as seen from the "top curves" in Fig. 13d, e and f, which show oscillograms of the time-base output and the "kicking" and "slow return" potentials at the deflection plate P_2 (centre) and at the screen G_2 (bottom). Note the satisfactory linearity of the scan and the sharpness of the tips of the "saw-teeth." All oscillograms 13a–f were taken with an oscillograph using a converter as a time-base generator.

The amplitude and the frequency of the time-base output may be controlled by C, i_b, C_3 and R_3. Using the Type I converter the maximum frequency attained by the circuit of Fig. 14 was 400 000 c/s, having an output amplitude of 400 volts peak-to-peak; this corresponds to a "rate of charging of C" of 160 volts/microsecond.

10. The Signal Converter in Television.

From Sections 3, 6 and 8 it will be already apparent that in the signal converter the output time base is automatically synchronised with the input signals. The advantages of the signal converter in television are manifold: great simplification of the television receiver by the elimination of the necessity of separating the synchronising signals from the picture content, and the line and frame synchronising signals from each other, the simplicity and the "wattless" operation of the signal converter itself, the possibility of combining the production of line and frame time bases in one converter; the generation of simplified synchronising signals in the transmitter; and the introduction of multiple interlacing; but the main advantage of the signal converter is the automatic and exact synchronisation in a television receiver. This is clearly seen if a brief comparison is made of the method of synchronisation provided by the signal converter with that provided by a conventional synchronising circuit.*

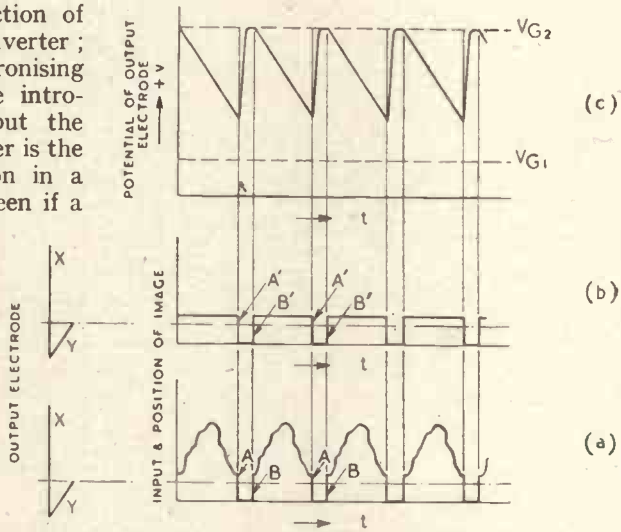


Fig. 15.—*The relation between the output of a converter and the synchronising signals of a television picture signal.*

A standard broadcast television signal is of the form shown in Fig. 15*a*. According to conventional practice in the television receiver the received signal is passed through a sync.-separating circuit, from which a signal of the form shown in Fig. 15*b* is obtained. The edges *A'* and *B'* of the synchronising signal thus obtained correspond to the edges *A* and *B* of the received signal. The time-base signal required to produce the scan of the television receiver is produced by a time-base generator, for example, by a gas-filled triode circuit as described in regard to Fig. 1. As was pointed out the fly-back of the time-base generator is actuated by the leading edge *A'* of the synchronising signal. The scan of the generator commences when the fly-back is complete. To produce good synchronisation the scan of the generator requires to be accurately synchronised with the start of the picture component in the received signal, which corresponds to the trailing edge *B'* of the synchronising signal. In order to achieve this, three conditions must be fulfilled: (1) At the transmitting side the width of the transmitted synchronising pulses (between *A* and *B*) must be constant; (2) At the receiving side the fly-back time must be constant; (3) At the transmitting side, in order that the scan, and therefore the fly-back, of the receiver should be constant, the time interval between the leading edges *A'*–*A'* of consecutive sync. pulses must be constant. These conditions are very exacting, and make accurate interlacing, particularly multiple interlacing, almost impossible to achieve.

When the signal converter is employed, the scan of the time-base output automatically starts in synchronism with the *trailing edge B* of the received sync. signal. All three of the above conditions therefore cease to be necessary, and exact synchronisation is automatically ensured. This principle marks a fundamental advance in the method of synchronising a time-base signal with any given periodic signal.

As was pointed out in Section 8, and is also apparent from Fig. 15*a*, the television signals may change their amplitude within wide limits, the picture content may alter its shape in any required manner, but as long as the sync. signal falls on the positive part *Y* of the output electrode of the signal

* See also synchronisation of conventional time base in Section 2.

converter and the rest of the signal on the negative part *X*, the time-base output is constant and is not affected by any of these changes. Thus the sync.-separation is not necessary. This " automatic sync.-separation " of the signal converter cannot fail as long as the d.c. component of the television signal applied to the deflection plate of the signal converter is retained.

the cathode-ray tube of the television receiver, then the potential applied to the plates at the beginning of each scan is V_{G_2} so that each scan starts at exactly the same level. It is of fundamental importance to realise that the scan and sync. signal periods may change considerably during the transmission of a picture, but as long as the synchronising period is longer than the time interval which is necessary for the output electrode to reach the potential level of G_2, the picture is accurately synchronised. If the variations of scan and fly-back periods are large the edges of the picture may be ragged, but the details of same will be well preserved.

The great complexity of the sync.-impulse generating system adopted in television transmitters[18, 19] should not be necessary using signal converters on the receiver side.

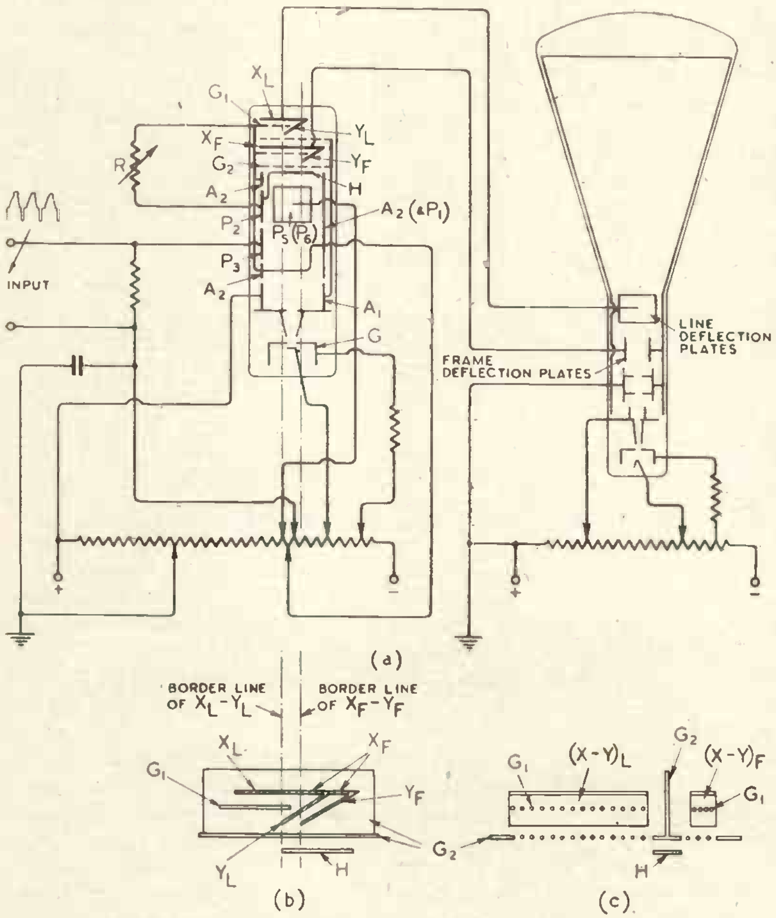
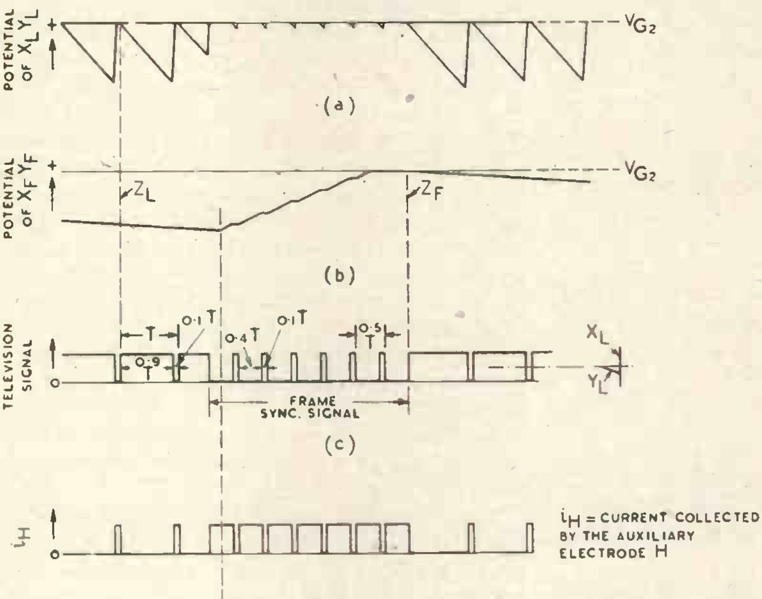


Fig. 16.—*Combination of the line and frame time bases in one converter. The circuit (a) and the construction of the double output electrode system (b).*

In contradistinction to the shape and the level of the time-base output of the converter-generator circuit of Fig. 14*d*, the time-base output of Fig. 15*c* of the pure converter circuit is trapeze shaped ; during the fly-back the output electrode always reaches the potential of the screen G_2, and stays there till the commencement of the scan. If the potential of the output electrode is applied directly to the deflection plates of

Fig. 16*a* shows a circuit in which the line and frame time bases for a television cathode-ray tube are produced in one signal converter. The line time base is produced on the output electrode X_LY_L, while the frame time base is produced on the output electrode X_FY_F. In Fig. 16*a* the line output electrode is shown diagrammatically lying above the frame output electrode. This is purely for convenience of representation ; in reality the line output electrode would lie in front of, or behind, the frame output electrode. The line of division between the X and Y portions of the line output electrode is, however, laterally displaced relative to the corresponding line of division of the frame output electrode. This is shown in Fig. 16*a* and also in Fig. 16*b*, which shows a section through the line output electrode, with the position of the line of division of the frame output electrode indicated. Fig. 16*c* shows a section through both output electrode systems taken at right angles to the section shown in Fig. 16*b*. A single electron image, in the form of a long line, falls on both line and frame output electrodes.



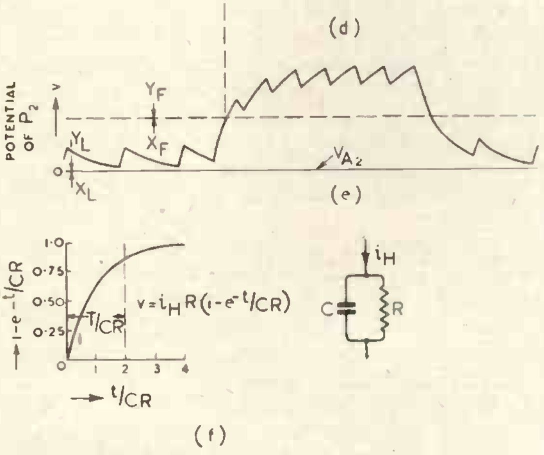


Fig. 17.—*The line (a) and frame (b) time-base output, when a double interlaced conventional television standard (c) is converted; the current of the auxiliary electrode H is given in (d) and the potentials at the deflection plate* P_2.

The circuit of Fig. 16*a* is suitable for use with synchronising signals such as were used during the transmissions from Alexandra Palace. Sync. signals of this type are shown in Fig. 17*c*. The complete television signal, including these sync. pulses, is fed to the deflection plate P_3 (Fig. 16*a*). During the intervals between the sync. pulses the electron beam falls on the negative parts X_L and X_F of the output electrodes, thus producing the "scan" part of the time bases. During the line sync. pulses, the electron image falls on the positive part Y_L of the line output electrode, producing the fly-back of the line time base, but continues to fall on the negative part X_F of the frame output electrode. During the line sync. pulses the image also falls on the electrode H, which collects a constant current i_H, as shown in Fig. 17*d*. Part of this current flows through the resistance R, while part is used to charge the capacitance C constituted by the deflection plates P_1P_2 and any additional condenser parallel to the capacitance of P_1P_2. The potential v across these plates after a time t is given by:

$$v = i_H R\,(1 - e^{-t/CR}).$$

This potential deflects the image towards the positive parts of the output electrodes. The time constant CR is so chosen that the electron image does not reach the positive part Y_F of the "frame" output electrode during the line sync. pulses, but does so during the frame sync. pulses, thus producing the fly-back of the frame time base.

