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## A New System for Component References in Circuit Diagrams

MOST of our readers will be acquainted with the practice of attaching letters and numbers to components in electronic circuit diagrams, for the purpose of facilitating reference in the descriptive text or in a list of values, ratings and "part" numbers. Some readers may not realise that the telephone engineer who deals with automatic switching circuits makes use of such letters for a different purpose. In his diagrams, relays with various functions are the most important items: capacitors and resistors are comparatively rare. He uses letters primarily to indicate functions (*e.g.*, "A" for impulse accepting relay) selected from a standard list with about 120 entries. Having used up most letters for reasonably self-evident functional codes for relays, he has few suitable letters for other components; capacitors and resistors are allotted *Q* and *Y* respectively. Further, he allots *letters* only to components (the "first" capacitor is *QA*) and reserves *numbers* to tags and terminals (*QA*1 is a terminal of *QA*), whereas the electronic engineer indicates the terminal of *C*1 by *C*1*A*.

So long as the two groups, electronic and telephone, kept apart, such differences of usage did not matter; now that each group is using the technique of the other to an increasing degree and (particularly in the fighting services) the same people have to understand the apparatus of both groups, these differences are fast becoming unbearable.

Attempts to produce a unified system failed, owing to the difficulty of making violent changes in the existing practice of either group. The British Standard Institution is preparing a supplement to B.S.530:1948 "Graphical Symbols for Telecommunication" which sets out a practical compromise, involving a minimum of change, based on the following argument:—

The electronic engineer uses many capacitors, resistors and valves and comparatively few relays; the telephone engineer does the opposite. Changes in practice would be reduced if relays, switches and similar components were treated on the "telephone" basis, and other components on the "electronic" basis.

With this in mind, components have been divided into two classes, conveniently described as "switch-like" (in which a *mechanical* movement produces an *electrical* discontinuity) and "non-switch-like" (the rest).

A switch-like component (*e.g.*, a jack *JK*) will be "numbered" *JKA*, *JKB*, etc., and the jack contacts *JKA*1, etc.

A non-switch-like component (*e.g.*, a resistor *R*) will be numbered *R*1, *R*2, etc., and the resistor terminals *R*1*A*, etc.

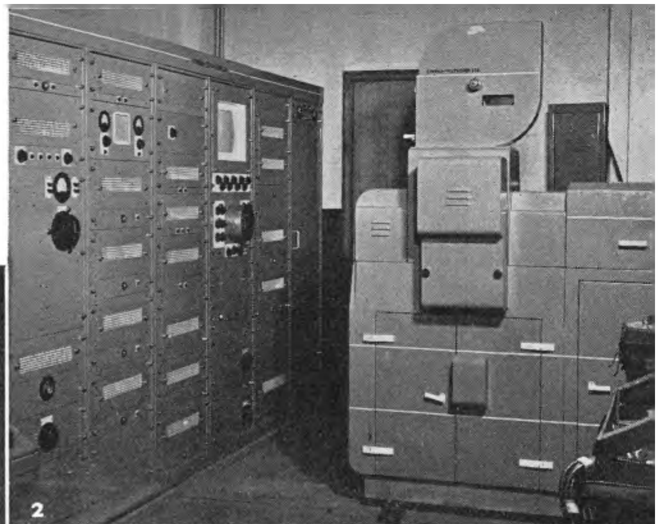
In devising the new system, some minor changes have been made by both groups in order to reduce conflicting meanings among the more important components. For example, a Fuse *F* has been changed to *FS* to avoid confusion with "*F*" Ring Trip Relay; a rotary switch magnet *R* has been changed to *RM* to avoid confusion with a resistor *R*. There has been a considerable amount of give and take between the two groups.

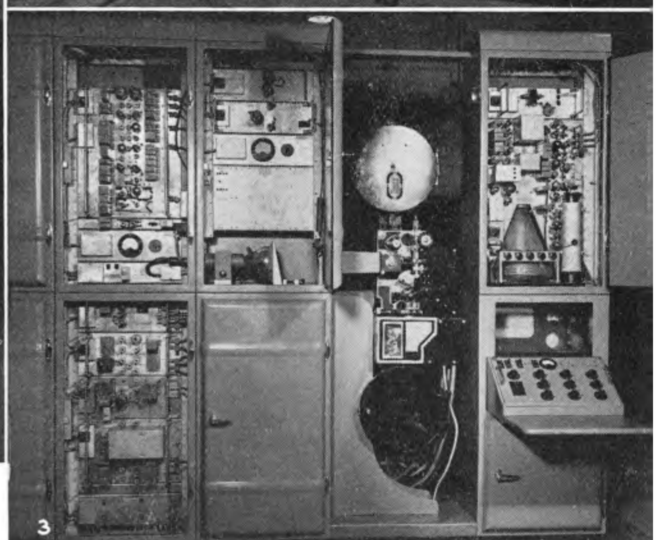
Changes of interest mainly to electronic engineers are:—

Fuse *F* to *FS*.
Battery *B* to *BY*.
Metal Rectifier *W* to *MR*.
Switch *S* to *SW*.
Transformer *T* to *TR*.
and a new reference
Test Jack *TJ*.

The new system—produced in a typically British spirit of compromise—reflects credit on the consenting parties. The B.S. Supplement is commended to the attention of intending authors. L.B.B.

# NEW TELECINE EQUIPMENT AT ALEXANDRA PALACE





*(Photographs supplied by courtesy of the B.B.C.)*

Two sets of telecine equipment, one made by Cinema-Television, Ltd., and the other by Electric and Musical Industries, Ltd., have just been installed at Alexandra Palace, where they are now being used for televising film programmes, such as the Television Newsreel. These sets each have a single projector, and they will eventually be replaced by two twin-projector sets which are on order from the same manufacturers. These equipments are illustrated as follows :—

1. *The projector manufactured by Cinema-Television, Ltd.*

2. *The "Cintel" projector is on the right and the ancillary equipment on the left.*

3. *To the right of the projector (manufactured by Electric and Musical Industries, Ltd.) is the control panel and monitoring cathode ray tube, and to the left the projection-type cathode ray tube for scanning the film.*

4. *On the right is the equipment manufactured by Cinema-Television Ltd., and on the left part of the equipment manufactured by Electric and Musical Industries, Ltd.*

# Television Time Base Linearisation

By A. W. KEEN, M.I.R.E.*

IT seems likely that television receiver design will, for some considerable time, be bound by the severely restrictive economic limitations at present in force, so that circuits will remain devoid of the refinements required for perfectly satisfactory performance. New circuit developments must, therefore, be of a relatively simple character to be immediately useful and it is the purpose of the present article to discuss a method of this kind which is effective in facilitating the achievement of satisfactorily linear scanning. The circuit technique will be discussed with television type time bases in view, but it is equally applicable to all cases in which the need to linearise an exponential voltage or current change arises.

The majority of commercial receivers employ time bases consisting of a sawtooth voltage wave generator feeding a power tetrode having the deflexion windings in its output circuit. While care is taken to produce a fairly linear drive for the output valve, and the latter is operated as a high impedance source of current in order to swamp the reactance of the deflector coil, reasonably good linearity can only be achieved by carefully matching the sawtooth voltage curvature against that of the grid voltage/anode current characteristic of the output valve, the two curves happening to be in opposite directions.[1] It is better to minimise the dependence of linearity upon the curvature of the characteristic since this varies from valve to valve and is subject to long period change. Any reduction in the non-linearity of the valve must, of course, be accompanied by a comparable improvement in the linearity of the sawtooth driving voltage. In the following sections a class of suitable correcting networks will be described; the basic principle is not new, one method of its application having been described briefly in the literature,[2,3,4] but several of the circuit adaptations to be discussed are believed to be original.

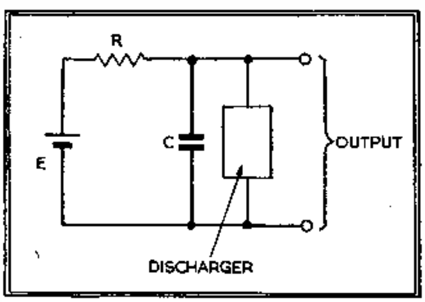



Fig. 1 (a). Simple " sawtooth " wave generator

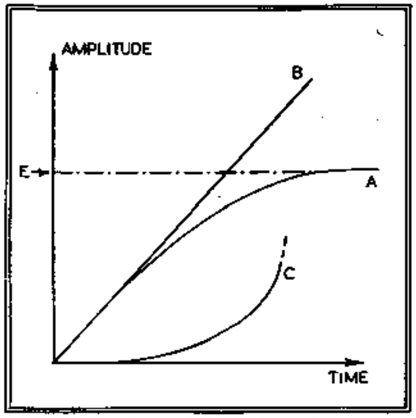



Fig. 1. (b) Output voltage characteristics of (a):—
A = actual output voltage
B = continuation of initial slope of A
C = difference B—A

## The Principle of the Integration Method of Linearity Correction

The principle of the method will be described with reference to Fig. 1 which shows at (a) a simple form of exponential (" sawtooth ") wave generator consisting of a series $C,R$ circuit connected across a constant source of direct voltage and having some form of discharge device, such as a thyratron (gas triode), connected across the capacitor. While the discharger remains inoperative, the voltage across the capacitor rises in the manner:—

$$V_A = \left\{ 1 - exp( - t/CR) \right\} E$$

where $E$ is the E.M.F. in the circuit, $exp$ denotes the exponential constant 2.7183... $t$ is time in seconds after the circuit is completed, and $C,R$ are the circuit component values.

This expression is plotted as curve $A$ in Fig. 1(b); it will be noted that the slope of this curve falls as the capacitor charge accumulates, so that the output voltage is non-linear. The extent of this non-linearity may be assessed by comparing curve $A$ with the straight line $B$ whose slope is the same as the initial slope of $A$; the difference $(B - A)$ is plotted as curve $C$. It is, however, known from experiment that a simple $CR$ network of the kind shown in Fig. 1(a) will provide a voltage output similar in form to $C$ for an applied voltage of the shape $A$. Accordingly, it would appear feasible to associate an additional $CR$ with the simple sawtooth generator of Fig. 1(a) in such a manner that its output is added, in correct proportion, to the exponential output of the basic network, so that the total output is made practically linear.

Before dealing with suitable circuits for combining the exponential change $(A)$ with the oppositely curved correction $(C)$, it should be mentioned that a practical but less satisfactory intermediate method of linearity improvement involves direct shaping of $A$ into something approaching the ideal $B$ by the use of a circuit of the type capable of generating $C$. If $R_2$ in the network of Fig. 2(a) is increased from zero to a very high value, the output wave will change continuously through the shapes sketched in Fig. 2(b). It will be observed that the initial downward curvature of the wave varies through a practically linear condition to upward curvature; beyond this stage, the wave

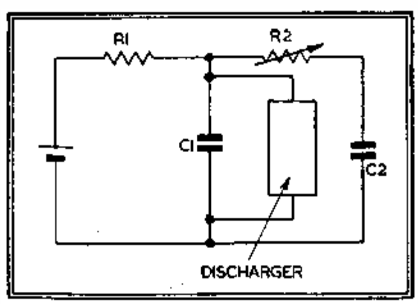



Fig. 2 (a). Addition of variable time-constant (i.e., C × R) shaping section to wave generator of Fig. 1 (a)

*Sobell Industries Ltd.

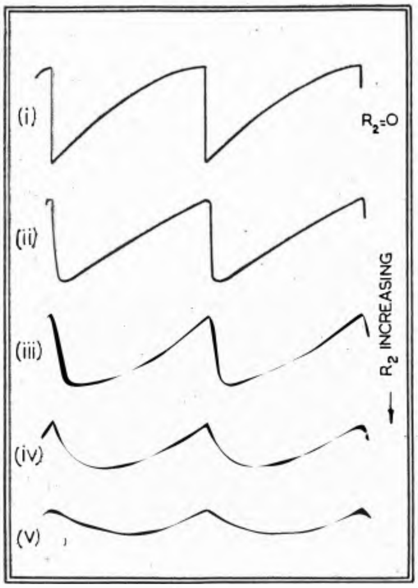



Fig. 2 (b). Output voltage wave of (a) for different values of $R_2$

quickly loses its rapid flyback feature and eventually becomes parabolic. The third waveform shown is very similar to $C$ of Fig. 1 and, when added to $A$, provides a slightly better approximation to linearity than the second waveform of Fig. 2(b).

## Basic Network

The first successful attempt to improve the linearity of the simple sawtooth generator along the lines suggested appears to have been made by G. F. Hawkins[5] whose basic circuits are given in Fig. 3(a), (b). In the first, the capacitor ($C_1$) of the basic $CR$ network is split into two series sections ($C_1'$,$C_1''$) and the additional $CR$ ($C_2R_2$) connected across the upper portion ($C_1'$). The total output of the network is, therefore, the sum of the correcting voltage developed by the extra $CR$ and the fraction of the normal exponential output appearing across the lower section ($C_1''$) of the split capacitor. Ignoring the loading effect of $C_2R_2$ on $C_1R_1$ and assuming that the current in $R_2$ is independent of the value of $C_2$ (i.e., that the product $C_2R_2$ is large), the ratio $C_1'/C_1''$ must be made equal to $C_1R_1/C_2R_2$.

This restriction does not prevent $C_2R_2$ from being made sufficiently large to minimise loading on $C_1R_1$ and to ensure a close approximation to the required correction waveshape. The resultant improvement in linearity is appreciable and of definite practical value.

In the alternative circuit, Fig. 3(b), the correcting $CR$ ($C_2R_2$) is directly in parallel with the entire capacitance of the basic network and, since the exponential output of the latter appears with negligible change of shape across $R_2$ of the corrector, provided $C_2R_2$ is large (*c.f.* an inverted $CR$ coupling), the combined output (exponential plus correction) can be obtained, and in the optimum proportions, by tapping into into $R_2$ at the correct point. $R_2$ should, for convenience of adjustment, be a continuously variable potentiometer. Making similar assumptions to those in the previous case, $R_2$ must be divided to make $R_2''/R_2 = C_1R_1/C_2R_2$.

The circuits just described are but two examples of a whole class of networks capable of responding in a similar manner to a constant direct applied voltage.[6] For example, the Y (T, or star) arrangement of the three capacitors of Fig. 3(a) suggests an alternative circuit (*see* Fig. 3(c) in which they form a closed ring ($\pi$, or delta) connexion; their values must, of course, be changed in accordance with the well-known star-delta (or T$-\pi$) transformation. Again, the response of the correcting section of the network of Fig.

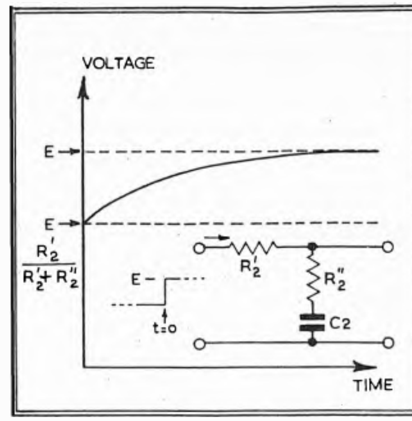



Fig. 4. Response of correcting section of Fig. 3 (b) to step voltage

3(b) to a "step" type applied voltage, as shown in Fig. 4, suggests the insertion of such a section between the applied voltage and the $CR$ network of the basic arrangement shown in Fig. 1(a). Ignoring mutual loading, the latter network would then operate on a rising voltage input with consequent improvement in overall linearity provided the rate of rise were chosen to compensate the normal tendency of the output voltage to fall. The network so derived is similar to that shown in Fig. 3(b); except that the two constituent networks are reversed in sequence. This last derivation applies equally to the network of Fig. 3(c).

An interesting point is that in all the networks so far discussed, the $R$'s may be replaced by $L$'s of high $Q$ and the $C$'s by $R$'s to obtain additional equivalents.[7] For exact equivalence in any particular case the component values must, of course, be correctly chosen.

## Practical Circuits

In considering the problem of linearising the output of a time base

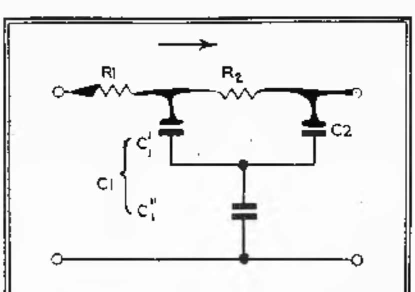



Fig. 3 (a)

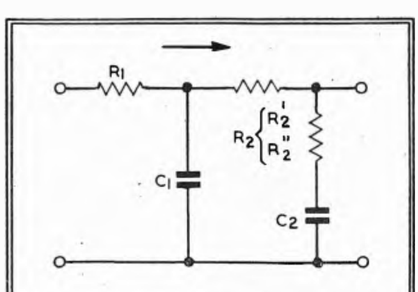



Fig. 3 (b)

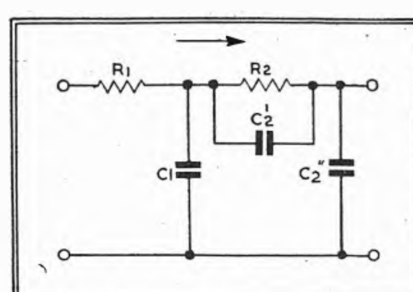



Fig. 3 (c)

Basic linearity corrected CR networks. (Note : With constant direct input voltage a triggered discharger is connected across $C_1$)

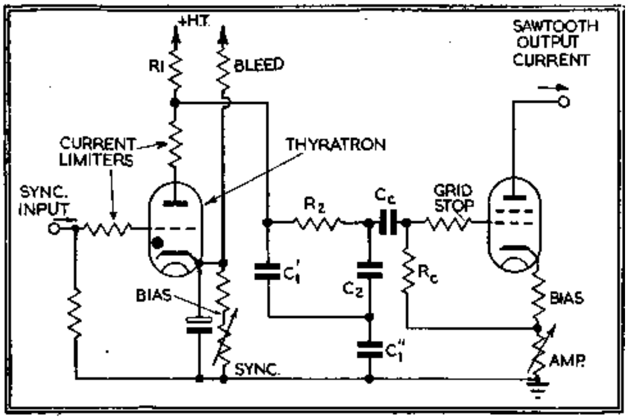



Fig. 5 (a). Thyratron scanning oscillator adaptation to Fig. 3 (a)

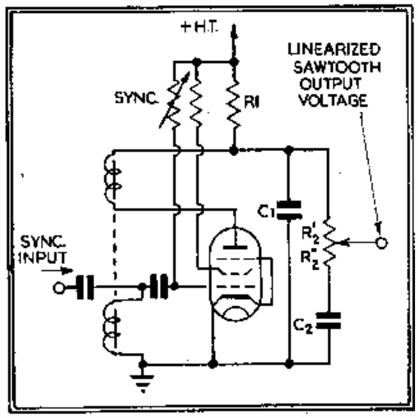



Fig. 5 (c) (*Right*). Blocking oscillator for producing a sawtooth waveform

it should be remembered that perfect linearity in the earlier stages is rendered futile by subsequent distortion; in fact, the only practical method of achieving linearity of the final output of a multi-stage circuit is to arrange cancellation of the unavoidable causes of distortion. This involves making such factors comparable in magnitude and readily controllable over an appreciable range. Thus, if it is desired to reduce the dependence of linearity upon the curvature of a valve anode current/grid voltage characteristic, *e.g.*, by applying negative feedback, the linearity of the applied sawtooth voltage must be improved correspondingly by a method such as the one under discussion.

An important point in regard to the integration method of correction is that it follows from a consideration of the response of the simple *CR* network to a single impulse which is maintained for an indefinite period. In practice, of course, the discharge device is regularly triggered so as to produce a recurrent sawtooth output voltage and the circuit conditions are thereby made more complex; this fact raises difficulties only when the flyback time is extremely short compared with the sweep time. Deterioration of the method is bound to occur, also, at very high recurrent frequencies when the effect of stray capacitances begins to become appreciable.

## Application to Sawtooth Generators

Three practical sawtooth generators incorporating integrator correcting circuits are shown in Fig. 5; all of which are suitable for television reception. Fig. 5(a) shows a straightforward adaptation of the network of Fig. 3(a) to the thyratron type of scanning oscillator.

The alternative network, Fig. 3(b) can be incorporated in the same type of oscillator, as shown in Fig. 5(b); in this case it will be noted that the correcting circuit is separated from the charging *CR* by the coupling capacitor $C_c$, and the grid-cathode leak $R_c$ of the output valve connected to the input of the correcting circuit, rather than across the output, in order to minimise loading of the latter circuit. The third application (Fig. 5(c)) represents an original development consisting of a blocking oscillator arranged to produce a sawtooth waveform.

The fourth example (Fig. 5(d)) shows how an additional large *CR* may be used to augment and control the linearising influence of the "bootstrap" circuit[3] on an exponential wave generator. Ignoring $C_2$,$R_2$ the circuit components will be identified readily since the left-hand triode is a conventional blocking oscillator sawtooth genera-

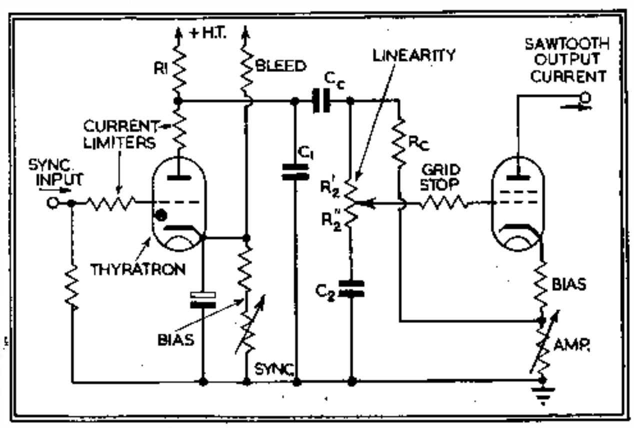



Fig. 5 (b)

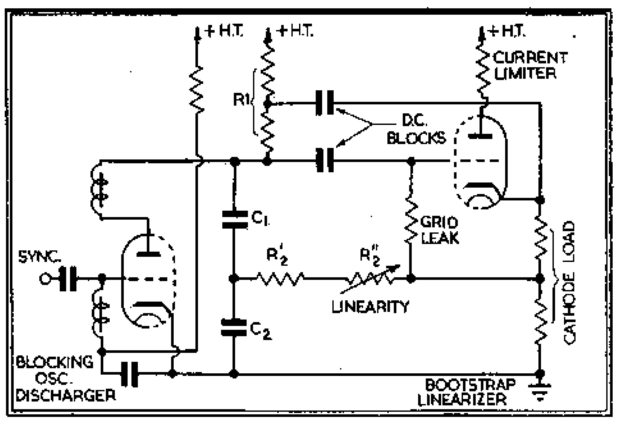



Fig. 5 (d)

Application of integrator correcting circuits to saw-tooth generators

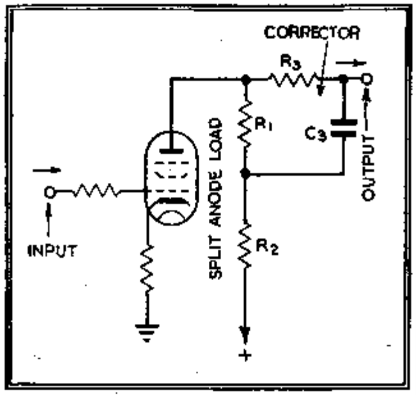



**Fig. 6 (a). Use of voltage-operated CR integrator correcting circuit**

tor and the right-hand portion of the double triode (*e.g.*, 6 SN7GT) is connected as a normal bootstrap. The slightly exponential output at the bootstrap cathode is used to feed the integrator corrector and the correcting wave developed across $C_2$ is inserted under $C_1$, whose lower plate is normally grounded. $R_2$ may alternatively be fed from the junction of the split anode load resistor ($R_1$) of the oscillator triode. The bootstrap valve may be anode loaded to obtain the push-pull output. The entire circuit is very suitable for driving the X plates of a small electrostatic C.R.T.; the additional triode is, however, hardly justified in an electromagnetic time base.

**Application to Time Base Voltage Amplifiers**

So far the correcting circuit has been directly associated with the wave generator; where voltage or current amplifiers follow the latter, the corrector may be introduced at a later stage. Two methods of incorporating a *CR* integrator in the type of voltage amplifier employed in time bases designed for electrostatic deflexion are shown in Fig. 6. At Fig. 6(a) a pentode having cathode current feedback is driven by an exponential voltage wave so that it delivers an exponential current into its output circuit. When the anode load is a resistor the output voltage will be similar to the input. If the load resistor is split and a *CR* integrator is connected across the lower part and the output point shifted as shown, a correction wave will be added to the normal exponential output developed across the upper portion. Ignoring valve distortion and mutual loading effects, the ratio $R_1/R_2$ should be made equal to $C_3R_3/\tau$ where $\tau$ is the equivalent time constant of the input wave source.

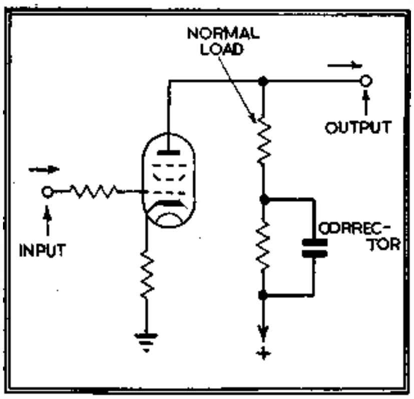



**Fig. 6 (b). Use of current-operated CR integrator correcting circuit**

Where an exponential current wave is available, as in the case just considered, the desired correction wave may be obtained by passing the current through a parallel *CR* (current operated integrator) in addition to the normal load *R*, as shown in Fig. 6(b). To a first approximation this *CR* should have the same time constant as the current source.

In Figs. 6(a), (b) the anode load resistor is divided; it is equally possible, of course, to divide the following grid resistor when a *CR* coupled stage follows the amplifier, *e.g.*, in a two valve paraphase amplifier circuit.

