Wireless World

RADIO AND ELECTRONICS

38th YEAR OF PUBLICATION

OCTOBER 1948

Proprietors: ILIFFE & SONS LTD.

Managing Editor: HUGH S. POCOCK, M.I.E.E.

Editor: H. F. SMITH

Editorial, Advertising and Publishing Offices:

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

Telephone: Waterloo 3333 (60 lines).

Telegrams: "Ethaworld, Sedist, London."

PUBLISHED MONTHLY

Price: 1/6

(Publication date 26th of preceding month)

Subscription Rate: 20/- per annum. Home and Abroad

Branch Offices:

Birmingham: King Edward House, New Street, 2.

Coventry: 8-10, Corporation Street.

Glasgow: 26B, Renfield Street, C.2.

Manchester: 260, Deansgate, 3.

In this Issue

OUR COVER: Atmospheric Direction Finder (see page 380)

Valves and their applications

EHT SUPPLIES FOR TELEVISION RECEIVERS

The conventional EHT Supply for a Cathode Ray Tube consists of a high voltage transformer, a high voltage rectifier such as the HVR2, and a smoothing capacitor of appropriate voltage rating with a value of about 0.1µF. Experience has shown this arrangement to be rather unreliable unless a very well-made, and therefore expensive transformer is used. This is because the peak current requirement of the C.R. tube may be no more than 0.1 mA so that the fineness of wire used in the transformer secondary is determined only by the difficulty of winding it. (45 S.W.G. wire will carry 6.2 mA at 1,000 A per sq. in.) In consequence cheap transformers may be wound with such fine wire that the expansion and contraction of the winding during use will eventually produce a breakage.

EHT from Line Time-base

One way of avoiding this difficulty in the case of Television Receivers is to rectify the high peak voltage produced across the primary of the line scanning transformer during the flyback period. This is an economical method as the cost of the high voltage winding is saved and a smoothing capacitor of only 0.001µF is adequate because of the high pulse frequency (10,125 c/s). Unfortunately it is difficult to get more than about 5½ kV. in this way unless one uses voltage doubling circuits, which, in turn, involve two rectifiers and three high voltage condensers, when the saving is not so great. One disadvantage of obtaining the E.H.T. voltage in this way is that the voltage depends on the setting of the line width control.

C.W. R.F. Oscillator

Another method is to use a radio-frequency oscillator feeding a tuned high frequency transformer as originally described by O.H. Schade. (Proc. I.R.E. Vol. 31, No. 4.) In this case the "goodness" of a design depends mainly on the Q of the secondary winding, and Litz wire has often to be used in order to obtain a sufficiently high Q in a reasonably small winding space. The oscillator valve can be a small triode, or a small output pentode such as the EL33, and the anode need not be insulated to a high voltage as the voltage step-up is obtained in the transformer. A limit to the efficiency which can be obtained with this circuit is set by the voltage regulation of the device, but for a given regulation this circuit is generally more efficient than the ringing choke circuit described below.

Ring Choke Circuit

In the ringing choke circuit a pentode such as the EL38 is used because the anode must be capable of withstanding high peak voltages. An inductor is inserted in the anode circuit of the valve, and its grid is supplied with a suitable voltage waveform. Current is allowed to build up in the inductor, and is then rapidly cut off. The inductive "kick" produced across the anode load is rectified to produce the high voltage D.C. output. In this circuit the Q of the anode inductance is not so important as in the case of the oscillator circuit because only the first peak of voltage is rectified. In consequence a very cheap construction can be used, and this consideration may more than offset the disadvantage of its lower efficiency.

Advantages of the EY51

The Mullard EY51 high voltage rectifier has been specifically developed for these applications. The filament consumption is only 80 mA at 6.3 volts—i.e., 0.5 watt, less than a fifth of that taken by the HVR2. It is therefore quite practicable to operate the heater from a winding on the line scanning transformer, oscillator coil or ringing choke. Adequate insulation for such a winding is easily provided and expensive high voltage filament transformers are avoided. The damping is small even in the case of the R.F. oscillator in which power losses are so important. The valve itself is so small that it can easily be supported in the wiring. This greatly simplifies the problem of insulation.

MINIATURE HIGH VOLTAGE RECTIFIER EY51

V_h	6.3V
I_h	80mA
C_{a-k}	0.8µµF
OPERATION WITH SINSUISOIDAL INPUT UP TO 500kc/s.	
Max. peak inverse voltage	15kV
Max. rectified current	0.5mA
OPERATION WITH PULSE INPUT	
Max. peak input voltage	10kV
Max. rectified current	0.1mA

In later articles the detailed design of these circuits will be considered. Each has its own sphere of usefulness and, if properly made, all are as reliable as the conventional circuit using a good transformer, more reliable than one using a cheap transformer, and, especially to the amateur who can make his own coils, they are considerably cheaper.

Mullard

Reprints of this report from the Mullard Laboratories can be obtained free of charge from the address below:

MULLARD ELECTRONIC PRODUCTS LTD., TECHNICAL PUBLICATIONS DEPARTMENT, CENTURY HOUSE, SHAFTESBURY AVE., W.C.2

MVM74

Wireless World

RADIO AND ELECTRONICS

Vol. LIV. No. 10 — October 1948

B.B.C. Television:

Realistic Technical Standards

EVEN before the war ended most of us showed a deep concern for the restoration of the British television service, and heated discussions arose as to the technical standards to be adopted. Everyone agreed that the service should be re-started at the earliest possible moment; that, if any change was to be made, it should be made then; but at that point unanimity ended. One group maintained that as speed was essential the pre-war 405-line system should be restored without change as soon as hostilities ended. Their opponents contended that the war-time suspension of the service gave an opportunity to make a change to a high-definition system that would endure for a long time. A third school of thought urged that definition should be increased slightly to a value giving a potentially "perfect" picture, claiming that this could be done without involving any fundamental change in the well-proven receiver manufacturing technique of which we had had several years' experience.

This attractive middle-course scheme, advanced with vigour and eloquence by its proponents, gained many adherents, but it was finally decided to restore the service with the pre-war standards basically unchanged. Though at the time many of us regarded this decision with mixed feelings, there can now be no doubt that it was a wise one. Equally wise, we are convinced, was the issue of the recent unequivocal statement that the B.B.C. standards would remain unchanged for a number of years. This decision, made by the Postmaster-General on the advice of the Television Advisory Committee and with full support of the industry, has cleared the air and removed all uncertainty.

As we see it, there was a real danger that definition, as expressed by number of lines, would become a fetish, and television would develop into a "technician's racket." That expression, perhaps, ill becomes a technical journal, but clearly a stage has been reached where considerations of practicability, economics and even expediency must outweigh questions of purely technical development.

In this matter there seems to be a very close parallel with newspaper illustrations, the standard of which has undergone little fundamental change for a generation. It would no doubt be technically possible for us to be given reproduced photographs of a vastly higher "definition," but to do so would be entirely unpractical and hopelessly uneconomic. So we find that the newspaper publishers of the whole world have tacitly agreed on a more or less uniform standard, which certainly seems to give an acceptable picture.

Does 405-line television also give an acceptable picture? We think it does, and at any rate until other links in the chain between object and viewer have been strengthened, it is extremely doubtful if it is worth while increasing the number of lines, with all the disadvantages inherent in such an increase. Some of the technical arguments in support of this statement are given elsewhere in this issue. In any case, the decision to retain 405 lines does not mean that all progress is at an end for perhaps as long as ten years. On the contrary, the B.B.C. system is susceptible to great technical improvement without any change whatever being made to its basic transmission standards. As somebody said the other day, "No one has yet seen a real 405-line picture."

Naturally enough, the decision to retain 405 lines indefinitely has provoked some criticism, though that we have heard so far is not convincing. One rather emotional complaint—deploring the fact that we are committed to the lowest definition standard in the world—seems to call for some comment. In this matter we can stand on our own feet; it is not necessary for us to peer anxiously around to see what others are doing. We have had the longest experience of a practical working television service, and we may yet convince other countries that our system is the right one on which to base an international standard.

FRESH PROGRESS

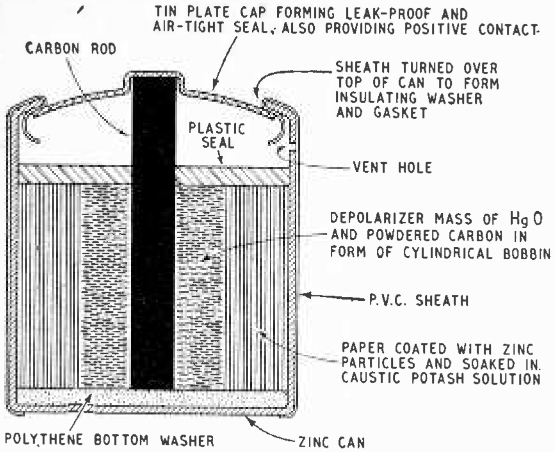


Fig. 1. Constructional details of the Vidor "Kalium" cell.

IT is good to be able to record yet another step forward in dry cell construction, this time from our own country. The Vidor "Kalium" cell has certain points of resemblance to the Ruben-Mallory mercury cell described in a previous article*: the negative electrode is zinc in both cases, the electrolyte caustic potash (KOH) and the depolarizer mercuric oxide (HgO); but the two cells are entirely different in design and appearance. They differ also to some extent in their performance, though both maintain a substantially constant E.M.F. for long periods under relatively heavy loads. The Ruben-Mallory cell is squat in shape and reverses the familiar Leclanché construction by having the can as the positive electrode, whilst the small round cap at the centre of the top forms the negative connection. The new Vidor cell looks almost exactly like its Leclanché dry cell counterpart. It is made in seven sizes of precisely the same dimensions as the dry Leclanché U1 to U7 series; its negative electrode is a zinc can; the positive electrode is a central carbon rod.

The only differences in appearance are that the can is enclosed (save at the bottom) in a polyvinyl chloride sheath and that the top of the cell carries not a black bitumen seal and a brass cap forming the positive contact, but a tin-plated cover with a raised central boss. The "Kalium" cell is thus completely interchangeable with existing Leclanché cells.

Fig. 1 shows diagrammatically the construction of the "Kalium" cell. The outer P.V.C. sheath is used as a precaution against any possible damage to equipment, should a can become punctured and allow electrolyte to escape. Actually puncturing of the can is of the rarest occurrence, even when cells stand in a fully discharged state; the sheath, however, makes assurance doubly sure. It also serves another purpose. The top of it is turned over inside the can; thus when the walls of the can are bent over to fix the tin cap in position, the P.V.C. forms an insulating washer and a leak-proof gasket. The positive electrode is normally a carbon rod, but may be of ferrous metal.

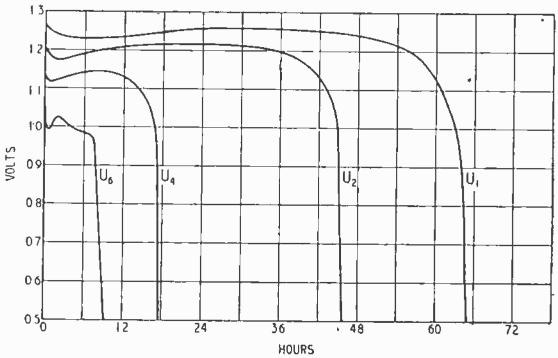


Fig. 2. Discharge of U1, U2, U4 and U6 sizes of "Kalium" cells through 6Ω continuously (personal receiver conditions).

Surrounding the rod is a bobbin-shaped mass of mercuric oxide and powered carbon, which forms the depolarizer. The electrolyte element consists of paper coated with zinc particles and soaked in caustic potash solution. A plastic seal at the top and a polythene washer at the bottom make all secure. Near the top of each can is a small vent hole which, with the P.V.C. sheath, forms a release valve should internal pressure occur. This deals adequately with any gassing that may take place when the cell is in series with others and current is driven through it continuously.

The makers state that the cells store particularly well; their shelf-life is, in fact, considerably better than that of dry Leclanché cells, for after 9-12 months' storage in normal conditions and six months of "tropical" storage, deterioration is slight. The working life, to a cut-off E.M.F. of 1.0V, of cells so treated, is very little shorter than that of new cells; there is, however, a falling-off of 10 to 15 per cent in the watt-hour output, but research work is going forward with a view to making considerable improvement here.

The chemical reactions of the cell are complex and interesting. Like those of other mercury-depolarizer cells, their exact nature has not yet been established with certainty; they are, however, probably as follows:—

(1) $Zn + 2H_2O = Zn(OH)_2 + 2H$.

The hydrogen is removed by

(2) $2H + HgO = Hg + H_2O$.

The zinc hydroxide is removed by

(3) $Zn(OH)_2 + 4KOH = K_2ZnO_2 + 2H_2O + 2KOH$.

The last is a comparatively slow reaction, but if the area of zinc is made sufficiently large there is no such build-up of zinc hydroxide as to impair the efficiency of the cell. The slowness of this reaction, though, may possibly be responsible for the slight fall in E.M.F. (vide Figs. 2 and 3), followed by a rise, which takes place at first

IN DRY BATTERIES

The Vidor "Kalium" Cell

By R. W. HALLOWS, M.A. (Cantab.), M.I.E.E.

when the cell is discharged at a high rate. From reactions (1) and (2) one ampere-hour is given by:

	grams
Zinc	1.22
Mercuric oxide ..	4.02
Water	0.65

If I read the designer's mind aright, he set himself the task of producing a dry cell as like the Leclanché as possible and containing all its good points, but none of its bad ones. Zinc—the "fuel" of the Leclanché cell—is, as metals go nowadays, reasonably plentiful and cheap; the construction of cells with the container forming the negative electrode and a carbon rod, surrounded by the depolarizing compound, acting as a conductor between the circuit and the positively charged electrolyte is both sound, from the manufacturing point of view, and convenient when cells have to be made into batteries.