After a sync. pulse has passed, the electron image is again deflected on to the negative parts of the output electrodes, and no longer falls on the electrode H. C then discharges through R, the potential across the plates P_1P_2 after a time t being given by:

$$v = i_B R\,(e^{-t/CR}).$$

The potential changes v across P_1P_2 are shown in Fig. 17*e*, for the convenient value $T/CR = 2$, where T is the line scanning period, i.e., the reciprocal of the line scanning frequency. The potential of the line output electrode is shown in Fig. 17*a*, and that of the frame output electrode is shown in Fig. 17*b*.

The S/P coefficient of the auxiliary electrode H can be smaller or larger than one. In Fig. 16*a* S/P is smaller than one and P_2 charges in a negative sense when the image falls on H.

The speed of the line and frame scanning of the C.R. tube is conveniently controlled by the grid bias of the signal converter changing the beam intensity. The relative speed of the line and frame scans may be adjusted either by shifting the image of the signal converter by the deflection plates P_5P_6 or a pair of magnetic deflection coils or advantageously by a variable condenser parallel to the frame deflection plates of the cathode-ray tube.

As already mentioned, by feeding the synchronising impulses to the control grid G and so biasing it positively during the sync. periods, the speed of the fly-back may be substantially increased. An auxiliary electrode similar to H can serve the same purpose

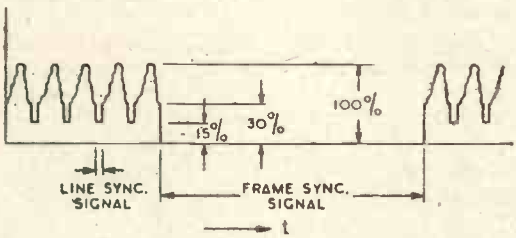


Fig. 18.—*Television synchronising standard convenient for a converter.*

with advantage. For example, the potentials produced across R may be fed to G (Fig. 16) via a condenser (not shown). When the S/P of the surface of H is greater than unity, positive pulses are applied to G during the sync. pulses.

The circuit arrangement of Fig. 16 could be simplified if the line sync. pulses were transmitted at a shallower level than the frame sync. pulses, as shown in Fig. 18. In this case the deflection plate P_2, the resistance R and the auxiliary electrode H are not necessary, since the deeper frame sync. pulses automatically deflect the image on to the positive part Y_F of the "frame" output electrode.

The main requirement governing the constitution of the frame sync. pulse of the conventional sync. signal standard of Fig. 17*c* was the desirability to keep the line time base in step during the frame sync. pulse and assure the double interlacing; these complexities are not required when a signal converter is employed and the very simple sync. standard of Fig. 19, for example, would ensure the accurate synchronisation of a quadruple interlaced picture. If the time periods of the "interlacing pulses" T_i are kept within the required tolerances the picture will interlace correctly. Fig. 19 may be followed with ease on the basis of the explanation given for Figs. 16 and 17.

Even higher multiple interlacing can be achieved simply if desired.

The television applications of the signal converter described in the preceding pages are capable only of producing an asymmetrical deflection, i.e., the potential variations of the output electrode are applied to one deflection plate only, while the opposite plate is kept at a constant potential. As is well known, an asymmetrical deflection produces trapezoid distortion and defocusing of the image of the cathode-ray tube unless the deflection system is screened and corrected.

The output of the signal converter may be applied in a symmetrical manner to the deflection plates of the cathode-ray tube either by the use of two conventional amplifiers or by a special and corrected output electrode system.

In the former case the output of the signal converter is applied in opposing phases to the grids of two identical amplifiers in more or less standard fashion.

In the latter case two output electrode systems are employed, each connected to a separate deflection plate of the cathode-ray tube; the X member of one output electrode is placed next to the Y member of the other output electrode and vice versa, and thus the electron image, which is elongated to fall on both output electrodes, charges the output electrodes and the deflection plates of the cathode-ray tube in opposing sense. One of the output electrodes could be similar to those previously described and the other may be constructed as shown in Fig. 20. Here the member W of the suppressor screen G_1 has a high secondary emission coefficient and is shaped in such a fashion as to trap the large number of secondary electrons emitted from W, so that they are collected by the output electrode Y; thus the negative charging efficiency of the output electrode is equal to $i_b \cdot S/P$, where S/P refers to W. The positive part Y may be shaped and corrected in accordance with the S/P characteristic, to keep the positive charging current a fraction of the negative charging and constant.

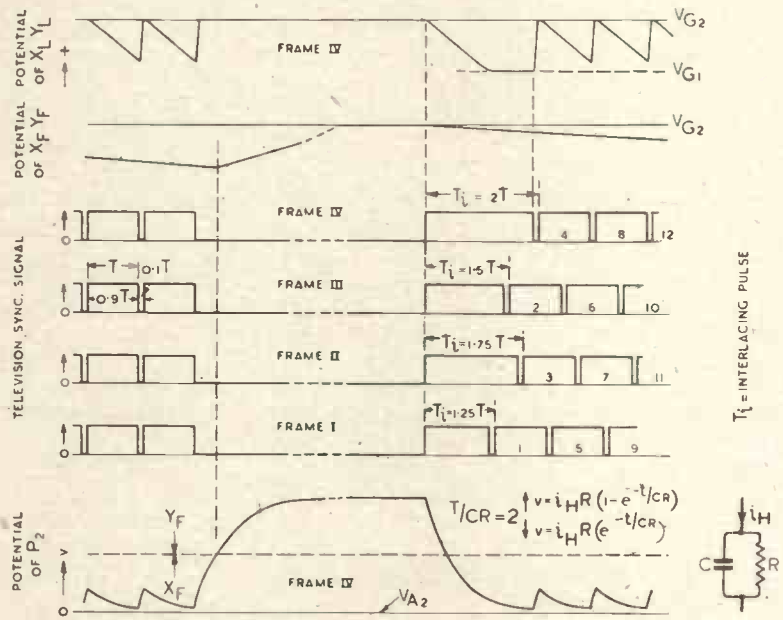


Fig. 19.—*Simple quadruple interlaced television sync. standard and the converter output.*

The adoption of symmetrical deflection using a signal converter introduces complications, but the advantages of accurate synchronisation, elimination of sync. separation, etc., are preserved.

The adoption of an asymmetrical deflection is, however, preferred, because the simplicity of the circuit is preserved, and because the necessary corrections to the deflection plates of the cathode-ray tube are simple.

The essential advantages of the signal converter are also retained when electromagnetic deflection is employed for the cathode-ray tube. Here the output of the signal converter would be applied to a conventional amplifier which is loaded with the deflection coils.

To summarise, it may be stated that by using deflection modulated cathode-ray valves it will be possible to simplify and improve the technique of television transmission and to build high quality and simple television receivers, consisting, for example, of two or three deflection modulated cathode-ray valves as amplifiers, one signal converter for producing and synchronising the time bases, two rectifiers for the supply potentials and one cathode-ray tube.

11. Frequency Limitations of the Signal Converter.

Assuming the peak-to-peak output potential of the signal converter to be 200 volts, the output load 10 $\mu\mu$F and taking the limiting beam current value of the Type I converter ($i_b = 1$ milliampere), the maximum frequency may be calculated

$$f_{max.} \simeq \frac{1 \cdot 10^{-3}}{200 \cdot 10 \cdot 10^{-12}} = 500\,000 \text{ c/s.}$$

Or at 20 volts output $f_{max.} \simeq 5$ Mc/s. Or the "rate of charging" of the output capacitance = 100 volts/microsec.

The Type I and II converters are of small power (see Section 8) and their maximum beam current value does not even approach the highest values which could be obtained with a more elaborate electron optical design. The effective length of the cathode is only 5 millimetres in the Type I converter ; by increasing the length to, say, 30 millimetres, by using several cathodes in parallel, by adopting output electrode systems similar to that of Fig. 20 and a more efficient electron

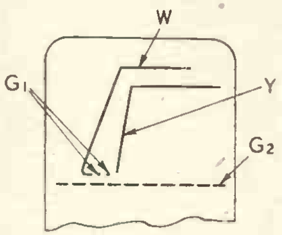


Fig. 20.—*Output electrode system for the efficient charging of the negative part of the output electrode.*

optical focusing system, the beam current of the signal converter may be increased to 100 milliamperes, and thus at 200 volts the maximum frequency would be 50 Mc/s. The frequency limitation in a deflection modulated valve, having similar dimensions and potentials to Type I converter, due to the transit time of the electrons between the deflection plates, is above 50 megacycles per second ; the transit time effect of the output electrode, the collector and suppressor screens is of lesser significance than the above.

12. Output Potential Limitations of the Signal Converter

The maximum output-time-base peak-to-peak potential attainable is determined by the critical potential V_2 (see Section 4 and Fig. 3) of the secondary emissive surface of the output electrode. This may be as high as 3000 volts, but nearly all the efficient secondary emitters have a V_2 which is at least of the order of 2000 volts.

13. Acknowledgments

The authors wish to express their gratitude to Sir Henry White-Smith, C.B.E., and Mr. Alfred Geoffrey Turner, who have for many years generously supported the television research work which was the basis of the conception of the subject-matter of this paper.

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APPENDIX

It will here be shown that the power of a "cylindrical" electron lens for paraxial electrons is twice the power of a "spherical" electron lens which has the same axial distribution of potential as the cylindrical electron lens.

Laplace's Equation for a non-polar electrostatic field, expressed in cartesian co-ordinates, is :

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0$$

where V is the potential at point (x, y, z).

For a spherical electron-optical system, i.e., a system in which the electrostatic field has axial symmetry, we transform to cylindrical co-ordinates, writing :

$$r^2 = x^2 + y^2.$$

Laplace's Equation then becomes :

$$\frac{\partial^2 V}{\partial r^2} + \frac{1}{r}\frac{\partial V}{\partial r} + \frac{\partial^2 V}{\partial z^2} = 0 \qquad \ldots \qquad (1)$$

the z-axis being taken as the axis of the electron lens.

For a cylindrical electron-optical system, i.e., a system in which the electrostatic field has a uniform potential in one direction at right angles to the axis of the electron lens, say, in the direction parallel to the x-axis, we retain cartesian co-ordinates, and write :

$$\frac{\partial V}{\partial x} = 0.$$

Laplace's Equation then becomes :

$$\frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0 \qquad \ldots \qquad \ldots \qquad (2)$$

From Eq. (1) it can be shown that the path of a paraxial electron through a "spherical" electron lens is given by :

$$\frac{d^2r}{dt^2} = -\frac{r}{2}\frac{e}{m}V''_0(z) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$\left(\frac{dz}{dt}\right)^2 = \frac{2e}{m}V_0(z) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where (r, z) are the co-ordinates of the position of the electron at time t, $-e$ is the charge and m is the mass of an electron, and $V_0(z)$ is the potential on the axis of the lens at the point $(0, z)$ measured relative to the point where the electron velocity is zero; $V''_0(z)$ signifies

$$\frac{\partial^2 V_0(z)}{\partial z^2}.^*$$

In the same way it may be shown that the path of a paraxial electron through a cylindrical electron lens is given, from Eq. (2), by:

$$\frac{d^2y}{dt^2} = -y\frac{e}{m}V''_0(z) \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$\left(\frac{dz}{dt}\right)^2 = \frac{2e}{m}V_0(z) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Equations (3) and (5) give respectively:

$$d\left(\frac{dr}{dt}\right) = -\frac{r}{2}\frac{e}{m}\frac{V''_0(z)}{\frac{dz}{dt}}dz \quad \ldots \quad \ldots \quad (7)$$

and

$$d\left(\frac{dy}{dt}\right) = -y\frac{e}{m}\frac{V''_0(z)}{\frac{dz}{dt}}dz \quad \ldots \quad \ldots \quad (8)$$

Consider a small section of the electrostatic field between z and $z + dz$.

Let the power of the elementary electron lens constituted by this section of the field be dF; the power of a lens is the ratio of the refractive index in the image space to the focal length in the image space,† the refractive index for an electron lens being the square root of the electrostatic potential, measured relative to the point where the electron velocity is zero. We may therefore write:

$$dF = \frac{\sqrt{V_0(z)}}{f'z} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

where f'_z is the focal length of the electron lens constituted by the electrostatic field between z and $z + dz$.

Consider an electron which enters this field moving parallel to the axis:

i.e. $\frac{dr}{dt}$ or $\frac{dy}{dt} = 0$ at z.