**Application to Current-Output Stages**

Electromagnetic deflexion is now universally employed in television receivers so that the time base circuits must provide *currents* of sawtooth shape to the deflector coils. For frame deflexion a *CR* coupling to the coil is usually employed, but the line coils are transformer coupled. In both cases the resistive component of the deflector coil impedance requires a linear rise in the voltage applied to, or developed across, the coil. The output valve may be arranged either as a high impedance source of current having the desired waveform (Fig. 7(a)) or as a low-impedance supply of the corresponding voltage waveshape (Fig. 7(b)). The former arrangement is usually preferred; both methods permit application of an integrator correcting circuit.

A typical example is shown in Fig. 8. The beam tetrode output valve is driven by an exponential sawtooth wave and is operated as a high impedance source, so that it feeds a current wave of similar shape, via the transformer coupling, to the deflexion winding $L_1$, and its series resistor $R_1$. The voltage developed across $R_1$ is used to drive current through an auxiliary winding $L_2$ of series resistance $R_2$. Provided $\omega L_2/R_2$ of this auxiliary winding is large, which is readily achieved at line frequency although not at frame frequency, the current in $L_2$ will approximate the required correction waveshape. Calculation of circuit values for this circuit is more difficult than for the preceding circuits, since the mutual coupling between the two windings will be appreciable and the winding resistances must be taken into account, but the circuit may be set up quite quickly by systematic experiment using tapped windings and a variable resistor $R_2$ across the compensating section ($L_2$).

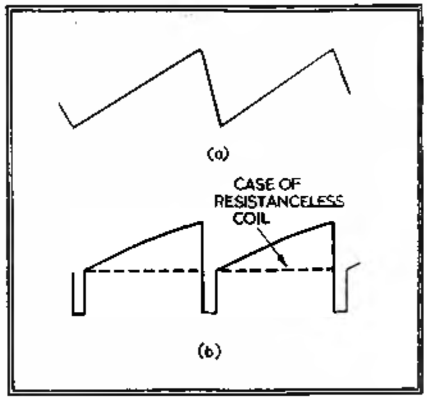



**Fig. 7. Ideal waveforms for current output stages**
**(a) Current output of high impedance source**
**(b) Voltage output of low impedance source**

It is simpler, in that the complication of the coil is avoided, to

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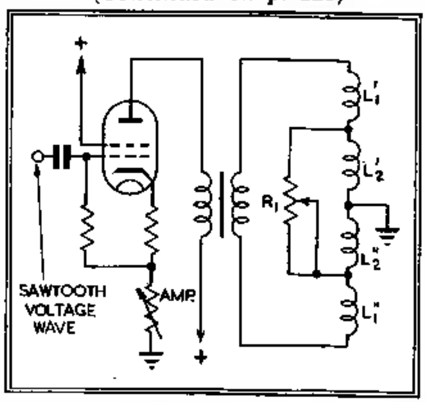
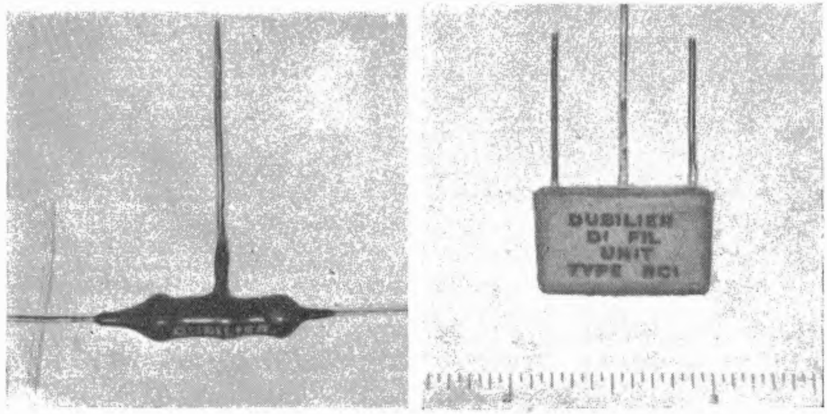



**Fig. 8. Application of integrator correcting circuit (current fed parallel LR) to current output stage of T.B. for E.M. deflexion**

# Multiple Component Units

## Simplification of Electronic Apparatus Assembly

By KATHLEEN F. GOUGH, B.Sc., A.M.I.E.E., A.Inst.P.*




Assembled forms of multiple components (both approx. full sized)
Diode filter of Figs. 1 and 2 network of Figs. 3 and 4

IN the preparation of electronic apparatus utilising the technique usually referred to as "printed circuits" it was originally the practice to construct the resistors as parts of the circuit by a painting or printing operation and to construct the capacitors by electrodes applied directly to the base on to which the main "printed circuit" was assembled. In a recent article in this Journal (†) it was pointed out that in many cases it is much more practical to assemble separate capacitor and resistor units on to the main printed circuit base. Such separate elements can be free of the disadvantages associated with their formation directly on the base plate as part of the printed-circuit and retain their electrical characteristics and stability.

Development work during the past 18 months has brought into being another form of network unit that has similar advantages to those last mentioned above, and moreover it is one which can be applied equally to "printed circuits" and to the more conventional forms of electronic apparatus manufacture. These units incorporate elements of well-known forms of resistors and capacitors and therefore retain the high qualities of the separate components with the added advantages in the number of external connexions that need to be made. These new units take various forms, such as for diode-filters, inter-valve coupling and combinations of coupling and filter networks. The units described in detail in the following paragraphs may be taken as typically representative of the many combinations that can be produced.

Filter and network units of various forms have been used recently in the United States, but all of them are of the "printed" variety with the resistor and capacitor elements formed directly on the base material, which is generally of a high-permittivity ceramic type. The sole exception has been the attachment of small disks of ceramic capacitors to certain forms of amplifier and similar bases.

The original designs of the multiple component units by Dubilier Condenser Co. date back to 1947,‡ when cylindrical forms of construction were devised to make use of existing forms of tubular ceramic and resistor components. One form of this unit, sketched in section in Fig. 1, provides the diode-filter network of Fig. 2. In these diagrams the resistor $R$ constituted by the cylindrical resistor element in the centre of the ceramic tube $C$ is connected across the two free terminals $W_1$ $W_2$ of the capacitors $C_1$ and $C_2$. The electrodes $E_1$ and $E_2$ on the inside of the ceramic tube provide this dual capacitance in conjunction with the outer electrode $E_0$ to which is attached the terminal wire $W_0$. Metal caps $P_1$ and $P_2$ soldered on the ends of the ceramic tube enclose the resistor element in its interior and enable the wires $W_1$ $W_2$ from the ends of the resistor to pick up the connexion to the electrodes $E_1$ and $E_2$.

Another pattern is shown in Fig. 3 with the tubular capacitor replaced by a flat mica dielectric element $M$ providing two capacitances between the two end clips $S_1$ $S_2$ and the central connexion tab $F$, which leads to the common earth potential terminal wire $W_0$. The resistance element $R$ is joined across the two clips $S_1$ $S_2$ and the whole is enclosed in a moulding as indicated by the dotted lines.

Attention has been paid to the layout and relative position of the parts and tests made on these units show that they offer the same attenuation to radio frequencies as do the separate and well spaced out components of similar electrical values. Typical values for this network in either cylindrical or flat form are:

$C_1 = C_2 = 100\ \mu\mu F$ and $R = 47{,}000\Omega$.

Other values can readily be substituted up to:

$C_1 = C_2 = 250\ \mu\mu F$ and $R$ up to 1 M$\Omega$

except in the cylindrical form of Fig. 1 where the capacitance is limited to 100 $\mu\mu$F for each element, while the same physical size is retained.

The cylindrical unit is shown with a protective wax coating to provide

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‡ British Patent Application No. 31917/47.

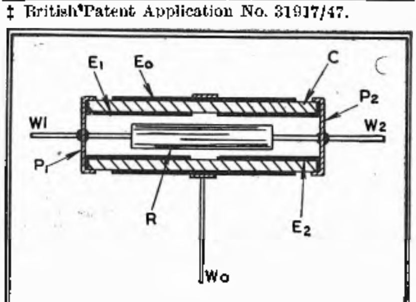


Fig. 1. Sectional form of network of Fig. 2

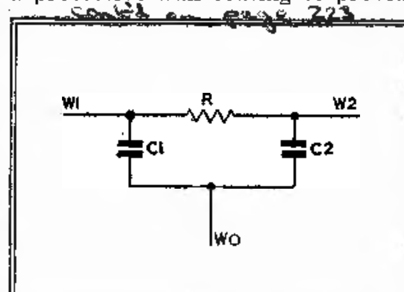


Fig. 2. Diode filter network

* Dubilier Condenser Co., (1925) Ltd.

† ELECTRONIC ENGINEERING, April 1949, pp. 125–128.

# VOLTAGE STABILISERS

## —Part II

By F. A. BENSON, M.Eng., A.M.I.E.E.*

### Stabilisers Employing Gaseous Discharge Tubes

THE tubes available operate at voltages from about 70 to 160 volts. For higher voltages tubes may be used in series as shown in Fig. 11. In this case a number of different stabilised voltages may be obtained for supplying several loads.

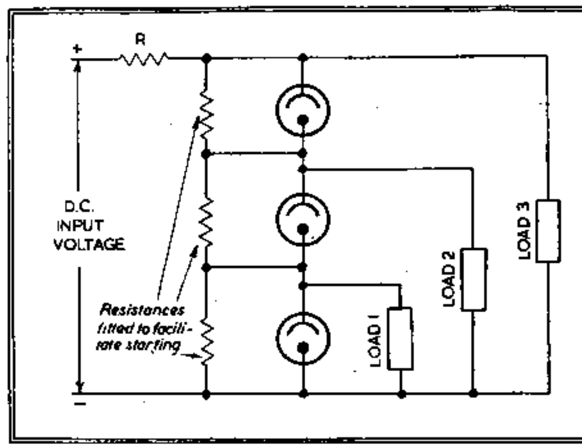


Fig. 11. Series arrangement of stabilisers to obtain stabilised voltages for several loads. Resistances are connected to facilitate ignition

Thus the method is extremely useful for stabilising low voltages, of the order of a few hundred volts, but is not suitable for high voltages due to the necessity for employing a large number of tubes in series each carrying a current of the same order of magnitude as the load currents making the efficiency of the system rather low. Even if the voltage supply is low, the method is only useful for small currents (see table below which gives maximum values of tube currents).

In some cases where a heavy load is permanently connected in parallel with the tube, it may be found difficult to strike the tube. In view of this the tube is sometimes fitted with a further electrode, known as an ignition electrode to ensure satisfactory operation. The voltage for this electrode may be obtained from a separate supply, but is usually obtained from the tube supply through an auxiliary resistance ($R'$), as shown in Fig. 12. In cases where several tubes are connected in series, as in Fig. 11, resistances should be fitted as shown, to facilitate starting. The stabilising action of a tube may be appreciated by referring again to Fig. 10. If the voltage $V_1$ is increased slowly from zero, no appreciable current passes through the tube until the voltage across it is equal to the striking potential, the latter depending on the design of the tube. Here the gas in the tube ionises, the "differential" or "dynamic" resistance of the tube decreases rapidly and it runs at a voltage lower than the striking voltage. The differential resistance of the tube varies with the voltage across it ($V$) and can be found for any such voltage from its current-voltage curve. Over the "straight" portion of the curve, where the voltage $V$ increases slightly as the current $I$ through the tube increases, the relation between $V$ and $I$ may be written

$$V = xI + v$$

where $x$ is the slope of the curve and is therefore small and $v$ is a constant which has a value determined by the design and material of the electrodes, the gas pressure, etc. Therefore, the output voltage across the tube is the sum of a large constant term $v$ and a small variable term $xI$. It thus remains approximately constant and is more nearly so the smaller the value of $I$. $I$ is kept small by employing a series resistance $R$ with a high value. Therefore, a large value of $R$ is essential for good stabilisation apart from the fact that it must also limit the current through the tube.

The regulation of a tube is defined as the change in tube voltage over the tube-current range and may be readily obtained from the characteristic curve of the tube. For, if at maximum tube current $I_{max}$ the corresponding value of tube voltage is $V_{max}$, and at minimum tube current $I_{min}$, the corresponding value of tube voltage is $V_{min}$, then the regulation is $(V_{max}-V_{min})$.

So far, mention has only been made of the stabilisation of D.C. by gaseous discharge tube. It has been suggested, however, that since the method has been used successfully for D.C. voltages it might also be utilised for A.C. ones. The first proposals[13,14] were to place two neon tubes back to back across the primary of a transformer with a resistance $R$ placed in series (Fig. 13).

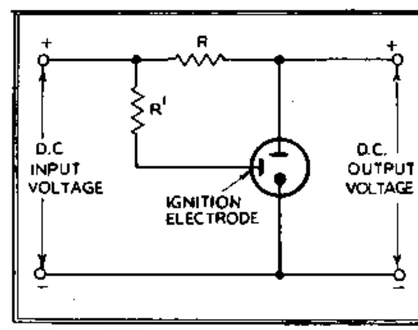


Fig. 12. Stabiliser tube with additional electrode to improve ignition when a heavy load is permanently connected

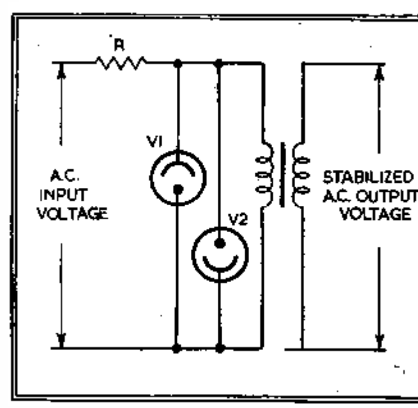


Fig. 13. Back-to-back arrangement of neon tubes for operation on A.C. supplies

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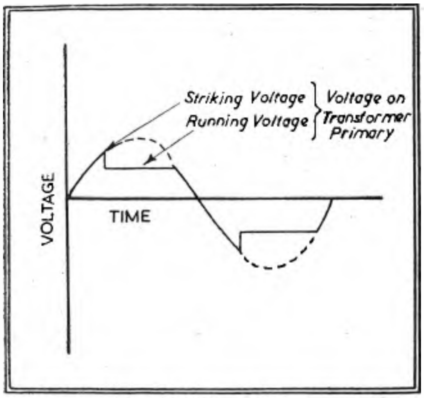


Fig. 14. Voltage waveforms for Fig. 13

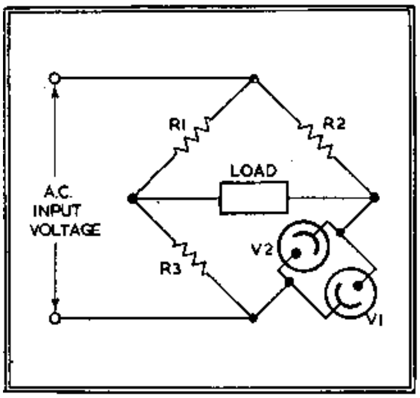


Fig. 15. Cherry and Wild bridge circuit of improved stability for operation on A.C. supplies

| Type | Striking Voltage | Normal Running Voltage | Max. Current (mA) | Quiescent Current (mA) | Min. Current (mA) | Regulation over Current range (volts) | Remarks |
|---|---|---|---|---|---|---|---|
| S130 | 160 (average) | 115-120 | 75 | 10 | 6 | 5 | — |
| VR75[17] | 100 " | 75 (approx.) | 40 | — | 5 | 5 | — |
| VR105[17] | 115 " | 105 " | 40 | — | 5 | 2 | — |
| VR150[17] | 160 " | 150 " | 40 | — | 5 | 4 | — |
| CV45 | 135 (max.) | 120 " | 75 | — | — | — | Fitted with ignition electrode |
| CV71 | 230 " | 160 " | 6 | — | — | — | Small " Osglim " indicator lamp |
| CV188 | 140 " | 100 " | 10 | 4 | 1 | — | — |
| CV286 | 110 " * | 95 " | 10 | 5 | 2 | — | Fitted with ignition electrode |
| CV287 | 170 " | 150 " | 10 | 5 | 2 | — | Fitted with ignition electrode |
| 13201A | 135 " | 90-110 | 200 | 100 | 15 | 5 | — |
| 7475 | 140 " | 90-110 | 8 | 4 | 1 | 1 | — |
| 4687 | 130 " | 90-110 | 40 | 20 | 10 | 6 | — |
| 85A1 | 125 " | 83-87 | 8 | 4.5 | 1 | — | — |
| QS70/20 | 95 (average) | 70 (approx.) | 20 | — | 2 | 6 | Miniature |
| QS96/10 | 110 " | 95 " | 10 | — | 2 | 5 | Miniature fitted with ignition electrode |
| QS150/15 | 177 " | 150 " | 15 | — | 2 | 5 | Miniature fitted with ignition electrode |
| QS150/30 | 160 " | 150 " | 40 | — | 5 | 4 | — |
| QS75/60 | 105 " | 75 " | 60 | — | 5 | 5 | — |
| QS105/45 | 150 "<br>130 " | †105 "<br>‡ | § 45 | — | 5 | 5 | Fitted with ignition electrode |
| QS150/45 | 180 "<br>170 " | ‖150 "<br>¶ | 45 | — | 5 | 5 | Fitted with ignition electrode |
| STV70/60 | 160 " | 70 " | 60 | — | 5 | 6 | — |
| CV1199 (NS2) | 140 (max.) | 97.5 | 180 | 50 | — | — | — |

* Ignition electrode connected to 150V positive through 0.25M resistor.
† Ignition electrode connected to 240V positive through 0.25M resistor.
‡ Anode and ignition electrode strapped.
§ Ignition electrode connected to 150V through 40K resistor.
‖ Ignition electrode connected to 200V through 80K resistor.
¶ At 25 mA.

On the positive half-cycle tube $V_1$ " strikes " when the voltage exceeds the striking voltage and then remains reasonably constant for the remainder of the half-cycle, as shown in Fig. 14. On the negative half-cycle tube $V_2$ operates and a similar waveform to that obtained during the positive half-cycle results. Thus, the value of the voltage applied to the transformer primary remains practically constant irrespective of input voltage variations. A higher degree of stability is obtained, however, by employing a bridge circuit similar to the one described by Cherry and Wild.[15] Three arms of the bridge consist of resistances while the fourth arm contains two neon tubes connected back to back (Fig. 15). The load is connected across one diagonal and the supply across the other. In some cases a balanced bridge circuit has been employed[16] but, as Cherry and Wild point out, much better stabilisation is obtained with an unbalanced bridge. They have also suggested a circuit to improve the efficiency of the stabiliser, in which resistances $R_1$ and $R_2$ (Fig. 15) are replaced by capacitors $C_1$ and $C_2$. In this latter case the efficiency varies from 30 to 50 per cent, depending on the value of the input voltage.

### Typical Characteristics

The typical characteristics of some available neon tubes are shown in the table above.

### Limitations of Circuits Employing Gaseous Discharge Tubes

It has already been stated that the voltage across a neon tube may be written $V = xI + v$, where $v$ is a constant and $x$ is the differential resistance of the tube. The value of $x$ varies considerably for any particular type of tube (in fact, over a range 3 to 1 for the CV188 tubes and probably of the same order for the other types).

Also the voltage across a neon tube varies with the ambient temperature, *e.g.*, in the case of the CV188 tube, if the ambient temperature increases by 1° C. the voltage across the tube decreases by about 0.01 per cent.

Other variations of tube voltage occur due to unknown causes and may in some cases be rather serious. Kirkpatrick[18] has given the results of a large number of tests on the tubes VR75, VR105 and VR150 which were obtained from several manufacturers. He has investigated the effect of factors such as time and temperature on voltage stability and he finds that even for tubes of the same type a wide range of operating characteristics exists.

After a neon tube has passed a certain useful life it continues to operate and the voltage across it moves rapidly out of the specified range. There is no obvious sign, during this period, that the tube is running abnormally.

Another disadvantage of this type

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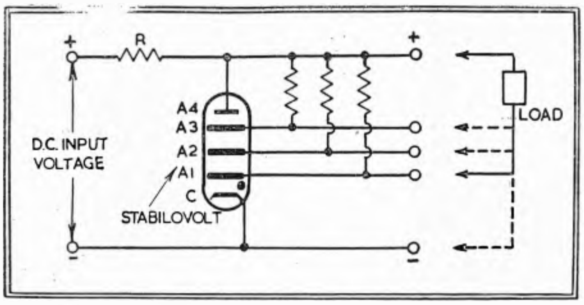
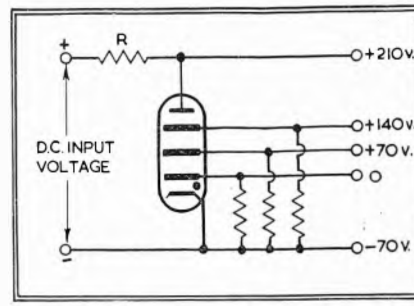



Fig. 16 (*Left*). Simultaneous stabilisation by means of the Stabilovolt

Fig. 17 (*Right*). Positive and negative voltage stabilisation




of stabiliser is that adjustment of voltage is only possible by changing the tube. The resulting stabilisation is, however, independent of the frequency of the input voltage.

The noise generated by a tube should also be small.

A few special high-stability neon tubes have been developed in which there is less tendency for the tube voltage to vary with time and temperature and there are only small variations from tube to tube. The table below gives the characteristics of one such tube (the 85A1).

### Neon Tube Type 85A1

*Preferred Operating Condition*:— Quiescent current, 4.5 ±0.2 mA. Characteristics at above operating condition:—

Running voltage, 83 to 86 volts.

Temperature coefficient of running voltage, −1.8 mV per °F.

Maximum per cent variation of running voltage for current change of 4.3-4.7 mA, 0.17 per cent; during life, 0.5 per cent; after first 300 hours of life, 0.2 per cent.

The noise generated by the valve over a frequency range of 30 c/s. to 10,000 c/s. is of the order of 70 microvolts.

### The Stabilovolt[19 20 21 22]

The Stabilovolt consists essentially of a simple neon tube in which there are a number of additional electrodes (usually three) between the anode and cathode. Simultaneous stabilisation of a number of D.C. voltages may be obtained by its use. The tube and a series resistance $R$ are connected across the input voltage (Fig. 16) and the load, or loads, connected across any number of gaps. The voltages across the various gaps are equal and are substantially independent of the current passing. Hence, the voltages across the loads remain practically constant. As in the case of the simple discharge tubes, the Stabilovolt requires a higher starting voltage than the running voltage, and it is recommended that the input voltage should not be less than one-and-a-half times the voltage developed across the tube. The resistance $R$ is again used to obtain satisfactory stability and to limit the current through the tube. Resistances of the order of 250,000 ohms are connected from one end of the tube (either will do) to each electrode, as shown in Fig. 16, to facilitate striking. In this way a large voltage is applied to each gap in turn and the striking voltage is less than would be required if all the gaps had to be struck simultaneously. A Stabilovolt can be run so that both a positive and a negative voltage can be stabilised at the same time as shown in Fig. 17.

The typical characteristics of some available tubes are given in the table below:—

The following example illustrates the method of calculating the performance of a tube. Suppose it is required to obtain a stabilised power supply of 280 V at 40 mA where the input voltage varies by ±5 per cent.

It is first necessary to choose a tube (or tubes) by referring to the given tables of characteristics. A tube type STV 280/80 is suitable.

Assume that at full load the tube current = 20 mA: supply current = 20 + 40 = 60 mA: supply voltage required = $1\frac{1}{2} \times 280 = 420$ volts: voltage drop across series resistance $(R) = 420 - 280 = 140$ volts

$$\therefore \text{ value of } R = \frac{140}{0.06} = 2{,}350 \text{ ohms}$$

approximately.

Now the variation of output voltage is approximately equal to the variation of input voltage multiplied by the tube differential impedance and divided by $R$.

*i.e.* Variation of tube voltage for ±5 per cent variation in input voltage (*i.e.*, 21 volts) is

$$\frac{21 \times n \times \text{gap impedance}}{2{,}350}$$

Here, $n$, the number of gaps, is 4 and the gap impedance is about 40 ohms, therefore the tube voltage variation is ±1.43 volts or ±0.51 per cent.

Assume now that the load current varies by ±10 mA. In addition to the tube voltage variation caused by the change in input voltage there is also a change in it due to this variation of load current.

The variation in tube voltage due

| Type | No. of Gaps | Minimum Applied Voltage to Tube and Series Resistances $A_4$—C | $A_3$—C $A_1$—C | $A_2$—C | Operating Voltage $A_4$—C $A_2$—C | $A_3$—C $A_1$—C | Permissible Tube Currents at Various Electrodes (mA) $A_4$ | $A_3$ | $A_2$ | $A_1$ | Minm Tube Current mA | Differential Impedance per Gap (ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STV280/40 ... ... | 4 | 420 | 320 110 | 210 | 280 140 | 210 70 | 35 | 40 | 60 | 60 | 5 | 60 |
| STV280/80 ... ... | 4 | 420 | 320 110 | 210 | 280 140 | 210 70 | 70 | 70 | 90 | 100 | 10 | 40 |
| CV1068 (VS68) ... | 4 | 420 | 320 110 | 210 | 280 140 | 210 70 | Maximum 60 | | | | — | — |
| CV1069 (VS69, NS1) | 4 | 420 | 320 110 | 210 | 280 140 | 210 70 | Maximum 80 | | | | — | — |

to the load current variation is equal to the product of the tube impedance and the change in current through the tube. The latter may be taken as the change in load current.

Therefore, the tube voltage change due to the variation in load current

$$= \pm \frac{10}{1000} \times \text{ tube impedance}$$

$$= \pm \frac{10}{1000} \times 4 \times 40 = \pm 1.6 \text{ volts}$$

$$= \pm 0.57 \text{ per cent}$$

since there are four gaps and the impedance per gap is about 40 ohms.