These are excellent points. Can they be retained in a cell of vastly improved performance? The answer is that they can, provided that it is possible to find an efficient substitute for the combination of sal-ammoniac electrolyte and manganese dioxide depolarizer to which nearly all the major shortcomings of the Leclanché cell are due. With them polarization is rapid and heavy, whilst depolarization is slow and never quite complete. The electro-chemical reactions of both primary and secondary cells are by no means beyond doubt; a simple working picture, however, of polarization and depolarization in a Leclanché cell may be obtained in the following way. In the ionized electrolyte, when the cell is under discharge, hydrogen molecules travel in vast numbers towards the carbon rod, round which they form a resistive envelope. There is no way of preventing the arrival of the hydrogen molecules, for they are the positive ions which convey positive charge to the carbon rod. What is needed is a means of making them "move on," once they have done their job and have been neutralized by collecting electrons delivered from the negative electrodes via the circuit and the carbon rod.

In a cell with a perfect depolarizing system, the hydrogen would be removed just as fast as its molecules arrived and were neutralized. The internal resistance of the cell would then remain constant, and the discharge curve of a cell would be a horizontal straight line, terminating in an almost vertical fall to zero when the electrolyte was exhausted.

The "Kalium" cell is not perfect, but the curves shown in Figs. 2, 3 and 4, show that the inventor has advanced a considerable way along the road towards his ideal. It will be seen that the E.M.F.s are substantially constant under loads very heavy in relation to the sizes of the cells.

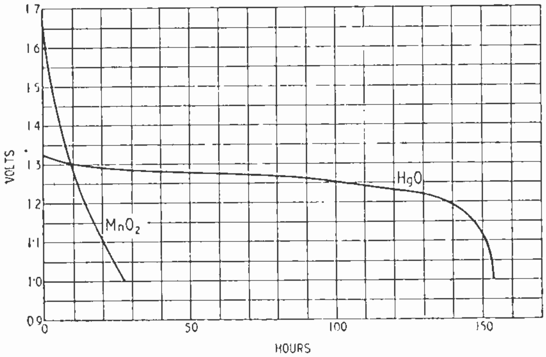


Fig. 4. Comparative performances of "Kalium" and Leclanché cells of the same size under Medical Research Council hearing aid test conditions (18.5Ω per cell). Note that the "Kalium" cell was discharged continuously and the Leclanché intermittently at 8 hours per day.

A particularly interesting point is that the hours of life of a "Kalium" cell are the same for a given load, whether it is discharged continuously or intermittently. There is no marked recuperation when a partly discharged cell is rested. Is this a strong point or a weak one? In years gone by some makers of dry-cell Leclanché batteries proudly proclaimed the marvellous recuperating powers of their wares. Your H.T.B. might drop 10 volts during an evening's listening; but whilst you slept it put nine of them back again. Wasn't that fine? Human beings do not have to recuperate unless they have been under the weather. And the same is true of primary batteries; only those suffering from a hangover resulting from a surfeit of undigested hydrogen need to make recoveries of that kind. In the "Kalium" cell depolarization very nearly keeps pace with electrolytic action, and the discharge curve has not the vicious sawtooth jags of the Lelanché.

My own tests are not yet complete, but so far as they have gone

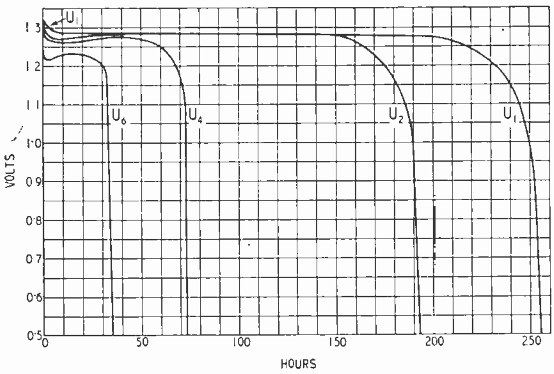


Fig. 3. Discharge continuously through 25Ω (hearing aid conditions) of U1, U2, U4 and U6 sizes.

Fresh Progress in Dry Batteries— they bear out the maker's claims. Some may criticize the E.M.F.s as being on the low side, ranging as they do from about 1.4V on open circuit to between approximately 1.10V and 1.25V (according to the load) on closed circuit. But it is surely more useful to have a cell which starts with a comparatively low E.M.F. and maintains it than one with a higher initial E.M.F. which shows a continual falling away under load. Certainly a source of constant E.M.F. for both H.T. and L.T. circuits should vastly simplify the problems of those who design hearing aids, portable wireless sets and personal receivers, of those who make the valves for them—and of those who use them.

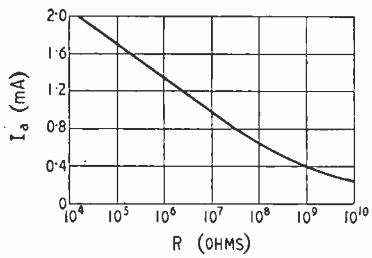
The fly in the ointment as regards the "Kalium" cell is that it is considerably more expensive to make than the Leclanché. Mercury is, unfortunately, neither plentiful nor cheap, and the "Kalium" cell needs over 4 grams of its oxide for each ampere-hour that it gives. If we cannot have more and cheaper mercury (and there seems little immediate likelihood of that), a new task for the research chemist working on dry cells must be to discover something less costly and less scarce which can take its place as a depolarizer. Both the Ruben-Mallory and the Vidor systems have shown that better dry cells can be made—at a price. What we need is the better cell at little or no extra cost. In view of the present state of activity in dry battery research, I have no doubt that it will come our way in the not-too-distant future.

ELECTRONIC MEGOHMMETERS

Measurement of Very High Resistance

By H. G. M. SPRATT

THE D.C. measurement of resistance, using portable non-electronic meters or galvanometers, becomes increasingly difficult as the order of the resistance value increases. This difficulty can be traced to either the low impedance or the low sensitivity of the indicating instrument, depending upon the method of measurement used, for it must be remembered that highly sensitive mirror galvanometers cannot be employed outside the laboratory. If, for example, a Wheatstone bridge is used, the supply voltage must be raised considerably when the unknown resistance is several megohms, if a noticeable deflection is to be obtained as balance is approached. Other methods employing a voltmeter and microammeter will probably be quite impracticable.



[Courtesy *Journal I.E.E.*

Fig. 1. This curve shows the relation between anode current and resistance for a grid-current type of megohmmeter.

The characteristics of the normal triode valve, however, are such as to enable some of the conventional methods to be utilized for resistance measurement up to $10^{12}\ \Omega$ and higher, as well as introducing at least one new method. Furthermore, no difficulty is experienced in constructing instruments based on these principles in a compact and portable form.

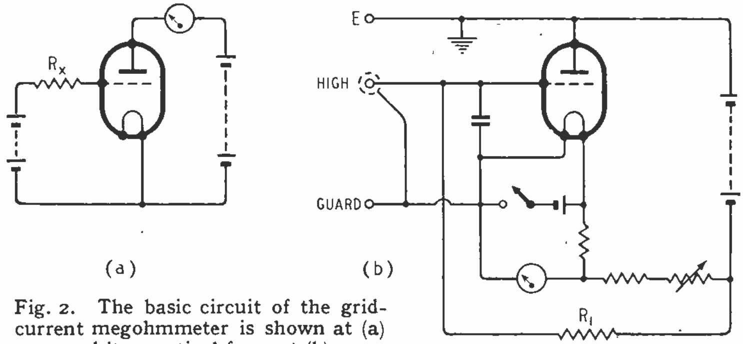


Fig. 2. The basic circuit of the grid-current megohmmeter is shown at (a) and its practical form at (b).

Grid - Current Method. — The new circuit referred to above appears to have received earlier consideration than adaptations of methods already known but it is not self-calibrating to the same extent and does not lend itself to extremely accurate measurements. As the following paragraphs show, however, it is a low-voltage instrument of great simplicity.

The circuit[1] depends upon the grid-voltage–grid-current characteristic of the normal triode. This characteristic, for small grid currents, approximates to the exponential form $I_g = Ae^{BV}$ where V is the negative grid voltage, I_g is the grid current and A and B are constants for a fixed anode voltage. If a resistance R is connected between grid and cathode, we get

$$V/R = -I_g$$
$$\text{so} \quad -V/R = Ae^{BV}$$

or $\log R = \log V + BV +$ a constant.

As the anode current depends upon the grid voltage, there is seen to be a definite relationship between it and the grid resistance, this relationship being indicated by the curve in Fig. 1, where I_a, the anode current, is plotted against log R. This curve approximates to a straight line over a considerable range and circuits operating on this principle will permit resistance measurements up to $10^8\ \Omega$ with an accuracy of a few per cent, or to considerably higher values if a positive voltage is included in series with the resistance.

Practical Applications. — Fig. 2(a) shows the basic form[2] and Fig. 2(b) a practical form of this circuit. The latter gives satisfactory operation with a 45–60-volt battery and, if the indicator is a 50–100-μA meter, will cover a range exceeding 10^5 to $10^{10}\ \Omega$. A guard terminal helps to eliminate surface leakage by returning such paths to cathode, while a capacitor of the order of 100–500

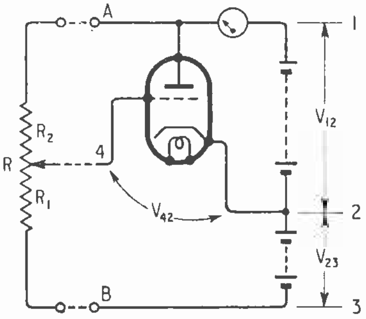


Fig. 3. The basic circuit of a substitution method of measuring resistance.

pF between grid and cathode reduces fluctuations due to noise voltages. The resistor R_1, between grid and H.T. negative, is some hundreds of megohms and ensures that the grid is never left entirely 'open.' Initial adjustment consists in setting the variable resistor in the cathode lead to give maximum deflection of the meter with the input terminals short-circuited.

It can be seen that a full calibration of this instrument can only be carried out by the application of a range of standard resistors. This prejudices its use as an instrument of high accuracy as the grid-voltage–grid-current characteristic may alter with time owing to grid emission caused by contamination. On the other hand it enables a variety of non-destructive insulation tests to be carried out to the order of accuracy usually required.

Substitution Method.—The outstanding asset of the normal triode for present purposes is its high grid-cathode D.C. resistance when the grid is maintained negative with respect to the cathode. This feature is immediately applicable to a substitution method of resistance measurement. It has been widely adopted and is described below.

Considering Fig. 3, let us assume that the valve is provided with H.T. and grid-bias supplies V_{12} and V_{23} respectively. The magnitude of V_{23} is somewhat higher arithmetically than the value V_{42} required for the normal operating point. Then if we connect across the terminals AB a potentiometer as shown, with the slider connected to the grid, we shall have to adjust it so that the drop across R_1 is equal to $V_{23} - V_{42}$ in order to obtain the normal anode current. Then, since $R = R_1 + R_2$;

$$\frac{R_1}{R} = \frac{V_{23} - V_{42}}{V_{42} + V_{23}}$$

$$\frac{R_2}{R} = \frac{V_{12} + V_{42}}{V_{42} + V_{23}}$$

$$\frac{R_2}{R_1} = \frac{V_{42} + V_{42}}{V_{23} - V_{42}}$$

Suppose we make $V_{12} = 100$ volts, $V_{23} = 3$ volts, $V_{42} = 1\frac{1}{2}$ volts and R a 1-MΩ potentiometer. Then :

R_1 will be 14,600 Ω

R_2 will be 0.985MΩ

and $\frac{R_2}{R_1} = 67.$

Now the grid-cathode resistance is high, and is likely to be of the order of $10^9 - 10^{10}\Omega$, so that the value given above for the ratio R_2/R_1 will still hold good even if R_1 and R_2 are increased a thousand-fold, so that R_2 is of the order of $10^9\Omega$.

Very High Resistances.—In applying this circuit to the measurement of very high resistances, the unknown is connected in place of R_2 and R_1 is made a calibrated variable resistor (preferably a decade resistance box). Calibration is effected by introducing a known standard resistor, not inconveniently high, in place of R_2. The ratio R_2/R_1, corresponding to a chosen value of anode current, can then be determined at comparatively low values of R_2 and R_1. In carrying out a measurement, the unknown is connected in place of R_2; R_1 is then adjusted to give the same anode current, the value of the unknown being determined by multiplying

A commercial meter, the Dawe Instruments Type 402B Insulation Tester, which operates on the grid-current principle.

R_1 by R_2/R_1. In practice there will probably be a demand for not only a specific meter deflection but also a specific and convenient value of R_2/R_1. This can quite easily be effected by providing a backing-off or balancing circuit, such as is shown in Fig. 4, where the meter is connected between the anode and a tap on the H.T. supply and a variable resistor included in the anode lead. Alternatively, by a small circuit change, the bias voltage can be made slightly adjustable to fulfil the same purpose. All

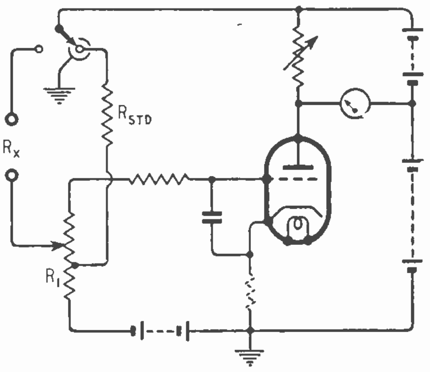


Fig. 4. The addition of a backing-off circuit to Fig. 3 is shown here.

instruments are then calibrated with R_2 as the standard resistor and R_1 as the calibrated variable, the anode or bias adjustment being set to give the required meter deflection at the correct

Electronic Megohmmeters—
R_2/R_1 ratio. For certain applications where precision measurements are not required and a simplified form of R_1 is justifiable, the meter scale can be provided with subsidiary markings indicating ±5%, ±10%, etc., off the calibration values.

The limit of measurement with the values given above would be about $10^9\Omega$ for an accuracy of 1–5%, this figure of accuracy depending mainly upon the quality of the resistance elements in R_1. Above this point, however, the grid-cathode resistance of the valve may start to become a significant factor. Nevertheless, the range can be extended upwards if such accuracy is not required, as is frequently the case. Moreover, by increasing V_{12} and/or decreasing $V_{23} - V_{42}$, we can easily raise the limit by another order.