Then for this electron the value of $\frac{dr}{dt}$ or $\frac{dy}{dt}$ at $z + dz$ is given by Eq. (7) or Eq. (8):

$$\frac{dr}{dt} = -\frac{r}{2}\frac{e}{m}\frac{V''_0(z)}{\frac{dz}{dt}}dz$$

or

$$\frac{dy}{dt} = -y\frac{e}{m}\frac{V''_0(z)}{\frac{dz}{dt}}dz$$

* See I. G. Maloff and D. W. Epstein, "Electron Optics in Television," First Edition, page 81.

† See L. C. Martin, "An Introduction to Applied Optics," Vol. I, page 34.

The angle θ which this electron makes with the axis after leaving this elementary electron lens is:

$$\theta = -\frac{dr}{dz} = -\frac{\frac{dr}{dt}}{\frac{dz}{dt}} = \frac{r}{2}\frac{e}{m}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz$$

or

$$\theta = -\frac{dy}{dz} = -\frac{\frac{dy}{dt}}{\frac{dz}{dt}} = y\frac{e}{m}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz$$

Then

$$f'_z = \frac{r}{\theta} = \frac{1}{\frac{1}{2}\frac{e}{m}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz}$$

or

$$f'_z = \frac{y}{\theta} = \frac{1}{\frac{e}{m}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz}$$

Then by Eqs. (9) and (4):

$$dF = \frac{1}{2}\frac{e}{m}\sqrt{V_0(z)}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz$$

$$= \frac{V''_0(z)}{4\sqrt{V_0(z)}}dz$$

for a spherical electron lens; or by Eqs. (9) and (6):

$$dF = \frac{e}{m}\sqrt{V_0(z)}\frac{V''_0(z)}{\left(\frac{dz}{dt}\right)^2}dz$$

$$= \frac{V''_0(z)}{2\sqrt{V_0(z)}}dz$$

for a cylindrical electron lens.

Hence it is seen that the power of any elementary electron lens forming part of a cylindrical electron lens with a given axial distribution of electrostatic potential is exactly twice the power of the elementary electron lens forming the corresponding part of a spherical electron lens having the same axial distribution of electrostatic potential. It follows that the total power of any cylindrical electron lens must be twice the power of the spherical electron lens which has the same axial distribution of electrostatic potential.

I.E.E. Wireless Section

THE Committee of the Wireless Section of the Institution of Electrical Engineers has nominated the following to fill the vacancies which will occur on the Committee on September 30th: Chairman, T. E. Goldup (Mullard); Vice-Chairman, Prof. Willis Jackson, D.Sc., D.Phil. (Manchester University); Ordinary Members, Capt. C. F. Booth (Post Office Engineering Dept.), H. L. Kirke (B.B.C.), O. S. Puckle (Cossor), T. Wadsworth, M.Sc. (B.T.H.), R. C. G. Williams, Ph.D. (Murphy).

Harmonic Generator for Frequencies Above 100 Mc/s.*

By W. M. Colles, M.A.

EXPERIMENTS at frequencies of from 100 to 400 megacycles per second carried out during 1938–39 mainly with super-regenerative receivers showed that some simple means of determining frequency was essential. The frequency range of one receiver, for instance, was some 10 Mc/s at 300 Mc/s, without coil changing, and it will be appreciated that the alignment of a transmitter and receiver under these conditions would be extremely difficult without some frequency meter.

Experiments with Lecher lines were tried and were partially successful, but had the

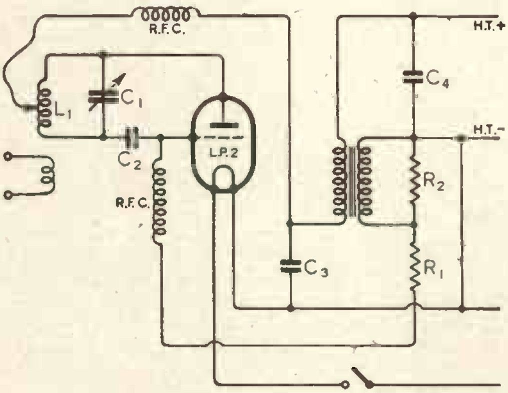


Fig. 1. *Circuit of the harmonic generator. The component values are:* C_1, 100 $\mu\mu F$; C_2, 0.0001 μF; C_3, 0.006 μF; C_4, 2 μF; R_1, 10,000 – 50,000 Ω *(optimum value found by trial)*; R_2, 200,000 Ω *(see text)*; L_1, 12¼" *of 16 S.W.G. copper wire coiled 1" diam. (length of coil 1.375")*; *R.F.C.*, ½ *mean wavelength of 22 S.W.G. enamelled wire on* ½" *diam. ebonite rod, close wound. The 5 : 1 L.F. transformer is selected for tone and stable note.*

drawback of requiring considerable space and a certain amount of power in the oscillating circuits employed.

Some time previously a simple I.C.W. transceiver† for 56 megacycles per second had been made using an LP2 valve with anode and grid circuits coupled by an ordinary L.F. transformer to produce an audible interrupted carrier for C.W. communication with a super-regenerative receiver. It was found that the R.F. output was extremely rich in harmonics and the instrument was modified to enable these to be used for frequency checking.

The procedure followed was to switch on the receiver whose frequency was to be checked, and turn the dial of the harmonic generator, recording the frequencies at which harmonics were heard.

An example is given below.

H.G. Dial	Frequency of Fundamental	Frequency of Harmonics			
Degs.	Mc/s				
18	63·0	6th	378	7th	441
29	54·8	7th	382	8th	438
37·5	49·6	8th	398	9th	446
49	44·1	9th	396	10th	441
61·5	40·1	10th	401	11th	441
72·0	36·8	11th	405	12th	442

The lower series is rising hence the higher series is the correct one, and the mean frequency is roughly 441 Mc/s. If the next series is calculated it will be found to fall. This is best shown graphically. This was the highest frequency ever recorded during these experiments, and the instrument being checked was actually a low-power transmitter adjusted to "squeg" with a high-resistance grid-leak and anode bypass condenser, using a P.M. moving-coil loudspeaker in the cathode circuit. While some frequency change in the carrier is probably produced by the "squegging" circuit it

* MS. accepted by the Editor, December, 1942.

† This term is widely used in the Services to denote a transmitter-receiver in which some of the components are common to both sets.

was under one per cent. and well within the frequency range of any receiver used with it.

The circuit of the harmonic generator is given in Fig. 1 and has few abnormal features. The frequency range must exceed an octave or identification of the lower frequencies is not exact. This requires the R.F. circuit to be arranged for a low self-capacitance, and the valve used should be selected by trial and error.

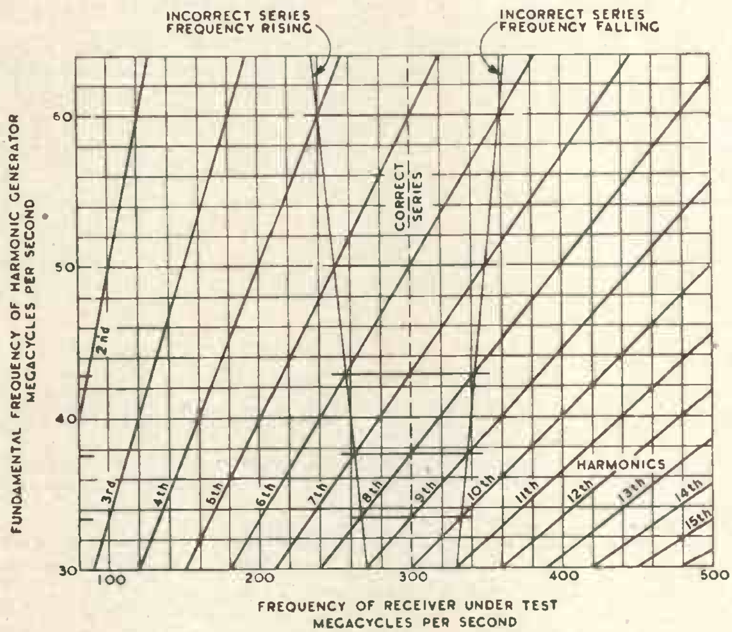


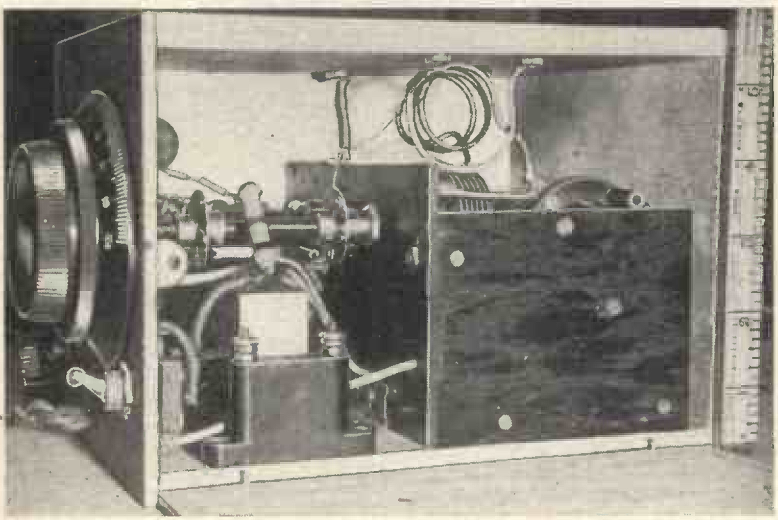
Fig. 2. *Assume receiver under test to be tuned to 300 Mc/s. Then harmonics will be heard as shown by the horizontal lines. If the wrong series of harmonics is chosen, the values obtained will not vary about a mean but steadily rise or fall as shown. In practice observational errors introduce other factors, and the rising or falling characteristic is of value in checking that the correct series is used.*

The instrument when completed covered the range 30 to 71 megacycles per second using a 100 $\mu\mu$F tuning condenser.

The loading resistance R_2 on the secondary of the L.F. transformer was found necessary to reduce the A.F. feedback at the H.F. end of the frequency range.

If omitted the plates of the tuning condenser flashed over when using 120 volts 15 mA for anode supply. Presumably the carrier and harmonic vectors were in phase when this occurred.

The illustration shows the inductance and coupling used to connect the oscillator to the Lecher line for calibration purposes. The power supply was obtained from a



The illustration shows certain components not mentioned in the article. These are parts of the original transceiver and are not required when the instrument is used as a harmonic generator. The send-receive switch, part of the key filter circuit, and the aerial connection can be seen.

120-volt battery and a partially discharged 2-volt accumulator, the H.T. voltage being kept at a constant value of 90 during calibration and when checking frequency.

The accuracy of the instrument is dependant on the selectivity of the receiver under test. With super-regenerative receivers at these frequencies selectivity is very poor and appreciable response may be obtained over a band some 600 kc/s in width. It should be noted that as the frequency increases the number of observations on harmonics increases and hence the overall accuracy remains the same. No loss of strength in the harmonics was noticed even when using the twelfth, and there is no reason to expect absence of higher harmonics. The mechanical arrangement of the dial and drive of the tuning condenser must be of good design and with little backlash or the accuracy will be impaired.

The instrument was originally calibrated on 60-feet Lecher lines using a thermo couple instrument. The values obtained were used to draw a rough calibration curve from which the frequency of a 300 Mc/s receiver was determined. Any departure of the harmonics observed from the mean value of the whole series was then subtracted from the fundamental frequencies as given by the rough calibration curve mentioned above, and an accurate curve drawn using these values.

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.

"Optimum Conditions in Class A Amplifiers"

To the Editor, "Wireless Engineer"

SIR,—While agreeing with your remarks in the February issue, which have caused me to re-read Nottingham's paper, I find that the latter rather gives the impression that harmonic distortion is not readily amenable to calculation. Another point that is not clear is to what extent, if any, the remarks are intended to apply to pentodes. I shall assume with good reason that tetrode or pentode operation is excluded, and the following remarks are intended to apply to triodes only, and demonstrate the effect of increasing load.

The actual powers on the first few harmonics resulting from Class A amplification are quite easily calculated. The results will be found perhaps more striking than anything that graphical methods can demonstrate. Allow me to start by quoting some figures from a recent paper.