Hence, the total tube voltage variation is $\pm 0.57$ per cent $\pm 0.51$ per cent which has a maximum value of $\pm 1.08$ per cent. Greater stability may be obtained if required by increasing the value of $R$ and using tubes with lower impedance or alternatively two tubes can be used in cascade, the output of the first tube being stabilised again by the second tube and its associated series resistor.

For higher voltages than those for which the tubes are designed, series operation of the tubes may be employed. Here, the tubes may be considered as one tube with an increased number of gaps. For example, if two tubes type STV280/80 are connected in series they will provide a stabilised voltage of 560 (together with stabilised voltages of 420, 280, etc.).

### Stabilisers Employing Thermionic Valves

Stabilising circuits employing thermionic valves can be arranged in many ways. The valves can be used in parallel with the input voltage, they can be placed in series with the load, so that the load current flows through them, or series-parallel valve combinations may be employed. Brief descriptions of simple circuits are given to illustrate the principles of operation of each of these types. These are followed by detailed accounts of several practical circuits which are modifications or improvements of the simple arrangements and have been found extremely useful. All the circuits employ a device for providing a constant reference voltage which is necessary for stabilisation, as shown in the Appendix. Batteries, or gaseous discharge tubes, are used for this purpose. In cases where a very high degree of stability is required a battery must always be used to give the reference voltage.

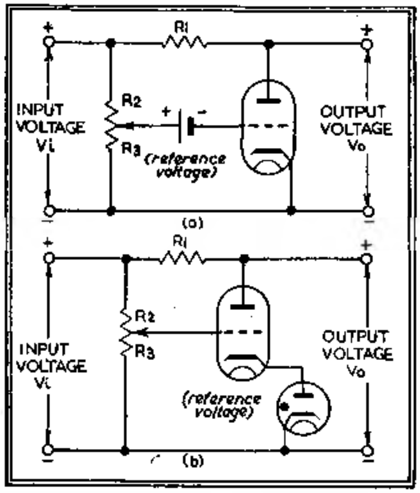



Fig. 18. (a) Stabiliser valve in parallel with supply voltage
(b) Stabiliser circuit with neon tube in cathode circuit

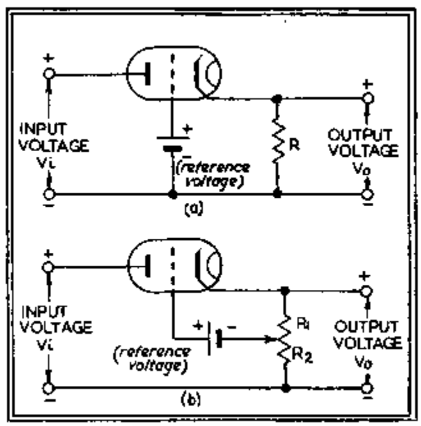



Fig. 19. (a) Simple series-valve stabiliser
(b) Modification of 19 (a)

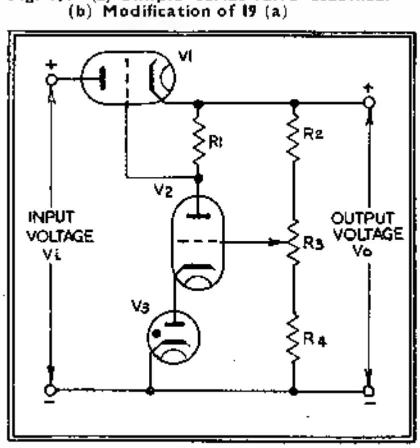



Fig. 20. Series - parallel circuit employing stage of amplification

Fig. 18(a) shows the circuit arrangement of a stabiliser where the valve is placed in parallel with the supply voltage[23, 24]. The grid voltage is controlled by the potentiometer $R_2R_3$ and the battery. An increase of input voltage, $V_i$, makes the grid voltage of the valve more positive so that its anode current increases and the voltage drop across $R_1$ increases. Hence, the output voltage $V_o$ remains substantially constant since the increase in $V_i$ is counteracted by the increased voltage drop in $R_1$. The battery can be eliminated by employing a neon tube in the cathode lead, as shown in Fig. 18(b)[23].

The series-valve stabiliser in its simplest form is illustrated in Fig. 19(a)[23]. The valve may be regarded as a series resistance which is controlled by the output voltage $V_o$; for any change in $V_o$ varies the grid voltage on the valve and hence the voltage drop across it in such a direction as to oppose the change in $V_o$. The disadvantage of this simple circuit is that the battery voltage must be of the same order of magnitude as the output voltage. To reduce the battery voltage the circuit of Fig. 19(b). has been suggested.[25] The effectiveness of these simple circuits may be improved by adding a direct-current amplifier in the grid circuit of the valve.

Fig. 20 shows one form of series-parallel valve circuit which is essentially similar to the arrangement of Fig. 19(b) but incorporates a stage of amplification. $V_2$ is the amplifier valve which has its anode connected through a suitable resistor $R_1$ to the positive side of the output voltage $V_o$ and its cathode connected through a neon tube $V_3$ to the negative side of $V_o$. $V_1$ is the series valve.

*(To be continued)*

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# Video Amplifier Testing— Using a Square Wave Generator

By T. B. TOMLINSON, B.Sc.(Hons.), Assoc.Brit.I.R.E.

THE wide band of frequencies necessary for faithful reproduction of the modulating signal in television video amplifiers introduces special problems not usually encountered in audio frequency amplifiers, where level amplitude frequency response and freedom from harmonic distortion are the usual requirements. In video amplifiers, the maintenance of substantially constant gain over the frequency band is important, but equal attention must be given to the phase/frequency characteristic, as this determines the time delay of the various frequency components of the signal in passing through the amplifier. For television purposes this bandwidth can be considered to extend from 50 c/s to at least 2¾ Mc/s., and most video amplifiers have a level amplitude/frequency characteristic with constant time delay over a wide band of frequencies in the middle of this passband. Thus there is generally a complete separation of low frequency and high frequency distortions. At the extreme high frequency and low frequency ends of the band, the maintenance of a definite constant time delay is more important than the preservation of a level amplitude characteristic, in order that substantially distortionless amplification may be possible. It will be assumed that the amplitude of the signal is not sufficiently great to introduce harmonic distortion, with which we are not concerned here. It must be borne in mind, however, that the video signal is of a transient nature and the amplifier must not introduce any appreciable modification of the intelligence contained in the signal; in other words, the wave-shape must not be impaired beyond certain tolerable limits. The simple steady state response is obtained by plotting amplitude/frequency response over the frequency spectrum using sine waves of constant amplitude and the method of doing this is so universal that it need not be described here. The other and less familiar steady state response is obtained by plotting the phase shift/frequency response over the frequency range; a method of deriving this curve has been described elsewhere.[1,2] Within limits, the inspection of these two curves enables one to estimate the response to a video signal. However, in the regions of high frequency and low frequency cut-off where the amplitude and phase characteristics are deteriorating, the transient performance is still unknown. This transient response can be observed from the response to a Heaviside unit function, *i.e.*, a suddenly applied voltage which thereafter remains constant in amplitude. If this "step voltage" is to be reproduced accurately the amplitude and phase characteristics must be linear from zero to infinite frequency. Thus, in practical amplifiers the response is determined by the ability of the amplifier to transmit high and low frequencies. The high frequency response determines the shape of the transient wave form at, and a short time after, the application of the "step voltage" and good high frequency response results in the reproduction of this sudden change of voltage as a steep and straight transition without overswing. The low frequency response determines the shape of the transient waveform after a much longer time has elapsed.

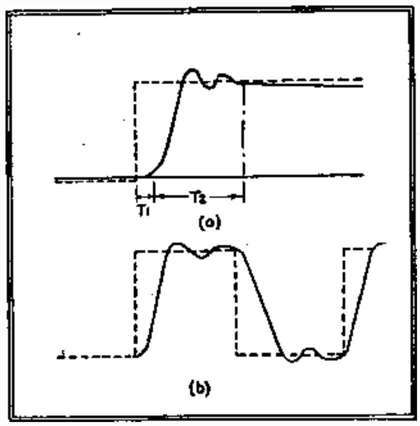



Fig. 1. (a) Step voltage waveform shown dotted, amplifier output in full line
(b) Similar waves for a square wave

The television signals consist of rapid non-repeated variations of voltage which do not attain a steady state, consequently a good "transient" response ensures acceptable fidelity of reproduction of these signals. Also, if the response to the "unit step" function is known, the response to any other transient analysis shows the extent of distortion introduced by the irregularities in the amplitude and phase characteristics over a given frequency spectrum, and also by the limitation of that spectrum to a given band of frequencies.

A graphical representation of these high frequency and low frequency effects is depicted in Fig. 1(a) The dotted line curve represents the "unit step" voltage waveform and the full line the amplifier output waveform. The time interval T, during which there is no response is given by the effective time delay in the amplifier and does not represent distortion; during time interval $T_2$, the output rises from zero to the steady voltage amplitude, probably after one or more cycles of damped oscillations commonly known as "ringing." This introduction of distortion is determined almost entirely by the amplitude and phase characteristics at the high frequency end of the passband. After this interval the amplitude of the output voltage declines at very slow rate, determined by the low frequency characteristics of the amplifier. The overall response is in effect that which the amplifier presents to a periodic square wave of infinite period, the output voltage falling to zero after infinite time has elapsed.

### High Frequency Response

To determine the high frequency transient response we need only consider the time interval $T_2$ in which all the effects of distortion appear. Thus, we could then use as an alternative waveform a square wave having a period of repetition equal to twice the interval $T_2$. This interval is just sufficiently long in time to permit the output response to have attained a substantially constant value before the next half cycle of the square wave voltage is applied. This square wave and the output waveform of the amplifier are shown in Fig. 1(b). This method of using a repetitive square waveform to determine the transient response was first suggested by Bedford and Fredendall[3] and used to calculate the approximate transient response of multi-stage video amplifiers.

Mathematical determination of the transient response is obviated when a square wave generator and a suitable oscilloscope are available, a stationary pattern being obtained on the screen of the oscilloscope; the deteriorated shape of the output waveform reveals the type and degree of distortion introduced by the amplifier. The fidelity at the high frequencies is shown by steepness of wavefront and character of damped oscillations, if any, when a square wave of high repetition frequency is used. Observation of the steepness of the wavefront enables one to calculate the resonant frequency of the high frequency compensating network used in the circuit.[3] The horizontal resolution of a television image is mainly determined by the steepness of the waveform of the response to a "step function" or of a square wave of suitable repetition frequency. In reality, the size of the scanning spot limits the sharpness of changes of picture shades and the most abrupt change from black to peak white in an average television system occurs over an interval of about 0.15$\mu$sec. This effect, known as the aperture effect, limits the requirements demanded of the video amplifier itself. Good low frequency response is shown by the ability of the amplifier to reproduce a low frequency square wave without rounding, or tilting of the waveform, or a combination of both these effects. The distortion of the low frequency square wave represents inability to maintain the correct degree of background shading from top to bottom of the television picture. Thus, in the case of a square wave having a repetition frequency of 25 c/s, a difference of 5 per cent between the highest and lowest points on the top of the waveform reproduced by the amplifier results in a 5 per cent variation of background shading from top to bottom of the raster. This is the maximum variation that is generally allowable in practice in order to obtain a satisfactory picture.[4]

Thus we see that direct information as to the transient response of the amplifier can be obtained by applying a square wave, i.e., a perfect recurrent transient, and observing the deteriorated shape of the output waveform. Now in the case of a symmetrical square wave, i.e., one having unit mark-space ratio, this is equivalent to a fundamental frequency $f_s$ combined with its odd harmonics which are therefore spaced $2f_s$ apart in the frequency spectrum. Consequently, it is interesting to regard the application of the square wave as a simultaneous test of the amplitude and phase characteristics of the amplifier at frequencies spaced $2f_s$ apart.[5] In other words, $2f_s$ is a measure of the electrical resolving power of the square wave test and one deduces that $f_s$ should be small compared with the pass-band of the amplifier. This enables the reproduced transient to have settled at a constant amplitude before the new transient is applied. The time necessary for this is governed by the pass-band (which determines steepness of waveform) and on the sharpness of high frequency cut-off (which determines the duration of "ringing"). In the case of video amplifiers for television reception this frequency is of the order of 200 Kc/s. As the frequency is lowered the low frequency effects appear and in general a square wave generator having two repetition frequencies (200 Kc/s. and 50 c/s) is quite sufficient. However, for the sake of completeness and for other purposes given later in the paper it is preferable to include most frequencies within the range separating these two frequencies, hence a step and a continuous frequency variation control are provided for this purpose.

The output voltage of the generator should be high so as to enable one to test a low gain video stage which modulates a television cathode ray tube having a long grid base—an output of some 10 volts peak to peak is quite suitable. Hence it is not necessary to amplify the output voltage; indeed, if this were so, the design of such an amplifier would have to be much more carefully considered than that of the one under test, and its performance tested by the square wave generator also. Considerable accuracy is afforded by this method of amplifier testing since slight changes in the amplitude and phase characteristics result in considerable modification of the output wave shape.

#### Low Frequency Response

For the observation of low frequency phenomena the square wave signal is applied at the input terminals of the amplifier and an oscilloscope connected directly to the output. It is a wise precaution to check the linearity of the time base trace before recording results. In the case of high frequency testing, the problem becomes more complicated. Without doubt, the video amplifier under test will have been designed to work into a given load capacitance and the effect of connecting the output to an oscillograph will be to increase this capacitance by some 20 pF. or so. The obvious procedure is to assess the values of the load capacitances and remove a capacitance (e.g., television tube connexion, plugs, leads to next stage, etc.) equal to that of the test oscilloscope and its connexion leads, so as to maintain the total load capacitance at the same value. If it is not possible to do this, then a cathode follower must be used between the output of the amplifier and the input terminals of the test C.R.O. This will insert only an extra load capacitance of some 5 to 10 pF., which can be more easily balanced out by the removal of connexions not essential to the test experiment. The design of such a cathode follower must be a subject of great care if it is not to be overloaded and if it is to have no effect on the overall response. It is not the purpose of this article to give this design procedure; the necessary information has been given previously.[6] To determine the values of these capacitances a bridge tester may be used, or the method of Seeley and Kimball[7] is an alternative. When performing the high frequency test, check that the transient has completely settled down during a single half cycle of the square wave by varying the repetition frequency, and note that this does not result in any change of shape or slope of the leading edge of the waveform.

If the effect of the detector load circuit is to be included in the test, the connexion of Fig. 2(a) is recommended. Fig. 2(b) gives an alternative mode of connexion, but is inferior in that it reduces the available output of the square wave generator. The author has found the Cossor Model 339 double beam oscillograph useful, the maximum output of the square wave generator being connected to the second deflexion plate in order to make direct comparison between input and output waveforms. The second beam may also be used to check the repetition frequency of the square wave generator by connecting to it a 200 Kc/s or other frequency sine wave voltage of sufficient amplitude. In this case it is useful to synchronise the multivibrator to the sine wave frequency in the manner indicated in the circuit diagram of Fig. 3(a).

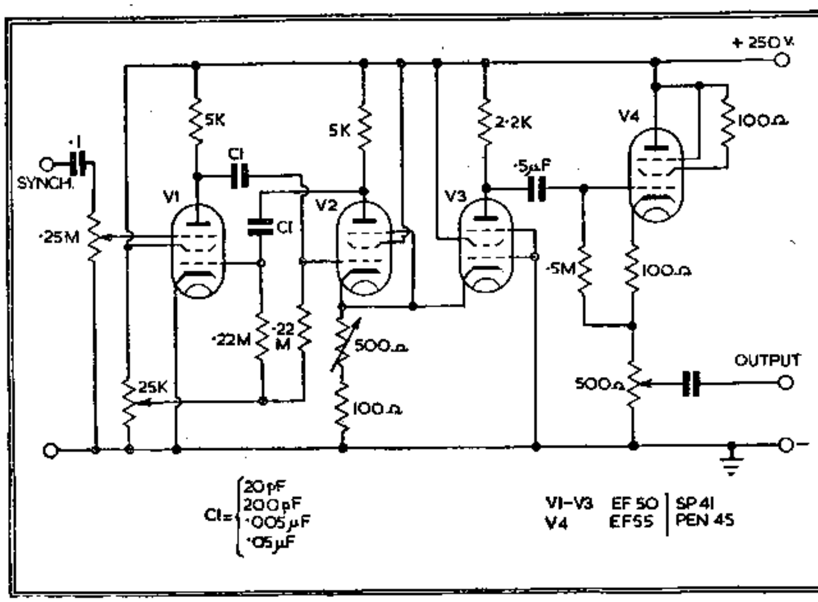



Fig. 3. (a) Square wave generator circuit, showing multivibrator synchronising connexions

## The Square Wave Generator

The square wave generator to be described is of a conventional type using a multivibrator, the output of which is "clipped" by a valve operating near to cut-off; by using a circuit similar to that described by Bartelink,[8] it is only necessary to carry out one "squaring" operation. The output of the "squaring" valve is fed into a cathode follower, the low output impedance of which prevents deterioration of the waveform when connected to a fairly large load capacitance. The complete circuit including component values is given in Fig. 3(a).

The multivibrator consists of two pentodes with equal anode load resistors and equal coupling capacitors connected in normal manner. It was decided to use pentodes so as to obtain a sufficiently rapid rise of the output square wave and for the same reason the anode load resistors were kept at the somewhat low value of 5 KΩ. The coupling capacitors are selected by a switch which constitutes the step frequency control. The grid resistors are made equal so as to obtain a mark-space ratio of approximately unity and are returned to a potentiometer which is connected across the H.T. supply; this enables one to vary the positive bias applied to the two grids and so serves as a continuously variable frequency control.

It is possible to obtain a waveform approximating to a square wave from either anode by suitable adjustment of the time constants. However, such a waveform needs to be "clipped" on both positive and negative sides before it is completely "squared." The waveform at the cathode is as shown in Fig. 3(b) and is seen to be already square on one side. Furthermore, the cathode output connexion is at low impedance and so the effect of the input capacitance of the following stage on the rise of the square wave is considerably less than in the case of a circuit using the anode connexion.

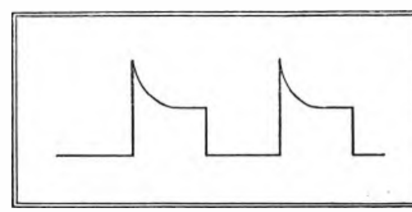
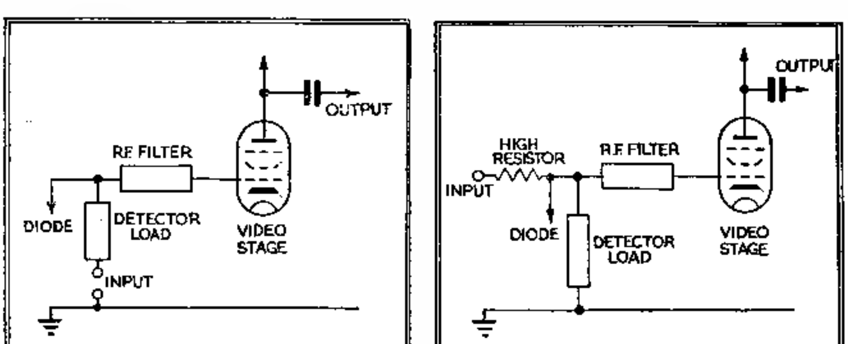


Fig. 3. (b) Waveform at cathode of multivibrator

The cathode of the squaring pentode is connected to that of the multivibrator valve, and its grid is directly earthed. By a suitable choice of the common cathode resistor the applied voltage is of sufficient amplitude to "switch" the grid-cathode voltage of this valve from zero to cut-off voltage. As the bias voltage across this common cathode resistor depends on the setting of the potentiometer used for varying the positive grid bias, there is no fixed optimum value for this resistor. Because of this, a 500Ω




Figs. 2. (a) and (b) Connexions of detector load circuit when included in low frequency response test

variable resistor is used, with a fixed resistor of 100Ω connected in series so as to prevent the bias voltage on the "squaring" valve falling below its normal working value. An amplified version of the squared waveform appears at the anode and is fed to the cathode follower through a coupling capacitor. This capacitor must be sufficiently large in order not to impair the shape of the waveform at the lowest repetition frequency. Due to the feedback action, the effective input resistance of the cathode follower is approximately five times greater than the value of its grid-leak resistor and so the value of this coupling capacitor need not be excessive. Variable amplitude of output voltage is obtained by using a potentiometer as the cathode load resistor of the cathode follower. Ideally, the power supply should be stabilised but this is not normally necessary if an extra large capacitance is connected across the H.T. supply. If a repetition frequency lower than 50 c/s is required it is recommended that a circuit using balanced push-pull squaring and output stages, similar to that of Cosby and Lampson,[9] should be used.

### Waveforms

A typical video amplifier stage is given in Fig. 4 and we shall now discuss the effect of the values of the components on the wave shape of the amplified square wave. The capacitor C represents the total effective stray capacitance and it will be assumed that, in the interests of gain, this is limited to as small a value as possible. $R_F$ represents the decoupling resistor and/or the H.T. source impedance, and $C_F$ the decoupling capacitor or the H.T. supply smoothing capacitor.

In Fig. 5(a) is shown the initial square wave, and the modification of its wave-shape by the more common types of distortion likely to be encountered are indicated in the other diagrams. For instance, in Fig. 5(b) there is a pronounced rounding of the diagonally opposite corners of the waveform. This may be caused by the excess time delay (*i.e.*, phase lag) of the high frequency components in passing through the amplifier. Assuming C to be reduced to a minimum possible value, we must reduce the value of $R_L$ and/or increase the value of L. If the rounding appeared at the

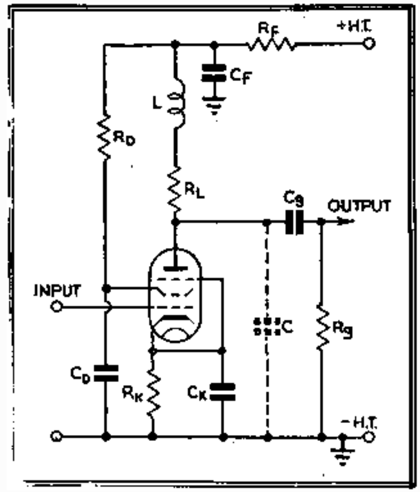



**Fig. 4. Video amplifier stage**

other two corners it would indicate a phase lead at the higher frequencies. Constant time delay at all frequencies but with attenuation of the high frequency components results in the rounding of all four corners as shown in Fig. 5(e). This can be removed only by reducing the value of $R_L$. If the attenuation of the high frequencies takes place too suddenly (*i.e.*, sharp cut-off) then we get ringing, as shown in Fig. 5(d). This is not so likely to occur with shunt compensation as with series, or filter type compensation networks.[10] The amplitude and duration of the ringing are determined by the sharpness of cut-off and the frequency of ringing approximates to the frequency at which the cut-off is most rapid. To reduce this effect to a tolerable amount in the case of Fig. 5(d), increase the value of $R_L$ until the waveform approaches that of Fig. 5(e). Then reduce the value of L, the compensating inductance; a further adjustment of $R_L$ may be necessary. In the case of Fig. 5(f) there is evidence of sharp cut-off and that the bandwidth of the amplifier is too narrow. The waveform can be improved by first decreasing L, after which an adjustment of $R_L$ may be necessary.

The time of rise of the transition edges is a measure of the bandwidth of the amplifier. The "rise time" has been defined as the time taken for the output voltage to attain 50 per cent of its final value[11] and also as the time taken to increase from 10 per cent to 90 per cent of this value.[5] In the opinion of the author the latter is the preferable definition as it includes more of those distortion effects appearing at the top of the waveform. Of course, the rise time must be corrected: un-waveform is only an approximate measure of that of the amplifier, since it must depend on the rise time of the initial waveform produced by the square wave generator. If the two are comparable the observed rise time must be corrected: unfortunately, this is not a case of simple subtraction and a curve relating the corrected and observed rise times is given by Kallmann.[6] In the case of the square wave generator described above, which has an initial rise time of about $0.1\mu$ secs., it is sufficient to say that in combination with an amplifier rise time of $0.1\mu$sec., there is a resultant observed value of $0.14\mu$secs. An amplifier rise time of $0.2\mu$secs. gives an overall rise time of $0.22\mu$secs., and if the ratio of amplifier rise time to initial generator rise time is greater than 3 : 1, the correction is less than 5 per cent. A good video stage for use in television reception should have a rise time not greater than $0.2\mu$secs.

We can now deduce that, as far as the reproduction of transient waveforms is concerned, a flat amplitude/frequency characteristic with sharp cut-off will give results inferior to those obtained with a steadily dropping amplitude characteristic in which attention is given to the phase response at the upper end of the frequency spectrum. It was mentioned earlier in the article that the horizontal definition is limited by the aperture effect: this attenuation of the high frequency components of a television signal is inherently free from phase distortion and so partial compensation for its effect can be given by a waveform of the type shown in Fig. 5(f)[12]. Thus the deliberate introduction of a ring into the response can be a means of improving the sharpness of the transition edges of the observed picture. It would appear that a "ring" frequency $f_r$ given by $f_r = 1/T$, where $T$ is the "width" of the spot measured on a time basis, gives a safe compromise as far as a typical television receiver is concerned. Care must be taken not to over-emphasise the ring, although the degree permissible is undoubtedly a function of viewing distance, picture contrast and, of course, personal taste.

We shall now discuss some of the waveforms obtained when using a square wave having a low repetition frequency. The wave shape may be tilted as in Figs. 5(g) and (h); this effect is mainly due to a non-linear phase characteristic, the phase at the fundamental frequency leading in the case of Fig. 5(g) and lagging in the case of Fig. 5(h). On the other hand, the wave may be rounded as in Fig. 5(i), indicating that the gain at the fundamental frequency is too low, or as in Fig. 5(j) when the "fundamental" gain is too high, there being no phase shift in either case.