There is a number of modifications and refinements to the basic circuit which may be introduced with advantage, and it is proposed to discuss them briefly. For example, the high-potential point of the unknown resistor is sometimes made negative by using a separate battery between B of Fig. 3 and R_2 instead of connecting R_2 to A. This arrangement has the advantage of preventing a high positive potential from being applied to the grid if a short-circuit across the test terminals occurs. If the positive potential is retained, a resistor of a few megohms inserted in the grid lead (see Fig. 4) will provide the same safeguard. Furthermore, this resistor, in conjunction with a small capacitor connected between grid and cathode, will reduce the effect of extraneous noise voltages.

Preventing Leakage. — It is normal practice to change over from standard to unknown resistor by means of a switch. With this arrangement it is necessary to guard the high-potential point of the standard resistor so as to prevent leakage to it from H.T. when it is out of circuit (see Fig. 4). For this purpose it is generally convenient to return both guard and cathode to earth potential. Guarding may also be desirable at the terminals or electrodes across which the unknown resistor is placed, for this point is one of the weakest as regards leakage.

Where precise measurements of the higher orders of resistance are required and the necessary care has been taken to reduce stray leakage to the absolute minimum, the use of an electrometer valve is essential. Otherwise it is not justifiable, but a type of valve with low internal leakage between grid and cathode should be chosen and individual valves will probably have to be selected. Furthermore it may be desirable to keep the resistance in the grid-cathode circuit constant by using the connections shown in Fig. 4 in preference to those of Fig. 3.

Feedback can sometimes be introduced with advantage into this circuit as it assists in reducing (a) changes in circuit constants accompanying valve replacement and ageing and (b) unsteadiness due to voltage variations if the instrument is mains-driven. As regards (a), we have so far envisaged operation at a fixed meter reading, supplemented possibly with the 5% and 10% markings mentioned above, with continuous variation of R_1. Such an arrangement is not always convenient or economical if R_1 is of the order of $10^9\Omega$ because of the demand for a large number of close-tolerance and stable resistors of high value. If the fixed meter reading can be replaced by a long calibrated scale of wide range (e.g., 10 to 1) and sufficient stability maintained, it will obviously be possible to make up R_1 of a comparatively small number of resistors differing in value by a factor of 10. In such a case the extra stability derived from negative feedback is particularly advantageous. This feedback is usually introduced in the form of a resistor in the cathode lead (shown dotted in Fig. 4). In referring to mains variations it should be recognized that operation of the valve from raw A.C. is quite feasible although, if the potential applied to the resistance under test is to be negative, a smoothed D.C. supply is advised for this purpose.

It is perhaps needless to add that, where the resistor elements in R_1 are too high to be wire-wound, it is essential for precision working, to use the best type of high-stability carbon resistors with low temperature coefficients.

Ultra-high Megohmmeter. — A modification of the basic circuit discussed above which is claimed to be capable of measuring up to $10^{17}\Omega$ is of interest[3] and is shown in Fig. 5. Here an electrometer valve is used in a slide-back circuit. A reading of the output is taken with S_1 open and $E_2 = 0$. S_1 is then closed and E_2 adjusted to give the same output reading. Then

$$R_x = R_s\left(\frac{E_1}{E_2} - 1\right)$$

The accuracy of results depend upon the accuracy with which E_1 and E_2 can be determined by conventional-type voltmeters and upon that of R_s which will have to be of the order of $10^{15}\Omega$ for measuring resistances of $10^{17}\Omega$.

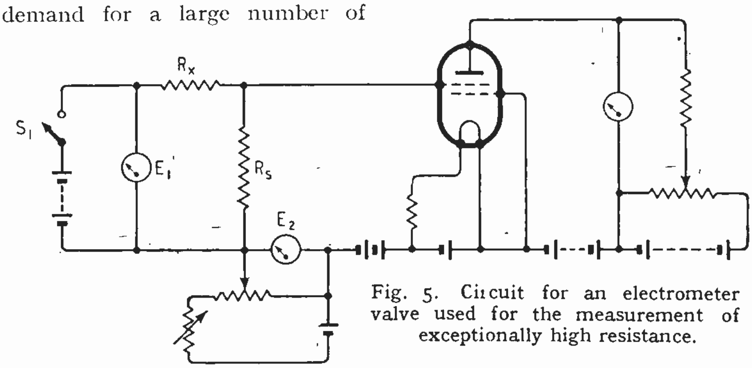


Fig. 5. Circuit for an electrometer valve used for the measurement of exceptionally high resistance.

Bridge Circuits. — At the beginning of this article mention was made of the Wheatstone bridge and the impossibility of maintaining sensitivity with normal portable galvanometers when the unknown resistance exceeded a few megohms. This lack of sensitivity is due to the low input resistance of the indicating instrument in comparison with the output resistance of the bridge. The difficulty can be overcome by substituting a sensitive valve voltmeter in place of the usual galvanometer. The usual precautions must be taken to ensure a high input resistance, such as selection of valves and correct biasing. Furthermore a regulated power supply is advisable otherwise the zero point of the indicator will drift too much to make an accurate balance possible. The outline of this circuit is shown in Fig. 6. Such an instrument does not show the same degree of superiority over other methods of measurement at $10^{10}\Omega$ and upwards as does the normal Wheatstone bridge at lower orders of resistance. Apart from the likelihood of drift mentioned above it is difficult to reduce leakage to a negligible quantity. There is yet one further difficulty. The standard bridge equation, $X = AB/C$ holds good and even when C has been reduced to its lowest practical value A and/or B will have to include calibrated resistors of the order of $10^6 - 10^8\Omega$. Such components are extremely difficult to obtain to the order of accuracy and stability normally expected in a Wheatstone bridge.

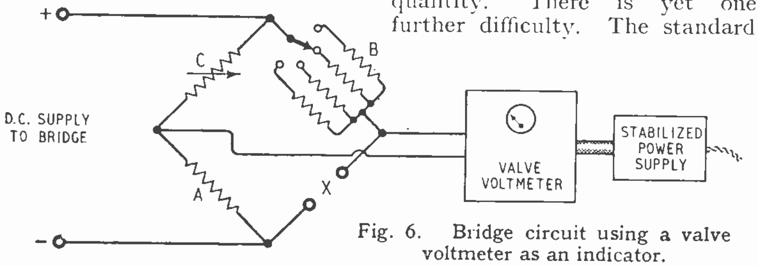


Fig. 6. Bridge circuit using a valve voltmeter as an indicator.

The instruments which have been described provide an easy means of extending the study of high resistance and insulation phenomena. The insulation resistance of electro-dynamic machinery and of power cables, for example, frequently increases at a steady rate from the moment of application for a period of hours and time plots of such characteristics can be taken without difficulty with the aid of these meters. Furthermore, of recent years insulation resistance has proved to be a satisfactory measure of other physical qualities, such as moisture content and instruments of this type lend themselves immediately to these fields of application.

REFERENCES

[1] Instruments incorporating Thermionic Valves, and their characteristics. James, E. G., Polgreen, G. R., and Warren, G. W. *J. Instn elect. Engrs.*, August 1939, Vol. 85, p. 242.

[2] High-resistance Measurement with Vacuum Tubes. Preizman, A. *Electronics.* 1935, Vol. 8, p. 214.

[3] Vacuum Tube Voltmeters. J. F. Rider p. 128.

IMPROVED HEARING AID

Automatic Volume Compression and long Battery Life

A DEVELOPMENT of special interest to students of hearing aid design is the introduction by Multitone Electric, 223, St. Johns Street, Clerkenwell, London, E.C.1, of a new instrument, the "Monostat," in which fully automatic volume control has been introduced to overcome the irritation and distress of widely fluctuating sound intensity levels and loud percussive noises, such as the slamming of doors.

The three-valve amplifier consists of the usual power output stage preceded by two stages of voltage amplification, and control of volume, both automatic and general level, is effected in the first stage. A small metal-oxide contact rectifier connected across the output from the final stage developes a negative voltage, which is applied through resistance-capacity filter circuits to the grid of the first stage. The time constants of the filter circuits have been adjusted to give almost instantaneous response in reducing gain and a recovering time which is long enough to avoid undue levelling and yet does not produce noticeable "holes" in the reproduction following sudden noises.

On test the A.V.C. system proved to be completely effective; in fact, persons with normal hearing might use the aid with advantage under noisy conditions, say, in a workshop. We found it much less distracting to carry on conversation in this way against an artificially produced background than by direct listening, and the quality of the voice, using a crystal-type earpiece appeared to be quite as natural.


"Monostat" hearing aid with crystal earpiece.

A selector switch enables the A.V.C. to be switched on or off and a third position gives a characteristic with falling H.F. response and no A.V.C. for special types of deafness.

Battery replacement is simple, both H.T. and L.T. being of the plug-in type. The hinged back of the instrument is spring loaded and flies open when a catch is depressed, revealing an engraved diagram showing how the fresh batteries should be inserted.

The $22\frac{1}{2}$-volt H.T. battery (costing 3s) gives a life of 350 hours on intermittent discharge. For the L.T. supply the new Vidor "Kalium" cell (see p. 352 this issue) will be employed. The U6 size costing 1s has a life of 30 hours. Alternatively, half a No. 8 Leclanché battery costing $2\frac{1}{4}$d can be used, but the duration will then be only about $4\frac{1}{2}$ hours.

The instrument, which measures only $4\frac{1}{2}$in × $2\frac{1}{2}$in × 1in and weighs $6\frac{1}{2}$oz, will be available in black with chromium and silver plated fittings or ivory with gilt finish. It is in no sense a cheap model and the price will be in the region of 37 guineas.

AMPLIFYING CRYSTAL

The Transistor : a 3-Electrode Germanium Contact Device

WORKING in Bell Telephone Laboratories, J. Bardeen and W. H. Brattain have developed a three-electrode germanium crystal contact device, known as the Transistor, details of which have been published in the *Physical Review*, Vol. 74, July 15th, 1948, pp. 230-233. Their experiments show that by placing point contacts of tungsten or phosphor bronze in close proximity (0.05 to 0.25 mm) on the specially prepared surface of a germanium block, interdependence of currents in the vicinity of the contacts can be utilized to obtain power amplification of the order of 20db.

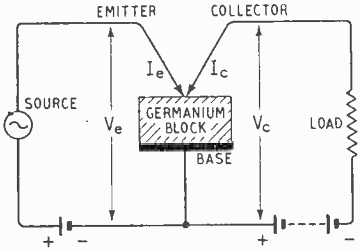


Fig. 1. Basic circuit of the Transistor.

A positive bias of about 1 volt is applied to the "emitter" contact, which also carries the input signal, and negative bias on the "collector" contact is adjusted until the collector current is of the same order as the emitter. A large proportion of the emitter current passes to the collector, and amplification results from the fact that the collector contact, and the load to which it is matched, has an impedance about 100 times that of the input (emitter) circuit. Thus the input/output impedance relationships as well as the polarity of the "H.T." supply voltage are the reverse of those found in conventional thermionic triodes.

Typical D.C. characteristics are shown in Fig. 2. The emitter current is given approximately by the expression:

$$I_e = f(V_e + R_F I_c)$$

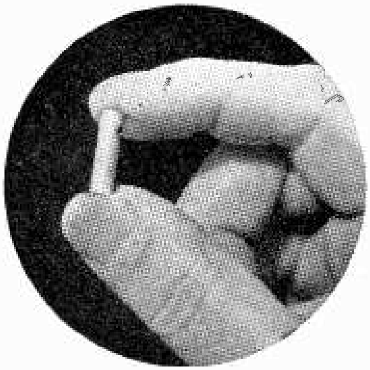
Where R_F is a constant which is independent of the bias. There is positive feedback, represented by the term $R_F I_c$, which under some conditions may cause instability. The device can, in fact, be used as an oscillator.

Theory

A reasonable explanation of the mechanism of conduction in the region of the contacts is possible in terms of statistical mechanics, but it is difficult to convey a plausible physical picture of the transport of current. According to prevailing theories, there are two types of semi-conductor, the n-type involving the migration of electrons and the p-type in which permissible but unoccupied electronic energy levels or "holes" are propagated through the crystal lattice structure, and are equivalent to a flow of positive electricity in the opposite direction to the electron flow. The nature of the conduction is influenced by impurities in the material.

In the Transistor the main body of the germanium is of the n-type with a thin surface layer of p-type germanium. It is thought that the current between the emitter contact and the main body of the germanium is conveyed by "holes," and that a large proportion of these "carriers" are attracted to the collector.

The mobility of the carriers is



Indicating the size of a typical Transistor semi-conductor triode.

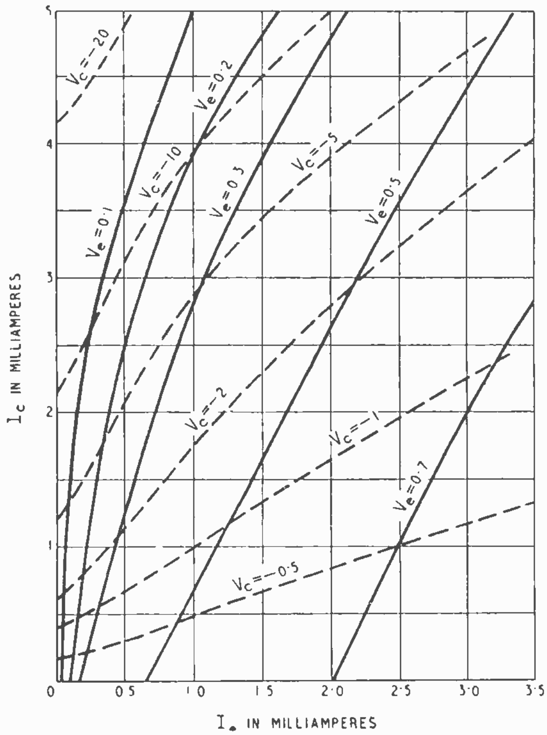


Fig. 2. Typical D.C. characteristics. The currents are the independent variables and the corresponding voltages, the dependent variables.

dependent on temperature and the field strength. In practice, the finite mobility is equivalent to transit time in a valve, and limits the response of the Transistor, at the contact spacings quoted, to frequencies below 10 Mc/s.

If satisfactory circuit techniques can be developed to meet the conditions of low input and high output impedance and positive feedback, and if signal/noise ratio is not unduly low, there would seem to be many applications in which Transistors could usefully take the place of valves. Bell Telephone Laboratories have already constructed an experimental radio receiver with a power output of 25 mW, using Transitors throughout and have also demonstrated a repeater amplifier and an A.F. oscillator.