Consider a triode having an impedance of 5000 Ω, a standing anode current of 30 mA at the operating point, and let this triode be swung all the way from cut-off to zero grid bias. Except for one illustration given later, the value of the exponent n of the power law connecting current and lumped voltage V_l is 3/2, so that the value of V_l corresponding to the above conditions is 5.5 volts, the mutual conductance 8 mA/V, amplification factor 40 (all in round numbers) if the cathode grid distance is 0.316 m/m. Assuming the lumped voltage at zero grid bias is 8 volts the anode supply is some 320 volts, the operating grid bias of course varying according to conditions of load. From equations (15) of the paper it may be seen or inferred that the alternating components of both anode current and power output (on any harmonic including the fundamental) depend only on the standing anode current and on the respective impedances and not at all on the input voltage provided the latter is always made equal to V_l. The power outputs on the fundamental, second and third harmonics respectively are as follows when the grid swing extends from cut off to zero grid and the load impedance (assumed purely resistive) is equal to that of the triode:

$$W_1 = 1293 \text{ mW} \qquad W_2 = 1.235 \text{ mW}$$
$$W_3 = 0.0134 \text{ mW}$$

from which we infer that the second harmonic is some 30 db. (and the third harmonic some 50 db.) down on the fundamental.

Now having regard to side-tone formation [1] these conditions are by no means as rosy as they sound. But what happens if, instead of making $z = r_p$ ($R = r_a$ in present notation) we make z/r_p exceed unity? The following figures provide the answer:

z/r_p	W_1	W_2	W_3
2	1150 mW	0.217 mW	0.00150 mW
3	970	0.055	0.00027
4	827	0.020	0.000067
6	633	0.004	0.000007
9	465	0.0007	0.0000005

For certain designs of triode figures should perhaps be based on a square rather than three-halves law. The effect of this is pronounced as affecting the 3rd harmonic*, which must be multiplied by 3.2 for $z/r_p = 1$, by 4.0 for $z/r_p = 2$, and

[1] *Proc. I.R.E.*, Vol. 26, No. 9, pp. 1093, 1938.

* The once popular idea that a parabolic characteristic does away with third harmonic cannot be sustained—the load upsets the square law relation.

by 6.0 for $z/r_p = 9$, but even if allowance has to be made for these possibilities the results as exhibited in the above table are still very striking. Taking $z = 3r_p$ as example, whereas the fundamental output is only some 1.3 db. down as compared with $z = r_p$, the second harmonic is so reduced as now to be 42 db. down and the third 65 db. down on the fundamental, while for $z = 9r_p$ the second and third harmonics are down 58 db. and (practically) 90 db. respectively.

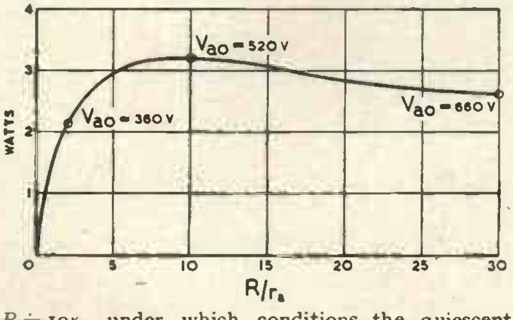
In view of the exceptional purity that can evidently be obtained using a triode in conjunction with a load impedance many times that of the valve, it would seem desirable that the pentode's pre-eminent position as an output valve in commercial receivers should be critically challenged. The limited range of output impedance which is destined to "match" the pentode is well known, less well known (because vested interests have kept it quiet) is the degree of side tone distortion[2] which results even if the optimum impedance matching condition is satisfied. There seems to my mind no question but that the issue for quality output now rests between triode output (single or push-pull) on the one hand and cathode follower circuit[3] on the other hand, pentodes being out of the reckoning, even for receiving sets.

W. E. BENHAM.

Fordcombe, nr. Tunbridge Wells.

To the Editor, "Wireless Engineer"

SIR,—When the condition of a limiting safe anode dissipation is added to the original conditions concerning $V_g = O$ and I_{min}, the relationship between load resistance and output power becomes peculiar to each valve considered. Not only the scale, but the shape of Fig. 5 in the February Editorial is changed if other operating conditions are assumed. This is shown if a valve is taken with $r_a = 1{,}700$ ohms, $\mu = 5.3$, $\epsilon = 85$ volts as before, but with $P_{am} = 20$W and I_{min} estimated at 20 mA. The calculated values of power output for various values of load resistance given here show that maximum power occurs at



$R \doteq 10r_a$, under which conditions the quiescent anode voltage is about 520 volts. It is, therefore, conceivable that cases may exist where the choice of R for maximum power output will not lead to a value of V_{ao} in excess of the rated value, as it does in the example worked out in the Editorial.

E. BRADSHAW.

The Royal Technical College,
Glasgow.

[2] Harries, "Amplitude Distortion," *Wireless Engineer*, Vol. 14, p. 63, Feb., 1937.

[3] Lockhart, "Cathode Follower Circuits," *Electronic Engineering*, Dec., 1942 and Feb., 1943.

"Transformed Networks"

To the Editor, "Wireless Engineer"

SIR,—The author of the article "Transformed Networks" (October, 1942), whilst giving the medium frequency of his illustrative band-pass filter (Fig. 1) $f_m = 2000$ c/s, omitted to indicate the actual frequency limits of the filter. They are also not very apparent on the attenuation characteristic (Fig. 3) due to the rather high inherent losses of the filter in the band-pass region.

However, when substituting the values of the components, as given by the author, in the classical formulae and calculating backwards, one finds that the formulae will satisfy all the author's values for $f_2 - f_1 = 320$ c/s, or $f_2 = 2160$ c/s and $f_1 = 1840$ c/s, except C_q for which the value 4.976 μF is obtained instead of 6.37 μF as found by the author. There is also a slight discrepancy in the value of L_q which should be 1.27 mH instead of 1 mH.

Haifa, Palestine. Z. FRIEDBERG.

[The last few lines of the above letter are rather misleading. The resonant frequency is 2000 c/s and if the capacitance be reduced from 6.37 μF to 4.98 μF as suggested, the inductance must necessarily be increased from 1.0 mH to 1.27 mH. No additional discrepancy is involved. The author stated that the filter was designed to have a bandwidth of 200 c/s, and from the data given this was undoubtedly an ideal value based on coils and condensers with negligible losses. As our correspondent states, the losses in the actual filters caused a widening and some indefiniteness in the pass-band. —G. W. O. H.]

Dipole Aerials

To the Editor, "Wireless Engineer."

SIR,—I was very interested in Mr. Wells' paper on dipole aerials in the May issue of *Wireless Engineer*. On page 225, when referring to Fig. 13 (*b*), actually he means Fig. 13 (*a*), the author states that the curve in this figure can be derived from results given in a paper by Lewin in *Marconi Review*. The curve, however, for a slightly smaller range of distances, is given directly as Fig. 409 in the second edition of Terman's well-known text book. The expression given in Appendix 1 for F_θ should be divided by sin θ. The correct expression is given in Mr. Wells' earlier paper in the *Journal I.E.E.* to which he refers.

I should like to suggest that the references in Mr. Bell's article on frequency modulation, in the May issue, might have included the names of the authors.

J. S. McPETRIE.

Teddington, Mddx.

D

Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

550 146.—Means for increasing the input impedance of a two-pass filter to secure a higher product of bandwidth and amplification factor.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 29th July, 1941.

550 171.—Amplifier with negative feed-back circuit designed to avoid the production of harmonic or combination frequencies.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 23rd May, 1941.

550 362.—Granulated carbon microphone to be operated by direct contact with the throat of the speaker.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 9th September, 1941.

550 468.—High-power amplifier comprising a number of push-pull stages connected in tandem with negative feed-back and automatic gain control.

Western Electric Co., Inc. Convention date (U.S.A.), 21st December, 1940.

AERIALS AND AERIAL SYSTEMS

550 009.—A short-wave aerial comprising a number of horizontal four-sided radiating units mounted one above the other on a vertical steel shaft.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.), 25th September, 1940.

550 537.—Dipole aerial for television terminating in an impedance-matching disc.

Marconi's W. T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.), 10th July, 1940.

DIRECTIONAL WIRELESS

549 847.—Combination of radio direction-finder with a gyroscopic compass for facilitating the operation of homing on to a beacon or for blind landing.

Lear Avia Inc. Convention date (U.S.A.), 11th January, 1940.

550 013.—Radio-navigational indicator arrangement to facilitate homing in the presence of a cross-wind.

Lear Avia Inc. Convention date (U.S.A.), 15th May, 1940.

550 131.—Radio direction-finding system in which the critical null or zero position is automatically sought and smoothly maintained.

Lear Avia Inc. Convention date (U.S.A.), 27th July, 1939.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television.*)

550 091.—Coupling or filter circuit which can be switched to show different band-pass characteristics, particularly for the I.F. amplifier of a superhet receiver.

Hazeltine Corporation (assignees of B. F. Tyson). Convention date (U.S.A.), 8th October, 1940.

550 340.—Electron-multiplier circuit, particularly for amplifying pulse modulated currents.

Electrical Research Products Inc. Convention date (U.S.A.), 15th August, 1940.

550 566.—Means for automatically stabilising the frequency of an oscillation generator particularly in a superhet receiver.

Standard Telephones and Cables and C. W. Earp. Application date, 11th July, 1941.

550 586.—Electron multiplier adapted to serve as the mixer stage of a superhet receiver.

F. J. G. van den Bosch and Vacuum-Science Products. Application date, 7th May, 1941.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION.

549 890.—Television transmitter in which the image of each picture element is first distorted unilaterally in order to increase the electron emission from a sensitised cathode and is then restored to its original shape.

Standard Telephones and Cables (assignees of H. E. Ives). Convention date (U.S.A.), 24th September, 1940.

550 376.—Television transmission system in which the line scanning frequency is derived from the direct illumination of a photo-electric cell.

Marconi's W. T. Co. (assignees of J. W. Cox) Convention date (U.S.A.) 1st November, 1940.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television.*)

550 094.—Circuit with non-linear characteristic, under the influence of a pulsed control, for expanding the volume range of electric oscillations.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th October, 1941.

550 127.—Wave guide of tapered cross-section for simultaneously handling signals of different frequencies.

Marconi's W. T. Co. (assignees of M. Katzin). Convention date (U.S.A.), 12th December, 1940.

550 430.—Morse keying device for automatically transmitting the SOS or other emergency call.

R. A. Rothermel; F. S. S. Wates; International Marine Radio Co.; and W. H. McAllister. Application date, 15th August, 1941.

550 554.—Frequency - modulating system with means for compensating for the asymmetry of the modulating voltage.

Marconi's W. T. Co. (assignees of M. G. Crosby) Convention date (U.S.A.), 26th September, 1940.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

550 016.—Valve having an inter-electrode spacing specifically calculated to reduce transit-time effects when amplifying very high frequencies.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 6th June, 1941.

550 032.—Process for making or rolling indirectly-heated cathodes of small diameter.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 23rd August, 1941.

550 067.—Pair of high-frequency valve oscillators with tubular anodes which form part of the valve envelope and are strapped together to form the inductance of the output circuit.

Marconi's W. T. Co. and E. G. Green. Application date, 28th May, 1940.

550 081.—Electronic device for generating circumferentially-propagated waves from vane-shaped electrodes which produce a region of space-charges subjected to an axial magnetic field.

The British Thomson-Houston Co. Convention date (U.S.A.), 27th July, 1940.

550 090.—Cathode-ray tube fitted with a magnetic system for producing an electron stream having a desired non-circular cross-section.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 11th September, 1941.

550 104.—Electrode arrangement of a valve of the so-called pentagrid-converter type as used for mixing two sets of oscillations.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th June, 1941.

550 318.—Compact construction of photo-electric cell in which a cathode of frusto-conical shape is formed on the re-entrant stem or press of the glass bulb.

The British Thomson-Houston Co. and H. R. Ruff. Application dates, 18th January and 30th July, 1940.

550 342.—Cathode-ray tube in which the electron stream is made to sweep over a number of co-planar insulated strips or anodes in order to generate or modulate a number of different frequencies.

C. J. Galpin. Application date, 8th August, 1941.

550 435.—Short-wave oscillator or amplifier with focusing electrodes for concentrating the electron stream on to two narrow anodes arranged on each side of a central cathode.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 4th September, 1941.

550 497.—Process for improving the insulation of the supports for the electrodes of valves used for voltage-stabilisation.

Marconi's W. T. Co. and C. P. Fagan. Application date, 7th July, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

549 970.—Screening can which also serves to press a valve firmly into position on a base or holder.

Standard Telephones and Cables; L. W. Houghton; and S. J. Holdstock. Application date, 11th June, 1941.

549 996.—Phasing adjustment for a balanced-bridge input circuit to a cathode-ray oscillograph. (Addition to 515 027).

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 14th June, 1941.