The tilt of Fig. 5(g) may be removed by increasing the value(s) of $R_g$ and/or $C_g$, and that of Fig. 5(h) by reducing $R_F$ and/or $C_g$. The rounding of Fig. 5(i) can be eliminated by increasing $R_F$ and/or reducing $C_F$, and that of Fig. 5(j) by reducing $R_F$ and/or increasing $C_F$. If it is not possible to modify the values of $R_F$ and $C_F$ then the directly opposite adjustments should be made to $R_D$ and $C_D$. In practice it is usual for either (g) or (h) to appear in combination with (i) or (j) and several adjustments in circuit values may be necessary. In fact, in the course of removing any of the transient distortions illustrated in the waveforms of Fig. 5, other types of distortion may be introduced, so that the final squaring of the output waveform will often be the result of several successive operations.

In order not to make the problem too complex and as it is not possible to compensate for the effect of the reactances of both $C_g$ and $C_k$ in a single stage, it is assumed that $C_k$ is omitted or, if its inclusion in the circuit is essential from gain considerations, it should have as large a value as is economically practical. Also the effect of $R_L$ on the waveforms of Fig. 5(g), (h), (i) and (j) has been neglected, and in any case its value is determined by high frequency considerations. For a more detailed account of low frequency adjustments the reader is referred to other literature.[7,13,14,15,16] In general, for a single stage amplifier, the only low frequency distortion encountered is that of Fig. 5(g) and this is readily removed by increasing $R_g$ and/or $C_g$. It is recommended that $R_g$ should be as large as other circuit parameters permit, so that the value and therefore the physical size of $C_g$ need not be excessive; this keeps the stray capacitances introduced by $C_g$ at a minimum, which is important from the point of view of high frequency response. The amplitude and phase characteristics can be derived from observation of the square wave response[11] and there is evidence of non-linear (*i.e.*, harmonic) distortion when the two half-cycles of the waveform are non-symmetrical.

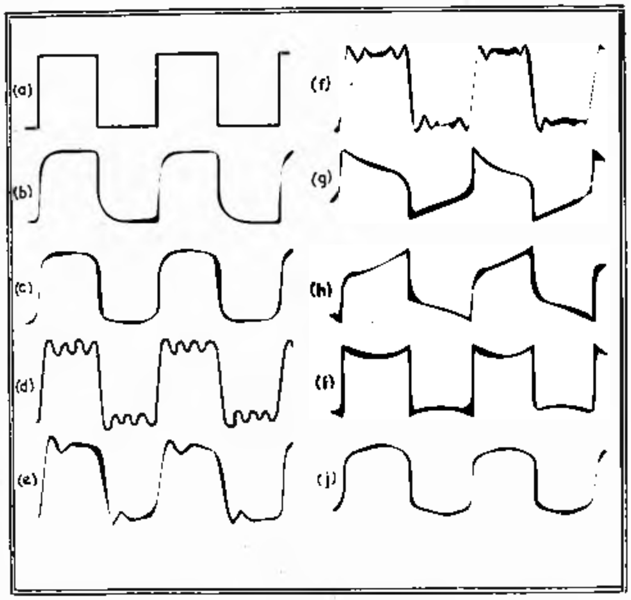



**Fig. 5. Effects on a square wave of the different types of distortion likely to be encountered in the video amplifier stage**

## Further Uses of the Square Wave Generator

One most useful application of the square wave generator is to use its output both to modulate a television receiver cathode-ray tube and at the same time to synchronise the line time base sweep generator. If a repetition frequency of about 200 Kc/s. is used, this results in a series of alternate black and white vertical bars appearing across the screen. The relative widths of these bars can be used as a measure of the linearity of the sweep and the sharpness of the edges of the bars is a measure of the fineness of focus. Using a repetition frequency of about 1,000 c/s. in like manner, the same test can be applied to investigate the frame time base linearity.

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# RADIO TELEMETERING

## Factors Influencing Choice of System

By G. L. HINCKLEY*

IN the field of aeronautical and guided missile research it is necessary to measure and record the magnitude and variation of certain physical quantities during flight. Often it is not possible or convenient to make the necessary records in the aircraft or missile and so the measurements are made by electrical instruments and the data so obtained is transmitted to the ground by radio telemetering methods. The record can then be made at the ground receiving station.

When a specification has to be drawn up for a radio telemetering system for a particular purpose, or for a wide range of applications, attention must be given to a number of factors, all of which will directly influence the choice of system to be adopted and also the conditions under which the chosen system will work.

This article is an attempt to present some considerations on these factors in the hope that it may prove of use to those wishing to use radio telemetering, and possibly to those who may have to specify the details of a system to be adopted for a particular purpose.

### Types of System in Current Use

First, let us consider briefly the various types of radio telemetering systems in current use. It is not suggested that the list is comprehensive but it should illustrate the very wide choice which is available and emphasise the necessity for careful consideration before choice is made of any particular system.

The many systems can be classified under two main headings, frequency multiplexing systems and time multiplexing systems. In the former, the data to be transmitted are converted, if not already in this form, into electrical variations of voltage, resistance or reactance, and these electrical variations are used to modulate a multi-channel radio transmission system so that each channel is given a separate frequency which is modulated by a particular data element, and all channels are transmitted simultaneously and continuously.

In time multiplexing systems the data elements are sampled in time sequence and the radio transmission system is modulated by voltages derived from each data element in turn. Thus information from only one of the data elements is transmitted at a time. Many variations of each of these two main types of system exist.

There exist also composite systems having certain features of both frequency and time multiplexing arrangements. For example, groups of channels may be selected in comparatively slow time sequence, all channels of each group selected being transmitted simultaneously and continuously during the period of selection. Alternatively, certain channels of a frequency multiplexing system may be transmitted normally, that is simultaneously and continuously, and other channels may be time multiplexed, each of these multiplexed channels carrying information from a number of data elements sampled in slow time sequence.

In the frequency multiplexing systems the most usual arrangement is for the various data elements converted into electrical variations, to be each used to modulate a sub-carrier. These sub-carriers are spaced in frequency and are all used to modulate the main radio frequency carrier continuously and simultaneously. The modulation of either sub-carriers or main carrier may be by amplitude, phase or frequency methods or a pulsed system may be used with amplitude, width, position or recurrence frequency modulation of the pulses.

The time multiplexing systems show an even wider variation in arrangement although all arrangements provide for the sequential sampling of the data elements. A wide variety of sampling or commutation devices are being used or tried; examples are, simple brush commutators, multiple contact switches operated in sequence by cam arrangements, rotating light beams with photo cells, rotating electron beams in high vacuum tubes, electronic commutators using pulse circuits and electrostatic or electromagnetic commutators having no direct connexion between moving parts.

Equally diverse methods of modulation are possible, simple direct amplitude or frequency modulation of the R.F. carrier may be used, or alternatively frequency or phase modulation of a sub-carrier which in turn is used to amplitude, phase or frequency modulate the main R.F. carrier. More complex methods require the production of pulses which may be amplitude, position, width or recurrence frequency modulated, or pairs of pulses may be generated in which the time interval between the pulses of each pair is modulated.

In all time multiplex systems synchronisation of the receiving and recording equipment to the transmission equipment is necessary in order to identify correctly the signals due to each channel so that the variations of the data elements of each channel may be separately analysed. The methods adopted for this synchronisation are almost as various as the modulation or commutation methods and may be provided by devoting one or more channels to the transmission of a signal of peculiar amplitude, width or frequency.

Each of the systems and variation of systems has particular merits and demerits, and to go into these in detail would take considerable time and space: but it is hoped to draw attention to what are believed to be the more important features so that the choice of system for a particular purpose may perhaps be narrowed down if not definitely established.

### Factors Influencing Initial Choice of System

The more important factors influencing the initial choice of system which is the most suitable for a particular purpose appear to be as follows:—

(*a*) *The nature of the physical data to be transmitted (e.g., accelerations, pressures, strains, temperatures, voltage levels, etc.).*

(*b*) *The number of such elements of data to be transmitted (i.e., the number of channels required).*

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(*c*) *The maximum frequency of variation of the data on each channel.*

(*d*) *The space and weight limitations on the transmission equipment (including the apparatus to convert mechanical data to electrical data where necessary).*

(*e*) *The overall accuracy required from the system.*

(*f*) *The operational life required for the transmission portion of the system.*

### Choice of System and Modulation Method

When the preceding factors have been quantitatively assessed a choice can usually be made between the frequency and time multiplex systems, for the number of channels which can conveniently be accommodated by frequency multiplexing systems is limited to about 6 to 10; otherwise the bandwidth requirements become excessive, the channel filtering arrangements become very complex and the problem of cross-talk between channels becomes serious. This limited number of channels can, however, handle data which is varying at frequencies up to several thousand cycles per second.

Time multiplexing systems can accommodate many more channels, but with mechanical commutation the limit of data variation frequency which can be handled is determined by the maximum permissible rotational speed of the commutating device. A sampling frequency of more than twice the highest data variation frequency must in practice be used, and each channel is usually sampled once per revolution of the commutator.

The first of the composite systems mentioned under the heading "Types of System in Current Use" has attractive possibilities when rapidly varying data occur on a larger number of channels that can normally be accommodated on a frequency multiplexing system and when the frequency of data variation is higher than can conveniently be handled by a time multiplex system. The information obtained is, however, discontinuous (a practical arrangement would allow for, say, 36 channels sampled in groups of six, each group being sampled for one second every six seconds). Less frequent group sampling would permit more groups and so a larger total number of channels.

It is clear, therefore, that the number of channels required and the maximum variation frequency of channel data will generally determine the choice between frequency and time multiplexing systems.

Space and weight limitations are likely to influence the choice between continuous wave and pulse modulation particularly if a time multiplexing system is chosen and the number of channels required is more than about a dozen. In general the pulse systems will be more complex and require more space than the C.W. systems. The pulse systems may conveniently use electronic commutators permitting high sampling rates with many channels; they also make possible the design of elegant display and recording equipment. Where the smallest possible transmission equipment is essential, frequency multiplexing systems and most pulse modulated time multiplexing systems are at a disadvantage, for at least one valve per channel will be required, whereas with a C.W. time multiplex system the commutation can often be performed at the input to the valve chain and in the very simplest of arrangements the total number of valves for the complete modulation and radio transmission equipment may be reduced to only two.

The choice of modulation system is influenced more by the accuracy that is required from the system than by other factors. All the usual considerations, well known to radio engineers, of the relative merits of amplitude, frequency, phase and pulse modulation methods apply to telemetering systems as to other radio-communication systems.

### Choice of Carrier Radio Frequency

The effect of the ionosphere on a radio signalling system is a serious difficulty in the transmission of accurate measurement data. Reflexions from this ionosphere may cause variations in the amplitude, phase or time of arrival, or the frequency of the received radio signal, and these variations may cause error. Reflexions from the ionosphere are almost entirely absent at carrier frequencies above about 200 Mc/s per sec. It seems, therefore, advisable to use frequencies above this value for radio telemetering purposes.

The use of directive receiving aerial systems will help to reduce the error due to reflexions of the signal from the surface of the earth, buildings and trees, and will also give an improved signal to noise ratio due to the aerial gain. Such directive aerials become quite practical at the higher radio frequencies.

The use of a very highly directive receiving aerial system is, however, not very convenient, for the difficulty of keeping the aerial directed on to the moving transmitter increases as the aerial beam width decreases. Auto-following techniques can, of course, be used but such additional complications are unwelcome.

Absorption of the radio signal by cloud or rain occurs when frequencies of about 3,000 Mc/s and above are used, also it becomes increasingly difficult at these frequencies to obtain the desired omnidirectional transmitting aerial radiation. It seems, therefore, that the highest practical carrier frequency is of the order of 1,000 Mc/s.

A further factor influencing against too high a carrier frequency is that of valve types available for the airborne transmitter. When it is necessary to keep the physical size of the airborne equipment to a minimum the use of transit-time or magnetron oscillators is prohibited, and triodes or pentodes must be used. With existing types of such valves the efficiency falls off rapidly with increasing frequency and this valve question probably sets an upper limit of about 600 Mc/s.

The physical size and arrangement of the transmitting aerial on the vehicle is obviously a matter of importance for it is undesirable that the aerial should introduce serious drag or otherwise affect the aerodynamic properties of the vehicle. Radio frequencies in the range 300-600 Mc/s. require quite small conventional rod aerials and are also convenient for the application of suppressed or slot aerials should rod aerials be unacceptable aerodynamically.

A radio frequency carrier of between 300 and 600 megacycles per second is therefore best for most telemetering purposes.

### Choice of Commutation Method for Time Multiplexing

The simplest form of time sequence sampling devices are undoubtedly brush commutators or cam operated switches. Their use, however, is limited to systems which do not require the transmission of rapidly varying data; for, as has already been mentioned, each channel is usually sampled only once per revolution of the sampling device and the maximum rotational speed possible with brush commutators or cam switches is probably not more than about 3,000 or 4,000 r.p.m., or 50 to 60 per second. This means that the maximum data variation frequency which can be transmitted is not more than 25-30 c/s. A further limitation to these mechanical contacting arrangements is due to the brush or switch contact noise voltages produced. This noise sets a lower limit to the signal levels which may be sampled and it will introduce serious errors if the commutation of strain gauge or other circuits producing signals of millivolt order is desired without pre-commutator amplification.

A commutation arrangement having attractive features for a telemetering system for transmitting information from a large number of pressure measurements, such as the distribution of pressure along the wing of an aircraft, is that using a rotating light beam and a photo cell. In this arrangement a light beam of very small cross section is rotated by a small revolving mirror and caused to pass in rapid sequence through a series of small shutters arranged around the periphery of a circle. A further small mirror, rotating synchronously with the first, collects the light emerging in turn from the shutters and directs it to a photo cell. Each of the shutters is controlled in aperture by one of the pressure points, thus the photo cell output is a voltage whose amplitude is modulated successively by each shutter and therefore by each pressure. The device can be made quite small and having small, light weight rotating parts can be operated at speeds well above 10,000 r.p.m. The signal to noise characteristic is little worse than that of the photo cell.

Similar in general principle to the rotating light beam commutator are the several variations of the rotating electron beam device. In these an electron beam within a high vacuum tube is deflected on to a series of target plates in time sequence and arrangements are made to permit modulation of the beam either continuously by a single external signal or in turn by as many external signals as there are target plates. The device may thus be used to sample in turn the amplitude of a number of voltages or sort out a time multiplexed signal into its component parts. Being of electronic character very high sampling or sorting speeds are possible. In telemetering application these devices have, however, very limited use due to the rather high modulating voltages required and to the undesirable complexity and bulk of the required deflexion circuit apparatus.

Commutation can also of course, be achieved by pulse circuit arrangements using ordinary electronic valves. Such arrangements are capable of giving a very satisfactory performance and can be designed to sample voltages of almost any level at any required speed, at least up to a million samples a second. Again, however, it is the complexity and the bulk of such arrangements that make them unsuitable for telemetering if a large number of channels have to be sampled and if the available space for the equipment is limited, as is usually the case.

It is apparent, therefore, that high speed commutation is a problem, especially when a fairly large number of channels are required, and particularly if the voltage levels of the channels are small due to the low output of the mechanical-electrical pick up devices. A possible solution to this problem of high speed low level commutation is offered by commutators which sample electrostatic or electromagnetic fields produced by the signals on the various channels. Usually such electric fields are very weak but it seems likely that by careful design satisfactory commutation may be developed which will provide for the sampling of up to about 50 channels at rates of around 200 per second of each channel where the signal on each channel is of millivolt order or greater.

### Conclusions

From the considerations presented it will be appreciated that the drawing of any rigid conclusions as to which system is the preferable one for any given purpose is an extremely difficult task unless all the influencing factors are known. Certain general conclusions can, however, be drawn.

The choice of the radio frequency to be used seems to be fairly definitely established within limits. The final choice of precise frequency will depend upon the frequency allocation authority and upon the transmitting aerial arrangement chosen.

The operational life required from the transmitting part of the equipment will influence the electrical and mechanical design. If, for rocket tests, only a few minutes operational life is required, apart from testing and setting up requirements, certain components may be operated at ratings above normal and very compact power supply sources may be used.

The overall accuracy required from the system will considerably influence not only the choice of system but also the electrical and mechanical tolerances of the various component parts.

Unless performance requirements demand otherwise there does seem to be a very strong case for the simplest possible system, for such a system should prove to be the most reliable. Reliability in telemetering is of paramount importance because all, or a large proportion, of the information regarding a particular experiment or test is to be obtained from the telemetering record; and often, as in the firing of a rocket, there is only one chance of doing the experiment. Every experiment will require considerable and expensive preparation, much of which may be wasted if the telemetering equipment fails to record the results.

If complex systems are contemplated, careful thought would seem to be necessary to decide whether the additional accuracy or other facilities really justify the greater potential unreliability. The limited space which is so often allocated to the telemetering equipment also favours a decision to use the simplest possible system.

It is very difficult to attempt any general statement of opinion as to what is the best telemetering arrangement for it is clear that a knowledge of particular requirements is necessary. It does seem, however, that the simpler systems have the advantage, and that many requirements of a telemetering system can be met by a time multiplexing system, using one of the forms of mechanical commutator, the output of which is used to frequency modulate a sub-carrier of about 100 Kc/s., the sub-carrier amplitude modulating the main R.F. carrier. This amplitude modulation is arranged to modulate

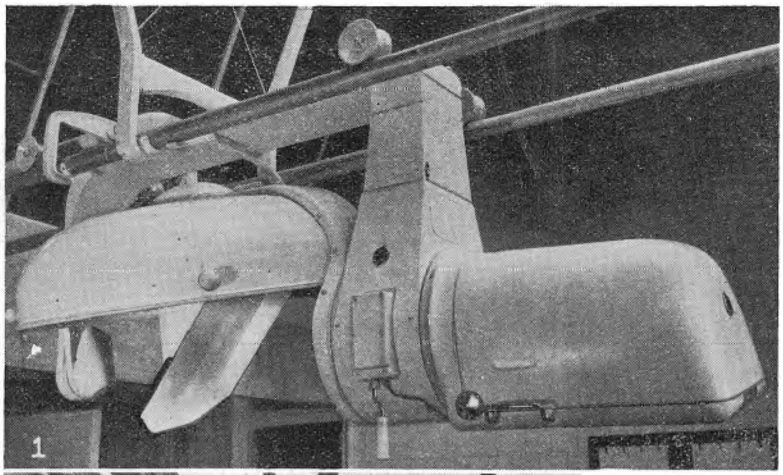
(*Continued on page 223*)

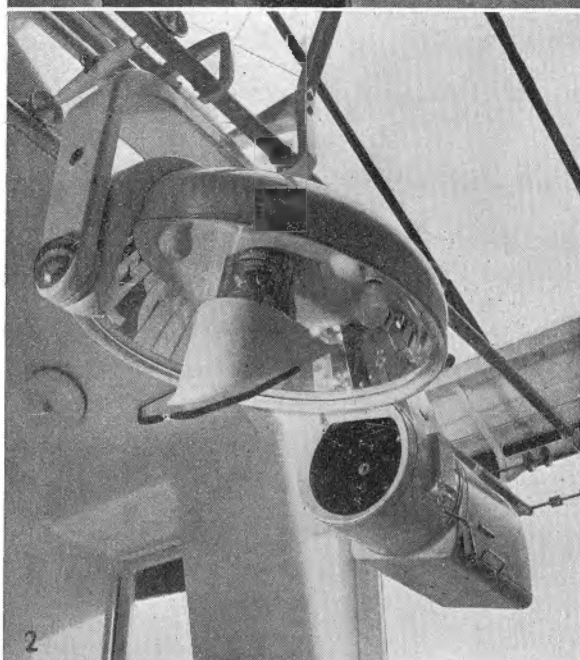
# TELEVISION /
# TEACHING OPE

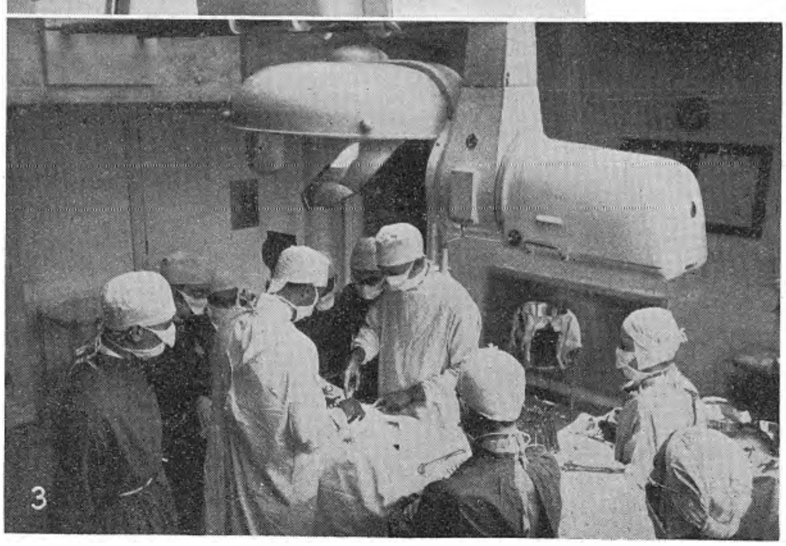
*The new Emitron television installation at Guy's Hospital, which has been designed in co-operation with the Director of Surgery, is claimed to be the only equipment of its kind in the world, and was demonstrated for the first time on May 11th, 1949.*

*At this demonstration, the removal of a boy's appendix was witnessed at viewing points in an adjacent lecture theatre and access to the gallery of the theatre was allowed while the actual operation was in progress so that a direct comparison could be made.*

*The possibilities of television as an aid to medical instruction have long been discussed, and although on a few special occasions in America television has been temporarily installed in an operating theatre to enable*




THE equipment illustrated in the accompanying photographs incorporates in one assembly the television camera with a shadowless lighting unit, and reproduces a view of the operation as nearly as possible similar to that seen by the surgeon, without in any way departing from established theatre conditions or techniques.

In unit construction with the lamp are the lens unit and television camera; the whole of this assembly can be rotated through 60° for operations on an inclined table or moved on an overhead track to allow flexibility in the theatre. The small handle for rotation of the unit can be seen in the lower centre of Figs. 1 and 4.

The lens unit which is motor operated from the control room, offers the choice of three magnifications so that the picture on the viewing screen represents at will any of the following areas:

(1) an overall field of approximately 20 in. by 25 in. extent.

(2) an approximately life-sized reproduction.

(3) a magnified close up of an area about 5 in. by 6 in.

A general view of the operating theatre is seen in Fig. 3 which shows the unobtrusive character of the installation. A view is shown of the camera—shown in Fig. 4 with the cover removed.

Vision equipment in the control room (*see* Fig. 5) comprises the camera channel and waveform generator, whose various units are housed in reinforced sheet metal cases with removable sides, the components being mounted on hinged panels providing a high degree of accessibility for maintenance. Operational controls are grouped on the front panel and multi-way plugs and sockets are provided at the rear for inter-connecting cables.

# ; AN AID TO ATIVE SURGERY

*groups of surgeons to watch the performance of some particular operation, the present installation is the first properly engineered permanent equipment which, at every stage, has been designed to meet the particular requirements of the medical profession. This was the first occasion, furthermore, in which operations have ever been televised in Europe*

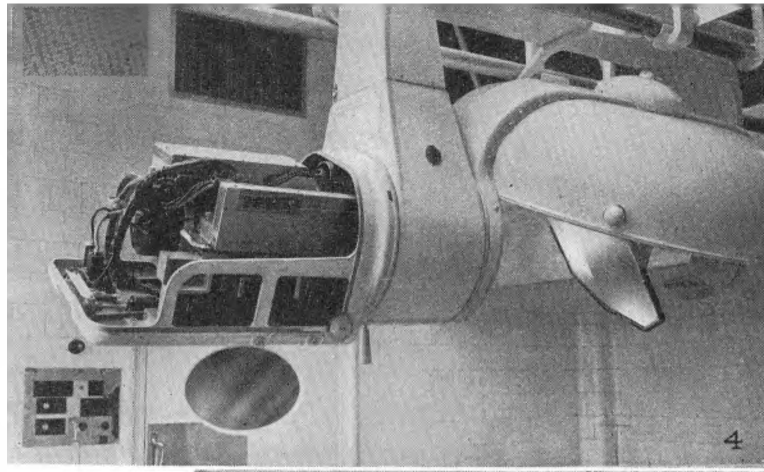
*At present television presentation of operations is still in a relatively experimental stage, but almost daily definition is being improved, and the technical problems involved in picking out in monochrome the different shades of tissue which an operation field displays, are being tackled successfully.*

The television camera employs a C.P.S. Emitron tube, the high sensitivity of which requires no increase in light but, in fact, is able to work with lenses of small aperture with the advantage of a useful depth of focus in the received picture. The C.P.S. Emitron surrounded by the focus and scan coils is mounted on a ball bearing carriage which, for optical focusing is motor driven and remotely controlled. The head amplifier and line scan generator units are mounted alongside accessible for maintenance and easily removable, while the whole camera can be rapidly detached if required.

A concealed microphone is mounted on the lighting unit on the opposite side of the camera to enable a surgeon to explain the course of an operation (*see* Figs. 1 and 2). The camera, lighting, sound and control cables are all taken through telescopic tubes to the control point situated in a room alongside the theatre gallery, and the whole apparatus has been designed so that it may easily be kept clean and sterile.

The camera control unit carries all the operational controls necessary for setting up the picture, and contains apparatus for generating the scanning voltage waveforms, together with the picture signal amplifier. The amplifier incorporates circuits for the introduction of suppression pulses, synchronising signals, and any other waveforms necessary for the operation of the type of camera in use.

Sound and vision signals are fed by cable to viewing points in the teaching department, one of which is seen in Fig. 6. At present four viewing sets are in use in lecture theatres, and elsewhere, and they are standard HMV sets with a 15 in. Emiscope tube, slightly modified to work on the signals received by cable.