The D.C. power consumption is 0.1 watt, and the overall efficiency is 25 per cent.

RADIO INTERFERENCE MEASUREMENT

Difficulties in Devising a Standard

This summary of the present position in regard to interference measurement was written by a member of the Technical Executive Committee of the Radio Industry Council, and is endorsed by that Committee. It is reproduced by permission from the "Technical Bulletin" of the Radio Component Manufacturers' Federation.

THE impression is very common around the radio industry that "they" ought to do something about radio interference measuring sets and that for want of a measuring set the whole interference position is getting out of hand. The note sets out the real position and outlines the possibilities of progress.

The fundamental catch is that the measuring set has to accept an input of any of an immense variety of types and assess not its magnitude but its annoyance. Working on a basis of a few types of interference an *ad hoc* international committee (C.I.S.P.R.) started work in Berlin in 1934 and proposed a design of valve voltmeter whose readings were somewhat like the annoyance factor of the interference. Since then there has been some doubt expressed in many places whether the proposed valve voltmeter is a close enough copy of the human brain while at the same time the gamut of interfering sources has been extended by the widespread introduction of thermostats and similar devices which create bursts of interference at fairly long intervals. At the moment therefore the interference measuring set must line up with the ear tolerably well all the way from the pure tone of the heterodyne interference through "white" noise and the smoothly repetitive noises to the ragged and discontinuous types. An attempt has been made by tinkering with the time constants of charge and discharge proposed by C.I.S.P.R. but these changes while doing good in some directions are thought to have done more harm in others, and an E.R.A. committee is now attempting to examine a wide enough range of interfering sources to provide an answer which will last for some time.

This difficulty has been the biggest of all the difficulties. Anyone can make a field strength measuring set and those of us who have to measure the C.W. or white types of interference in the absence of a measuring set do so by improvising with a calibrated receiver by a standard signal generator. The Americans have produced such field strength measuring sets and have attempted to use them for noise measurement by building time constants into the AGC system of the same order as those recommended by C.I.S.P.R. Such devices are fundamentally wrong since in the absence of an input the receiver turns itself up to full gain and may not turn itself down until after a short burst of input is passed. This weakness is now realized and the convenience of this type of measuring set must, it is agreed, be sacrificed.

There is a British Standard describing a measuring set covering medium and long broadcast bands and incorporating the measuring technique of the C.I.S.P.R. This measuring set has been extended to cover short-wave broadcast bands by its original designers, the Post Office, still using the same technique and in fact taking this technique into frequencies for which there is as yet no international agreement for its use. This measuring set used old-fashioned circuit arrangements and components and is clumsy and costly by modern standards. The Post Office has recently modernized this equipment and is having it manufactured.

This equipment is admittedly a stop-gap and has many faults: one which has been mentioned is that it has (in common with most broadcast receivers) a gap in its coverage near 460 kc/s to dodge its intermediate frequency. Apparently by so doing it also dodges a number of industrial oscillators. However, it would have been better to have raised this point with the B.S.I. committee when discussing this receiver rather than now when it is too late to do anything about it in this design. The work which the B.S.I. committee did is being incorporated by Marconi Instruments in a design sponsored by R.A.E., but this will be a very large and ambitious research tool and will not be of immediate use to the engineering or electrical industries. There is no project in operation which will produce a really good measuring set of wide applicability, nor will there be as long as the radio industry omits to do anything about getting one made. For years I have suggested that the radio industry had within its members the means for doing all the stages of this work but the industry has always taken the attitude that this mysterious "they" ought to do it. The present position is unsatisfactory though in practically no other country is it really much better. In some countries (e.g., Switzerland) there is legislation based upon obsolete technique and measuring sets. In other countries (e.g., North America) there is widespread activity based upon unsound measuring sets. The fact that other countries are doing things badly is no excuse for us to do them as badly and the radio industry itself must find a way of doing better.

REDUCING HEATER HUM

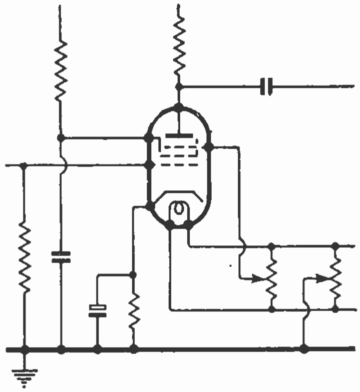
Neutralizing by Injection of Anti-phase Voltages

By K. G. BRITTON, D.Phil. (with P. E. BAYLIS)

THE sources of hum in high-gain amplifiers have been discussed from time to time in this journal,[1] and practical steps have been suggested for mitigating the nuisance. There are, however, two points which require consideration. First, in experimental work, it is not always expedient that time be spent on an elaborate layout which may have to be rejected, and, secondly, when even quite elementary precautions are taken it is the heater hum which becomes the predominant factor and each valve makes its own individual contribution.

Various methods have been suggested for overcoming this nuisance, such as varying the heater-cathode potential and by balancing the earth connection of the heater system by means of the so-called humdinger. Far too often these methods prove only partially effective, and for really high-gain amplifiers one is driven back to D.C. heating for the early stages. It was desired to avoid this alternative and to make a hum control system which could be applied rapidly and effectively to each valve in turn, and it is believed that the system to be described is effective enough to make the valve noises themselves the more important factor in the circuit.

At best, the overall application of a humdinger can only give an approximate solution, for each individual valve requires its own particular setting of the control. The only solution along these lines is, therefore, to supply each early valve with its own heater winding and centre-point control, an expensive and elaborate solution. It was found by experiment that the heater hum introduced by each individual valve was substantially in phase with the heater voltage at the terminals of the valve. The solution which suggested itself, therefore, was to inject into the valve the appropriate proportion of the heater voltage in anti-phase to the hum. This proved to be singularly effective, and was achieved in a number of ways of which a typical one is shown in the figure.



Method of balancing out hum voltage.

The heater winding itself must be centre earthed, and the best method of achieving this will be discussed later. Each valve to be treated then has connected across its heater pins a low-resistance potentiometer of 50 or 100 ohms. A hum voltage is picked up from the slider of the potentiometer. In pentode valves the best point of injection proves to be the suppressor grid, which is connected to this potentiometer slider. In valves of the tetrode type a similar effect may be obtained by taking the screen decoupling condenser to this point rather than to earth. With triodes a considerable measure of control may be obtained by taking the lower end of the cathode resistor to this point, but in this case the resistance of the potentiometer in relation to the value of the bias resistor must be considered. In any case, the control is not so good, and it is nearly always advantageous to use tetrodes or pentodes rather than triodes even when small gains are required.[2]

The only point needing further consideration is the centre earthing of the heater winding. It must be remembered that there are now certain points, which are normally earthed, which are separated from earth by the two halves (approximately) of the potentiometer in parallel with each other plus whatever centre earthing arrangement there may be on the heater winding. Often it is perfectly satisfactory to use the normal centre tap of the winding if one is provided, but there is the possibility of a rather long loop which can introduce trouble. Another solution which we have tried and which seems to be free from unpleasant defects is to discard the centre tap and connect a 50-ohm resistor from each side of the heater system to earth at a point near the place where hum control is taking place. A similar solution which gives a further measure of control is to use a normal humdinger. Valves which are to be controlled by hum injection are removed and the centre tap is adjusted to give the best results for the remaining stages. When this adjustment has been made it must not be touched again. The earlier stages are then introduced one by one and their hum removed by means of their individual controls.

In conclusion, it may be said that work is proceeding on this and kindred problems, but that in a high-gain amplifier made for test purposes, using a single heater winding throughout, the hum could be reduced so as to be quite inaudible below the level of the valve noises.

---

[1] *Wireless World*, May, 1946, p. 142; Feb. 1947, p. 57.

[2] *Wireless World*, July, 1944, p. 196.

NEGATIVE FREQUENCY

How to Distinguish −f from +f

By

"CATHODE RAY"

STUDY of modulation, frequency changing and related arts during the last two months brought us inescapably into the realm of negative frequency. We found, for example, that the Synchrodyne works by means of a frequency changer which shifts the carrier-wave frequency of the selected transmission to zero, so that the lower sideband is bound to be negative. Then again, if a signal is modulated by another of higher frequency, the "difference" frequency is negative.

What, if anything, does a negative frequency mean? Can it be distinguished from a positive frequency, and if so how? It would certainly sound odd if the Electricity Board were to offer their supply at −50 c/s (though it sometimes seems to be moving in that direction!) just as it would for the voltage to be specified as $230\sqrt{-1}$. Both statements, on the face of them, are nonsense; but we saw (in "*j*," Feb., 1948, issue) that $\sqrt{-1}$ can be given a reasonable interpretation in terms of phase. So can −50 c/s. Even the highbrow books dodge the issue or gloss over it most shamefully, but let us away with such evasiveness and face it boldly.

Consider a single alternating current, frequency *f* c/s. As we ought to know by now, it can be represented by a single vector rotating at *f* revs per sec, as in Fig. 1. The length of the vector is fixed, to represent the peak value of current, I; but when it is viewed from a position such as A, it looks as if it were alternately growing from a point to full length, back to zero length, then negatively, and so on, as in the succession of snap-shots shown at P. If hundreds of snapshots were taken during one revolution and placed side by side they would fill up the wave-shaped outline shown dotted. This continually changing *apparent* length represents the instantaneous value of current, *i*. (Of course, unless *f* were well below 10 c/s a real human observer would see nothing but a blur; but that does not alter the fact that a vector revolving at any speed presents an end-on view that goes through the sequence shown.) The thing to

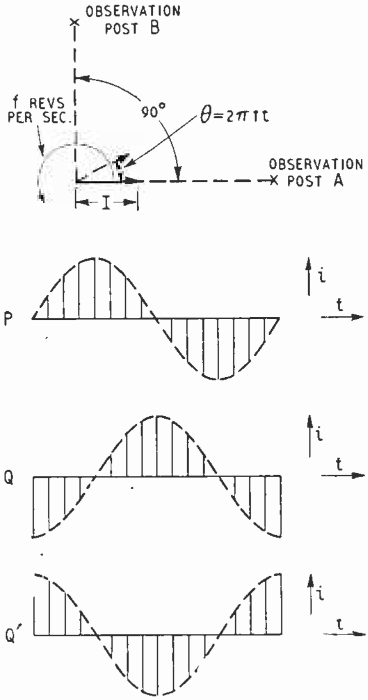


Fig. 1. At P is shown a succession of "snapshots" of the vector as seen from A, during one revolution. Seen from B, its appearance varies as shown at Q. Neither viewpoint reveals the direction of rotation. For that one has to have both views at once. Views P and Q′ together would indicate reverse rotation, or negative frequency.

note is that it is impossible to say, from this one viewpoint, whether the vector is rotating anti-clockwise (which is conventionally described as positive rotation), or clockwise (which means negative). Positive and negative frequency both appear the same, which is what we have been assuming for the last month or two and getting away with it.

The reason for this ambiguity is that the vector looks the same pointing towards one as it does when pointing away in the opposite direction. If one were to move to position B—or any other in the plane of rotation—it would be no better. The sequence of appearances would be as shown at Q, which is the same as P with a phase difference of 90 deg (corresponding to the angle through which the viewer has moved from A to B); and without reference to A the direction of this phase difference is unknown, so one still cannot tell which way round the vector is going.

But if it were possible to have an eye in both places at once (or do the same thing in a more practical way with the help of mirrors) one would see both P and Q simultaneously, and correlation of these two views would prove that the vector was rotating positively. If, however, the two views were P and Q′, together they would indicate negative rotation.

Considering the thing vectorially, then, leads to the conclusion that the sign of the frequency (+ or −) has no meaning when the alternating signal or supply is single phase, but can be given a conventional meaning with a 2 (or more)-phase supply. Note the word "conventional," which means that this is one of those things that people have to agree on; not an absolute unalterable fact of the universe. People agreed to mark the carbon electrode of a Léclanché cell "+," and continue to do so, even though what is now known about the direction of electric currents would make a "−" a more sensible convention. Still, as long as everybody agrees, even a cock-eyed convention works. In a similar way, + and − signs are useful for distinguishing alternating currents that look alike by a single-phase test but neverthe-

Negative Frequency—
less turn out to be different when examined in two different phases at once.

You will probably lodge an objection at this stage; namely that vectors are imaginary things, which may help to make A.C. theory clearer in the mind but are not A.C. itself. Coming down from airy fancies to physical realities, how does one tell a $-f$ from a $+f$ on the bench?

If you have a single-beam oscilloscope and connect one pair of its deflection plates to a source of very low frequency voltage, the deflection of the spot from its normal position will vary in exactly the same way as the apparent length of the imaginary vector. If the other pair of plates is fed from a linear time-base generator, the spot will trace out a wave like the dotted line at P in Fig. 1. And if the time base is locked to the frequency under observation, it will retrace the same wave over and over again, so there is no need for the frequency to be low enough for the spot to be followed by eye. This is a single-phase or single-position observation, which is incapable of showing whether the frequency is + or −.

If you have a double-beam 'scope you can examine a 2-phase supply if you have a 2-phase supply. Some people—though very few nowadays, because it is non-standard—do have a 2-phase electric power supply laid on, and if they connect the two phases to the two beam deflectors, as in Fig. 2, the beams will trace out a pair of waves either like P and Q or P and Q′ in Fig. 1. (Unlike the output from a push-pull amplifier, which has a phase difference of 180 deg, the difference between the two "live" wires in a 2-phase power supply is normally 90 deg.) Taking one of them (say Phase 1) as the reference or standard, the other can be either leading or lagging. The frequency of Phase 2 is the same in both cases—equal to that of Phase 1—and the voltage is normally the same. The distinction between the two possible sorts of Phase 2 can be made by calling one of them a positive frequency and the other a negative. Heavy electrical engineers may not have a double-beam 'scope handy, but they are quite likely to have a 2-phase induction motor. Such a motor distinguishes between positive and negative frequencies (as just defined) in a very practical and significant fashion, by rotating anticlockwise (positively) with one and clockwise (negatively) with the other. But, of course, it all depends on how Phase 1 has been connected to the motor (or 'scope). The Phase 2 that was declared "negative" with one Phase 1 connection will be "positive" if Phase 1 is reversed. There is nothing new about that with + and −; the sign can only be decided by reference to something else, such as earth in the case of potentials. A positive potential with one reference may

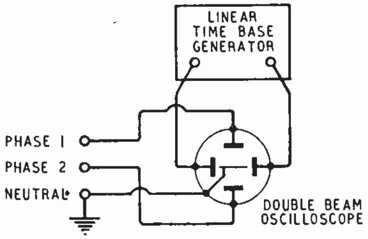


Fig. 2. A practical method of distinguishing negative from positive frequency.

be a negative with another. In the same way, the sign of a frequency has no meaning in a single-phase circuit. That is how we have been able to ignore it in recent issues, and many radio people ignore it all the time.