550 123.—Piezo-electric device for converting variations of mechanical pressure into variations of potential in accordance with a straight-line law.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 26th November, 1941.

550 130.—Condenser constructed of stacked sheets of dielectric so as to have a predetermined temperature coefficient.

Dubilier Condenser Co. (1925). Application date, 13th June, 1941.

550 193.—Multiplex signalling system utilising frequency modulation.

Marconi's W. T. Co. (assignees of H. O. Peterson). Convention date (U.S.A.), 19th June, 1940.

550 405.—Triggering circuit for producing pulses of the order of microseconds from grid-controlled gas-filled relays.

Standard Telephones and Cables (assignees of F. G. Hallden). Convention date (U.S.A.), 7th September, 1940.

550 409.—Multiplex signalling system with means for preventing the currents in one selective channel from affecting signal channels on adjacent frequencies.

Western Electric Co. (communicated by Western Electric Co., Inc.). Application date, 17th December, 1941.

550 419.—Construction of a condenser comprising stacked strips of insulating material carrying coatings which are mutually interlaced.

Dubilier Condenser Co. (1925) (communicated by W. Dubilier). Application date, 1st July, 1941.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is not necessarily an indication of the importance attached to the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

1621. ELECTROMAGNETIC FIELDS IN RADIO: III [Wave Transmission in Space].—M. Johnson. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 115–118.)

1622. RADIO WAVES IN THE IONOSPHERE [Simplified Explanation of Their Behaviour].—T. W. Bennington. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 96–99.)

1623. RADIO DATA CHARTS—No. 6 [Resonant Length of a Capacity-loaded Quarter-Wavelength Transmission Line].—J. McG. Sowerby. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 106–107.)

1624. SHUNT-EXCITED BROADCASTING ANTENNA.—Banerjee & Tiwari. (*Indian Journ. of Physics*, Oct. 1942, Vol. 25, Part 5, pp. 337–342.) *See* 1684.

1625. ON THE SOLAR CORONA.—H. Alfvén. (*Physik. Berichte*, 15th Sept. 1942, Vol. 23, No. 18, pp. 1739–1740.) Long summary of the paper in *Ark. Mat., Astron. och Fys.*, Vol. 27, 1941, setting out the writer's theories (and their agreement with Edlén's results): *see* also 3504 of 1942.

1626. RESULTS OF OBSERVATIONS OF THE CORONA SPECTRUM OF JUNE 19TH 1936, AT OMSK.—G. Shajn. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Sept. 1940, Vol. 28, No. 9, pp. 778–781: in English.)

Among other points, "no proportionality was observed between the fall of equivalent width of emission lines and the intensity of continuous spectrum with increasing distance from the solar limb. . . This is in disagreement with the result of Grotian, who claimed the proportionality in question, with all the important consequences of this statement." This deviation from proportionality is obviously of high importance from the point of view of the interaction between the atoms or ions responsible for the emission lines and the free electrons responsible for the continuous spectrum. Further, "a careful study of the spectrum of corona in the region 3850–4050 shows, in opposition to Grotian's suggestion, no trace of absorption lines of ionised calcium K and H (Fig. 4). A comparison with the computed theoretical profile leads to a striking discrepancy, and this seems to be *experimentum crucis* of the current theory of absorption lines in the spectrum of inner corona, which are supposed to be due to Doppler's broadening under the influence of thermal velocities of electrons. This is discussed [in the full paper] from the point of view of reconciliation with the hypothesis of non-thermal motion of electrons, and some suggestions are made with respect to the effect of fast electrons."

Finally, "there is an analogy between the coronal and some chromospheric lines (helium, hydrogen) with respect to their variability, their relationships to the continuous background, and perhaps with respect to the delay in the intensity increase with approach to the solar limb (the last holds probably for helium in chromosphere). Basing on this and on the known relationship between the protuberances and the details of coronal structure, as well as on the consideration of the motions and the conditions of excitation, one may assume that a single source (energetic emission of the ultra-violet quanta or of the fast particles) controls the equilibrium, motion, and excitation in the chromosphere, in the protuberances, and in the inner corona."

1627. Fluctuations of Solar Radiation, from the Viewpoint of Terrestrial Magnetism [Relations between Fluctuations of Components (Corpuscular & Short-Wave Radiations) lost in the Atmosphere above 50 km, and the Geomagnetic Elements].—J. Bartels. (*Physik. Berichte*, 1st Oct. 1942, Vol. 23, No. 19, p. 1797 : short summary of brief survey in *Forschungen und Fortschritte*, No. 19/20, Vol. 18, 1942.)

1628. Production, Concentration, and Decomposition of Ozone by Ultraviolet Light. —A. W. Ewell. (*Phys. Review*, 1st/15th Jan. 1943, Vol. 63, Nos. 1/2, p. 65.) Summary only.

1629. On the Influence of Temperature on the Absorption Spectrum of Ozone in the Huggins' Bands [and the Incorrectness of Barbier & Chalonge's Deductions of Very Low Temperatures : etc.]. — E. Vassy. (*Comptes Rendus* [Paris], No. 5, Vol. 214, 1942, p. 219 onwards.) For a summary see *Physik. Berichte*, 1st Oct. 1942, Vol. 23, No. 19, p. 1810, and for later work *see* 989 of April.

1630. Elementary Absorption of Light in Its Passage through Clouds [Calculations based on Methods of Geometrical Optics, neglecting Diffraction Effects: Energy absorbed in Unit Volume of Cloud composed of Droplets all of Radius R is Independent of R and of Number of Droplets, depending only on Total Water Content : Increase or Decrease of Absorption must therefore correspond to a Condensation or Evaporation : etc.].—G. Zanotelli. (*Physik. Berichte*, 1st Oct. 1942, Vol. 23, No. 19, pp. 1809–1810.)

1631. The Nature of the Primary Cosmic Radiation.—M. Schein & M. Iona. (*Phys. Review*, 1st/15th Jan. 1943, Vol. 63, No. 1/2, p. 60.)

Demonstrates, in accordance with previous work, that the main body of the primary cosmic radiation does not consist of electrons. Summary only. Refers to 2356 of 1941.

1632. On the Theory of the Anomalous Reflection of Optical Line Gratings [Wood's Bright Bands].—K. Artmann. (*Zeitschr. f. Physik*, 25th Sept. 1942, Vol. 119, No. 9/10, pp. 529–567.)

These intensity anomalies occur only for one particular direction of polarisation of the incident light, and are traced to the phase-coincidence between an infinite number of multiply-diffracted waves leaving the grating in a tangential direction. The formulae of Rayleigh and Fano, which yield only qualitatively correct values for the intensity-distribution in the neighbourhood of these bands, are replaced by quantitatively correct formulae, which are found to agree satisfactorily with experimental results.

1633. Scattering of Light and Relaxation Phenomena in Liquids [and the Origin of the "Rayleigh Line Background"].—Gross. (*See* 1786.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1634. The Recording of Thunderstorms.—J. Lugeon. (*Bull. de l'Assoc. Suisse des Élec.*, 27th Jan. 1943, Vol. 34, No. 2, pp. 29–43 : in German.)

Survey of work in various countries since 1919 : the Lugeon "Atmoradiograph" (1926 onwards) : the Lugeon-Nobile "Radiomaximograph" (1939) giving the absolute value of intensities : its use in estimating distances : the Lutkin narrow-sector "Radiogoniograph" (1926) and Nobile's improved version (1940 : *see* 1635, below) : thunderstorm classification for Alpine regions : geographical distribution : the "Simpson-Lugeon" theory of the heat thunderstorm : the zone of silence : Swiss recordings in 1940 : appeal to Swiss hydro-electric industry to establish triangle of radiogoniometric stations by adding two more to the central Zurich station : etc., etc.

1635. A Direction Finder for Atmospherics [at the Zurich Meteorological Station].—G. Nobile : Lutkin. (*Bull. de l'Assoc. Suisse des Élec.*, 27th Jan. 1943, Vol. 34, No. 2, pp. 43–46 : in German.)

Referred to in 1634, above. "This apparatus records automatically, with a precision of 1°, the azimuthal directions of the electrical parasites produced by lightning strokes, independently of the distance of the storm, for example over the American coast of the Atlantic. The radiogoniometry of very distant storms is possible even when extremely violent storm centres are in the immediate neighbourhood of the recorder."

1636. Thunderstorm - Warning Service and Thunderstorm Observations of the North-East Switzerland Power Company, Baden ("NOK" Network).—W. Zobrist. (*Bull. de l'Assoc. Suisse des Élec.*, 27th Jan. 1943, Vol. 34, No. 2, pp. 46–49 : in German.)

PROPERTIES OF CIRCUITS

1637. Coupled Resonant Circuits for Transmitters [Derivation of Simple & Useful Relationships]. — N. I. Korinan. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 28–32.)

1638. An Impedance-Matching Transformer [Simple Method for Matching the Antenna to the Transmission Line].—T. A. Gadwa. (*Q.S.T.*, Feb. 1943, Vol. 27, No. 2, pp. 22–26.)

1639. Some Graphical Solutions of Parallel Circuits.—R. C. Paine. (*Electronics*, Dec. 1942, Vol. 15, No. 12, pp. 90, 92, 94, 96, 98, and 100.)

1640. Discussion on "A Contribution to the Theory of Network Synthesis."—(*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 80–82.) The original paper by Whiteman is in *Proc. I.R.E.*, May 1942, Vol. 30, pp. 244–247: *see* 347 of February.

1641. A 3-Resonant-Circuit Transformer.—M. R. Winkler. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 96–100 and 204.)

A two-stage band-pass amplifier having high and variable selectivity with uniform band-pass response embodies a three-resonant-circuit transformer and complementary two-circuit transformer. A simplified procedure for designing suitable transformers of optimum performance is given.

1642. On Ohm's Law.—R. O. Kapp. (*Distrib. of Elec.*, April 1943, Vol. 15, No. 150, pp. 91–92.)

1643. Circuit Calculations [Examples of Graphical Methods for Solving Circuit Problems].—G. W. Stubbings. (*Elec. Review*, 2nd April 1943, Vol. 132, No. 3410, pp. 449–450.)

1644. A General Symbolic Method for the Treatment of Variable-Régime Phenomena in Linear Systems with Concentrated Constants [with Application to Transients in Chains of Coupled Circuits or Filters, etc.].—L. Vallese. (*L'Elettrotecnica*, 10th & 25th June and 10th & 25th July 1942, Vol. 29, p. 238 onwards.)

1645. Reactance Networks with Resistance Terminations [and Their Properties as Filters].—F. S. Purington. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 69–72 and 197, 198.)

1646. Pick-Up Accessories [Design & Construction of Low-Pass Filter & Feeder Unit].—J. Brierley. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 100–103.)

1647. Simple Quartz-Crystal Filters of Variable Bandwidth.—G. Builder & J. E. Benson. (*Wireless Engineer*, April 1943, Vol. 20, No. 235, pp. 183–189.)

The paper discusses methods of varying the bandwidth of commercial receivers using a single quartz crystal in a bridge-balanced circuit, and the calculation of the maximum obtainable bandwidth. One commonly used circuit is shown to be indistinguishable from a confluent band-pass filter which is, however, not directly realisable physically using a quartz crystal. Simple m-derived sections and bridged-T sections are so realisable and provide useful alternative designs.

1648. The Potentiometer Idea in Network Calculation [Elimination of Unnecessary Current Terms in A.C. Voltage Calculations].—H. Stockman. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, p. 85.)

1649. Attenuation and Phase-Shift Equalisers [Semi-Graphical Method of Designing Compensating Networks to obtain Desired Attenuation/Frequency and Phase-Shift/Frequency Curves].—W. Saraga. (*Wireless Engineer*, April 1943, Vol. 20, No. 235, pp. 163–181.)

1650. Existence of Periodic Solutions for Certain Differential Equations.—S. Lefschetz. (*Proc. Nat. Acad. Sci.*, Jan. 1943, Vol. 29, No. 1, pp. 29–32.)

The type of equation considered generalizes the equation for the response of an electrical series circuit with resistance and capacitance (both constant) and an inductor with specified current-flux saturation curve. The existence of periodic solutions for such an equation is proved.

1651. Optimum Conditions in Class A Amplifiers [Letters indicating Simplifications to the Mathematical Analysis & a New Method of Approach].—K. R. Sturley: E. M. Hadfield. (*Wireless Engineer*, April 1943, Vol. 20, No. 235, pp. 181–182.) *See* 1027 of April.

1652. Comparison of Voltage—and Current—[Negative-] Feedback Amplifiers [to Assist in Choosing Type and Quantity required in Particular Circumstances].—E. H. Schulz. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 25–28).