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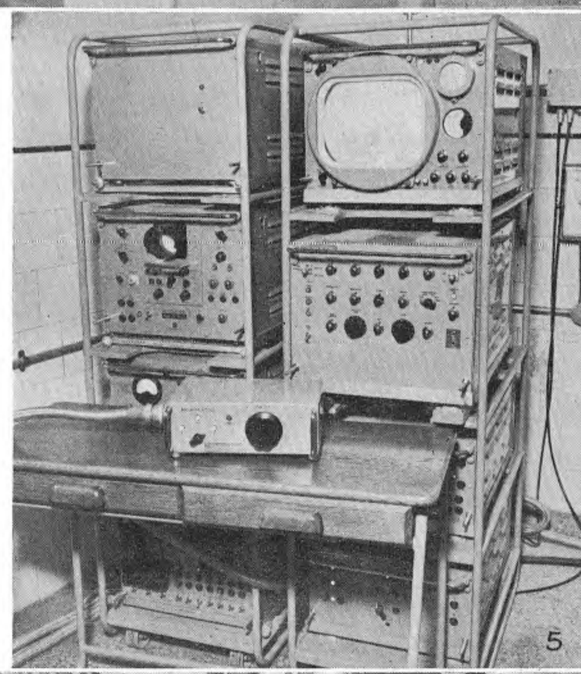

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*[Photographs by courtesy of E.M.I. Ltd.*

# The Harmonic Content of Multivibrator Waveforms

By W. C. VAUGHAN, M.B.E., Ph.D., A.M.I.E.E.

DESPITE the fact that the output waveform of the multivibrator is well known for the richness of its harmonic content, quantitative data for the amplitudes of the various component harmonics do not appear to be readily available. It is the purpose of this article to provide this information and at the same time to indicate the manner in which the harmonic content changes as the waveform undergoes modification within the general pattern usually obtained with multivibrator types of circuit.

According to Fourier's Theorem, a complex periodic waveform defined by a function $y=f(x)$ may be represented by a series consisting of a constant term and a number of harmonically related sinusoidal terms. In most instances an infinite number of terms is required to give an exact representation of the original waveform, but it is usual to find that the series converges so rapidly that for all practical purposes very few terms are of importance. The general form of the Fourier expansion is as follows:

$$y = f(x) = H_0 + H_1\cos(x + \phi_1) + H_2\cos(2x + \phi_2) + \ldots H_n\cos(nx + \phi_n)$$

The coefficient $H_0$ represents the mean value of the function over a complete cycle, $H_1$ is the amplitude of the fundamental, $H_2$ that of the second harmonic and so on. Each term of the type $H_n\cos(nx+\phi_n)$ may be regarded as the vector sum of $A_n\cos nx$ and $B_n\sin nx$ so that the above expansion may be written as the double series:

$$y = f(x) = A_0 + A_1\cos x + A_2\cos 2x + \ldots A_n\cos nx + B_1\sin x + B_2\sin 2x + \ldots B_n\sin nx$$

a form which is much more convenient to us, when the wave-shape it is desired to analyse is made up of two or more simple waveforms which can be dealt with separately.

The output of the multivibrator is, in general, of the pattern shown in Fig. 1 and it will be seen that its

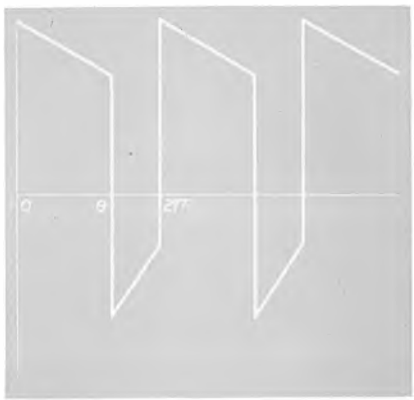



Fig. 1. Waveform of multivibrator output

ordinates can be regarded as the sum of square and triangular portions as shown in Fig. 2. Each of these can be represented by a Fourier double series, so that if the former portion is defined by a function $y' = f'(x)$ and the latter by $y'' = f''(x)$, it follows that:

$$y = y' + y'',$$

where
$$y' = f'(x) = A_0' + A_1'\cos x + A_2'\cos 2x + \ldots A_n'\cos nx + B_1'\sin x + B_2'\sin 2x + \ldots B_n'\sin nx$$

$$y'' = f''(x) = A_0'' + A_1''\cos x + A_2''\cos 2x + \ldots A_n''\cos nx + B_1''\sin x + B_2''\sin 2x + \ldots B_n''\sin nx$$

Providing both these functions are referred to a common origin the corresponding sinusoidal terms in the two expansions will be in phase and may therefore be added directly in order to obtain the coefficients of a double series representing the complete waveform. Thus:

$$y = (y' + y'') = (A_0' + A_0'') + (A_1' + A_1'')\cos x + (A_2' + A_2'')\cos 2x + \ldots (A_n' + A_n'')\cos nx + (B_1' + B_1'')\sin x + (B_2' + B_2''\sin 2x + \ldots (B_n' + B_n'')\sin nx$$

### Square Portion

The separate portions of the waveform now require individual treatment. The square portion has a value $a_1$ between $O$ and $\theta$, and a value $-a_2$ between $\theta$ and $2\pi$. It will therefore be defined by the function:

$$y' = f'(x) = \Big[\, a_1 \Big]_0^{\theta} = \Big[ -a_2 \Big]_{\theta}^{2\pi}$$

Following the usual processes of Fourier analysis, an expression for the mean value $A_0'$ is obtained from:

$$A_0' = \frac{1}{2\pi}\int_0^{2\pi} f'(x)dx$$
$$= \frac{1}{2\pi}\left\{\int_0^{\theta} a_1 dx - \int_{\theta}^{2\pi} a_2 dx\right\}$$
$$= \frac{1}{2\pi}\left\{a_1\theta - a_2(2\pi - \theta)\right\}$$

Expressions for the $A_n'$ and $B_n'$ coefficients are obtained in the following manner:

$$A_n' = \frac{1}{\pi}\int_0^{2\pi} f'(x)\cos nx\,dx$$
$$= \frac{1}{\pi}\left\{\int_0^{\theta} a_1\cos nx\,dx - \int_{\theta}^{2\pi} a_2\cos nx\,dx\right\}$$
$$= \frac{1}{n\pi}\left\{(a_1 + a_2)\sin n\theta\right\}$$

$$B_n' = \frac{1}{\pi}\int_0^{2\pi} f'(x)\sin nx\,dx$$
$$= \frac{1}{\pi}\left\{\int_0^{\theta} a_1\sin nx\,dx - \int_{\theta}^{2\pi} a_2\sin nx\,dx\right\}$$
$$= \frac{1}{n\pi}\left\{(a_1 + a_2)(1 - \cos n\theta)\right\}$$

### Triangular Portion

Dealing now with the case of the triangular portion, this is seen to have a value $\dfrac{b_1}{\theta}$ $(\theta - x)$ between $O$ and $\theta$, and $-\dfrac{b_2}{2\pi - \theta}$ $(2\pi - x)$

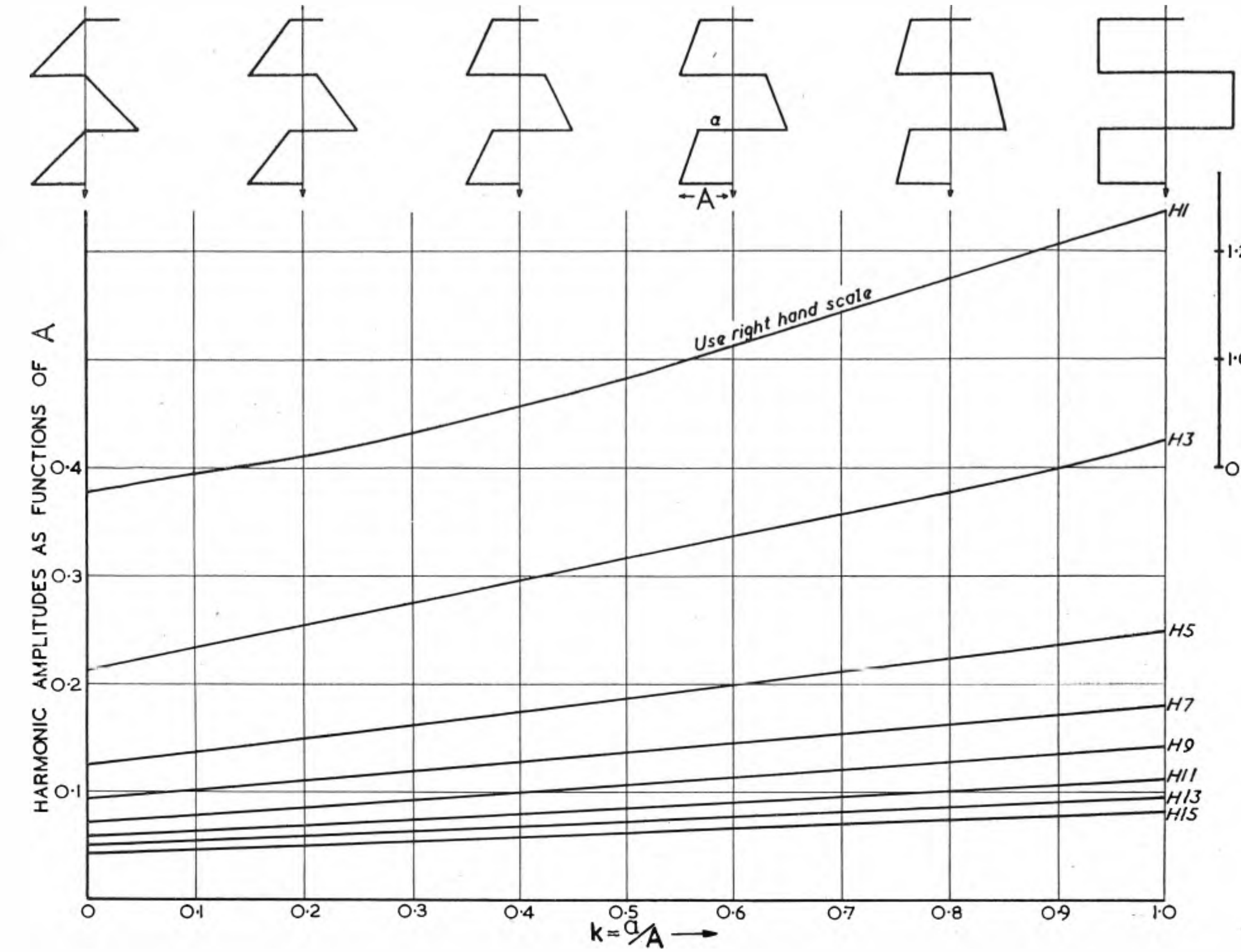



**Fig. 4 Plots of Harmonic Amplitudes as a function of k**

between $\theta$ and $2\pi$. It will therefore be defined by the function:

$$y'' = f''(x) = \left[\frac{b_1}{\theta}(\theta - x)\right]_0^{\theta}$$

$$= \left[-\frac{b_2}{2\pi - \theta}(2\pi - x)\right]_{\theta}^{2\pi}$$

The mean value of this portion of the wave is obtained from the relation:

$$A_0'' = \frac{1}{2\pi}\int_0^{2\pi} f(x)dx$$

$$= \frac{1}{2\pi}\left\{\int_0^{\theta}\frac{b_1}{\theta}(\theta - x)dx - \int_{\theta}^{2\pi}\frac{b_2}{(2\pi - \theta)}(2\pi - x)dx\right\}$$

$$= \frac{1}{2\pi}\left\{\frac{b_1\theta}{2} - \frac{b_2}{2}(2\pi - \theta)\right\}$$

The $A_n''$ and $B_n''$ coefficients are determined as follows:

$$A_n'' = \frac{1}{\pi}\int_0^{2\pi} f''(x)\cos nx\,dx$$

$$= \frac{1}{\pi}\left\{\int_0^{\theta}\frac{b_1}{\theta}(\theta - x)\cos nx\,dx - \int_{\theta}^{2\pi}\frac{b_2}{(2\pi - \theta)}(2\pi - x)\cos nx\,dx\right\}$$

$$= \frac{1}{n^2\pi}\left\{\frac{b_1}{\theta}[1 - \cos n\theta] + \frac{b_2}{(2\pi - \theta)}[1 - \cos n\theta + n(2\pi - \theta)\sin n\theta]\right\}$$

$$B_n'' = \frac{1}{\pi}\int_0^{2\pi} f''(x)\sin nx\,dx$$

$$= \frac{1}{\pi}\left\{\int_0^{\theta}\frac{b_1}{\theta}(\theta - x)\sin nx\,dx - \int_{\theta}^{2\pi}\frac{b_2}{(2\pi - \theta)}(2\pi - x)\sin nx\,dx\right\}$$

$$= \frac{1}{n^2\pi}\left\{\frac{b_1}{\theta}[n\theta - \sin n\theta] - \frac{b_2}{2\pi - \theta}[n(2\pi - \theta)\cos n\theta + \sin n\theta]\right\}$$

Adding together the appropriate coefficients for the square and triangular portions of the original complex wave the $A_0$, $A_n$ and $B_n$ terms for the double series representing the latter are obtained. Thus:

$$A_0 = A_0' + A_0'' = \frac{1}{2\pi}\left\{\theta\left(a_1 + \frac{b_1}{2}\right) - (2\pi - \theta)\left(a_2 + \frac{b_2}{2}\right)\right\}$$

$$A_n = A_n' + A_n'' =$$

$$\frac{1}{n\pi}\left\{(a_1 + a_2 + b_2)\sin n\theta +\right.$$

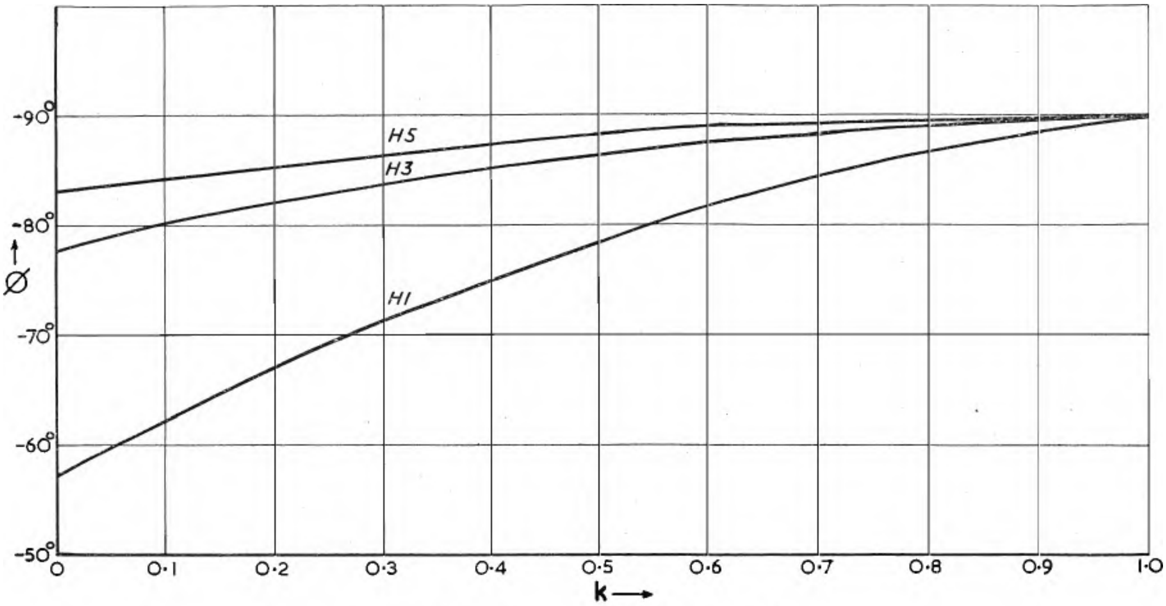



Fig. 5. Plots of Phase Angles as a function of k

$$\frac{1}{n}\left[(1 - \cos n\theta)\left(\frac{b_1}{\theta} + \frac{b_2}{2\pi - \theta}\right)\right]\Bigg\}$$

$$B_n = B_n' + B_n'' =$$

$$\frac{1}{n\pi}\Bigg\{(a_1 + a_2 + b_1) - (a_1 + a_2 + b_2)\cos n\theta -$$

$$\frac{1}{n}\left[\sin n\theta\left(\frac{b_1}{\theta} + \frac{b_2}{2\pi - \theta}\right)\right]\Bigg\}$$

The analysis of any waveform conforming to the general pattern of Fig. 1 may now be obtained by inserting the values of the variables $a_1$ $a_2$, $b_1$ $b_2$, and $\theta$. Usually, however, the radio engineer is concerned principally with the symmetrical type of output waveform shown in Fig. 3, in which case very considerable simplification of the above expressions is possible. In this instance the general terms reduce to:

$$A_o = 0$$

$$A_n = \frac{2b}{n^2\pi^2}[1 - \cos n\pi]$$

$$B_n = \frac{(2a + b)}{n\pi}[1 - \cos n\pi]$$

from which it is evident that both $A_n$ and $B_n$ are zero for even values of $n$. Thus the waveform shown in Fig. 3 contains only odd harmonics whose amplitudes may be computed

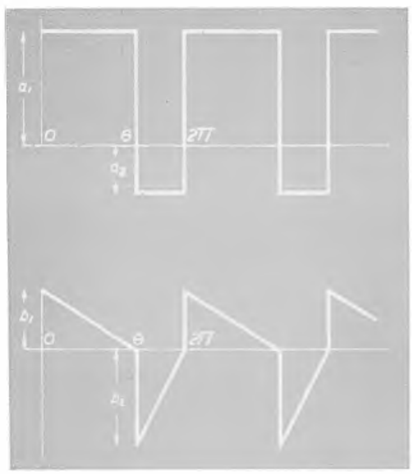



Fig. 2. Component parts of waveform in Fig. 1

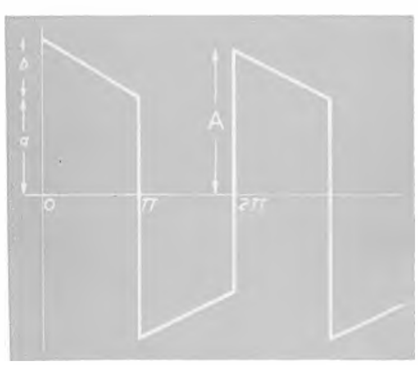



Fig. 3. Typical symmetrical waveform

from:

$$A_n = \frac{4b}{n^2\pi^2}$$

$$B_n = \frac{2(2a + b)}{n\pi}$$

If the peak amplitude $(a + b)$ is represented by **A** and the ratio $a/\mathbf{A}$ is denoted by $k$, then all possible variations of the waveshape in question may be investigated by giving values between 0 and 1. The coefficients in respect of the odd harmonics then become:

$$A_n = \frac{4\,\mathbf{A}}{n^2\pi^2}(1 - k)$$

$$B_n = \frac{2\,\mathbf{A}}{n\pi}(1 + k)$$

The values of $A_n$ and $B_n$ up to and including the 15th harmonic are shown in Table 1. The harmonic amplitudes $H_n$ of the expansion

$$y = f(x) = H_o + H_1\cos(x + \phi_1) + H_2\cos(2x + \phi_2) + \ldots \ldots H_n\cos(nx + \phi_n)$$

may be calculated from the relation

$$H_n = \sqrt{A_n^2 + B_n^2}$$

and the phase angles $\phi_n$ from

$$\tan^{-1}\phi_n = -\frac{B_n}{A_n}$$

The values of these are set out in Table 2. $H_n$ and $\phi_n$ are shown graphically in Figs. 4 and 5.

It is important to know how closely a Fourier series consisting of a

**TABLE I**

**$A_n$ and $B_n$ Coefficients as Fractions of Peak Amplitude A**

| k = | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ ... ... | .4052 | .3647 | 3242 | .2836 | .2431 | .2026 | .1621 | .1216 | .0810 | .0405 | .0000 |
| $B_1$ ... ... | .6366 | .7003 | .7639 | .8276 | .8912 | .9549 | 1.0186 | 1.0822 | 1.1459 | 1 2095 | 1.2732 |
| $A_3$ ... ... | .0450 | .0405 | 0360 | .0315 | .0270 | .0225 | .0180 | .0135 | .0090 | .0045 | .0000 |
| $B_3$ ... ... | .2122 | .2334 | .2546 | .2759 | .2971 | .3183 | .3395 | .3607 | .3820 | .4032 | .4244 |
| $A_5$ ... ... | .0162 | .0146 | .0129 | .0113 | .0097 | .0081 | .0064 | .0049 | 0032 | .0016 | .0000 |
| $B_5$ ... ... | .1273 | .1401 | 1528 | .1655 | .1782 | .1910 | .2037 | .2164 | .2292 | .2419 | .2546 |
| $A_7$ ... ... | .0082 | .0074 | .0066 | .0058 | .0048 | .0041 | .0033 | .0025 | .0016 | .0008 | .0000 |
| $B_7$ ... ... | .0909 | 1008 | .1091 | .1182 | .1273 | .1364 | .1455 | .1546 | 1637 | .1728 | .1819 |
| $A_9$ ... ... | .0050 | .0045 | .0040 | .0035 | .0030 | .0025 | .0020 | .0015 | .0010 | .0005 | .0000 |
| $B_9$ ... ... | .0707 | .0778 | .0849 | .0919 | .0990 | .1061 | .1132 | .1202 | .1273 | .1344 | .1415 |
| $A_{11}$ ... ... | .0033 | .0030 | .0027 | .0023 | .0020 | .0017 | .0013 | .0010 | .0006 | .0003 | .0000 |
| $B_{11}$ ... ... | .0579 | .0636 | .0694 | .0752 | .0810 | .0863 | .0926 | .0984 | .1042 | .1099 | .1157 |
| $A_{13}$ ... ... | .0024 | .0022 | .0019 | .0017 | .0014 | .0012 | .0010 | .0007 | .0005 | .0002 | .0000 |
| $B_{13}$ ... ... | .0490 | .0538 | .0587 | .0637 | .0686 | .0735 | .0784 | .0833 | .0881 | .0930 | .0979 |
| $A_{15}$ ... ... | .0018 | .0016 | .0014 | .0012 | .0011 | .0009 | .0007 | .0005 | .0003 | .0002 | .0000 |
| $B_{15}$ ... ... | .0424 | 0467 | .0509 | .0552 | .0594 | .0636 | .0679 | .0721 | .0764 | .0806 | .0849 |

**TABLE II**

**Phase Angles $\phi_n$ and Harmonic Amplitudes $H_n$ (shown as Fractions of Peak Amplitude A)**

| | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_1$ ... ... | .7548 | .7896 | .8298 | .8748 | .9237 | .9761 | 1.031 | 1.088 | 1.149 | 1.211 | 1.273 |
| $\phi_1$ ... ... | −57.3° | −62.5° | −67.0° | −71.0° | −75.1° | −78.0° | −80.9° | −83.4° | −86.0° | −88.1° | −90.0° |
| $H_3$ ... ... | .2169 | .2369 | .2571 | 2777 | .2984 | .3189 | .3400 | 3610 | 3821 | .4032 | .4244 |
| $\phi_3$ ... ... | −78.0° | −80.2° | −82.0° | −83.5° | −84.8° | −86.0° | −87.0° | −87.9° | — | — | −90.0° |
| $H_5$ ... ... | .1283 | .1409 | .1534 | .1659 | .178[illegible] | .1912 | .2037 | .2164 | .2292 | .2419 | .2546 |
| $\phi_5$ ... ... | −82.7° | −84.1° | −85.1° | −86.1° | — | — | — | — | — | — | −90.0° |
| $H_7$ ... ... | .0912 | 1002 | 1093 | .1183 | 1274 | .1365 | .1456 | .1546 | .1637 | .1723 | 1819 |
| $\phi_7$ ... ... | −84.9° | — | — | — | — | — | — | — | — | — | −90.0° |
| $H_9$ ... ... | .0709 | .0779 | .0850 | .0920 | .0990 | .1061 | .1132 | .1202 | .1273 | .1344 | .1415 |
| $\phi_9$ ... ... | −86.1° | — | — | — | — | — | — | — | — | — | −90.0° |
| $H_{11}$ ... ... | .0580 | .0637 | .0695 | .0753 | .0810 | .0868 | .0926 | .0984 | .1042 | .1099 | .1157 |
| $\phi_{11}$ ... ... | −86.8° | — | — | — | — | — | — | — | — | — | −90.0° |
| $H_{13}$ ... ... | 0491 | .0538 | .0587 | .0637 | .0686 | .0735 | .0784 | .0833 | .0881 | .0930 | .0979 |
| $\phi_{13}$ ... ... | −87.2° | — | — | — | — | — | — | — | — | — | −90.0° |
| $H_{15}$ ... ... | .0424 | .0467 | .0509 | .0552 | .0594 | .0636 | .0679 | .0721 | .0764 | .0806 | .0849 |
| $\phi_{15}$ ... ... | −87.6° | — | — | — | — | — | — | — | — | — | −90.0° |
| r.m.s. whole wave | .5773 | .6083 | .6429 | .6807 | .7211 | .7637 | .8088 | .8544 | .9018 | .9504 | 1.0000 |
| r.m.s. to 15th harmonic | .5718 | .6019 | .6357 | .6728 | .7123 | .7543 | .7981 | .8431 | .8903 | .9387 | .9870 |

limited number of terms represents the original waveform. Synthesis of a curve from the limited series for the purpose of comparison is always a tedius process and a better method is to compare the r.m.s. value of the original waveform with the effective r.m.s. value of the limited series. Since the latter consists of a constant and a number of sinusoidal terms, its mean square value may be readily shown to be:

$$\overline{y_n^2} = H_o^2 + \tfrac{1}{2}(H_1^2 + H_2^2 + \ldots H_n^2)$$

The mean square of the original wave is defined as:

$$\overline{y^2} = \frac{1}{2\pi}\int_0^{2\pi} f^2(x)dx$$

and since in the case in question

$$f(x) = \mathbf{A}\left\{k + \frac{1-k}{\pi}(\pi - x)\right\}$$

between $O$ and $\pi$, and is repeated with a negative sign between $\pi$ and $2\pi$, it is evident that

$$\overline{y^2} = \frac{1}{2\pi}\int_0^{2\pi} 2x. \left[\mathbf{A}\left\{k + \frac{1-k}{\pi}(\pi - x)\right\}\right]^2 dx$$

$$= \frac{\mathbf{A}^2}{3}\left\{(1 + k + k^2)\right\}$$

Figures showing a comparison of the r.m.s. value of the whole wave up to and including the 15th harmonic are shown at the foot of Table 2.