After all that discussion, then, the mysterious negative frequency seems to be just an arbitrary way of labelling leading and lagging phase differences for the sake of distinguishing them. So why bring frequency into it at all, and make a mystery about something that is quite simple and well known? And is there any guidance at all about which label to put on, like there is with potential (with reference to earth), or is any guess as good as another?

The whole matter begins to make much better sense when one looks closely into frequency changers and such-like, and especially the Synchrodyne and the modulation filter system I described. In case you have forgotten about them, or didn't read it, consider an ordinary superhet. As is well known, it is liable to "second-channel interference." That is because there are always two signal frequencies that can combine with the oscillator frequency to give the intermediate frequency, so the I.F. amplifier is quite unable to distinguish between them, and amplifies both equally, though one may be the wanted programme and the other an interfering station on a different frequency. It is necessary to rely entirely on the "pre-selector" tuning circuits to discriminate between the two, and if those circuits are not sufficiently selective it is just too bad.

In the days when receivers had an I.F. of about 110 kc/s, second-channel interference was quite a problem, because the wanted and unwanted stations were separated by only 220 kc/s, and two or even three tuned circuits are not enough to make a strong signal, 220 kc/s off tune, negligible compared with a weak signal on tune. The present-day 465-kc/s I.F. separates the two channels by 930 kc/s, and gives the tuner a better chance.

Suppose, for example, that the wanted station is on 1,000 kc/s. If the I.F. is 465 kc/s, the oscillator must be set to oscillate at 535 kc/s or 1,465 kc/s—usually the latter. A station working on 1,930 kc/s can also combine with 1465 to give 465 kc/s, so that is the "second channel"—twice I.F. from the first or intended channel. Although these two channels are indistinguishable from the I.F. amplifier's point of view, they are different frequencies originally, so can be distinguished by pre-frequency-changer tuning.

A Synchrodyne, as I said last month, is a superhet in which the I.F. is zero. One of its advantages is that a low-pass filter accepting all frequencies below some specified frequency—say, 5 kc/s—is generally easier to design to an exacting specification than a band-pass filter covering the same total band of frequencies placed high up in the R.F. spectrum. For example, if it is necessary to accept a 5-kc/s-wide band, cutting off all others sharply, it is easier if that band is 0-5 kc/s than if it is, say, 5,000-5,005 kc/s. For some purposes in telecommunications (such as single-sideband amplification) the

5,000-5,005 sort of proposition is so unattractive that it is worth the trouble of frequency-changing it down to 0-5, by using a 5,000-kc/s oscillator, so as to be able to use a 5-kc/s low-pass filter The snag is that signals in the band 4,995-5,000 kc/s also combine with 5,000 kc/s to give signals in the 0-5-kc/s band; and to the low-pass filter they are all the same as if they had originated in the desired 5,000-5,005 band. And the design of a pre-selector to weed out the 4,995-5,000 signals is just the nasty sort of job that the scheme is intended to avoid.

Since the 5,000-kc/s oscillator can be said to reduce the frequencies of all the original signals by 5,000 kc/s, the wanted band can be said to be moved to 0 to +5 kc/s and the unwanted (but unavoidably accepted) band to −5 to 0 kc/s. In this way the two lots of signals can be given + and − frequency labels according to a definite and reasonable system. 5,005 kc/s when modulated by 5,000 gives 5,005 + 5,000 = 10,005 and 5,005 − 5,000 = 5, whereas 4,995 modulated by 5,000 gives 9,995 and −5.

A low-pass filter, being a single-phase device, cannot tell −5 kc/s from +5 kc/s. *It can, in fact, be regarded as a bandpass filter*—the one in the example admits the band −5 to +5 kc/s; a total width of 10 kc/s.

That idea, possibly still rather novel to most readers (though I certainly don't claim originality) ties up with a diagram I showed in "Channels of Communication" (June, 1947), regarding which I said that the audio-frequency band can be considered to be a side-band of a zero-frequency carrier wave, and that whatever carrier wave was used for a channel of communication the bandwith occupied was the same. This might have seemed to contradict the common impression that whereas a telephone channel to convey speech frequencies up to, say, 5 kc/s, has to have a band width of just under 5 kc/s, directly they are used to modulate a transmitter for a radio link the bandwith has to be doubled to accommodate two sidebands each nearly 5 kc/s wide. That apparent discrepancy can be cleared in one way by pointing out that (with suitable precautions) the full range of the information can be conveyed by one sideband only. We now see—I hope—that it can be cleared in another way by saying that an A.F. low-pass filter to separate 0 to 5 kc/s from other frequencies also accepts 0 to −5 kc/s; a total band of 10 kc/s, just as in the R.F. condition. 0 to −5 kc/s can, in fact, be regarded as the other sideband of the zero-frequency carrier wave.

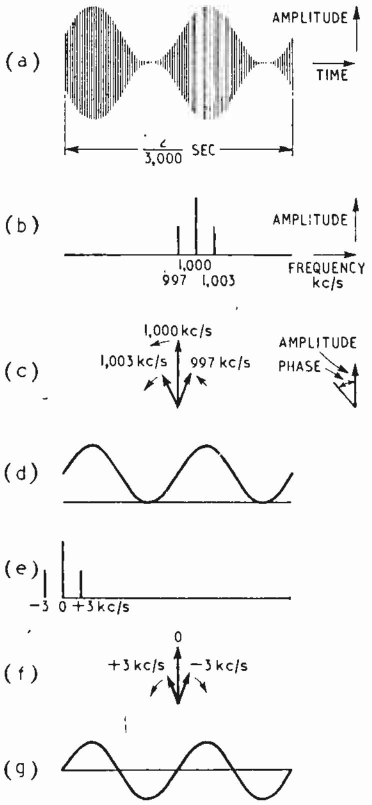


Fig. 3. A high frequency (1000-kc/s) carrier wave modulated at 3 kc/s, represented in three ways—*a*, *b*, and *c*. A zero-frequency "carrier wave" modulated at the same frequency is shown in the same ways at *d*, *e* and *f*. *g* is an alternative to *d*, representing a different "phase" of the "carrier wave."

I am going to return to the system in which the negative frequencies represent second-channel interference; but in the meantime this Z.F. carrier-wave idea is worth thinking about a little more. Suppose we start off with the old familiar case of a R.F. carrier wave modulated by a single A.F.—say, 1,000 kc/s and 3 kc/s respectively—and express this in various words and diagrams. The way that everybody finds easiest to "see" is to describe the product of the process as a 1,000-kc/s wave-train varying in amplitude at a rate of 3 kc/s. The diagrammatic representation of this description must be an amplitude/time graph, and assuming the modulation to be 100 per cent, it will look something like Fig. 3*a* if prolonged for the space of two-thirds of a millisecond (i.e., two cycles of the modulation frequency). The R.F. cycles are too numerous to show separately, but we know there are more than 600 of them in the short length of graph shown.

The alternative description that everybody finds so much more difficult to visualize, and some never quite believe, though it is a much easier form to handle mathematically, is that the thing consists of a 1,000-kc/s carrier wave plus waves of half the amplitude at 997 and 1,003 kc/s. Using the same form of diagram, an incredibly patient person could draw a few hundred cycles of these three, correctly to scale, add them all together to make a single graph, and arrive at—Fig. 3*a*. While a complete cure for the sceptic, this is one he is not likely to be persuaded to take. A much more practical diagrammatic expression of the statement is the spectrum form—an amplitude/frequency diagram—as in Fig. 3*b*. which explains itself. A third form of diagram—yes, it is the vector or amplitude/phase diagram, Fig. 3*c*, which you will be getting tired of. All these diagrams are just different views of the same thing. The spectrum is a Fig. 1 view of the vector diagram with all the vectors simultaneously pointed up and spaced along their axis to mark their respective frequencies. The two little vectors in Fig. 3*c* rotate respectively 3 kc/s faster and slower than the big vector, which is doing 1,000 kc/s; and as a succession of diagrams during one modulation cycle demonstrates, this condition ensures that the resultant—the single vector equi-

Negative Frequency—

valent to the two small ones—is always in the same line as the carrier vector, so the combination with it is equivalent to a carrier vector which varies its length between double-normal and zero, at carrier frequency. Such a pulsating vector, viewed as from A in Fig. 1, appears to vary in amplitude in exactly the way traced out in the amplitude/time graph, Fig. 3*a*.

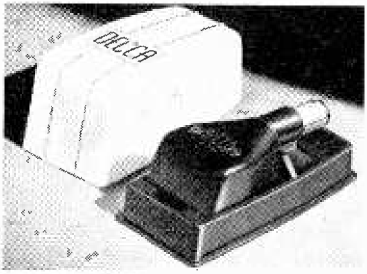
Now suppose, to the great relief of anyone who is trying to visualize Fig. 3*c* rotating at its various working speeds, that the carrier frequency is drastically reduced. To give the greatest possible relief, let us suppose that the carrier frequency is reduced to zero, so that its vector is brought to a standstill. Then the two side vectors rotate at equal speeds but in opposite directions. One is doing +3 kc/s and the other − 3 kc/s. The slowing-down of all the radio frequencies by an equal amount can be done physically by a frequency changer; and the Synchrodyne is a practical case in which the carrier wave is reduced to zero, but of course the usual apparatus does not distinguish between +3 kc/s and −3kc/s—all we know is that we get 3 kc/s.

The vector diagram, however, does suggest that these two frequencies do exist, and that a two-phase system ought to be able to distinguish them. Before examining this point, take another look at the slowed-down Fig. 3*c*. The resultant of the oppositely rotating side vectors is always either straight up or down, directly adding to or subtracting from the stationary carrier vector. I needn't go through it all in detail again; you will easily see that the resultant of the whole lot can be represented (if the carrier vector has come to rest in a vertically upward position) in amplitude/time form as in Fig. 3*d*, which is drawn to the same scale as Fig. 3*a*. The blur of R.F. cycles has been replaced by D.C.; and we have the sort of thing that one might get in the anode circuit of a fully loaded (and surprisingly perfect!) audio amplifier. If the carrier vector had stuck in the downward position, that would represent the same thing with leads reversed. And if it had finished horizontally, so as to be invisible from viewpoint A in Fig. 1, the two side-band vectors would be left on their own to give Fig. 3*g*— a pure A.C. of frequency 3 kc/s. In fact, the amplitude of A.C. of any single frequency varies in a manner which is represented by the resulant of two half-size vectors rotating in opposite directions. So it looks as if *any* A.C. may, for all we know, consist of equal parts + and − frequency.

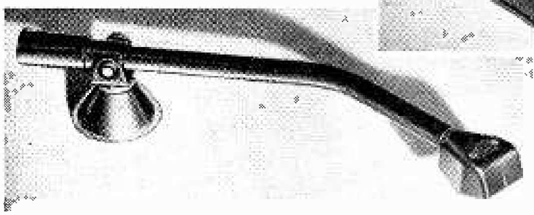
Turning from this shattering thought to the apparatus in which, for practical convenience of filter construction, a 5,000-5,005-kc/s band had been transported by a 5,000-kc/s modulator to 0-5 kc/s, only to run into interference from signals in the band 4,995-5,000 kc/s, is there any way out of the difficulty? You have, I hope, been well prepared to look for the solution in a 2-phase system. Such a system is described by N. F. Barber in *Wireless Engineer*, May, 1947; and as it is a rather specialized type, not likely to be adopted by many in what I might make bold to refer to as my constituency, I will not attempt to reduce it in detail to "Cathode Ray" terms. In brief, applying it to our example, the original signal is put in to a 2-phase modulator, giving two outputs, in both of which the wanted signals are in the band −2.5 to +2.5 kc/s; that is to say, the modulating frequency is 5,002.5 kc/s instead of 5,000. Each of these outputs is put through a separate low-pass filter with a cut-off at 2.5 kc/s. All the interference is thereby disposed of. The trouble now, in a single-phase system, would be that signals which were originally 5,000 and 5,005 kc/s would both appear indistinguishably as 2.5 kc/s. But by using another 2-phase modulator to shift the frequencies into an all-positive band the two are given their proper 5 kc/s separation. The second frequency-changer could also have a 5,002-5 oscillator, to restore the signals to their original places in the spectrum, rid of all unwanted frequencies. Or they could be transferred elsewhere, as required.

We have managed to get through all this without any sin-and-cos! But in case any readers deplore that, here, as a tailpiece, is what it has to say about negative frequency. The situation we saw at the start—the minus going unnoticed because to a single observer there is no difference between $-f$ and $+f$—arises in mathematics because sin and cos are ambiguous. Cos starts from a positive peak, and decreases in exactly the same manner whether one goes forwards or backwards. Put concisely, $\cos\theta = \cos(-\theta)$. Also $\sin\left(\frac{\pi}{2}+\theta\right)=\sin\left(\frac{\pi}{2}-\theta\right)$. When the books deal with modulation (etc.) by multiplying two cos and/or sin terms together, they conveniently forget this ambiguity, to save themselves the embarrassment of producing a negative frequency and having to explain it. They give the results f_1+f_2 and f_1-f_2 (if f_1 is higher than f_2), but drop out f_1-f_1. It exists, all the same, and, as we have seen, can even be separated from its mirror image, f_1-f_2!