1653. High-Frequency Response of Video Amplifiers.—A. Preisman. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 16, 19, 20, 38, 41, and 45.) To be continued.

1654. Behaviour of a Balanced D.C. Amplifier [Previously Unreported Properties of the Barth Circuit employing the FP54 Electrometer Tube].—R. C. Spencer & LeRoy Schulz. (*Review Scient. Instr.*, Jan. 1943, Vol. 14, No. 1, pp. 10–14.)

1655. De-ionization Considerations in a Harmonic Generator employing a Gas-Tube

Switch.—W. G. Shepherd. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 66–74.)

"A description is given of an experimental investigation of the properties of a thyratron operating as a high-frequency switch in a circuit which permitted the generation of a wide band of harmonics. The experiments indicate that there is an operating frequency below which no difficulties in de-ionization occur and above which stable operation requires that the grid potential fulfil certain conditions. It has been found possible to operate certain standard thyratrons at switching frequencies as high as several hundred kilocycles per second."

1656. Simple Pulse-Generating Circuits [providing Slow D.C. Pulses].—L. E. Greenlee. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 118, 120, 122, and 124.)

1657. Simple Test Oscillator [Practical Uses of the Transitron Oscillator].—A. G. Chambers. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 104–105.)

1658. A Frequency-Modulated Resistance-Capacitance Oscillator.—C.-K. Chang. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 22–25.)

1659. Radio Data Charts—No. 6 [Resonant Length of a Capacity-Loaded Quarter-Wavelength Transmission Line].—J. McG. Sowerby. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 106–107.)

TRANSMISSION

1660. Developmental Work in Micro-Wave Technique [particularly the Writer's "Turbator" Generator for Wavelengths around 10 cm, and Its Advantages over the Magnetron & Klystron].—F. Lüdi. (*Bull. de l'Assoc. Suisse des Élec.*, 18th Nov. 1942, Vol. 33, No. 23, pp. 666–670: in German.)

Applications of decimetric waves:—beam communication, for secrecy: detection of objects: direction and distance determination (by pulse or frequency-change methods): multi-channel communication (substitute for the h.f. cable): etc. Beam aerials. "Q"-meter. Generating methods: the similarity between the oscillation mechanisms of the retarding-field triode, the magnetron, and the klystron. Objections to the magnetron, particularly back-heating and the weight of the magnet necessary to provide the strong field; these do not, however, apply to magnetrons used for reception. Back-heating makes the permissible filament-loading the controlling factor in a transmitting magnetron, in place of the maximum anode-dissipation. The comparative failure of many attempts with water-cooled magnetrons have confirmed this.

The true solution is found by a closer examination of the electron mechanism in the electric and magnetic fields. "The electrons do not describe simple circles: these circles themselves have a forward motion perpendicular to the electric field . . . so that the electron paths become cycloidal (Fig. 7). If a synchronous rotating field is superposed on the radial d.c. field, the 'rolling circles' describe, under the influence of the constant radial and tangential field-components, a small additional movement . . . According to the starting phase of the electrons with respect to the radial component of the rotating field, the mid-points of the 'rolling circles' are either drawn slightly together or apart, with the effect of 'bunching.' Calculation shows that the compression factor is determined by the same quantities as in the klystron, though the distance between the 'bunching' and 'catching' electrodes is arbitrarily great on account of the circular arrangement, so that the building-up currents can be kept small. With accurate construction they may be less than 1 mA. Under the influence of the tangential rotating field, the electron bunches move radially to the anode, so that there is no need to set the magnetic field obliquely: only, or practically only, those electrons which take part in the oscillation move to the anode." The following important consequences are thus obtained: (1) the axial adjustment of the magnetic field prevents back-heating, which is further impeded by the incommensurability of the 'rolling circle' frequency with the natural frequency of the resonant circuit: (2) this same axial adjustment results in the working point lying on the lower bend of the current/voltage characteristic, instead of on the upper bend, near the saturation point, as in the case of the oblique-field magnetron: thus the new arrangement has a low sensitivity to heating-current fluctuations: (3) since the space-charge region is involved, and because of the larger constructional dimensions, oxide cathodes can now be used: (4) because the oscillation frequency is not determined by the "rolling circle" frequency but by its velocity of progression, much lighter permanent magnets can be employed (for instance, 350 instead of 1300 gauss for a 10 cm wave).

A comparison between the control curves (Fig. 8) of a magnetron and a "turbator" shows that the electron mechanism of the latter allows a stable, single-wave oscillation to be obtained, without stabilising devices, with 100 times greater output (some watts). The valve construction is very simple, consisting only of the resonator, two side plates, and a tungsten spiral. Models of transmitters and receivers, made by the Brown Boveri Company, were successfully demonstrated. *See* also 1693.

1661. "Microwave Transmission" [1 mm to 1 cm: Book Review].—J. C. Slater. (*Communications*, Dec. 1942, Vol. 22, No. 12, p. 54.)

1662. Aircraft Wireless [Short-Wave Transmitter].—Windecke. (*Brown Boveri Review*, Dec. 1941, Vol. 28, No. 12, pp. 414–417.)

1663. An Impedance-Matching Transformer [Simple Method for Matching the Antenna to the Transmission Line].—T. A. Gadwa. (*Q.S.T.*, Feb. 1943, Vol. 27, No. 2, pp. 22–26.)

1664. Coupled Resonant Circuits for Transmitters [Derivation of Simple & Useful Relationships]. — N. I. Korinan (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 28–32.)

1665. Frequency Modulation. — Guanella & Schwartz. (*Brown Boveri Review*, Dec. 1941, Vol. 28, No. 12, pp. 417–422.)

1666. A Frequency-Modulated Resistance-Capacitance Oscillator.—C.-K. Chang. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 22–25.)

1667. Methods for the Automatic Scrambling of Speech [Wireless Transmission Secrecy].—Guanella. (*Brown Boveri Review*, Dec. 1941, Vol. 28, No. 12, pp. 397–408.)

1668. Wartime Developments in Carrier Current Communication.—G. Abraham. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 76, 77 and 187.)

Radio-frequency signals guided over power lines are attenuated more than low-frequency transmissions, but readily available tuners are easily adapted to the reception of such signals. Four systems of distribution, and coupling considerations, are discussed.

1669. Radio Sounding in the United States [a Review describing Equipment and Methods].—C. B. Pear. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 82–85.)

1670. Pack Communications Equipment for Fire Fighting [as Used in the New York Fire Department].—A. H. Meyerson. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 7–11 and 42, 43.) To be continued.

RECEPTION

1671. A Battery-Fed All-Wave Receiver [5–3000 m, with Special Attention to Selectivity, Sensitivity, & Amplitude-Limitation for Reduction of Interference: Designed primarily for Weak Signals, for Interception, etc.].—O. Grob. (*Bull. de l'Assoc. Suisse des Élec.*, 18th Nov. 1942, Vol. 33, No. 23, pp. 670–673: in German.)

The amplitude-limiting is obtained by two selenium rectifiers connected in opposite directions across the headphone terminals: the limiting action begins at about 2 mw. Extra terminals, cutting out the limiter and its additional distortion, are provided for intrinsically "good" signals. For signals above 12 Mc/s double frequency-transformation is employed: the first two valves, hitherto used as h.f. amplifiers, become the first mixing valve and the first oscillator valve respectively. The first i.f. is not fixed but varies, over the range of one coil unit (there are 10 in all), from 1·5 to 3·2 Mc/s: this plan has certain advantages (1, 2, 3 on p. 671). The second i.f. for the double frequency transposition is 465 kc/s. The receiver band width is adjustable in three steps: in the "narrow" adjustment a quartz filter is connected in the 465 kc/s i.f. amplifier, enabling absolute single-sideband reception to be obtained. In the long-wave range (100–750 kc/s), where the i.f. is changed automatically from 465 kc/s to 70 kc/s by the insertion of the correct coil unit, the "narrow" setting makes the l.f. amplifier selective for the frequency 900 c/s, so as to give a band width of 50–100 c/s. The valves comprise 9 pentodes, 2 hexodes, and 1 double triode, consuming 0·47 A at 6 V for heating and 30 mA at 120 V for anode supply. If a converter driven off an accumulator is used, the consumption is 2·7 A at 6 V.

1672. Receiver Design Factors in Aircraft Communications [with Particular Reference to the Development of the S101 and S102 Receivers].—C. W. McKee. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 22–24 and 26, 46–48.)

1673. Superheterodyne Tuning [Graphical Method of determining Values of Circuit Constants for Ganged Control of Signal & Oscillator Tuning].—D. Riach. (*Wireless Engineer*, April 1943, Vol. 20, No. 235, pp. 159–162.)

1674. An Automatic 1000 Cycle Receiver [to Operate an Alarm on Receipt of 1000 c.p.s. Modulation].—C. H. Topmiller. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 28, 29 and 31.)

1675. Frequency Modulation. — Guanella & Schwartz. (*Brown Boveri Review*, Dec. 1941, Vol. 28, No. 12, pp. 417–422.)

1676. Frequency Modulation: IV [Pre-emphasis, De-emphasis, & the Double-tuned Discriminator].—C. Tibbs. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 111–114.)

The reduction in noise-level which is produced by pre-emphasis of the higher audio-frequencies is discussed, together with the method of de-emphasis at the receiver. The discriminator is introduced with an investigation into the functioning of the double-turned type of circuit. *See* 1061 of April.

1677. High-Frequency Response of Video Amplifiers.—A. Preisman. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 16, 19, 20, 38, 41, and 45.) To be continued.

1678. Automatic Frequency and Phase Control of Synchronization in Television Receivers [of Particular Advantage in Conditions of Severe Noise].—K. R. Wendt & G. L. Fredendall. (*Proc. I.R.E.*, Jan. 1943, Vol. 3, No. 1, pp. 7–15.) *See* 829 of March.

1679. Comparison of Voltage—and Current—[Negative-]—Feedback Amplifiers [to assist in Choosing Type and Quantity required in Particular Circumstances].—E. H. Schulz. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 25–28.)

1680. Simple Quartz-Crystal Filters of Variable Bandwidth.—Builder and Benson. (*See* 1647.)

1681. Pack Communications Equipment for Fire Fighting [as Used in the New York Fire Department].—A. H. Meyerson. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 7–11, and 42, 43.) To be continued.

1682. Agreement between the Electrical & Electricity-Supply Associations and the Swiss Postal Administration regarding the Fight against Radiophonic Interference.—(*Bull. de l'Assoc. Suisse des Élec.*, 18th Nov. 1942, Vol. 33, No. 23, pp. 682–685 : in French.)

AERIALS AND AERIAL SYSTEMS

1683. Loop Antennas for Aircraft.—G. F. Levy. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 56–66.)

" .... the electrical and mechanical design of aircraft loop antennas differs considerably from that of other types. In this paper those characteristics, requirements, and design considerations which are associated uniquely with aircraft loop antennas operating in radio-range or beacon band extending from 200 to 400 kilocycles will be discussed. . . . The 'low-impedance' & the 'high-impedance' types of air-core loops are considered and analysed mathematically on the basis of their receiving efficiency and directive properties. . . . Iron-core loop antennas which have been used extensively abroad are considered separately & comparison is made with air-core types."

1684. Shunt-Excited Broadcasting Antenna.—S. S. Banerjee & S. Y. Tiwari. (*Indian Journ. of Physics*, Oct. 1942, Vol. 25, Part 5, pp. 337–342.)

A theoretical study of the effect on the intensity of the field radiated when the point of excitation is gradually altered. The field intensities for quarter, half, and full wavelength antennae are calculated at a ground distance of one wavelength from the base, and suitable points for excitation are indicated. Refers to 3681 of 1937 & back references.

1685. A Note on the Characteristics of the Two-Antenna Array.—C. W. Harrison. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 75–78.)

"The definition for the 'effective length' of a transmitting antenna, which was recently brought to the attention of readers (3326 of 1941) is used in deriving expressions for the radiation function, radiation resistance, directivity, and gain of a two-vertical-antenna array when the relative phase of excitation and current amplitudes are of arbitrary value. . . . Since the assumption of a perfect earth is made, the results are precise only for antennas operated at broadcast frequencies, and at longer wavelengths."

1686. Theory of Antennas of Arbitrary Size and Shape : Correction.—S. A. Schelkunoff. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, p. 38.) Error in Fig. 9 of 1049 of 1942.

1687. The Calculation of Aerial Capacitance [Reasons for Errors in Some Methods of Calculating Capacitance of Umbrella & Other Aerials].—G. W. O. Howe. (*Wireless Engineer*, April 1943, Vol. 20, No. 235, pp. 157–158.)