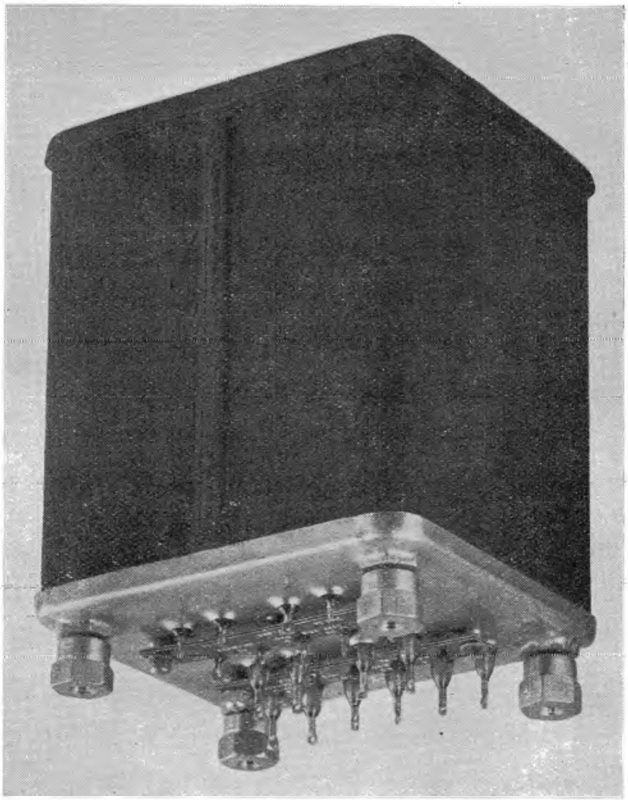
It is apparent from these computations that modification of standard waveshape, in the manner considered, has a greater effect on the lower order harmonics than the higher, and that the amplitudes of the latter gradually approach values

$$6.366\ \frac{(1 + k)}{n}\ \text{(odd harmonics only).}$$

Similarly, the phase angle $\phi_n$ approaches more and more closely to $-90°$ as the order of the harmonic increases.

# Hermetically Sealed Transformers

By M. C. JONES, A.M.I.E.E.*



An Hermetically Sealed Transformer for sub-chassis wiring.

DURING recent years it has become increasingly important to design electronic equipment capable of witastanding any knowa climatic condition. This has been due to the fact that standard equipment may often be required to work in any part of the world without modification, and the degree of success of that equipment in comparison with others can often only be judged by its reliability. To increase our foreign trade, components must be developed which will not break down under conditions of temperature and humidity unknown in this country. In tropical climates the relative humidity of the atmosphere is normally well over 80 per cent with day temperatures of approximately 35-45° C., falling to about 20-25° C. at night, with a consequent increase in R.H. to the point of saturation. In arctic climates the night temperature is often −30° C. and in aircraft flying at 40,000 ft. temperatures lower than −40° C. have been recorded. At the other end of the scale, temperatures in dry hot climates approach +50° C. These conditions are very exacting for delicate equipment, and it has been established that the worst of them is moisture.

In order to ascertain the reliability of components in equipments, an inter-service test schedule has been drawn up in which equipments are subjected to temperatures varying between −40° C. and +71° C. and up to +60° C. at a relative humidity of 95 per cent. To pass this schedule, equipments must not only be able to withstand the simulated climatic conditions, but they must operate satisfactorily at full load for varying periods, the time depending on the ambient temperature.

* ardners Radio Ltd.

When the normal type of "open" transformer was subjected to such tests, it was soon apparent that some modification or re-design was essential, to prevent the ingress of moisture into the windings, as it was this that caused continual breakdown.

### Effects of Moisture on Open Transformers

An open power transformer, being a component which dissipates heat, "breathes" the surrounding air. This "breathing" action takes place during warming-up and cooling down, when the surrounding air is being alternately sucked in and expelled from the windings. If this surrounding air is moist, and it always is, to a greater or lesser extent, the reliability of the transformer is impaired in two ways, both actions being simultaneous. Firstly, the resistance of the inter-winding insulation is lowered to a point where it is insufficient, causing voltage breakdown between windings; and secondly, water soluble salts set up electrolytic action which attacks the copper wire. Both these effects are accelerated at elevated temperatures, but the climatic conditions need not be very severe for either to be fatal.

Some appreciable increase in life can be obtained by protecting the insulating materials by vacuum impregnating the whole bobbin with thermo-setting varnish and retarding the ingress of moisture by dipping the complete assembly in a bituminous compound. This process gives a marked increase in life for a small extra cost, but since moisture is capable of penetrating the bitumen in time, it is not sufficient to give 100 per cent reliability under extreme climatic conditions. The only successful method is to enclose the transformer completely with materials which have a zero moisture diffusion coefficient.

### General Requirements of the Hermetically Sealed Transformer

One of the most important factors today in the design of electronic equipment is weight. Every component must be as small and as light as possible, and unfortunately, this is in direct contradiction to hermetic sealing, as the power/weight ratio must inevitably decrease. Every consideration must be given, therefore, in the design, to keep the weight at a minimum. The container must, of course, be of robust construction, for if it is punctured it will probably be less reliable than its normal open counterpart.

Several methods of hermetic sealing have been tried with varying degrees of success, but the one which proved most reliable, was by supporting the transformer assembly in an iron container partly filled with oil. This method had the great advantage that it did not entail the introduction of new types of equipment and machinery. Iron was chosen as being an easy metal to solder, and if hot tin is dipped after being cut, bent and pressed to shape, the metal is protected from the elements. Additionally, iron is lighter than copper or brass and to some extent acts as a magnetic screen. The container is only partly filled with oil to reduce weight, as well as to relieve excess pressure when the transformer is warm.

### Design

The limiting factor in the electrical design is temperature. The insulating materials in everyday use normally withstand, when varnish impregnated, a temperature of + 100 to 110° C. for several years, and since the transformer is required to work in an ambient temperature of +71° C. the maximum permissible temperature rise for the windings is limited to 39° C. or preferably only 29° C. For practical purposes, a safe limit is 35° C. The temperature rise for open type transformers is limited to 40° C., but as hermetic sealing greatly reduces the radiation area, both the iron and copper losses must be reduced from those usually employed to avoid excessive temperature rise. The amount of de-rating of the flux and current densities is dependent on the cooling area and the design of the container, as well as the operating frequency and the core material.

The mechanical design is the most important factor in hermetic sealing, as if there is the slightest leak in the container the whole object of enclosing the transformer is lost. It may be first thought that a metal container of simple design would be suitable, but since the internal temperature may reach +110° C. the filling medium, whether it be solid, liquid, or gas, will expand, causing high mechanical stress. Provision must therefore be made to cope with this expansion by either making the container of adequate

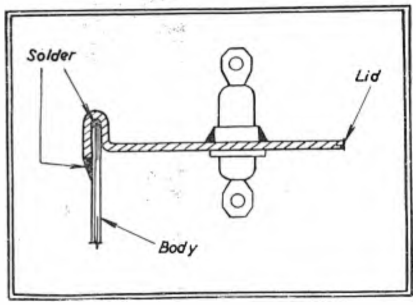



Fig. 1. Lid and body assembly

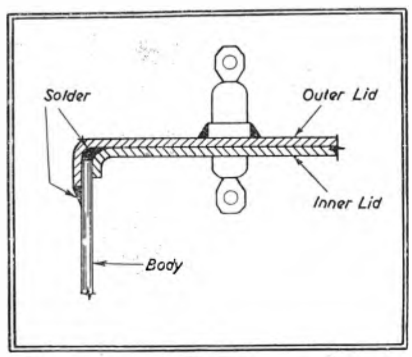



Fig. 2. Improved type of lid and body assembly

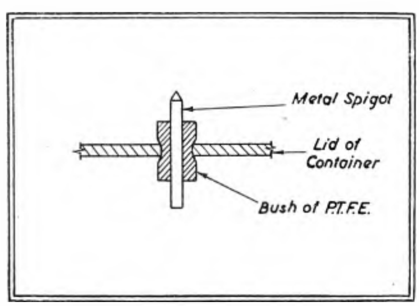



Fig. 3. P.T.F.E. bush

mechanical strength or arranging for the internal volume to increase by means of bellows fitted either internally or externally. If the second method is employed, then space must be sacrificed in the equipment to allow for the expansion of the bellows, and as this is highly undesirable, it is better to use the first method. In order to keep the temperature rise of the windings to a minimum, the container must be filled, or partly filled, with a medium which has a higher thermal conductivity than air, and for this purpose transformer oil is used. Other media, such as petroleum jelly, bitumen or nitrogen could be used, but the increase in thermal conductivity which would be obtained is not sufficient to warrant their use, in view of the difficulties which would be encountered in injecting these media into the container. Furthermore, the characteristics of transformer oil are well known through its almost universal use in larger transformers. Fluids, however, are virtually incompressible, and since transformer oil has rather a large coefficient of expansion, an air space, which can be compressed, must be left in the container. The amount of oil to be used is calculated so that at the test temperature of + 110° C. the internal pressure is approximately 12 lb./sq. in. This figure has been found to be the best compromise between the limitation of temperature rise of the windings on the one hand, and the ease of manufacture of the container on the other. The test pressure normally used is twice the maximum working internal pressure so that the container must be designed to continuously withstand varying pressures from less than zero to +24 lb./sq. in.

The strongest mechanical shape is spherical, but this is impractical, owing to the shape of standard laminations, the difficulty of fixing the transformer in the container and of supporting it in the chassis of the equipment. The next strongest shape is cylindrical, but here again, unless annular laminations or "C" type cores and toroidal windings are used, the space occupied by such a design would be uneconomical, and so the container has to be cubical.

For ease of assembly it has been found best to manufacture the container in three parts—body, base and lid, which are subsequently soldered together. The body is fabricated from one sheet strip and joined with a double rolled vertical seam so that the inside of the body so formed is finished flush, the extra thickness of the seam being on the outside. The lid and base are identical and made with rounded corners and flanged by means of a press tool. This seamless construction avoids the possibility of leaks occurring at the corners. These pressings are made so that the flanges are a good fit on the outside of the body. It was found that it was absolutely essential to reinforce the joints between the body and the lid, and also between the body and the base, as without additional support these lap seams fractured under pressure test. These pressings were accordingly first made, as shown in Fig. 1, which was entirely satisfactory, but as the moisture condensed, a lake formed in the recess of the lid lowering the leakage path of the bushes. The design was therefore modified, and a secondary inner lid and base provided to give the required support as shown in Fig. 2. The edge of the body still fitted into a channel all round and the lake disappeared as the outside surface was now flat. A container with a volume of 100 cu. in. made in this manner with a 22 B.W.G. body and 20 B.W.G. end caps has successfully withstood a test pressure of 50 lb./sq. in. without leaking, even though the body became somewhat distorted.

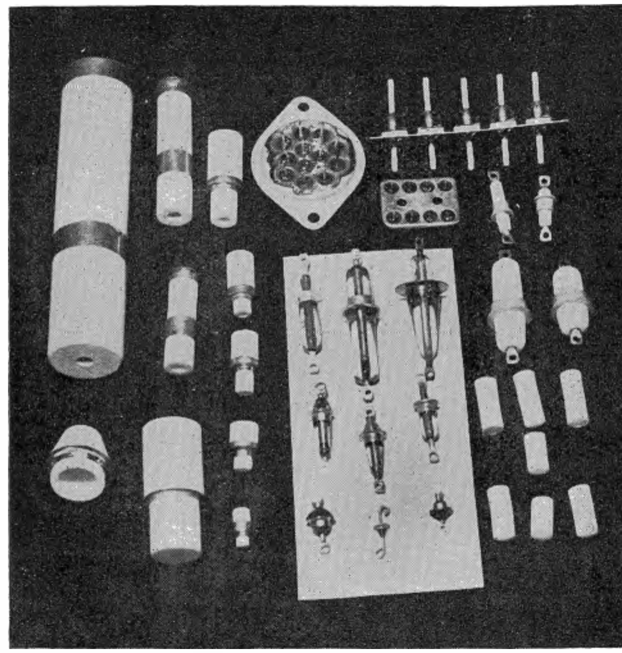


Fig. 4. An assortment of available sealing bushes. The new P.T.F.E. bushes are shown in the bottom right-hand corner

### Winding Terminations

The weakest link in the sealing is the insulating bush for leading out the winding terminations, as the choice of material at the present time is either ceramic or glass, both being rather fragile. The ceramic bushes have either silver or platinum deposited on them in suitable places for them to be soldered in position, but as at soldering temperatures the tin of the solder tends to dissolve silver and to a lesser extent the thinner deposit of platinum, it is difficult, although not impossible, to ensure a perfect air and oil tight joint with even the most skilled of workmen. The other type of bush—the Kovar/Glass seal—has been found to give more reliable performance, as it has a wider flange for soldering to the container lid and the flange does not suffer from being partly dissolved during soldering. Care must, however, be exercised as the glass will fracture if subjected to too great a thermal shock, and it has been found profitable to pre-heat the seals before soldering. Until recently the use of Kovar/Glass seals has been somewhat restricted due to their being manufactured in only two sizes, the larger one being suitable for only 1 KV working, but new sizes are now available extending the range to 5 KV working.

Two new types of seals will shortly be available, one of which is made from an entirely new material, polytetrafluorethylene (P.T.F.E.), the other is ceramic which, from external appearance, resembles the Kovar/Glass type with ceramic replacing glass. The use of P.T.F.E. for the insulating bush is a completely new departure as the sealing does not depend on soldered joints. Sealing is effected by forcing in an oversize metal spigot through the central longitudinal hole distorting the bush to grip firmly the smooth sides of the hole in the panel. The finished shape of the bush is as shown in Fig. 3.

Insufficient time has elapsed since the introduction of both these new bushes for exhaustive tests to be made, but from preliminary results, both types show advantages, in some respects, over previous designs.

Fig. 4 shows an assortment of seals which are available; those on the left being the silvered and platinised ceramics, Kovar/Glass in the centre, with the new type ceramic and P.T.F.E. on the right.

### Assembling the Transformer

The transformer may be mounted in the container with either the laminations at right angles to the plane of the base or parallel with it. The latter method has many advantages over the former, the most important being that some attempt can be made at standardisation of sizes for containers for given ratings. If the I.S.C.C. preferred schedule of laminations is used, it is possible to cover a very wide range of VA ratings with only ten different sizes of laminations, and therefore only ten different base areas are required for this wide range. The height of the container only varies with change in thickness of lamination stack. Furthermore, the fixing centres can conveniently be made the same as those of the four corner bolt holes in the standard " T " and " U " laminations and can be jigged accurately. If the laminations are mounted on right angles to the plane of the base, the same range of VA ratings would require about 30 different base areas and fixing centre dimensions, if each individual rating within the range was designed for maximum efficiency and economy of space. In addition, the cost of manufacture would be greater, as three times the number of press tools for forming the bases and lids would be required.

The first operation in the assembly is the soldering of the bushes and filter plug into the lid, and this may be accomplished by means of R.F. heating or by " floating " this lid in a bath of palm oil maintained at a temperature of about 250° C. Palm oil, however, gives off sickly fumes at this temperature, which require special extraction.

The laminations and bobbin are supported rigidly from both ends of the container by four brass pillars on each side of the lamination stack, the lid and its associated inner lid being first fixed to the upper sets of pillars and the leads from the winding soldered to the spigots of the appropriate insulating bushes. In order to provide for maximum heat conduction from the core, pads of copper foil, insulated from the lamination by glass tape, are clamped under the frames and positioned so that they fill the space between the body and the core in all four sides. The body of the container is slipped over the assembly, the upper edge fitting into the slot between the inner and outer lids. The container assembly is completed by fitting the inner and outer bases, four screws fixing them to the four lower brass pillars. A cross section of a typical assembly is shown in Fig. 6. Sealing of the container is effected by soldering all seams and screw heads. The container is pressure tested by inflating it to 24 lb./sq. in. and immersing it in water. Any pin holes will be evident by a stream of air bubbles, but inflation of the container should be carried out at least three times to ensure that there is not the slightest leak. Before filling with the correct amount of any transformer oil and sealing over the filer plug, the whole unit is first dried under a vacuum (0.2 in. of mercury) for four hours. After sealing, the transformer is heated to a temperature of + 110° C. for a period of four hours, and then subjected to scrutiny under ultra violet light for traces of oil which might have leaked through small pin holes caused by sealing over the filler plug.

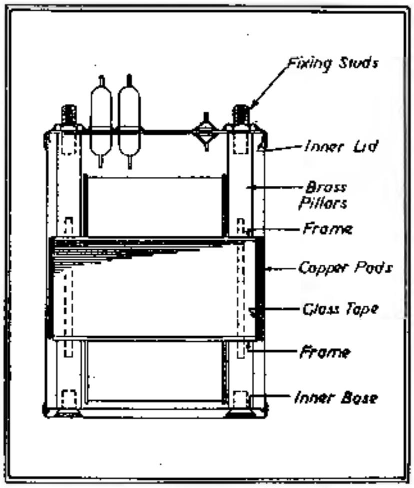



Fig. 5. Cross-section of hermetically sealed transformer

**Future Development**

Every designer of electronic equipment tries to keep his equipment as small as possible, and in consequence of this, transformer manufacturers are constantly being asked to reduce size and weight. This can only be accomplished at the moment by using some of the newer grain oriented magnetic materials for the core, and toroidal winding. The gain, however, is so small at 50 cycles as to be uneconomical, but considerable space and weight can be saved at the higher power frequencies. The real limitation to size is undoubtedly the present limitation of temperature rise. The development of high temperature insulating materials, such as silicones, which will withstand temperatures of approximately 180-200° C. without deterioration, would greatly influence the dimensions and weight of hermetically sealed transformers.

The author is indebted to Gardners Radio, Ltd., for permission to publish the text and photographs. Patents are pending in regard to certain methods of manufacture described.

## Micro-Wave Radio Link for Television Outside Broadcasts

B.B.C. engineers in collaboration with British manufacturers are actively engaged on the exploitation of lightweight outside broadcast equipment. The aim is to extend the scope of these operations and to increase the speed with which the equipment can be set up so that events of exceptional topical interest can be televised. In particular an improved radio-link has been developed to transmit television pictures from the cameras to Alexandra Palace for broadcasting in the normal service.

This equipment, which works on the extremely short wavelength of $4\frac{1}{2}$ centimetres, is now being tested, and exceptionally clear pictures free from all interference are at present being received over a distance of seven miles. There seems to be no reason why equally good results should not be possible at ranges of 20 miles, or even further by covering the distance in two or more stages.

At these extremely short wavelengths the paraboloid aerial can be made to concentrate the radio waves into a very narrow beam. The transmitting and receiving apparatus is light and easy to carry, and thus marks an important advance from the apparatus developed for this purpose before the war, which filled two large motor lorries.

## June Meetings

### The Television Society

Midlands Centre

Date: June 1. Time: 7 p.m.
Held at: Chamber of Commerce, New Street, Birmingham.
Lecture: "The V.H.F. Link."
By: A. H. Mumford, G.P.O.

### The Institution of Electronics

Midlands Branch

Date: June 15. Time: 7 p.m.
Held at: Chamber of Commerce, New Street, Birmingham.
Lecture: "Electronic Equipment in Biological Research."
By: G. Parr. M.I.E.E.

### The Radar Association

London Branch

Date: June 7. Time: 7 p.m.
Held at: Albert Tavern, Victoria Street, London.
Monthly meeting.

### The Institution of Electrical Engineers

Radio Section

*Cancellation of Summer Visit*

The Committee of the Radio Section regret that circumstances have arisen which make it impracticable to arrange the Summer Visit announced in the April issue of the *Journal*.

## New Lens for Television

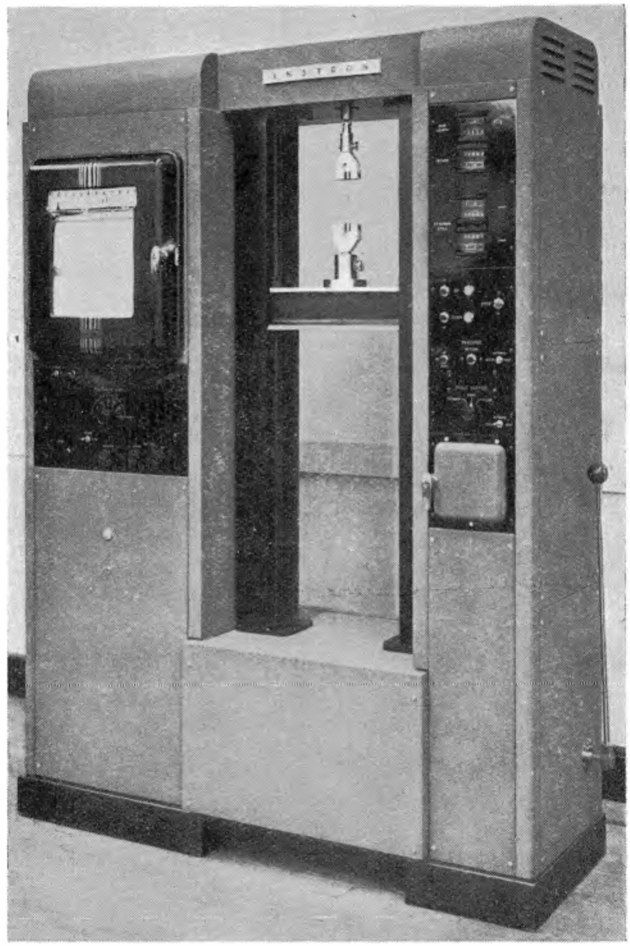
A further step in the development of television outside-broadcast equipment was taken in the arrangements for televising the Cup Final at Wembley recently. On this occasion one of the cameras was fitted with a device known as "Zoom Lens." This lens enables the camera to choose any part of the scene and then gradually magnify it until a close-up view is obtained. The effect is just as if the camera were moving towards this part of the scene, making it grow larger and larger until it fills the whole screen. Focusing is automatically and continually corrected.

This particular lens is a wholly British development. Its inventor is Dr. H. Hopkins, B.Sc., Ph.D., F.Inst.P., who is optical consultant to the B.B.C. Engineering Division and also to the makers, Messrs. W. Watson and Sons, of Barnet.

Zoom lenses have been made before and used both here and in the United States in film production and also in American television. The new British lens, however, works on an entirely different principle and is by contrast much lighter and more optically efficient. It will undoubtedly be a valuable acquisition to the B.B.C.'s mobile television equipment.

# Made in America

Being a selection of American electronic equipment and products, with notes compiled from the manufacturers' data.



## Tensile Strength Testing

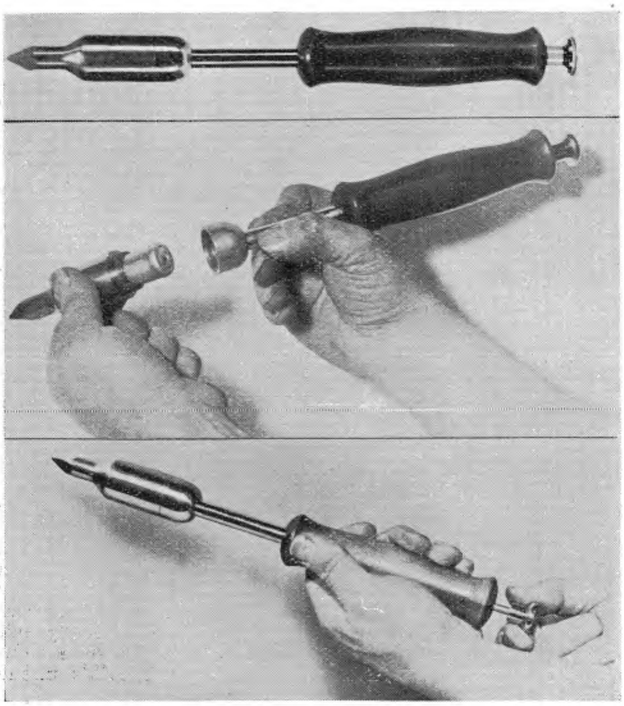
THE New Instron tensile testing instrument is designed to measure accurately the load elongation properties of textile fibres, plastic films, laminates, rubber, paper, rope and adhesives. Tensile ranges from 10 grammes to 1,000 pounds are provided in twenty steps, and the speed of separation of the testing jaws can be varied from 0.02 to 20 in. per minute, in twelve steps. The elongation of the sample under test is recorded graphically on a moving chart, so that the resulting trace is a load-elongation curve for the material, at a constant rate of elongation. The standard chart speeds are also variable, from 0.2 to 50 in. per minute, in ten steps.

The instrument utilises an electronic weighing system based on the electric strain gauge principle for detecting and recording the load applied to the sample under test. The pulling jaw is operated by an unusual drive that provides a controlled rate of elongation of the sample, over a wide range of speeds, in either direction of travel, and with instant reversibility. The chart of the high speed recorder is driven at various speed ratios with respect to this jaw, so that tensile load-elongation curves of the material are made accurately at constant rate of elongation.

*Instron Engineering Corporation,*
*2 Hancock Street,*
*Quincy 71,*
*Massachusetts.*

## New Chemical Soldering Iron

REQUIRING no electric current or external heat of any kind, a new type of soldering iron utilises a chemical cartridge that heats the iron to working temperature in 5 seconds and maintains heat for 6 to 8 minutes, depending on the type of work done. The cartridge, which is about the size of a small flashlight battery, contains a primer and is ignited in a manner similar to that of firing a bullet.