LIGHTWEIGHT PICKUP

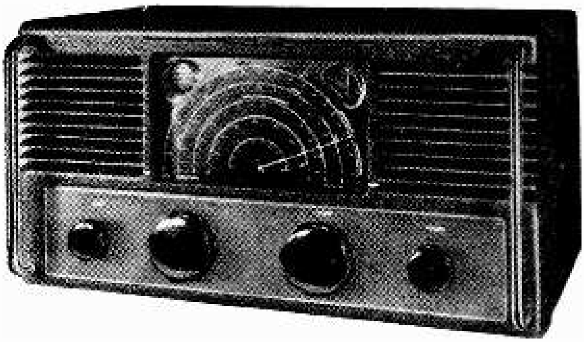


THE Decca "ffrr" pickup, used in "Decola" electric gramophones, is now available separately either as a replacement head (£4 14s 8d) or with 8-in tone arm (£6 14s 4d); both prices including purchase tax. Replacement sapphire stylus elements will be available.



SEAFARER'S RECEIVER

Eddystone Model 670 Broadcast Superhet



This view of the Eddystone 670 shows the large calibrated dial and the disposition of the controls. The bandspread dial is in the top right-hand corner of the main dial.

ALTHOUGH described as a marine receiver the new Eddystone Model 670 is essentially a broadcast set and not, as might be supposed, one of the communications type.

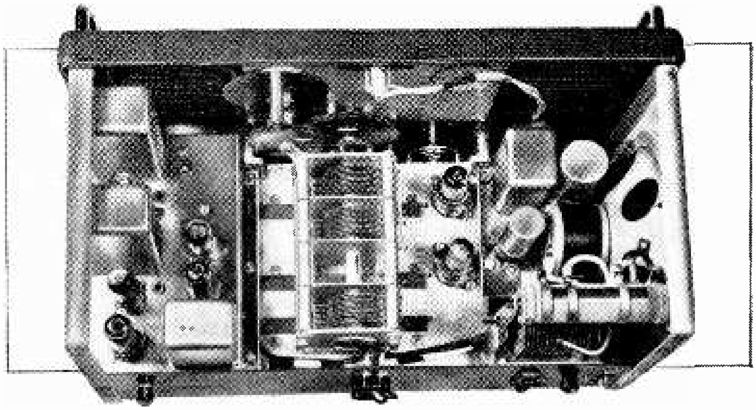
The set is primarily intended for personal use on board ship and in view of this has been designed for operation on either A.C. or D.C. supplies of from 100 to 110 volts or 200 to 250 volts.

Particular attention has been given to the performance of the set on the short waves, as for long periods the high frequencies will often be the sole medium for broadcast reception. The use of a novel expanded tuning scale ensures precise re-setting of the set to any previously logged station. It is a mechanical system embodied in the reduction drive and provides the equivalent of 90ins of scale for each range.

There are four wavebands in this set, covering, respectively, 1,220 to 522 kc/s (246-575m), 2.75 to 1.2 Mc/s (110-250m), 13 to 5.8 Mc/s (23.1-51.7m) and 30 to 12.8 Mc/s (10-23.5m). In addition to the short and medium broadcast bands the set covers the so-called trawler band and the four amateur bands of 1.7, 7, 14 and 28 Mc/s.

Seven miniature valves on B8A bases are used in a superheterodyne circuit having one R.F. stage, combined frequency changer, one I.F. amplifier, A.G.C., detector and A.F. amplifier and finally a push-pull output stage delivering about 2 watts to a 6in loudspeaker mounted on the left-hand side of the chassis.

A.C.-D.C. technique with series-connected valve heaters and a tapped voltage dropping resistor is employed with a selenium-type rectifier providing H.T.



The layout of the Eddystone 670 chassis is particularly neat and gives access to all parts. The coil box is below the deck.

Special care has been taken to prevent interference to, or from, other radio sets in the vicinity, a very important matter on board a ship where so much depends on radio for navigation and other essential services. Modern ships use a vast amount of electrical machinery and as interference from them may be carried along the ship mains, a mains filter for use external to the set is available if required.

The coil unit is a 3-compartment die-cast metal box in which all trimmers and padders are included and the whole set is enclosed in a compact and stout metal cabinet measuring only 16¾in by 9in by 10½in overall and finished in brown crackle enamel.

A point of interest regarding the supply circuit is that the mains leads and their plugs and sockets are completely insulated. Particular attention has, in fact, been given to insulation throughout, in addition to which all components are the tropical grade, so necessary in a set of this kind which is almost sure to be used in every conceivable variety of climate and weather.

The controls comprise a spin-wheel tuning system, large illuminated dial with calibrated scales and the subsidiary band-spread scales previously mentioned, waveband switch, volume control and a combined tone compensator and on-off switch.

On the back are sockets for the mains input, voltage adjusting panel and sockets for a single wire or dipole aerial. There is also a pair of sockets and a plug which enables the internal loudspeaker to be disconnected and an external one, or headphone, plugged in instead.

We were able to give the set a brief test and knowing the conditions under which it would normally be used it was made in fairly close proximity to a considerable amount of electrical machinery and with a mediocre aerial. Performance was very satisfactory; the A.G.C. system works particularly well and the mains filter was found to be definitely worth having in this location. Adjacent channel selectivity is very good and the wavelength and frequency calibrations are extremely accurate.

The makers are Stratton & Company, Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham, 31, and the price of the receiver is £37 10s., the filter unit costing £2 10s.

AIR COMMUNICATIONS

New Radio Equipment for Aircraft and Airports

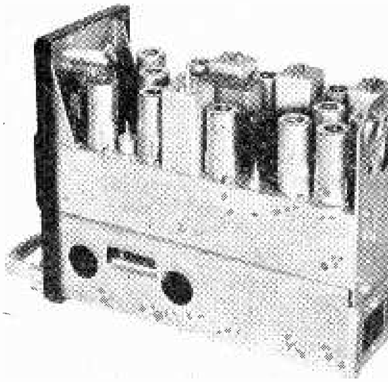
(Left) Marconi portable radio telephone for use on airfields.

(Right) Murphy MR60 5-channel V.H.F. transmitter-receiver and control unit.

THE fine display of V.H.F. radio telephone equipment for ground and air use was a notable feature of the wireless section at the Flying Display and Exhibition held this year at Farnborough by the Society of British Aircraft Constructors.

Standard Telephones were showing two V.H.F. aircraft sets, the STR12 and STR9, the former being a 12- and the latter a 4-channel set giving crystal control of transmitter and receiver. As with all aircraft sets of this kind, remote control is employed and the crystals (of which there are 24 miniatures in the STR12) are fitted in an accessible position on the control unit. The main reason for this is to enable the crystals to be changed in the air if other spot frequencies are required.

A similar arrangement is adopted by Murphy in their MR60 aircraft set. Five spot frequencies are provided with the crystals and crystal oscillator included in the remote control unit. The set covers the aircraft band of 116 to 132 Mc/s, but in order to avoid retuning for each change of crystal this range is divided into four bands, each 4-Mc/s wide, and by motor-operated switching any one of the bands can be selected from the remote control unit. The five chosen crystals can be arranged either to be all in one 4-Mc/s band or distributed over the whole range. The same crystal serves for both the transmitter and receiver.



Chassis assembly of the G.E.C. BRT 600 V.H.F. set. The power unit is in the base.

Since size and weight is at a premium in all aircraft equipment, these sets are condensed into the smallest possible volume. They are outstanding examples of what can be achieved with miniature valves and components.

The new G.E.C. set type BRT600, which measures $3\frac{7}{8} \times 7\frac{7}{8} \times 9\frac{1}{2}$in, contains a transmitter, a receiver and a rotary transformer. Some of its 11 miniature valves are used in a dual capacity, the crystal oscillator and frequency multipliers being one example. These serve either as a crystal drive for the transmitter, or, with an appropriate crystal switched in, become the local oscillator for the receiver. Then, the two audio stages function either as modulator or as A.F. amplifier for the receiver.

Ekco were showing their combined transmitter and receiver for light aircraft in which a similar system for conserving valves and components has been adopted.

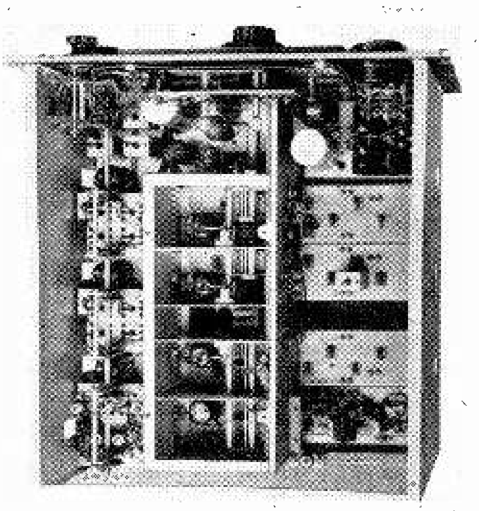
Still another lightweight radio telephone set for aircraft was seen on the Plessey stand. Described as the Model TR51 it provides five channels using the same crystal for transmit and receive and covers 116 to 132 Mc/s. The design permits crystals to be changed in the air if other channels than those chosen are required. The overall size is $12\frac{1}{2} \times 6 \times 5$in and the weight is $9\frac{1}{2}$lb only. The R.F. output is 1 watt and the power consumption 50 watts.

In addition to providing air-to-ground M.C.W. and R.T. communication the new Cossor V.H.F. set can be used also for reception of beam approach marker signals. In the latter case a small B.A. amplifier is used and the output is fed into the main part of the V.H.F. receiver. For communication purposes the range of the set is 100 to 124 Mc/s and four pre-set channels are available.

For transmission a crystal oscillator is followed by a doubler and push-pull trebler which drives a push-pull P.A. to 6 or 7 watts R.F.

output. The receiver has an R.F. stage, a mixer with local oscillations derived from a crystal oscillator-trebler and a sextupler, three I.F. amplifiers, detector, A.G.C. and two A.F. stages. With motor generator and B.A. receiver the whole occupies only 13 × 17 × 8in.

Other radio equipment in the V.H.F. category shown included the latest Standard Telephones instrument landing and runway approach receivers, the STR14 and STR15.



Chassis view of the new Redifon R50 communications receiver.

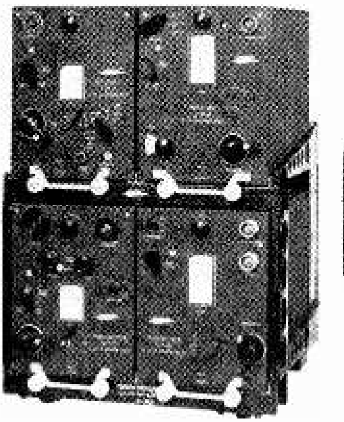
Ground equipment was represented by two distinct classes. There were the higher-powered transmitters built in rack form for flying control on and over the airport and in the approach areas, and some very compact portable and mobile sets for use by ground personnel at remote parts of the airfield.

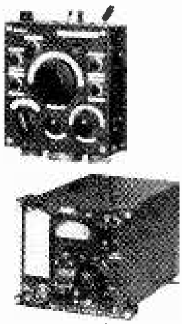
One example of the first mentioned is the Marconi TGV472 transmitter of 50 watts output and covering a wide V.H.F. band including the aircraft one of 116 to 132 Mc/s. Single-or multi-channel operation can be provided, also amplitude or frequency modulation.

As a stand-by for this set, or where lower power will suffice, Marconi's have a 10-watt set, A.M. or F.M. as required, which is known as the type TAV410. It is self-contained and very compact, weighing but 15½lb and measuring 2 × 15½ × 7¼in, and it can be either battery or mains operated. It is thus suitable for use in vehicles on the airfield. There was also a "Walkie-Talkie" set described as the type H19.

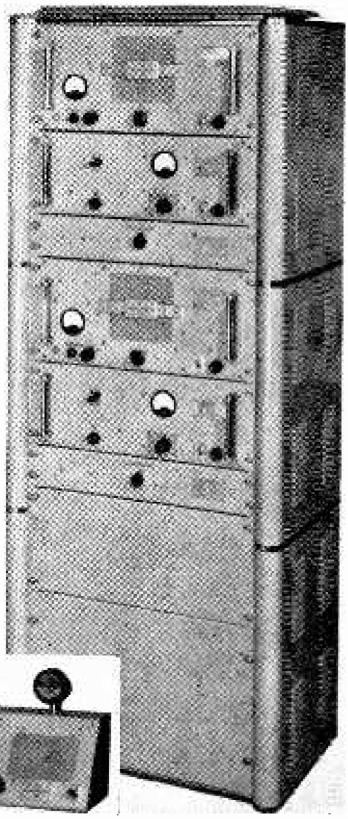
Self-contained units assembled in a standard 19-in rack and made up for single- or multi-channel operation were a feature of the Pye Telecommunication exhibit. The transmitter panel gives 12-watts output and includes modulator and power supply. The same form of construction is used for the receiver units each of which consists of a 17-valve superhet, loudspeaker and power pack. It is A.C.-operated.

An interesting feature of the Ekco airport V.H.F. station is the inclusion of D.F. facilities using a modified form of the communications receiver and a pair of rotatable dipoles controlled from the operating position in the tower.

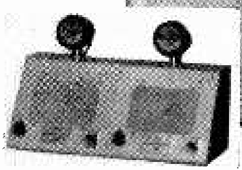




(Left) Standard Telephones STR 16/17 medium and high frequency aircraft installation.



(Right) Two-channel Pye V.H.F. airport R.T. installation.



The latest H.F.-M.F. communications equipment made by Standard Telephones provides for operation over a wide range of frequencies. The STR16 H.F. installation, for example, includes a 30-watt transmitter giving a range of about 500 miles on telegraphy at 5,000ft and 150 miles on telephony. The receiver covers 2.4 to 13 Mc/s in two bands. There is a companion 10-watt M.F. communications set covering 150 to 505 kc/s giving a range of about 150 miles and including D.F. facilities. It is described as the STR17.

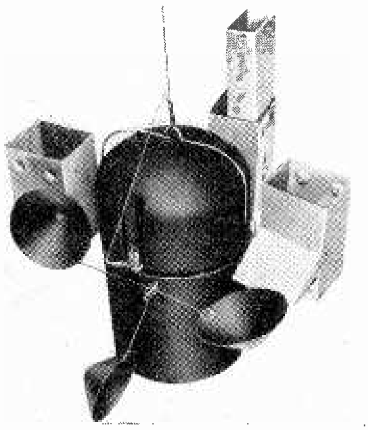
One of the latest pieces of equipment introduced by Marconi's is a 12-valve communications receiver, the AD94. It has six ranges, two covering 150 kc/s to 510 kc/s and four covering 2 to 18.5 Mc/s. The B.F.O. is crystal controlled The normal I.F. bandwidth is 5 kc/s, but for C.W. operation a crystal filter can be brought into use giving 1 kc/s bandwidth. The calibration of this receiver is such that pre-tuning to any desired frequency can be effected with an accuracy of ± 2 kc/s. Its power supply is provided by a built-in rotary converter consuming 1 amp at 28 volts.