1688. The Measurement of Cable Constants at High Frequencies.—Goldschmidt. (*See* 1724.)

VALVES AND THERMIONICS

1689. A Diode for Voltage Measurement on Decimetric Waves.—M. J. O. Strutt & K. S. Knol. (*Philips Tech. Rundschau*, April 1942, Vol. 7, No. 4, p. 124 onwards.) With nine illustrations.

1690. "High Frequency Thermionic Tubes" [Book Review].—Harvey. (*Elec. Review*, 9th April 1943, Vol. 132, No. 3411, p. 494.)

1691. Shot Effect in Photocells with Secondary-Emission Multiplication.—Hartmann & Rothe. (*See* 1712.)

1692. De-ionization Considerations in a Harmonic Generator employing a Gas-Tube Switch.—Shepherd. (*See* 1655.)

1693. Valve Generators for Ultra-Short Waves Based on Transit-Time Control [Transator & Turbator].—Lüdi. (*Brown Boveri Review*, Dec. 1941, Vol. 28, No. 12, pp. 395–396.)

1694. The "Turbator" Generator for 10 cm Waves, and Its Advantages over the Magnetron and Klystron.—Lüdi. (*See* 1660.)

DIRECTIONAL WIRELESS

1695. Direction-Finding Apparatus in the Service of Aerial Navigation [Lecture, with Particular Reference to D.F. Errors and the Equipment manufactured by the Hasler Company, of Berne].—Ch. Robert. (*Bull. de l'Assoc. Suisse des Élec.*, 18th Nov. 1942, Vol. 33, No. 23, pp. 659–666 : in German.)

In the subsequent Discussion, Wertli (Brown, Boveri) stresses the advantages of ultra-short waves, and quotes foreign results showing errors of less than 2° over 200–300 km distances. Wehrlin (also of the Hasler Company) states that similar work has been carried out in Switzerland, but regards the ultra-short waves as a useful adjunct to long-wave working, which gives an accuracy within half a degree. Lugeon refers to Nobile's direction finder having an accuracy within a tenth of a degree, equal to or perhaps better, for aerological soundings, than that given by optical methods : it tracks a balloon within ± 50 m at a distance between 60 and 100 km, as was shown in a recent case which he mentions.

1696. Considerations on the Radio Guidance of Aeroplanes [Influence of Position of Aeroplane, and of the Shape of Its Aerial : " Radiation Surfaces " : etc.].—F. Raymond. (*Rev. Gén. de l'Élec.*, March 1942, Vol. 51, No. 3, p. 217 onwards.) With five illustrations and a table.

1697. Loop Antennas for Aircraft—Levy. (*See* 1683.)

1698. A Note on the Characteristics of the Two-Antenna Array.—Harrison. (*See* 1685.)

1699. The Recording of Thunderstorms, *and* A Direction Finder for Atmospherics.—Lugeon : Nobile. (*See* 1634 & 1635.)

1700. South African I.E.E. [President's Inaugural Address]. — E. T. Price. (*Elec. Review*, 16th April 1943, Vol. 132, No. 3412, p. 524.)

Refers to production of radio d.f. equipment in large numbers completely from materials available in South Africa. Summary only.

ACOUSTICS AND AUDIO-FREQUENCIES

1701. On the Velocity of Propagation of Sound in Quartz [and Its Dependence on the Direction : Calculation of the Three Principal Velocities from the Secular Equation, and Confirmation of Gross's Experimental Values].—K. Wulfson. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 30th Sept. 1940, Vol. 28, No. 9, pp. 792–793 : in French.)

1702. Contemporary Problems in Television Sound.—C. L. Townsend. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 3–7.)

1703. " Acoustics of Music " [Book Review].—T. Bartholomew. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, p. 42.)

1704. Selected Problems in Architectural Acoustics [pertaining to Recording Studios & Conditions of Microphone Pickup].—M. Rettinger. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 18–22.)

1705. Public Address Systems.—S. Hill. (*Elec Communication*, 1943, Vol. 21, No. 1, pp. 13–26.)

Deals with apparatus, acoustical problems, planning and installation to overcome acoustical defects of the auditorium, " time delay," extraneous noise, auditory perspective by stereophonic means, and ends with a description of three existing installations.

1706. The Subjective Measurement of the Quality of Telephone Circuits : I and II.—Panzerbieter & Rechten. (*Bull. de l'Assoc. Suisse des Élec.*, 4th Nov. 1942, Vol. 33, No. 22, pp. 634–635 : 13th Jan. 1943, Vol. 34, No. 1, pp. 22–24.) French version of the German work dealt with in 3023 of 1942 and 1141 of April.

1707. Pick-Up Accessories [Design & Construction of Low-Pass Filter & Feeder Unit].—J. Brierley. (*Wireless World*, April 1943, Vol. 49, No. 4, pp. 100–103.)

1708. Improved Low-Frequency Horn.—P. W. Klipsch. (*Journ. Acous. Soc. Am.*, Jan. 1943, Vol. 14, No. 3, pp. 179–182.)

Measurements on the horn described in 727 of 1942.

1709. The Reduction of Record Noise by Pick-Up Design [to Reduce its Mechanical Impedance at the Stylus Point].—A. D. Burt. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 90–93 and 198, 199.)

1710. A Simple Beat-Note Oscillator [20 c/s to 12 kc/s, by Combination of First Harmonic of 300 kc/s Generator with Second Harmonic of 200 kc/s Generator : Diode Rectification & One Stage of A.F. Amplification].—R. Schumann. (*Funkschau*, No. 6, Vol. 15, 1942, p. 90.)

1711. The Measurement of Transcription-Turntable Speed Variation.—H. E. Roys. (*Proc. I.R.E.*, Feb. 1943, Vol. 13, No. 2, pp. 52–55.)

" Speed constancy or freedom from speed fluctuation (' wows ') is becoming more important due to the widespread use of records in radio broadcasting.

Equipment of a simplified nature which will evaluate the wow content as a single figure is needed for standardisation purposes. Some of the existing equipment is reviewed . . ."

PHOTOTELEGRAPHY AND TELEVISION

1712. Shot Effect in Photocells with Secondary-Emission Multiplication [and Its Action in Limiting the Detection of Very Low Light-Intensities: with Tabulated Results of Measurements].—W. Hartmann & A. Rothe. (*Fernseh-G.m.g.H. Hausmitteilungen*, 1941, Vol. 2, No. 3, p. 81 onwards.)

1713. Contemporary Problems in Television Sound.—C. L. Townsend. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 3–7.)

1714. "The Future of Television" [Book Review].—O. E. Dunlap. (*Electronics*, Dec. 1942, Vol. 15, No. 12, pp. 176–179.)

1715. "4000 Years of Television" [Book Review].—R. Hubbell. (*Electronics*, Dec. 1942, Vol. 15, No. 12, p. 180.)

1716. Method of Measuring the Sensitivity of Television Pick-Up Tubes.—R. Theile & R. Filipowsky. (*Telefunken-Röhre*, Dec. 1941, No. 23, p. 316 onwards.) With eleven figures.

1717. Automatic Frequency and Phase Control of Synchronisation in Television Receivers [of Particular Advantage in Conditions of Severe Noise].—K. R. Wendt & G. L. Fredendall. (*Proc. I.R.E.*, Jan. 1943, Vol. 3, No. 1, pp. 7–15.)

1718. The Measurement of Cable Constants at High Frequencies.—Goldschmidt. (*See* 1724.)

MEASUREMENTS AND STANDARDS

1719. Radio-Frequency Voltmeter.—(*Bell Lab. Record*, Jan. 1943, Vol. 21, No. 5, p. 126.)

The voltmeter can be used for measuring voltages up to 10 000 volts at frequencies up to 50 Mc/s. It incorporates a capacitance potential divider, the voltage across the larger capacitance being measured with a valve rectifier and milliameter.

1720. Electrostatic Measuring Instruments: A New Electrostatic Voltmeter with Light-Spot Indication [Heterostatic & Idiostatic Connections of the Quadrant Electrometer: Its Range, Frequency Range, Scale Characteristic, & Applications: the Siemens Quadrant Electrometer].—P. M. Pflier. (*Siemens-Zeitschr.*, April/June 1942, Vol. 22, No. 2, pp. 66 onwards.) *See* also 1470 of May.

1721. A Diode for Voltage Measurement on Decimetric Waves.—M. J. O. Strutt & K. S. Knol. (*Philips Tech. Rundschau*, April 1942, Vol. 7, No. 4, p. 124 onwards.) With nine illustrations.

1722. Range-Extension for All Types of Measuring Instruments: II — Alternating-Current Meters [of Rectifier Type].—H. G. Mende. (*Funkschau*, 1942, Vol. 15, No. 6, p. 85 onwards.)

1723. Simplified Method for the Study of the Sensitivity of a Measuring Bridge [Wheatstone (D.C. & A.C.), Kelvin, Carey-Foster & Other Types].—M. G. Ney. (*Rev. Gén. de l'Élec.*, April 1942, Vol. 51, No. 4, p. 249 onwards.)

1724. The Measurement of Cable Constants at High Frequencies [for Wire Broadcasting, Television, Aerial Feeders, Multiple Telephony, etc.].—R. Goldschmidt. (*Bull. de l'Assoc. Suisse des Élec.*, 18th Nov. 1942, Vol. 33, No. 23, pp. 652–658: in German.)

Author's summary:—"A new method is described by which all the properties of a cable can be measured on a short specimen length with sufficient accuracy for the influence of the constructional elements (conductors and dielectric) to be determined quickly. The method, which is a graphical one, involves the measurement of the open-circuit and short-circuit impedances as functions of the frequency." Fig. 5 shows an illustration of the measurements applied to a rubber-insulated delaying cable used for surge-testing with an oscillograph. *Cf.* Ditl, 110 of January, and Anderson and others, 837/839 of March.

1725. The Use of Counter Circuits in Frequency Dividers.—E. L. Kent. (*Journ. Acous. Soc. Am.*, Jan. 1943, Vol. 14, No. 3, pp. 175–178.)

Application of the systems described in 3061 of 1940.

1726. Behaviour of a Balanced D.C. Amplifier [Previously Unreported Properties of the Barth Circuit Employing the FP54 Electrometer Tube].—R. C. Spencer & LeRoy Schulz. (*Review Scient. Instr.*, Jan. 1943, Vol. 14, No. 1, pp. 10–14.)

1727. On the Velocity of Propagation of Sound in Quartz.—Wulfson. (*See* 1701.)

1728. Method of Measuring the Sensitivity of Television Pick-Up Tubes.—R. Theile & R. Filipowsky. (*Telefunken-Röhre*, Dec. 1941, No. 23, p. 316 onwards.) With eleven figures.

SUBSIDIARY APPARATUS AND MATERIALS

1729. HIGH-SPEED CATHODE-RAY OSCILLOGRAPHY [Re-design of Existing Commercial Equipment to permit Recording of Extremely Short Transients].—Bryant & Newman. (*Engineering*, 26th March 1943, Vol. 155, No. 4028, pp. 241–242.)

Long summary of a Technical Paper (No. 27) received from the Engineering Experimental Establishment, University of Minnesota.

1730. AN AUTOMATIC SWEEP RELEASE FOR THE CATHODE-RAY OSCILLOGRAPH.—Rivault & Haubert. (*Rev. Gén. de l'Élec.*, April 1942, Vol. 51, No. 4, p. 259 onwards.)

1731. A NEW TIME-BASE ARRANGEMENT FOR HIGH-SPEED CATHODE-RAY OSCILLOGRAPHS [Circuit with Large & Small Condensers charged in Parallel & discharged in Series through Non-Inductive Resistance: Exponential Course of Potential across Terminals of Small Condenser].—Angelini. (*L'Elettrotecnica*, 10th Aug. 1942, Vol. 29, p. 326 onwards.)

1732. A SCANNING ELECTRON MICROSCOPE.—Zworykin & others. (*A.S.T.M. Bulletin*, Aug. 1942, No. 117, pp. 15–23.)

1733. CHARACTERISTICS OF ELECTRON LENSES.—Spangenberg & Field. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 128, 130: summary only.) For the full paper *see* 2464 of 1942.

1734. THE PREPARATION AND EFFICIENCY OF THE FAST GEIGER-MÜLLER COUNTER [Dependence of Efficiency on the Partial Pressures of Argon and Alcohol: No Change in an Argon-Alcohol Counter when the Partial Pressure of the Argon is Raised from 11 cm to 74.5 cm].—Rochester & Jánussy. (*Phys. Review*, 1st/15th Jan. 1943, Vol. 63, No. 1/2, pp. 52–54.)