After the cartridge has been placed in the copper tip of the iron it is set off by the impact of a spring rod which is pulled out and released at the back of the handle. The pointed end of the rod strikes the primer that generates the heating action, which is created by the chemical mixture of metal powders similar to magnesium and an oxidising agent.

The heat developed is about 250 watts peak, hence the iron can be used on heavy as well as light soldering jobs. A new cartridge is required each time the iron is used.

*The Kemode Manufacturing Co.*
*161 West 18th St., New York.*

## R.C.A. Television Components for Kinescope RCA-16AP4 (Form CTV-1004).

R.C.A. booklet Form CAV-1004 provides technical data, including characteristics and dimensional outlines for 18 RCA television components for use in receiver designs employing the new 16-in. metal-cone cathode-ray tube RCA-16AP4. In addition, the booklet contains typical deflexion circuits and associated circuit of a pulse-operated, high-voltage supply. Obtainable from:

*Commercial Engineering,*
*R.C.A Tube Department,*
*Harrison, N.J.*

## Radio Telemetering

(*Continued from page* 211)

the carrier so that the peak to mean ratio of the R.F. output is about three to one. Such a system is very flexible and can be designed to handle up to about 50 channels. The simplest possible arrangements will give overall accuracies of around 10 per cent, but with some increase in complexity up to about 2½ per cent is possible.

Either brush or cam operated switch commutators seem to be the simplest and most suitable if their sampling rates are high enough and if the voltage levels to be measured are of about one tenth volt or greater. For higher sampling rates or for the sampling of lower level signals, the electrostatic or electromagnetic field commutators seem to be the most promising if their successful development is possible.

In conclusion it should be stated that the considerations and opinions presented are the result of study of published and unpublished reports on the subject, and of conversations with the designers and users of telemetering equipment.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this paper.

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## Multiple Component Units

(*Continued from page* 199)

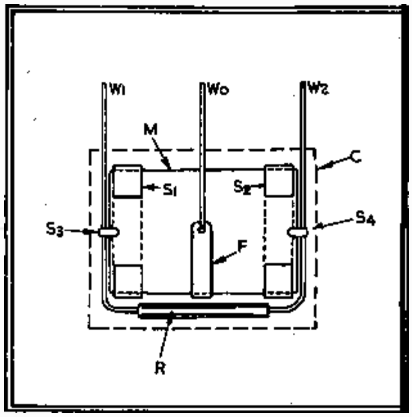


**Fig. 3. Multiple component using mica capacitors**

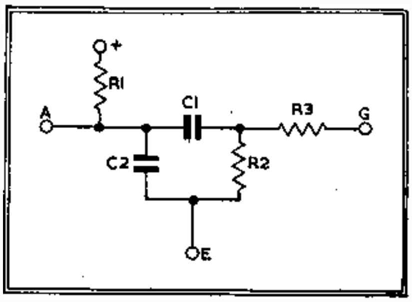


**Fig. 4. Inter-valve and grid-filter coupling circuit**

resistance to moisture. The flat form of unit is moulded in a special resin which provides great mechanical rigidity for holding the separate elements and the terminal wires firmly in place. This moulding is not damaged by accidental contact with a soldering iron, as is the wax coating, while in addition it is unaffected by low temperatures down to −40° C., a temperature that often causes wax coatings to crack and flake off.

The cylindrical form, from its construction with ceramic elements, provides its own rigidity and so does not require the moulding for that reason.

A combined inter-valve coupling and grid-filter is sketched in Fig. 4 as a typical example of another form of network. This unit can be made in cylindrical form about ½ in. diameter by 1⅛ in. long with four projecting terminal wires for joining respectively to the H.T., Anode, Cathode (or Earth) and the Control grid of the succeeding stage. These four wires replace the ten connexions that would otherwise be required—and provide an obvious substantial saving to the apparatus assembler.

## Television Time Base Linearisation

(*Continued from page* 211)

apply the method which involves merely the connexion of a variable $R$ across the entire deflector coil. As $R$ is varied it changes the coil current waveform in the manner illustrated by Fig. 2(a) and is set at the point where the curvature changes from upwards to downwards. This simpler method is often used in commercial practice since an $R$ across the coil is needed for flyback damping. With careful design $R$ can be set for optimum linearity without producing unsuitable damping; this difficulty does not arise when the damping is switched in by a diode operated by the flyback pulse.

This article is based on an unpublished analytical report, on "The Integration Method of Linearising Exponential Waveforms" and is published by kind permission of Sobell Industries, Ltd.

### Appendix

The slope of the exponential charging curve $A$ of Fig. 1(b) is given by

$$\frac{d}{dt}\left\{1 - exp(-t/CR)\right\}E$$
$$= (CR)^{-1}exp(=t/CR)\,E$$
$$= (CR)^{-1}E \text{ at } t = o \quad \ldots\ldots \quad (1)$$

The equation to the straight line $B$ is therefore

$$V_B = (CR)^{-1}\,Et \quad \ldots\ldots\ldots\ldots \quad (2)$$

The expression for the correction curve $C$ is obtained by subtracting from (2) the expression for curve $A$ ($V_A$); thus

$$C_v = -V_A + V_B =$$
$$\left\{-1 + exp(-t/CR) + (CR)^{-1}t\right\}E$$

Using $exp\,(-t/CR) =$
$$1-(t/CR) + (t^2/C^2R^2 2!) - (t^3/C^3R^3 3!) + \ldots$$

this reduces readily to $V_c =$

$$(CR)^{-1}\int\left\{1 - exp(-t/CR)\right\}dt$$
$$= (CR)^{-1}\int V_A dt$$

*i.e.*, correcting voltage is proportional to the integral of the exponential curve.

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[4] O. S. Puckle. "*Time Bases*," p. 87, Chapman & Hall, 1943.

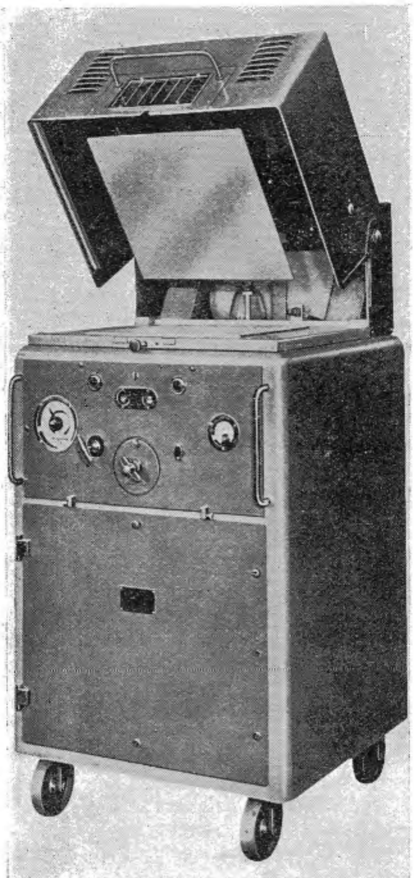
[5] Murphy Radio, Ltd., and G. F. Hawkins, British Patent No. 511,600.

[6] A. W. Keen. "*Television Time Base Linearisation*" Proc. I.R.E. Jan. 1949, P.61

[7] O. S. Puckle. *ibid*, Appendix IV, pp. 178-183.

[8] B. Newsam. British Patent No. 403,843. See also Puckle *ibid*, p. 95.

# ELECTRONIC at the



### Grass Drying Equipment

(*Photo above*)

AN important application of High Frequency Heating was seen in this novel experimental demonstration. By means of the E.M.I. High Frequency Heater model DH35 and the ancillary equipment (produced by the Aldersley Engineering Co., Ltd. of Wolverhampton) grass is specially treated, dried and produced in a form most suitable for livestock consumption. The use of dielectric heating ensures that the full nutritive value of the grass is maintained, it being considerably higher in protein and carotin content than grass treated by any other process.

*E.M.I. Factories, Ltd., Hayes, Middlesex.*

### Industrial Valves

AMONG the range of electronic flash tubes exhibited by Mullard Electronic Products, Ltd., were the LSD3 (*illustrated right*), which has proved most suitable for lightweight portable flash equipment; the LSD2 microsecond flash tube for ultra high-speed photography; a new 1,000-joule tube specially designed for stage and film photography; and the LSD8 tube for stroboscopic use.

*Mullard Electronic Products, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.*

### Marconi Industrial Instruments

*pH Meter (Direct Reading) TF889*: Portable, direct reading, battery operated indicator covering the range 1 to 11 pH.

*pH Meter TF511D*: Battery electrometer for the precise laboratory measurement of pH, and other mV potentials developed by electro-chemical action.

*Moisture Meter TF933* : A portable instrument designed for the rapid and accurate estimation of the moisture content of a wide range of hygroscopic substances—particularly cereals and tobacco.

*Moisture-in-Timber Meter TF874* : For the determination of moisture content in timber and synthetic boards.

*Conductance Meter TF721B* : A portable, self-contained battery instrument calibrated in megohms, and covering the range equivalent to a resistance of 1 megohm to 1 million megohms without the use of external batteries.

*Varistrobe TF906* : A mains-operated stroboscope for the observation of rotating, reciprocating or vibrating mechanisms.

*Thickness Meter TF884* : A non-destructive method of determining the thickness of plating or paint deposits on a ferrous base.

*Electronic Counter TF922* : For counting a million periodic or random impulses at rates up to a hundred thousand per second, or for the measurement of time intervals up to ten seconds in steps of 10 micro-seconds. Quantities or time intervals are displayed as illuminated numbers on a six-decade scale.

*Conductivity Recorder TF863* : in conjunction with a suitable conductivity cell of known constant (available as an accessory) the instrument determines and records electrolytic conductivity. It has a coverage of 0 – 1 millimho, which is obtainable over a variety of ranges.

*Marconi Instruments, Ltd., St. Albans, Herts.*

### Westalite Rectifiers

THE principal exhibit on the stand of the Westinghouse Brake & Signal Co. showed a new method of automatic constant current density control for electroplating power supply, using Westalite rectifiers. This system automatically maintains the current density at the surface of the work constant, regardless of the area of the work in the vat.

Typical applications of Westalite rectifiers to industry were working exhibits, of a magnetic separator, a vibrating screen and an automatic weighing machine, all operated from A.C. supplies through rectifiers.

A new method for the prevention of corrosion of buried pipe lines was also demonstrated. A rectifier has been developed for this work, using magnetic amplifier control to provide a constant output current irrespective of the earth resistance. The earth current is readily adjustable to any desired value depending on local conditions and, once set, is very largely unaffected by fluctuations in the supply voltage.

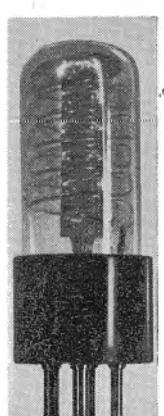
*Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, London, N.1.*

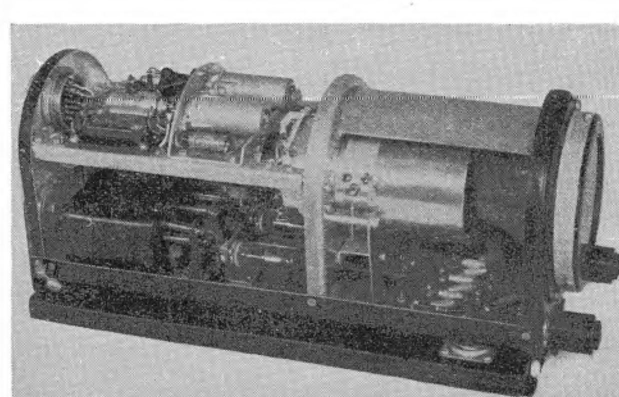
### Aircraft Radar

(*Illustrated below*)

CLOUD and collision warning radar equipment recently developed by E. K. Cole, Ltd., was among the new electronic products exhibited by the Company at this year's B.I.F. This is an X-Band radar system designed primarily for the detection of cumulo-nimbus clouds, and thus areas of severe turbulence associated with such clouds. The equipment may also be used for detecting high ground in the path of an aircraft, and other aircraft in the vicinity. It consists of seven units—scanner, transmitter-receiver, servo amplifier, synchroniser, indicator, control unit and monitoring unit.

*E. K. Cole, Ltd. Southend-on-Sea.*





# EQUIPMENT B.I.F.

### Airmec Radiation Monitor, Type 1021

*(Photo at foot of page)*

AN instrument designed for the detection of the presence of radio-active material in all substances as a safeguard to human life. The instrument is fitted with a beta probe also sensitive to gamma rays and a separate alpha probe is available if required. The instrument converts the pulses from the probe unit to rectangular pulses of constant amplitude and duration and these are then read off the meter which indicates the intensity of the presence of radio activity. A loudspeaker is also incorporated to enable the instrument to be used some distance away or under bad lighting conditions. The finish is in cream enamel with chromium handles and speaker escutcheon. The probe unit has a perspex handle.

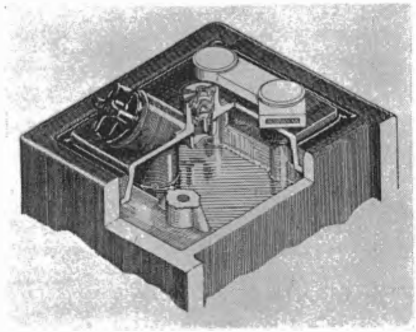
*Airmec Laboratories, Ltd., High Wycombe, Bucks*

### Television Cables

THREE types of television downlead cables were exhibited on the stand of British Insulated Callenders Cables, Ltd.: co-axial, screened twin, and unscreened twin.

List reference numbers of the co-axial types are: T3020, for use in normal signal strength areas; T3022, a similar cable but with a stranded inner conductor giving greater flexibility; T3026, a low-attenuation type cable for areas of low signal strength.

Screened twin cables are: T3098, with copper tape screen and polythene sheath,



for normal service areas; T3109, a similar cable but with metallised paper and wire braid screen and P.V.C. outer sheath. This construction gives greater flexibility at the expense of greater attenuation. T3100, with copper tape screen and polythene outer sheath.

Two types of unscreened lead-in are available: T3066, for normal signal strength areas; and T3068, which has less attenuation, for low signal strength areas.

Characteristics of these cables are tabulated below:—

| List No. | Overall Diameter (Inch) | Impedance (Ohms) | Attenuation (db/100 ft.) 45 Mc/s. | Attenuation (db/100 ft.) 61.75 Mc/s. |
|---|---|---|---|---|
| T3020 | 0.23 | 71 | 2.8 | 3.2 |
| T3022 | 0.23 | 71 | 2.9 | 3.4 |
| T3026 | 0.45 | 71 | 1.2 | 1.4 |
| T3098 | 0.23 | 80 | 2.6 | 3.0 |
| T3109 | 0.27 | 80 | 4.2 | 4.9 |
| T3100 | 0.63 | 80 | 1.0 | 1.2 |
| T3066 | 0.10×0.16 | 80 | 3.2 | 3.8 |
| T3068 | 0.16×0.20 | 80 | 2.8 | 3.3 |

*B.I. Callenders Cables, Ltd., Bical House, Bloomsbury Street, London, W.C.1*

### Exide Side-filling Batteries

*(See sketch on left)*

THE Chloride Electrical Storage Co., Ltd., have designed a new lid for their Exide, Ironclad and Exide storage batteries. This embodies an inclined filling aperture which makes for easier filling and topping-up in confined spaces. The filling opening is located at one side and inclined outwards to facilitate side filling, while the gas vent remains centrally situated. As the side-filling plug is blind, there is no risk of acid splash when the vehicle is cornering.

Batteries with the normal vertical filling opening will continue to be made, and the type of battery to be fitted to any vehicle can be decided by its location.

*The Chloride Electrical Storage Co., Ltd., 6-10, Whitfield Street, London, W.1.*

### Television Accessories

BELLING & LEE, LTD., showed the following items of interest to viewers:—

Television aerial assemblies in three individual kits comprising (1) dipole, reflector and cross-arm for either London or Midland frequencies, (2) mast, and (3) lashing harness and chimney brackets.

"*Veerod*" aerial for reducing interference and "ghost" images, for use within ten miles of the transmitter. A higher signal-to-noise ratio is claimed for this aerial over the "H" type.

"*Doorod*" aerial for indoor use in high signal strength areas where interference is not severe.

A new communual amplifier for use in large buildings and blocks of flats to enable up to twenty receivers to be fed from one aerial. The total power consumption of the amplifier is approximately 50 watts.

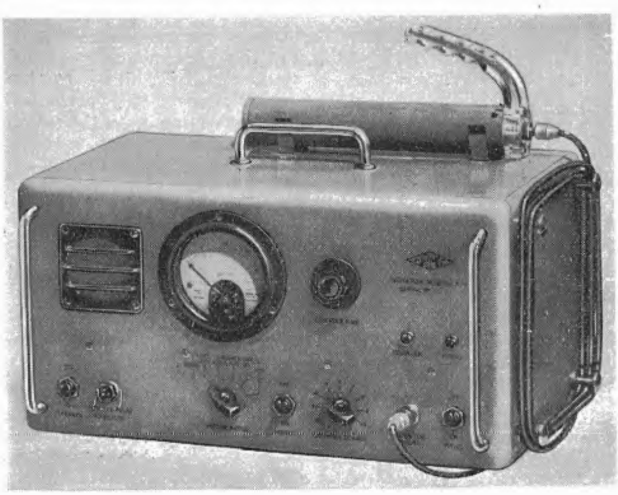
*Belling and Lee, Ltd., Cambridge Arterial Road, Enfield, Middlesex.*

### "Kodatron" Speedlamp

*(See left)*

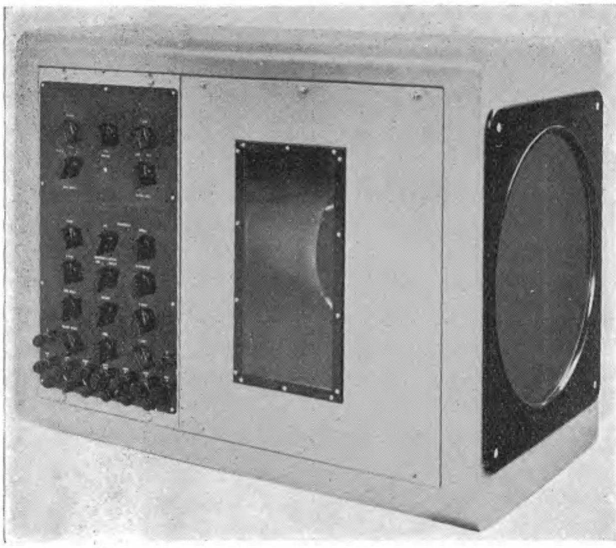
THE "Kodatron" Speedlamp gives a brilliant flash of very short duration (about 1/5000th second). It is particularly suitable for the production of sharp "arrested motion" pictures in black-and-white or colour. The speedlamp consists of a flash discharge tube (which, unlike the ordinary flash-bulb, can be used over and over again) mounted in a wide-beam reflector, on an extensible 3-section column of chromium-plated steel. The flash tube is mounted concentrically round a 100-watt modelling lamp, which is switched on, before the flash is made, to enable lighting arrangements to be studied. The "Kodatron" is suitable for all standard A.C. voltages and requires no special installation. Power consumption (300 watts maximum) is a fraction of that of normal studio lighting. Maximum height of lamp: 8 ft.; minimum, 3 ft. 6 in.

*Kodak, Ltd., 184, Regent Street, London, W.1.*



# Electronic Equipment at the B.I.F.

—continued



### Demonstration Oscilloscope

(*See above*)

CINEMA-TELEVISION, LTD., exhibited a large screen instrument designed for demonstration work. A 15-in. tube is incorporated, giving a trace 9 in. or more in length. This should be visible at the rear of the largest lecture theatre.

The controls are placed at the side of the oscilloscope so that they may be adjusted without obstruction of the screen, and the demonstrator can view the screen from the rear through the glass side-panels while making adjustments.

Other advantages are the inclusion of a two-channel electronic switch to enable two waveforms to be examined together in their correct phase relationship, and a suppressed fly-back stroke for extra clarity of presentation.

*Cinema-Television, Ltd., Worsley Bridge Road, London, S.E.26.*

### Miniature Paper Capacitors

A NEW Dubilier development in miniaturisation consists of a metallised paper capacitor section moulded in a special hard resin, giving the maximum mechanical rigidity.

These capacitors are cylindrical in shape with wire terminals projecting axially.

They are extremely small and compact and they are impervious to atmospheric moisture. They can be operated over the wide temperature range of $-40°$ C. to $+70°$ C., and they are made in capacitance values up to $0.003\mu F$ for 350 volt D.C. working and over $0.003\mu F$ to $0.01\mu F$ at 150 volt D.C. working.

*Dubilier Condenser Co., Victoria Road, North Acton, London, W.3.*

### Metals for Electrical Use

JOHNSON Matthey and Co. have been active for many years in the manufacture of fine and super-fine wires. Resistance wires in nickel-chromium, copper-nickel and Minalpha drawn to high standards of precision were shown. These are available bare, enamelled or silk covered. The section also embraced, among many other wire products, wires and woven gauzes in stainless steel for filtration and screening, platinum and rhodium-platinum for thermocouple use, fine silver for high rupturing capacity fuses and wires plated or clad with silver for electronic applications.

The production of electrical contacts and materials was covered by a section which included samples of typical products. Manufacturing facilities in this branch cover contact applications in a range of equipment from telephone relays, domestic switches and appliances to industrial control gear and heavy switchgear.

*Johnson, Matthey and Co., Ltd., 73-83 Hatton Garden, London, E.C.1.*

### Magnetic Amplifiers

AS the result of the extensive research on magnetic amplification which Elliotts have made, standard magnetic amplifier units have been evolved, which are suitable for a variety of purposes. Examples of applications of Elliott magnetic amplifiers demonstrated on their stand were the photo-electric counter, automatic lighting controller for street lighting systems, thermo-couple amplifier and a servo amplifier.

*Elliott Bros. (London), Ltd., Century Works, Lewisham, London, S.E.13.*

### Messrs. Ferranti, Ltd.

THE Ferranti electronics section displayed a range of stroboscopic lamps argon or neon filled (blue or red discharges) and a modified version of the lamp designed for use as a pulse tetrode for use in heavy duty relay operation.

Incorporating the NSP1 stroboscopic lamp referred to above, a complete transportable stroboscopic equipment was shown, the Ferranti Synchrolite, which can be used for observing reciprocating or rotating motion up to 300 c/s. This equipment has recently been redesigned and a novel feature is the easily removable lamp housing which permits the lamp itself to be used away from the equipment.

The Ferranti range of cold cathode tubes which have a reliable trigger voltage, are capable of converting a signal of microwatts into a pulse of a few watts. Two types of triodes were shown, the K3, neon filled, and the K3A, argon filled.

An addition to the cold cathode range was the KD60 stabiliser tube in a new design of mounting (cartridge type). This stabiliser will give a constant voltage over a range of 100 microamps up to a maximum of 2.5 mA.

A range of indirectly heated electrometer valves was shown, having a stability of a very high order and insulation values of not less than $10^{13}$ ohms. Mechanical superiority is claimed for these valves over existing types.

Among the new developments of the Ferranti Electronics Department was a new 12-in. cathode ray tube in heat-resisting glass having an almost flat face due to a new glass manufacturing technique.

Also being shown for the first time was a voltage stabiliser, Type KD60, having a low running voltage (61.5 volts), and a current range of 125 microamps to 2.5 milliamps. Regulation at 1.0 to 1.2 milliamps $= \pm 0.15$ volts. There was a demonstration of the KD60 showing its application as a voltage divider.

Also of interest was a working model of the Ferranti Servodyne. This is an electronic equipment, intended for use as a controlling medium for processes which require positive and precise control. The equipment is in effect a self-balancing servo mechanism which will observe an error in any of several forms and provide the necessary correction via the motor unit which supplies the mechanical output power of the mechanism. The input to the equipment depends upon the particular application, it may for example, be the small power derived from a photo-electric cell, the unbalanced power of a bridge circuit or the output of a piezo electric crystal. The model of the Servodyne demonstrated was intended to illustrate the sensitivity and high rate of follow when observing, photo-electrically, different coloured lines on opaque or transparent backgrounds or the edges of materials. In this connexion, the equipment has been successfully applied as a web guider on slitting machines in the paper converting industry, and a cloth guider on pin stenters in the textile finishing industry.

*Ferranti, Ltd., Hollinwood, Lancashire.*

## Morganite Products

*Potentiometers*

*Type Q.*—Non-switch, or fitted with S.P. or D.P. switch.

*Rating* : 0.5 watt when uniformly loaded. 0.02 watt for each 10 degrees of element when used as a variable resistor with non-linear grading.

*Range* : Linear grading from 500 ohms to 5 megohms.
Log grading from 1,000 ohms to 3 megohms.

*Type A.*—This new product is a small-sized instrument-quality unit adapted for mass production by standardisation. It is designed with a die-cast rotor and spindle and double-clenched terminals. Is now available in the non-switch version and shortly will be manufactured with either S.P. or D.P. switches, which are further interchangeable on the non-switch type.

*Rating* : $\frac{1}{2}$ watt when uniformly loaded. 0.01 watt for each 10 degrees of element when used as a variable resistor with non-linear grading.

*Range* : Linear grading, 1,000 ohms to 2 megohms.
Log, 1,000 ohms to 2 megohms.

*Other Types.*—Type H is the sealed tropical type and M is the non-tropical version, both of $1\frac{1}{2}$ watts rating. Type LH, rating $\frac{1}{4}$ watt, is a small sealed potentiometer, approved by the Services. Type BJ is a midget potentiometer of 1/10 watt rating, panel sealed, which can only be supplied in a non-switch version.