Designed for use in large aircraft is a new Marconi high-power transmitter, type AD107, covering the high and medium frequencies with

Air Communications—
independent, but complimentary, units. Each section provides for 10 crystal-controlled spot frequencies with either local or remote control and the power output is between 100 and 150 watts over 2 to 18.5 kc/s. The equipment is fully tropicalized and wide use is made of miniature parts in order to conserve space and weight.

Several different models of transmitters and receivers for ground stations and for communication with aircraft were shown by Rediffusion. There was a 100-watt transmitter, the type G54, designed for C.W., telephony and navigational services on 250 to 520 kc/s. Eight crystal-controlled spot frequencies or a continuously tunable electron-coupled master oscillator can be provided, the latter having a stability of 0.1 per cent.

The transmitter consists of four separate units mounted in a steel cabinet. They comprise power supply, modulator, R.F. and aerial coupling units, and the form of



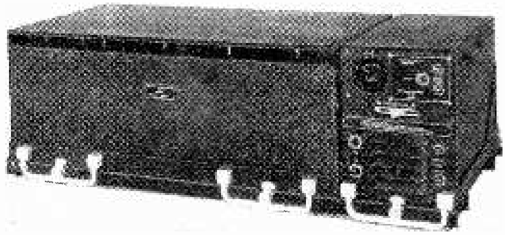
Radio sonde meteorological balloon transmitter shown by Salford.

construction facilitates servicing when the need arises. The whole equipment is fully tropicalized.

A new communications receiver was also seen on this stand. Known as the model R50 it is a 12-valve superhet covering, in eight bands, the exceptional frequency range of 13.5 kc/s to 32 Mc/s. Two R.F. and three I.F. amplifiers are employed and there is also a double-diode noise limiter. The A.C. power unit has a voltage stabilizer. A D.C. version is available.

A unique feature of the set is that the I.F. is switched from 465 kc/s to 110 kc/s when receiving on 13.5 to 26 kc/s and on 240 to 606 kc/s. Also, there is the choice of five bandwidths, ranging from 250 c/s to 17 kc/s.

Since meteorological reports play such a vital part in flying, special interest attaches to the various devices used in compiling them. For investigating the conditions prevailing in the upper atmosphere radio-equipped balloons



Decca Navigator Mark VI aircraft receiver with power unit.

Plessey 5-channel V.H.F. radio telephone for light aircraft.

have long been used, and the latest form these transmitters take were shown by Salford Electrical Instruments.

Last year saw the introduction of two automatic radio direction finders for use in aircraft, and both G.E.C. and Marconi were showing the latest version of these sets. Decca were showing a new aircraft receiver for the Decca system of long-range radio navigation. Some of the latest improvements incorporated include continuous and automatic lane identification, independent cross check of position and provision for use on up to five Decca Navigator chains. Receiver and power unit fit into the standard aircraft racking and operate from the low-voltage D.C. supply. Remote indicators, described as Decometers, are provided for the pilot and the navigator.

GRAPHICAL CIRCUIT SYMBOLS

Revised British Standard Issued

A REVISION of "Graphical Symbols for Telecommunications" has just been issued (BS530: 1948; British Standards Institution, 28, Victoria Street, London, S.W.1; price 10s 6d.) This revision (the second) appears after a gap of eleven years, and, as might be expected, the number of symbols has grown considerably to keep pace with advances in the art. The publication of this new edition is a matter of some importance, especially in the world of wireless, as, out of 100 pages, a bare half-dozen only are exclusive to such non-radio subjects as wire telephony.

In addition to symbols purely for circuit diagrams, there are also representations of units comprising groups of components (e.g., amplifier, modulator) for use in "block schematics" or skeleton diagrams. There is also a set of symbols (e.g., direction finder, vision pick-up) for use on plans.

Where the British standard symbol differs from the international standard issued by the I.E.C. the difference is indicated and the I.E.C. symbols which so differ are given.

It is stressed in the foreword that circuit symbols should not be pictures, but should be simple in form, so they can be easily drawn. The primary purpose of graphical symbols is to indicate the electrical functions of the circuit. They are not intended to give guidance in the constructional details of apparatus; mechanical construction of apparatus to be represented is thus of secondary importance.

FOR CONSTRUCTORS

A LIMITED number of receiver chassis, suitable for incorporation in radio-gramophones, will shortly be for disposal from Multitone Electric, 223, St. Johns Street, Clerkenwell, London, E.C.1. The circuit is similar to that used in Multitone Radio Set for the Deaf (*Wireless World*, October, 1946) and includes a push-pull output stage. It covers short, medium and long waves, but the auxiliary microphone amplifier circuits are omitted. The price, including tax, will be £12 14s 1d.

WORLD OF WIRELESS

Television at Home and Abroad • New European Wavelength Plan • Kits of Parts Taxable • B.B.C. Finance

405 *Lines to Stay*

SIMULTANEOUS statements issued last month by the Post Office, the Television Advisory Committee and the Radio Industry Council make it clear that the present technical standards of the B.B.C. television service are to remain unchanged for a number of years, unofficially interpreted as five years if the next step is to be a comparatively minor one, and up to ten years if it is to be something sweeping, like colour.

The Post Office statement is welcomed by the industry for several reasons, the main one being that the present system allows the development of television services at minimum cost. The official industry statement urges the adoption of the 405-line system as a European standard.

Exporting Television

BRITISH television is being featured at the British Exhibition which opened in Copenhagen on September 18th.

Arrangements have been made by the R.I.C. for cameras and transmitting gear, similar to that used by the B.B.C., to be installed by Pye for the demonstration of 405-line television throughout the period of the exhibition. The equipment is housed in two vehicles, one containing the picture control room and the other the 25-watt transmitter. E.M.I. 605-line film-scanning equipment is being used for film transmissions.

Television receivers are being demonstrated in the Nimb Restaurant, where the transmitted picture is received by a master receiver from which the output is fed to the sets being demonstrated by Bush, Cossor, Ekco, Ferranti, G.E.C., H.M.V., Marconiphone, Mullard, Murphy, Pye and Ultra.

In addition to the television exhibit, which is a concerted effort under the ægis of the R.I.C., the British radio industry is well represented by over thirty firms who have stands of their own.

Amateur Exhibition

THE second annual amateur radio exhibition organized by the R.S.G.B. will be opened at 2.30 p.m. on November 17th, by Dr. R. L. Smith-Rose, Director of Radio Research, D.S.I.R. It will be held at the Royal Hotel, Woburn Place, London, W.C.1, and will remain open until November 20th (hours 11 a.m. to 9 p.m.).

Admission will be by catalogue, price 1s if purchased at the door, or 1s 3d by post from the society, New Ruskin House, Little Russell Street, London, W.C.1.

European Wavelengths

IT is anticipated that by the time this issue appears a new European frequency allocation plan will have been agreed upon by the delegates of the thirty-two nations participating in the European Broadcasting Conference which has been meeting in Copenhagen since June 25th.

The responsibility for drawing up the final frequency plan for European broadcasting stations (below 1605 kc/s) has been entrusted to the Frequency Allocation Committee—one of six set up by the Conference. This has been presided over by H. Faulkner, Deputy Engineer-in-Chief, G.P.O., one of the delegates of the U.K. It will be recalled that alternative provisional allocation plans were drawn up by a committee of representatives of eight European countries for consideration by the present Conference (see *Wireless World*, June, p. 223).

It is learned from the International Broadcasting Organization, which is participating as an observer, that the question of allocating frequencies to the various occupied zones of Germany provoked considerable discussion in the general assembly.

P.T. on Kits

THE Commissioners of Customs and Excise have decided that for the present the following kits of parts including any loudspeaker or cabinet supplied therewith, are liable for Purchase Tax at the rate of 33⅓ per cent of the wholesale value:—

(i) R.F. tuned coil assemblies covering the medium- and/or long-wave broadcast wavebands, or television waveband.

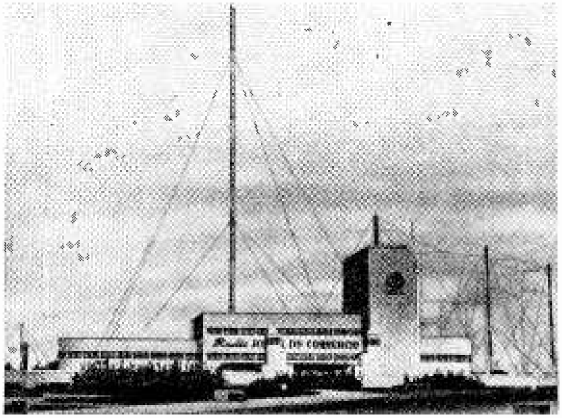
(ii) Kits of parts, whether or not complete or assembled, which include a coil assembly as at (i) above.

(iii) Kits of parts, whether or not complete or assembled, which are sold for the assembly of domestic, portable or car receivers, e.g., an unassembled receiver sold in two or more separate kits for use in assembling a particular receiver.

B.B.C. Report

THE Governors of the B.B.C. have issued the Report for the year ended March 31st last, which is the first full year of operation under the new Charter issued on January 1st, 1947.

Little that is not already known of the activities on the engineering side is included in the report. The financial statement shows that the income for the Home and Television Services totalled £9,986,420, of which £8,927,363 came from licence fees and £1,047,253 from publica-



BRAZILIAN STATION. The recently opened broadcasting station near Recife, Brazil, which was equipped by Marconi with a 20-kW M.W. transmitter and two 15-kW S.W. transmitters. A square section mast radiator is used for medium waves and the S.W. arrays are supported on six short masts

World of Wireless—

tions. A balance of over a million pounds was brought forward into this year. The Corporation received a Government grant-in-aid for the Overseas Services of £4,025,000.

It is announced in the report that negotiations are being made for securing a site in London for a new television headquarters.

The Report has been published by H.M.S.O. as Cmd. 7506.

PERSONALITIES

L. W. Hayes, chief of the B.B.C. Overseas Engineering and Information Department, who has been one of Great Britain's representatives at most of the international radio conferences during the past few years, has been elected vice-director (in charge of broadcasting matters) of the International Radio Consultative Committee. The C.C.I.R. is one of the permanent organs of the International Telecommunication Union, the duties of which are to study technical radio questions regarding the operation of stations. The new director is Dr. Balth van der Pol, of Germany

Major H. E. Watterson, who was with Marconi's before the war, has returned from Shanghai where he has been for the last two years with U.N.R.R.A. as consultant and adviser on telecommunications. He was commissioned in the Royal Signals at the outbreak of the war and was posted to the Radio Security Section of M.I.8 (War Office). From 1942 until V.J. Day he was with the Embassy in Chungking

A. F. Bulgin, M.B.E., chairman and managing director of the company bearing his name, has been promoted to the rank of Wing Commander in the R.A.F.V.R. Training Branch.

IN BRIEF

An increase of 3,400 over the previous month was shown in the number of television licences in force at the end of July, when the total was 58,250. The month's figure for broadcast receiving licences, including those for television, was approximately 11,292,750.

Amateurs' Examination.—Of the 700 entrants for the City and Guilds Radio Amateurs' Examination held in May, 528 were successful. Ten of the thirteen overseas candidates passed. The examiner's report states that the standard of the candidates' work was much higher than in previous examinations. Copies of the question papers for the past three years are available, price 4d each, from the Department of Technology, 31, Brechin Place, London, S.W.7. The next examination will be held on May 11th, 1949, from 7 to 10 p.m

U.S.W. Amateur Band.—It is learned that the negotiations for the release of the 420-460 Mc/s band for British amateurs, to which reference was made last month, have been concluded and that the band will be available from October 1st Power will be limited to 10 watts.

Gee.—The Scottish Gee Chain, which has for some time been under construction, is now operating experimentally on 73.8 Mc/s. It will eventually work on 69 Mc/s. The master station is at Lowther Hill, Dumfries; with slaves at Craigowl Hill, Angus; Ru Stafnish, Argyll; and Great Dun Fell, Cumberland.

S.I.M.A.—The Electronics Section of the Scientific Instrument Manufacturers' Association has arranged for a series of technical papers to be read at meetings to be held at the Caxton Hall, Westminster, S.W.1, on November 18th and 19th. The morning and afternoon sessions on the first day will be devoted to electronics in scientific research and those on the second day to electronics in industry. Full particulars and tickets are obtainable from S.I.M.A., 26, Russell Square, London, W.C.1.

F.M. Patents.—Dr. Edwin Armstrong, the inventor of the F.M. method of transmission, has filed a suit against the Radio Corporation of America and the National Broadcasting Company for alleged infringement of five of his basic F.M. patents.

Readership in Electronics.—Mullard's offer to finance a Readership in Electronics at the City and Guilds College of Imperial College has been accepted by the University of London. The Readership will be mainly concerned with post-graduate teaching of research.

E.M.I. Scholarships.—A scholarship carrying a three-year course in telecommunications engineering at E.M.I. Institutes is being sponsored by E.M.I. It will be awarded by open competition through recognized educational authorities. There is also a postal course scholarship.

Mullards.—A complete list of all reference cards for Mullard valve testers issued up to July, 1948, together with details of the valve types each card will test, has been prepared by the manufacturers. Owners of Mullard Master Test Boards wanting a free copy should write, mentioning the serial number of the instrument, to Mullard Electronic Products, Ltd., Valve Sales Department, Century House, Shaftesbury Avenue, London, W.C.2.

Wire Broadcasting. — The development of wire broadcasting in this country is traced by R. H. Coase in the August issue of *Economica*. The first relay exchange was opened in January, 1925; by December, 1929 there were 34 exchanges with some 8,500 subscribers. At the end of September last year there were 293 exchanges and 755,925 subscribers.