1735. THE USE OF COUNTER CIRCUITS IN FREQUENCY DIVIDERS.—Kent. (*See* 1725.)

1736. "ELECTRICAL COUNTING" [with Special Reference to Alpha and Beta Particles: Valve Technique in Sub-atomic Research: Book Review].—W. B. Lewis. (*Nature*, 3rd April 1943, Vol. 151, No. 3831, p. 377.)

1737. APPLICATION OF ELECTRONICS TO PHYSIOLOGY [Temperature Control, Precedence Indicator, Phototube Myograph, and a Membrane Manometer].—Gibson. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 86–89 and 206.) *See* also 2460, 2890, & 3836 of 1942.

1738. CATHODE SPUTTERING WITH OBLIQUE INCIDENCE OF THE IONS [Unexpectedly High Sputtering Power of Thin Wires (even when Free-Path Lengths are so long that Güntherschulze's Explanation cannot hold) traced to Increased Effectiveness of Ion Impacts at Tangential Incidence (analogous to Behaviour of Secondary-Electron Emission) and also to Rise in Temperature].—Fetz. (*Zeitschr. f. Physik*, 25th Sept. 1942, Vol. 119, No. 9/10, pp. 590–601.)

1739. LIQUID DIELECTRICS [Power Factor, Conductivity, & Polar Contents].—Piper & others. (*Ind. & Eng. Chem.*, Dec. 1942, Vol. 34, No. 12, pp. 1505–1509). Industrial Edition.

1740. REFRACTIVE INDICES OF GASES AT HIGH RADIO FREQUENCIES.—F. J. Kerr. (*Proc. Phys. Soc.*, March 1943, Vol. 55, Part 2, No. 308, pp. 92–98.)

The paper describes the determination of the refractive indices of dry air and water vapour at a frequency of 58.3 Mc/s. The refractive index is obtained from a comparison of the length of standing waves set up in a resonant coaxial line in a vacuum with the length of the waves in the gas. "This result shows that the refractive index of water vapour is considerably greater than that of dry air, so that the water vapour in the atmosphere will have a large effect on the refraction of ultra-short waves. The figure agrees well with the value of 1.0060 obtained by Tregigda (1940) for the dielectric constant of water vapour at 42 Mc/s at 99.8°C. and 76 cm Hg, using a heterodyne method."

1741. COMPRESSED-POWDER MAGNETS WITH SYNTHETIC RESIN BINDER.—Dehler. (*Stahl und Eisen*, 19th Nov. 1942, Vol. 62, No. 47, pp. 873–876.)

Permanent magnet alloys of the Fe-Ni-Al type are glass hard, very brittle and the only machining operation possible is grinding. The casting of these alloys is difficult, especially if small holes have to be provided for fitting pole pieces, etc. A method of compacting the powdered alloy by means of a resin binder (6% phenol) is described. By suitably grading the powder (*e.g.* 50% 1 mm., 20% 0.3 mm., 30% 0.5 mm., grain size) density of the compact is of the order of 90% of original alloy density. (Compacting pressure—1000 atmospheres, hardening temperature—180°C.) The moulded product comes out true to size and no machining is necessary. The magnetic qualities of such powder magnets are within 20% of the corresponding values for the cast material. The new process also enables the production of filaments by extrusion. By adopting appropriate binders, a magnetic paste or paint can be obtained which has proved useful when additional magnetic fields have to be provided in any arbitrary locality.

1742. MODERN MAGNETIC MATERIALS [Discussion before British Institution of Radio Engineers: Description of New Magnetic Alloy composed of Non-Magnetic Materials].—Sowter & Tyrrell. (*Electrician*, 9th April 1943, Vol. 130, No. 3384, p. 373.)

1743. A New Double-Yoke Electromagnet for the Testing of Magnet Steels [specially suited for Routine Testing of Nickel-Aluminium Steels of High Coercivity].—Stablein & Steinitz. (*Tech. Mitteil. Krupp*, 1935, Vol. 3, pp. 129–135. Summary in *Journal Roy. Aeron. Soc.*, April 1943, Vol. 47, No. 388, p. 149.)

1744. An Apparatus for Magnetic Testing at High Magnetising Force.—Sanford & Bennett. (*Journ. Res. Nat. Bur. Stds.*, 1943, Vol. 10, pp. 567–573.)

1745. Powder Metallurgy.—Jones. (*Engineering*, 26th March 1943, Vol. 155, No. 4028, pp. 244–245.)

Long summary of a paper read before the N.E. Coast Inst. of Engineers and Shipbuilders.

1746. Powder Metallurgy [Industrial Technique: Products & their Applications, Including Magnet Steels].—Jones. (*Engineering*, 19th March 1943, Vol. 155, No. 4027, pp. 221–240.)

1747. The Vibrations of Contact Springs [Calculation of Resonant Frequencies: Tolerances: etc.].—Haringx. (*Philips Tech. Rundschau*, May 1942, Vol. 7, No. 5, p. 155 onwards.)

1748. Light-Current Connector Contacts ["Tuchel" Plug Contacts].—Tschanter: Tuchel. (*Zeitschr. V.D.I.*, 1942, Vol. 86, No. 9/10, p. 150 onwards.) *See* also Dewald, 1284 of April, where designs of this contact for power as well as communication currents are described.

1749. Progress in Engineering Knowledge during 1942.—Alger & Stokley. (*Gen. Elec. Review*, Feb. 1943, Vol. 46, No. 2, pp. 90–114.)

Reviews developments during 1942 and includes dielectrics (Formex wire), electronic equipment, magnetic materials (powder metallurgy applied to "alnico"), and ultra-short-wave radio.

1750. The New Thermoplastic Synthetic Resins and the Importance of Their Electrical Applications [with Observations on Their Mechanical, Thermal, Dielectric, & Hygroscopic Characteristics: the Problem of the Replacement of Mica: etc.].—Codolini. (*L'Elettrotecnica*, 10th April 1942, Vol. 29, No. 7, p. 152 onwards.)

1751. Synthetic Rubbers and Plastics: Part II [Introduction to their Chemistry: Dependence of Physical Properties on Molecular Structure].—Tunstall. (*Distrib. of Elec.*, April 1943, Vol. 15, No. 150, pp. 93–98 and 117.)

1752. Photo-Electric Alloys of Alkali Metals.—Sommer. (*Proc. Phys. Soc.*, March 1943, Vol. 55, Part 2, No. 308, pp. 145–154.)

The properties of the caesium-antimony alloy, first described by Görlich, have been investigated. It was found that this alloy has the stoichiometric formula $SbCs_3$, has the electric resistance of a semi-conductor, and emits under favourable conditions about 1 photo-electron for 5 incident light quanta at 4600 AU. Alloys of similar structure were also investigated, and the effect of superficial oxidation was studied.

1753. New Uses for Glass.—Turner. (*Journ. Roy. Soc. Arts*, 2nd April 1943, Vol. 91, No. 4636, pp. 224–235.)

The electrical applications mentioned are heat-treated glass insulators, which compare favourably with the best porcelain types, and glass fibre insulation on copper wire, which gives the same performance as cotton, but with a substantial reduction in bulk and weight.

1754. Fibrous Glass [Characteristics for Electrical Purposes].—Robertson. (*Elec. Review*, 16th April 1943, Vol. 132, No. 3412, p. 515. Summary only.)

1755. Copper Refining [Description of Processes & Plant in a Modern Refinery].—(*Elec. Review*, 2nd April 1943, Vol. 132, No. 3410, pp. 443–447.)

1756. The Machining of Presspahn [with Tools for Wood & for Metal: Some New Glues & Their Good Results: Mechanical & Electrical Testing: etc.].—Tschudi. (*Bull. de l'Assoc. Suisse des Élec.*, 27th Jan. 1943, Vol. 34, No. 2, pp. 50–52: in German.)

1757. Paper Condensers of the Bell System.—Brotherton. (*Bell Lab. Record*, Jan. 1943, Vol. 21, No. 5, pp. 123–126.)

1758. An Automatic 1000-Cycle Receiver [to Operate an Alarm on Receipt of 1000 c/s Modulation].—Topmiller. (*Communications*, Dec. 1942, Vol. 22, No. 12, pp. 28, 29, and 31.)

1759. The Design of Small Static Transformers [up to 500 Watts, for 45 c/s Frequency].—Albin. (*L'Elettrotecnica*, 25th April 1942, Vol. 29, No. 8, p. 180 onwards.)

1760. Volume Rectification of Crystals.—Sen. (*Indian Journ. of Physics*, Oct. 1942, Vol. 25, Part 5, pp. 329–335.)

Experiments to show that the volume rectification effect is not confined to crystals like carborundum, zincite, and silicon, having no centres of symmetry, but is also exhibited by, *e.g.* galena, iron pyrites, and pyrolusite, possessing axes of symmetry. From the results it is suggested that the so-called volume rectification may not take place within the body of the crystal, but may be due to the differential effect of the surface rectification occurring at the two large contacts of the crystal with the electrodes.

1761. ENGINE-DRIVEN EMERGENCY POWER PLANTS [Selection, Installation, and Maintenance in WIBW Transmitting Station].—Troeglen. (*Proc. I.R.E.*, Jan. 1943, Vol. 31, No. 1, pp. 15–18.)

1762. ON THE POROSITY OF [Arc-] WELDED SEAMS [and the Influence of the Presence of Sulphur].—ter Berg & Sack. (*Physik. Berichte*, 1st Oct. 1942, Vol. 23, No. 19, p. 1787: summary, from *Philips Tech. Rundschau*, No. 3, Vol. 7, 1942, p. 94 onwards.)

1763. ON THE ORIGIN OF RADIATION OF LONG AND SHORT DURATION IN PHOSPHORS WITH AN ORGANIC ACTIVATOR [Proof of Independent Existence of Centres of Radiation of Long & Short Duration in Boric-Acid Phosphors activated with Uranin, etc.].—Lewschin & Tugarinov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 20th July 1940, Vol. 28, No. 2, pp. 115–119: in English.)

1764. RADIO SOUNDING IN THE UNITED STATES [a Review describing Equipment and Methods].—Pear. (*Electronics*, Jan. 1943, Vol. 16, No. 1, pp. 82–85.)

1765. VOLTAGE-REGULATED POWER SUPPLIES.—Bereskin. (*Proc. I.R.E.*, Feb. 1943, Vol. 31, No. 2, pp. 47–52.)

"It is the purpose of this paper to discuss the problems involved and to develop an orderly procedure for designing and constructing these voltage-regulated power supplies for specific applications. The correlation between design data and actual tests on a finished model will also be shown."

1766. WAR-TIME SOLDERING [Describes Compact, Light, Soldering Iron supplied from Tapped Low-Voltage Secondary of Small Transformer].—Walker. (*Electrical Review*, 9th April 1943, Vol. 132, No. 3411, pp. 489–490.)

1767. APPLICATIONS AND LIMITATIONS OF MECHANICAL-ELECTRICAL ANALOGIES, NEW AND OLD.—Miles. (*Journ. Acous. Soc. Am.*, Jan. 1943, Vol. 14, No. 3, pp. 183–192.)

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"The orientation fluctuations are not constant, but vary in time owing to thermal motion. Changes in the orientations of the molecules occurring during the process of the scattering of light should produce changes in the frequency of scattered light, and these to my mind are responsible for the 'Rayleigh line background' on the scattered-light spectrogram" [hitherto attributed to the free rotation of the molecules in the liquid]. . . . "It may be seen from the above that the explanation suggested in this paper for the origin of the 'Rayleigh line background' is confirmed experimentally. The investigation of the 'Rayleigh line background' supplies a new spectroscopic method for the determination of the time of relaxation for the molecules of a liquid. The method is also applicable to non-polar liquids."

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A continuous metal shield surrounds the whole H.T. and L.T. wiring and makes good contact with the engine. The resistance of grounding connexions and joints in the shield must not exceed 0.002 ohms, anodised surfaces and non-metallic gaskets must be eliminated, and grounding points must be not more than 9–18 inches apart. In order to supply adequate electrical insulation inside the shield, and to minimise effects of moisture, corona, and acid products of the air in severe aeronautical conditions, the system may be ventilated with dry air, or the individual conductors may be embedded in a special compound. Methods of testing the system are discussed, together with the effects of fitting damping resistors at the sparking plugs. A recent development is the use of a low-voltage distribution to individual sparking coils located at or near the sparking plugs.

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.