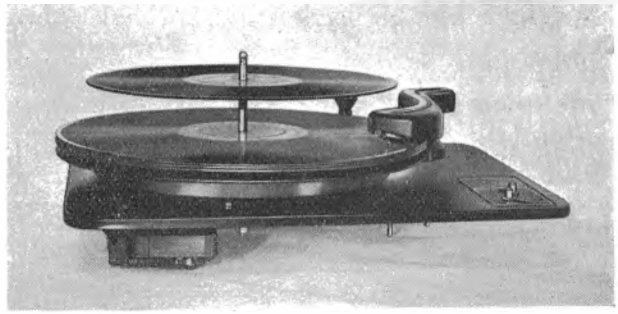
*Fixed Resistors.*—Two types have been standardised: "T," $\frac{1}{2}$ watt and "R," 1 watt, both with axial wires embedded in a solid moulded body. These two resistors are available from stock in a full range of standard values for 20 per cent and 10 per cent tolerances, and can also be supplied with 5 per cent tolerance in eight weeks from receipt of order.

*Grade 7 Resistors.*—These heavy duty resistors are made from homogeneous mixtures of conductors and ceramic bonds, so that they have a close-grained texture and are mechanically and electrically robust. Terminations are of the metallised surface type for mounting in spring clip holders. Power ratings are high and are determined by the permissible temperature, which can rise to 200 deg. C. for continuous loading. These resistors are non-inductive and have a high surge capacity which makes them suitable for use in high frequency circuits.

*Grade 8 Resistors.*—This Company has now commenced production on a new resistor material known as Grade 8. It is a semi-conductor which decreases in resistance value with applied potential. It is thus suitable for many surge protection applications, especially in lightning arrestors and switch gear.

*Automobile Ignition Interference Suppression.*—A range of suitable suppressors for both plug and H.T. lead applications has been developed and quick deliveries can be given.

*Morganite Resistors, Ltd.,*
*Bede Estate, Jarrow, Co. Durham.*



## Londex Relays

THREE new relays were shown by Londex, Ltd., a midget A.C. relay, a miniature relay and a super-sensitive relay. These should find many uses in civil aviation, radar equipment, remote control and electronic equipment in the industrial field.

Another recent development is the miniature Mercury Switch relay for use with thermo-couples and with other sensitive circuits.

Other items displayed were the range of Londex Timers, the floatless "Electra-level" equipment and photo-electric control apparatus for high-speed counting and sorting and printing register control operations.

*Londex Ltd.,*
*Anerley Works, 207 Anerley Road,*
*London, S.E.20.*

## Plessey International, Ltd.

*Press Button Single Record Player*

THIS is a single record player for 10-in. or 12-in. records, operated by press button, which automatically places the pick-up on the record and starts and stops the turntable. It weighs $4\frac{1}{2}$ lb. and requires a clearance of only $2\frac{5}{8}$ in. below the top of the mounting board and 2 in. above.

Two buttons are incorporated, one for 10-in. and the other for 12-in. records. When either is depressed the pick-up arm is lifted over the playing groove of the selected record and the turntable is set into motion. Upon release of the pressure on the button, the pick-up is lowered on to the playing groove, the record is played through and the turntable stops.

*Automatic Record Changer*
*(Illustrated above)*

This represents a breakaway from conventional design, being not only smaller, lighter and less complex than the usual types, but completely automatic. Its mechanism is almost entirely of pressed steel construction, cadmium finished, while its system of assembly reduces servicing time to a minimum. A cabinet clearance of $2\frac{1}{2}$ in. below and 4 in. above the base plate is necessary. Its weight is approximately 8 lb.

A distinctive feature is the centre spindle upon which the records are stacked. This resembles the normal spindle but incorporates a tiny collapsible shelf and expanding ring which operates automatically and releases the records as they are required for playing or rejection. Eight records, 10-in. or 12-in. or 10-in. and 12-in., mixed, can be accommodated, and these can be repeated or rejected at will by operating the pre-selection button. The approximate changing time between records is 4 seconds.

An automatic declutching device is fitted which prevents damage to the mechanism should the pick-up arm be mishandled.

*Plessey International, Ltd.,*
*Ilford, Essex.*

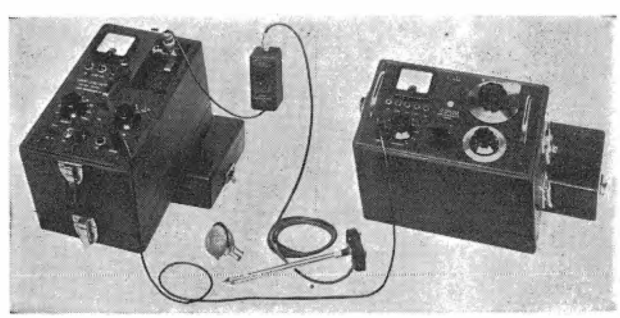
## Sound Level Measurement and Analysis

*(Photo below)*

THE type 1400 Sound Level Meter has a wide range of technical and industrial applications, giving a direct reading in db. of noise reaching the non-directional crystal microphone. Weighting networks are provided to vary the response according to application. The type 1401AF Analyser may be connected to the output of this meter to obtain a detailed record of the individual component frequencies and their relative amplitudes.

Also in this range of instruments are the various adapters and special meters for measuring vibration. Direct readings of displacement, velocity and acceleration of vibrating bodies can be obtained.

*Dawe Instruments, Ltd.,*
*130, Uxbridge Road, Hanwell,*
*London, W.7*



# BOOK

## Microwave Transmission Circuits

By George L. Regan. Pp. 725 + xvii. McGraw Hill Publishing Co. Ltd. Price 51s. in U.K.

A DETAILED discussion of the functioning of a microwave radar system naturally leads to a separation of the main components of the system into groups, each group being treated as a unit with its own special techniques and principles. In the very detailed treatment undertaken in the M.I.T. Radiation Laboratory series on radar techniques and principles, each particular unit, such as the transmitter, receiver, or aerial has one or more volumes devoted to its description.

The practical problems encountered in combining those units together to make a workable radar set call for the design of many additional microwave components none of which falls naturally into any one of those groupings. For example, waveguide twists and bends, coaxial to waveguide transformers, rotary joints, choke couplings, connectors, power dividers and many other devices are necessary in a set designed for high performance. The present book, vol. 9 of the Radiation Laboratory series, deals with these components and the techniques and principles used in their construction. It is a long book and there are no less than seven contributing authors.

Following a short introductory chapter there is a long chapter on elementary line theory which is developed in sufficient detail to provide the theoretical background for the following chapters. Impedance and admittance charts are clearly explained. The difficulties associated with the application of the impedance concept to waveguides are not avoided and although they are not treated in much detail the reader is left in no doubt about the nature of the difficulties, and references are given to other sources where more detailed treatment can be found.

The next chapter is a short but useful discussion on the materials and construction techniques used in the design of microwave components.

Chapter 4 presents a long discussion of rigid transmission lines. A wide variety of topics is treated. Bead supports and stub supports for coaxial lines, choke-flange couplings, waveguide corners, matching diaphragm and transformers are all treated in considerable detail and the extent to which these various discontinuities can be treated by theory is indicated. The effect of fringing fields at discontinuities is emphasised and indications are given of the steps necessary to reduce the effect to a minimum in any practical design.

The next chapter deals with flexible coupling units and lines and contains data on standard American coaxial cable and cable connections. A description is given of the various types of flexible waveguide in use.

Transition units are described in the next chapter. A very full and clear discussion is given on broadbanding techniques, and in this connection many examples are given of the use of impedance and admittance charts. There is a long section on coaxial line to waveguide transformers, and of rectangular to cylindrical waveguide junctions, ending with a treatment of mode filters in cylindrical waveguides.

The engineering problems met with in the design of rotary joints are among the most difficult practical problems in radar engineering and completely satisfactory solutions have yet to be produced. Chapter 7 outlines the various solutions which have been used in American radar. The discussion makes it obvious that further progress is bound up with the development of new materials, particularly dielectrics and sealing compounds.

In Chapter 8, which is concerned with tuners, power dividers and switches, it was surprising to find no reference to the form of directive feed so widely used in British radar test equipment. In Chapter 2 there is a description of an experimental set up which contains a directive feed but there is no treatment of the theory of this device in the text.

The last two chapters contain a valuable discussion of the theory and design of microwave filters. The treatment is by no means elementary and some of those who have specialised in microwave techniques may find the material difficult, particularly since a knowledge of conventional filter theory is assumed. Waveguide filters are widely used in the design of broadband T R cells, but beyond this there have been few applications of filter theory to microwave techniques. It is likely, however, that the future will see a large increase in the applications of filter theory and for this reason the information contained in these chapters is to be welcomed.

It is likely that the book would have been improved if less space had been devoted to the description of so many standard components. The design principles and techniques would have been sufficiently stressed by the description of the design procedure for a smaller number of components. On the other hand the space devoted to filter theory could have been made larger and more self-contained by including a summary of the main theorems of conventional filter theory.

# REVIEWS

The binding and printing are of the usual excellence associated with all volumes of this series. Unfortunately there are a fair number of small but irritating errors and omissions in certain parts of the book. For example, in the curves of Fig. 4.24 and Fig. 4.25 the letters are omitted in the former and the numerals in the latter. On page 172 confusion is caused by a reference in the text to Fig. 4.26 instead of to Fig. 4.29. There is a reference in one part of the book to a Vol. 31 of the Radiation Laboratory series.

The design information contained in this volume can only be found elsewhere in various American and British reports. Anyone concerned with the design of new microwave components would be well repaid by a study of the relevant portions of this book.

T. J. B.

## Radio Valve Data

Characteristics of 1,600 Receiving Valves, by the staff of "Wireless World." Iliffe and Sons Ltd. Price 3s. 6d.

THE annual issue of the *Wireless World* Valve Data Supplement had, by the time the war started, become the standard source of information; but publication has been unavoidably suspended since 1940 owing to paper restrictions. At last it has been possible to produce the first post-war edition. The material now appears as a separate book, containing 80 pages of *Wireless World* size.

"Radio Valve Data" gives the main electrical characteristics of 1,600 British and American receiving valves, the information comprising figures for normal operating conditions arranged in tabular form. Valves are classified according to type under the headings Frequency Changers, Screened Tetrodes and Pentodes, Output Valves, Diodes, Triodes, Rectifiers (Valve and Metal), Tuning Indicators, Barretters and Voltage Stabilisers. The British valves are further grouped under manufacturers' names and then sub-divided into obsolete, replacement and current types, according to the makers' categories.

Additional tables and diagrams give the base connections for all valves, and an index enables any valve to be easily found by type designation. A separate list of those American-type valves which are made in this country is included; data is also given on crystal valves and signal-frequency metal rectifiers.

## Metal Rectifiers

By H. K. Henisch. (Oxford University Press) 168 pages, 55 figures, 15s. net.

THIS book is one of a new series of monographs on the physics and chemistry of materials. Its contents may be described in three parts. The first portion of the text gives an account, with attention to relevant details, of the methods of manufacture of rectifiers of the cuprous oxide, selenium, magnesium-cupric sulphide and germanium types. Germanium rectifiers have found important applications as detectors in radar receivers, while other types find their chief uses in low-frequency power rectification and in instruments for A.C. measurements. The second section of the text deals with the characteristics of rectifiers of the above types. These include voltage current, resistance and temperature characteristics, hysteresis, creep and ageing effects, self capacitance and behaviour under alternating current conditions.

It view of the author's physical approach to the subject it is natural that a considerable section of the text should be devoted to a discussion of the theories of rectification. A straightforward account of current theories is given which includes no difficult mathematics. Modern theories, such as that of thermal diffusion, the diode theory and the theory of tunnel penetration are fully treated while a short account of some of the numerous earlier theories of rectification is included. In this theoretical discussion there is a term "electromagnetic wave-groups" (page 83, para. 5.5.3, sentence ii) which may be misleading. It may be an unnoticed error and should rather read "electron wave-groups." The last two chapters provide notes on the practical operation of rectifiers and on possible future developments respectively. An extensive bibliography, arranged in chronological order, is provided at the end of the text and there is a short subject index of the main topics.

The mechanism of rectification at a metal semi-conductor boundary is often described without any reference to the properties of the other metal semi-conductor contact which must necessarily influence the practical behaviour of the system. The author has been careful to describe the function of the second contact as an integral part of the dry rectifier. On the whole, the lucid treatment of the experimental and theoretical aspects of rectifiers will commend the book to those concerned with the practical uses of dry rectifiers who wish to have a critical but compact account of the subject but have little time to make their own survey of the field. The book will be very valuable to students as part of an introduction to the electronic properties of solids which it is hoped this series of monographs will provide.

G. F. J. GARLICK.

# BOOK REVIEWS *(continued)*

## Introduction to Television

By A. Folwell. (Chapman & Hall), 9s. 6d.

THE author explains in his preface that the object of his book is to present television to such people as management, administration and sales staffs and to establish a foundation for amateurs and service engineers. For that purpose he assumes that they have some knowledge of the circuitry and principles of sound broadcast receivers. He then confines himself conscientiously to their limitations and requirements, though perhaps taking too much for granted their comprehension of some of the more popular terminology.

As a rule in an elementary description of television it is usual first to draw the parallel with sound broadcasting and then follow the sequence from the transmitted scene to the viewing screen. In certain circumstances, while perhaps presenting the most direct approach, the reader can become lost n the many steps to be followed. The author of this book, on the other hand, deals first with the cathode-ray tube and the formation of the raster.

A brief description of the signal sequence is followed by a well prepared discussion on modulation and bandwidth. Diagrams representing modulated R.F., however, appear to fail in their purpose because, instead of using the more conventional method, the author shows the "wavy envelope" filled in with mechanical "tinting" rather than the more laboriously drawn, but much more clear, R.F. "waves."

Basic circuitry is then dealt with, but here the author, despite the statement on p. 102 that such is not his intention, enters into arguments on various points of design. These, bearing in mind his intended audience, are of rather debateable value.

Chapters on the frequency changer and D.C. restoration are well and clearly written.

More attention to the final revision would probably have prevented such loose statements as: (p. 15) "This adjustment becomes the 'Focus' Knob"; (p. 16) "These electrostatic . . . systems of electronic focusing, when compared with optical methods are" (p. 44). The repeated use of the words "former" and latter" (particularly on p. 17) is apt to be rather confusing.

The book will undoubtedly be of interest to those for whom it was written. A Glossary of Terms used might prove an additional help.

P. NICHOLSON.

## F.B.I. Register of British Manufacturers

1948/9 21st edition. By Kelly's Directories Ltd. and Iliffe and Sons Ltd. Price 42s. 752 pages.

THE only complete guide to Members of the Federation of British Industries, their products and services, this latest edition totals nearly 1,000 pages including advertisers' announcements and includes up-to-date details of many hundred new F.B.I. Members.

The 1948-9 F.B.I. Register lists nearly six thousand firms and their products, and includes much information of the greatest interest and utility to overseas buyers. Especially valuable is the Products and Services Section, with more than 5,000 product headings facilitating the rapid identification of supply sources, the Address Section giving complete information on every Member, and the Brands and Trade Marks Sections indicating the makers of branded products. There are reference facilities in French and Spanish, while the classification has been improved and greatly extended.

Produced under an arrangement with the Federation of British Industries, the new F.B.I. Register will have world-wide distribution to importers, buyers, Trade Commissioners, Chambers of Commerce, etc., and will provide valuable support for the export drive. Sir Frederick Bain, M.C., President of the F.B.I., and Deputy Chairman of I.C.I., says in his foreword, "We believe this Register is a real service . . . in these days when, owing to the scarcity of materials, orders have to be spread over many different firms, the Register becomes an increasingly valuable sales instrument."

The five main sections of the Register have reinforced guide tabs for ease of reference.

Contents include. Foreword by the President, Sir Frederick Bain, M.C.,—The F.B.I.: Its Aims and Activities—Overseas Organisation and Trade Openings Department — Regional Organisation of the F.B.I.—*Products and Services*: Member Firms classified by products and services: Member Associations classified by industries—*Advertisements;* Addresses: Alphabetical Directories of the addresses of Member Firms and Associations—*Brands and Trade Names* with indication of products and their manufacturers—also *Trade Marks.*

# NOTES FROM THE INDUSTRY

### Chapman and Hall, Ltd.

Messrs. Chapman & Hall have acquired from Pilot Press, Ltd., their complete range of scientific and technical books. This includes the well-known "Frontiers of Science" series, which will be continued in its present form.

All inquiries for these books should be addressed in future to Messrs. Chapman & Hall, Ltd., 37 Essex Street, Strand, London, W.C.2, or to Book Centre, Ltd., North Circular Road, Neasden, N.W.10.

### Gamma Rays Available for Industry

The Ministry of Supply announce that radium and radon, which are sources of gamma ray radiation, can now be supplied for industrial radiography use.

Radium, which is best suited to factories and foundries, where there is constant radiographic work, can be hired for periods of not less than six months; the average time to fulfill an order is two months.

Radon is sold outright, and only one week's notice of an order is required.

### New G.E.C. Director

The General Electric Co., Ltd., announces the appointment to its board of directors of Mr. A. S. Black, manager of the Scottish branches of the company.

Mr. Black joined the G.E.C. in Glasgow in 1910. After serving in the 1914/18 war he was appointed manager of the Edinburgh branch and in 1935 he was transferred to Glasgow as assistant manager of the G.E.C. Scottish branches, becoming manager on the retirement of Mr. P. J. Sims in 1937.

### T.C.C. Co., Ltd.,—U.I.C. Co., Ltd.

The Telegraph Condenser Company, Limited, will undertake the production and sale of silvered mica and ceramic condensers hitherto made by United Insulator Company, Limited. Ceramic dielectrics (made by U.I.C.) will also be sold through T.C.C. To ensure the full effectiveness of this transfer, and to provide for the necessary continuity of quality and general good service, key personnel from the U.I.C. Research, Development, Production and Sales Departments will join the T.C.C. organisation.

The United Insulator Company, Limited, will specialise in the manufacture of ceramic dielectrics, insulators and other ceramic bodies.

### Manchester Electronics Showrooms

F. C. Robinson & Partners, Ltd., of 308 Deansgate, Manchester 3, are now northern representatives for Cinema-Television, Airmec Laboratories, Furzehill Laboratories, Evans Electroselenium, Electronic Instruments, Wayne Kerr Laboratories, Sargrove Electronics, British Physical Laboratories, J. Langham Thompson, Baldwin Instruments and G.E.C.

### Change of Address

All departments of H. J. Enthoven & Sons, Ltd., are now at: "Enthoven House," 89 Upper Thames Street, London, E.C.4. The telephone number (MANsion House 4533) remains unchanged.

The Mond Nickel Company, Ltd. announce that they are moving their head offices from Grosvenor House, Park Lane, to Sunderland House, Curzon Street. After that date the address of the head offices of the Mond Nickel Company, Ltd., Henry Wiggin & Company, Ltd., and Mond Nickel (Retirement System) Trustees, Ltd., will be Sunderland House, Curzon Street, London, W.1. Telephone: GROsvenor 4131. Telegrams: Nictatio, Telex, London.

### A MODERN HOME-BUILT TELEVISOR FOR THE MIDLANDS AREA

We have received numerous enquiries regarding the design of the "Televisor" to receive the Sutton Coldfield television transmissions.

This preliminary announcement is to notify readers that the design of the modified vision and sound unit is now far advanced, and further details will be issued as soon as tests have been completed.

The general design and layout of the "Televisor" chassis will not be changed, and instructions for modifying existing chassis to receive the Midlands wavelengths will also be published in this journal.

### Publications Received

*Mullard Valve Data Booklet.*
A pocket-sized booklet containing the information previously issued as a wall chart. Equivalent valves of other makers are listed, together with recommendations for the substitution of modern valves for obsolete types. From *Mullard Electronic Products, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.*

*A Prospector's Handbook to Radio-active Mineral Deposits.*
A guide for prospectors, geologists and mining engineers in their search for radioactive minerals. From *His Majesty's Stationery Office.* Price 6d.

*G.E.C. Torches, Cycle Lamps, Hand Lamps and Lighting Batteries.*
A catalogue of dry-cell lighting accessories. From *G.E.C., Ltd., Magnet House, Kingsway, London, W.C.2.*

*G.E.C. Quartz Crystal Units.*
Types, performance and references of G.E.C. crystals. From *Salford Electrical Instruments, Ltd., Peel Works, Silk Street, Salford 3, Lancs.*

*Colvern Wire-Wound Potentiometers.*
A leaflet on their products. From *Colvern, Ltd., Mawneys Road, Romford, Essex.*

*Microwave Equipment.*
A description of the Plessey centimetric radio link for providing multi-channel two way radio telephone communication. From *The Plessey Co., Ltd., Ilford, Essex.*

*Sorbsil Brand Silica Gel.*
An outline of the main characteristics of the product and the methods of its application as an adsorbent and catalyst support. From *Lever Brothers & Unilever, Ltd., Unilever House, London, E.C.4.*

*Elliott Magnetic Amplifiers.*
A description of the standardised range of magnetic amplifiers and ancillary equipment. Free on request from *Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13.*

*Telcon House Magazine No.1.* Intended primarily for their staff as its name implies, this magazine will also interest their clients both at home and overseas; it is issued by *The Telegraph Construction and Maintenance Co., Ltd., Telcon Works, Greenwich, London, S.E.10.*

*"B.I.M. Management Extracts, Vol. 1, No. 2.*
A comprehensive review of recent books on applicable subjects issued by *The British Institute of Management, 17 Hill Street, London, W.1.*

# CORRESPONDENCE

### Leakage Inductance

DEAR SIR,—In the article on "Leakage Inductance" by N. H. Crowhurst, published in issue No. 254 of April, 1949, I was surprised not to find any statements on the sort of iron cores used. My opinion is that without knowing the characteristic data of the iron core, as for instance, permeability, it is impossible to state directly the leakage inductance in millihenries, the latter being proportional to the total inductance of the coil. This total inductance depends greatly on the data of the iron core and changes with them. The leakage inductance changes in the same ratio.

I am sure that for a definite geometrical layout of various windings, as treated in the article, there could only be a stated ratio between total and leakage inductance. Their actual values depend, however, as I have said, on the sort of iron core used. That is why I cannot understand how the author can state direct values without referring to a certain kind of iron core.

DR. GEORG SKALAR,
Vienna.

### Mr. Crowhurst replies :

*Dr. Skalar's difficulty appears to arise from the use of an approach that does not lend itself readily to practical determination of leakage inductance: the mutual inductance between two coils is given by* $M = k\sqrt{L_1L_2}$*, where* $k$ *is the coupling factor,* $L_1$ *and* $L_2$ *are the inductances of the coils; leakage inductance is regarded as a secondary quantity which is a function,* $L_1$ *or* $L_2$ *and* $(1 - k)$*. The only way that all the inductances can be made to change in the same ratio by introduction of magnetic material would be to "impregnate" the whole structure with material of uniform permeability. In practice, the magnetic material does not occupy either the space inside the winding (between individual turns) or between windings, so the assumption of constant* $k$ *cannot be made.*

*The inductance due to the core is of the order of a thousand times the leakage inductance between windings, thus* $k$ *approaches unity so closely that deduction of* $(1-k)$ *by evaluating* $k$ *is rather indeterminate.*

*The simplest approach to leakage inductance is by the concept of an ideal transformer, in which the iron takes zero magnetising current, the two windings are resistanceless and occupy the same space. The magnetising current is then added as a shunt loss, while winding resistance and leakage inductance are series elements. The leakage flux paths, over the part considered, are through the windings themselves and the inter-winding space, where the permeability is unity. Whether the remainder of the flux paths is in air or through iron, its reluctance is negligible compared to that through the coils to a very much greater degree than the similar approximation made for a long solenoid. Physical variations in winding dimensions are responsible for greater variations in leakage inductance than are even wide variations in core permeability.*

### Reducing the Effect of Capacitance in a Screened Cable

DEAR SIR,—It may interest you to know that the method of reducing the effect of capacitance in screened cables described in your March issue by V. H. Attree is patented in Sweden under patent number 107,146, filed May 6, 1939. There is also a very similar American patent, number 2,282,319, held by W. J. Brown, filed February 28, 1941, entitled "Method of reducing leakage", which seems, however, to be limited to D.C. compensation.

The Swedish patent covers both A.C. and D.C. and it is pointed out that it is valid not only to screened cables but also to components of amplifiers and electrodes in electronic valves.

It is worth noting that, if the said method is used for reducing the capacitance of a cable, the microphonic effect of the cable also practically disappears as there is not any capacitance left to vary with the mechanical vibrations of the cable.

INGE I: SON SVEDBERG.
Svenska Radioaktiebolaget, Stockholm, Sweden.

### Mr. Attree replies :

*All circuits of this type are derived from the fundamental idea of the Kelvin "Guard Ring." In the U.S.A. the use of a valve cathode to give the "guard" potential is the basis of all circuits of the "Bootstrap" family.*

*With respect to Fig. 3; in the Swedish patent this is the well-known technique of neutralisation applied to a low frequency circuit. Unfortunately, the circuit given is critical of valve characteristics, so that small changes in operating conditions may set up self-oscillation. Further, I note that there is no screen voltage on the first valve. I have had occasion to use neutralisation, at low frequencies, and I have come to the conclusion that a practical arrangement is only possible if a low gain amplifier is used, well stabilised by negative feedback. Furthermore, it is desirable to restrict the upper end of the pass band in order to avoid possible oscillation at very high frequencies. A typical arrangement, applied to a phototube circuit, was given in the May issue of* ELECTRONIC ENGINEERING.

### B.B.C. Television Transmitter

DEAR SIR,—I am giving below the information on the frequency limits within which the television transmitter that we have ordered from Marconi's Wireless Telegraph Co., Ltd., will operate.

The transmitter will operate within the band 41 Mc/s. to 68 Mc/s. and is not restricted to the band 42 Mc/s. to 46 Mc/s. as stated in the editorial of the May issue of ELECTRONIC ENGINEERING. The actual frequency on which it will operate has not yet been decided.

Would you please publish a correction to this effect, in order to prevent people getting the mistaken idea that the carrier frequency of the Northern Television Service will be between 42 Mc/s. and 46 Mc/s.

Yours sincerely,

P. E. F. A. WEST,
Engineering Information Department, B.B.C.