"Wireless Engineer."—With the October issue of our sister journal, *Wireless Engineer*, it celebrates its twenty-fifth anniversary. Originally *Experimental Wireless*, it later became *Experimental Wireless and Wireless Engineer*, and eventually, in September, 1931, adopted its present title. The changes in the title illustrate the gradual change of the coverage of the contents from the original experimental outlook to the present engineering standard. With this change the Abstracts and References section of the journal, which includes abstracts from and references to articles on radio and allied subjects in the world's technical press, has grown from its original 1½ pages to the present average of 21 pages a month.

Servo-Mechanism.—A course of seventeen lectures on servo-mechanism is to be given at the Manchester College of Technology on Friday evenings from 7.0 to 9.0, commencing on November 12th. The fee for the course, which is one of many sponsored by the Manchester and District Advisory Council for Further Education, is two guineas. The pamphlet covering the series of post-advanced lectures in electrical and mechanical engineering is obtainable from the Education Offices, Deansgate, Manchester, 3.

Scientific Films.—This year's International Festival of Scientific Films will be held at the Royal Empire Society Hall, Northumberland Avenue, London, W.C.2, from October 8th-10th. Tickets for the two daily sessions (2.30-5.30 and 7.30-10.30) and details of the programme may be obtained from the Scientific Film Association, 34, Soho Square, London, W.1.

Marconi Veterans.—A reunion and luncheon is being held on October 9th at Caxton Hall, Westminster, London, S.W.1, for veterans of the Marconi International Marine Communication Co.

Broadcasting Stations.—The fourth edition of our booklet "Guide to Broadcasting Stations," will be published during October. It has been entirely revised and the information given has been checked against the records of the B.B.C. Tatsfield Receiving Station. The 64-page booklet, which is obtainable from booksellers and newsagents, price 1s, or by post from our Publishers, price 1s 2d, contains details of frequency, wavelength and power of European M.W. and L.W. broadcasting stations and S.W. stations of the world.

British Kinematograph Society.—The headquarters of the society are now at 53, New Oxford Street, London, W.C.1 (Tel.: Temple Bar 2092).

Wanted.—Copies of the July and August issues of *Wireless World* are wanted by our Publishers to complete their files. Full price will be paid.

FROM ABROAD

Personal Television.—It is announced by the Pilot Radio Corp. of America that it is producing a small television set with a three-inch C.R.T. To be known as the "Candid T-V," it is tunable over the complete thirteen television bands (from 44 to 216 Mc/s), includes a built-in aerial, weighs only 15 lb and costs $99.50. The aluminium cabinet measures 14in × 13½in × 9in.

High-Power F.M.—A 250-kW F.M. transmitter has been brought into regular service on 100.5 Mc/s in California. The station, which is licensed to Eitel-McCullough, Inc., the valve manufacturers, is situated on Mt. Diablo, 3 849 feet above sea level.

International Television.—In addition to the main lectures mentioned last month, three of the twenty-one short papers read at the International Television Convention, held in Zurich from September 6th to 10th, were by British engineers. They were: "Television Distribution over Short Wire Lines," by P. Adorian (Rediffusion); "Comparison of British and American Television Standards," by L. H. Bedford (Marconi's); and an introduction to the discussion on large screen television by A. G. D. West (Cinema Television).

Amateurs head the list of non-broadcast stations in the U.S. compiled recently by the F.C.C. with a total of 68,449. Aeronautical services are next with over 20,000, followed by maritime services with over 14,500. At the bottom of the list comes "citizen's radio" with 39 stations.

U.N. Broadcasts are now radiated from Geneva twice each weekday on 18.450 and 6.672 Mc/s. The programmes, of ten-minutes' duration, are broadcast in English and then French at 1800 and 2100 G.M.T.

U.S.S.R. Television.—After an interval of eight years the Leningrad television station has resumed transmissions.

German Radio Exhibition.—It is announced by the International Broadcasting Union that a radio exhibition is to be held in Dusseldorf, in the British Zone of Germany this autumn. This is the first since the war.

Sound Insulation.—A second supplement has been issued by the U.S. National Bureau of Standards to the report on Sound Insulation of Wall and Floor Construction. This fifteen-page supplement contains the results of tests conducted since 1940 when the first supplement was issued. The original report (B.M.S.17) was prepared in 1939.

INDUSTRIAL NEWS

Plessey-Ediswan Agreement.—Arrangements have been made whereby the sole distribution of the complete range of radio components and accessories manufactured by the Plessey Co., of Ilford, Essex, will be undertaken by the Edison Swan Electric Co. One of the first items to be introduced is the new Plessey automatic record changer which will handle up to eight 10in and 12in mixed discs.

Pye Canada, Ltd., is the name of a new company formed by Pye, of Cambridge, to establish a production plant at Ajax, Ontario. The company plans to produce domestic radio and television receivers and other electronic equipment.

Holiday and Hemmerdinger are holding an exhibition of electronic equipment, components and accessories at the Grand Hotel, Manchester, from October 12th-14th. Admission to the exhibition, which will be open daily from 10 a.m. to 9 a.m., will be by ticket obtainable from the organizers at 74-78, Hardman Street, Deansgate, Manchester, 3.

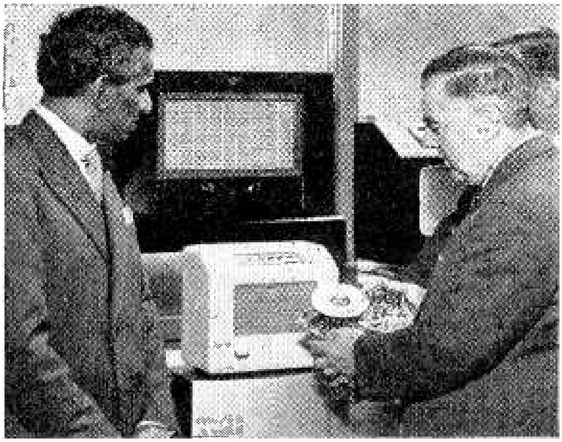
Tannoy.—The sales, installation and maintenance of Tannoy equipment is being taken over by Sound Rentals, Ltd., of Canterbury Grove, West Norwood, London, S.E.27, who for a long time have specialized in the hire and rental of Tannoy gear. It will be recalled that Guy R. Fountain, Ltd., the manufacturers of Tannoy products, recently went into compulsory liquidation. The Board of Sound Rentals has been reorganized and Guy R. Fountain is now managing director.

B.V.A.—The Board of the British Radio Valve Manufacturers' Association has re-elected G. A. Marriott (G.E.C.) as chairman and F. Jones (Marconiphone) as vice-chairman.

Beethoven Electric, of Chase Road, London, N.W.10, is to open in the near future a new factory in High Wycombe which will eventually be the Head Office.

EXPORT

Target Exceeded.—An analysis of the export figures for the first half of the year, to which reference was made last month, shows that the radio industry exceeded its Government-set target of £1,000,000 a month. The total value for the six months was £6,297,130. Although fewer receivers and radiograms were exported during the first six months of this year than during the same period last year—the value was £1,979,000 compared with £2,249,000—the demand for communications equipment (£1,705,000), components (£1,586,000) and valves (£1,025,000) was unprecedented.



INDIAN RECEIVER. H.E. the High Commissioner for India during his visit to the E.M.I. factory, Hayes, was shown a new receiver chassis by H. W. Bowen, managing director. It appears to have onlaid wiring. A similar chassis has been designed for the Indian market.

Australian Television. — The Australian Government has asked for tenders for the supply of two 5-kW television transmitters for erection in Sydney and Melbourne and, alternatively, for 500-watt stations for erection in each of the six State capital cities. Tenders close on November 25th.

Multicore.—A 25 per cent increase in tonnage of Multicore solder exported during the first eight months of this year, compared with 1947, is recorded by Multicore Solders, Ltd. Export licences are no longer required for cored solders, and, as a result, supplies have been sent to forty-three countries this year.

Export Licences.—The Headquarters of the Board of Trade Export Licensing Branch has moved from Stafford House to Regis House, King William Street, London, E.C.4 (Tel.: Avenue 3111).

MEETINGS

Institute of Electrical Engineers

Inaugural address of the president, T. G. N. Haldane, M.A., October 7th.

Radio Section.—Inaugural address of the chairman, F. Smith, O.B.E., on October 13th.

Discussion on "What should be the Design Considerations of Services' Radio Equipment?" on October 19th. Openers, S. J. Moss and G. C. F. Whittaker.

The above meetings will be held at 5.30 at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group.—Inaugural address of the chairman, D. H. Hughes, at 6.0, on October 12th, at the Cambridgeshire Technical College, Cambridge.

North-Eastern Radio and Measurements Group.—Inaugural addresses of the chairmen, F. Smith, O.B.E. (Radio Section) and S. Whitehead, Ph.D., M.A. (Measurements Section) at 6.15 on October 18th at King's College, Newcastle-on-Tyne.

North-Western Radio Group.—"The Velodyne," by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., and A. M. Uttley, Ph.D., at 6.30 on October 20th at the Engineers' Club, Albert Square, Manchester.

Southern Centre. — "Three-Dimensional Cathode-Ray-Tube Displays," by E. Parker, M.A., and P. R. Wallis, B.Sc. (Eng.), at 6.30 on October 13th, at the R.A.E. College, Farnborough.

South Midland Radio Group.—"The Design of High-Fidelity Disc-Recording Equipment," by H. Davies, M.Eng., on September 27th at 6.0 at the James Watt Memorial Institute, Great Charles Street, Birmingham.

British Institute of Radio Engineers

London Section. — Annual general meeting and address of the president, L. H. Bedford, O.B.E., M.A., at 6.0 on October 21st, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section.—"Secondary Electron Emission," by L. D. Oliphant, B.Sc., at 6.30 on October 13th, at the Heriot-Watt College, Edinburgh.

British Sound Recording Association

"The Limitations of the Loudspeaker," lecture demonstration by P. J. Walker at 7.0 on October 22nd at the Royal Society of Arts, John Adam Street, London, W.C.2.

Unbiased

By FREE GRID

"Apologia pro Vita Sua"

IN spite of "Diallist's" mellilo-quent remarks last month about my alleged vain imaginings concerning the meaning of the prefix "ter," I refuse absolutely to do a Galileo as I have still the odd idea, which I share with Cicero and Horace who used the word freely, that it is the best Latin for thrice. Apparently the three hundred-odd bishops who attended the recent Lambeth Conference are labouring under the same delusion, judging by their reference to the commemoration next January of the tercentenary of the beheading of that stalwart champion of the Church, Charles I.

But I have certainly never fallen into the error of imagining that its Greek equivalent was "tri" nor yet the adjective "treis." I have always thought it to be "tris." Only a few months ago, when I chanced to be in Cambridge, I heard some uncouth fellows in King's College chapel "raise the *trisagion*," as No. 423 in "Hymns A. & M." quaintly puts what is more commonly known as singing the *ter-sanctus*. But, of course, you can expect anything in a town where a chemist calls himself a chymist, as does one of the pharmaceutical

"When in Rome . . ."

fraternity whose shop is on the opposite side of the street to King's College.

Where it is a matter of euphony "tris" does sometimes lose its final letter as does the Latin "tria." I have never denied the bilingual nature of "tri," nor was I unaware that it was as much at home on the Appian Way as in the shadow of the Parthenon. I am afraid that like Mr. Winston Churchill I am a bit of a terminological iconoclast. He tells us in an autobiographical sketch how he came up against pedagogic authority quite early in his scholastic career by drawing attention to the illogicality of there being a vocative case to *mensa* even though it is the same as the nominative.

I can sympathize with him as I feel much the same about the illogicality of the indiscriminate and apparent dó-as-you-please mixing of adverbial and adjectival prefixes (or should I say prefices?). But I have no more hope than Mr. Churchill of getting things straightened out. Why, even the Editor refuses to adopt a logical word like metrocyme, cymatometer or cymometer in place of the seemingly hybrid wavemeter. Like most totalitariocrats he does not lack a specious reason which in this case is that meter, like the word mete, is possibly derived from the Anglo-Saxon "metan." Maybe he is right, but where did the Anglo-Saxons get their word and at what date?

As for Mr. Jefferson, of Stockholm, who also chides me with equal mellifluence which I heartily reciprocate, surely he is a little illogical. He tells us that in his opinion there is no real reason for sticking to Greek in seeking a prefix for cycles-per-second, when nearly everyone which he mentions and favours is Greek, the remainder hailing from the other side of the Aegean.

The Marcopoff

IT is astonishing how few inventors have given their names or had them given to the things which they invented. I can think of one—the late Mrs. Bloomer of cycling fame, and for aught I know to the contrary her invention has long since been superseded by modern developments more in keeping with the Government's wishes for limiting the consumption of textiles on the home market.

When we come to the world of electricity and magnetism there are, of course, many famous names which are used, either in full or in abbreviated form, to denote units of measurement, for circuit properties and the like. Faraday and a whole host of others occur to my mind. Even in the world of radio we find that Hartley, Franklin, Colpitts, Schmitt and Puckle among others have received recognition of their work by this means; but unless I am very greatly mistaken the most famous name of all in radio has not been used in this manner. I refer, of course, to Marconi, and to forestall anybody who may seek to belittle Marconi's work by pointing out that, academically speaking, he was not numbered among those who sat in the seats of the mighty, I would point out that neither was


"One of the few, the immortal names"

Nelson who was only a humble vice-admiral at the time of his death.

To some of you it may seem a little difficult to choose a unit of measurement to which Marconi's name could be attached, but surely there is one circuit property which cries aloud for it. I refer, of course, to aerial radiation resistance, at present expressed in ohms which have to rub shoulders with the more vulgar sort of ohms used by ordinary electrical engineers. To couple Marconi's name with any property of an aerial would be particularly apposite for reasons which those of you who read *W.W.* diligently will realize. It is not too much to say that it was his idea of an elevated aerial which really changed wireless from a laboratory curiosity to a practical commercial proposition. I have no desire, however, to make Mr. Bevin's task more difficult than it is and so am willing to compromise by calling the new unit a "Marcopoff" as a sop to Popov.

Even in the field of broadcasting programmes there is scope for paying honour to famous radio names and at the same time improving the standard of certain performers by using a carefully chosen yardstick to measure the degree of success or otherwise achieved in their efforts to entertain us, more particularly in the field of spontaneous humour. As a listener from the days of Writtle I would suggest the "Eck" as a suitable unit; some of the moderns might then be surprised to find themselves well down among the micro-ecks.

STABILIZED POWER SUPPLIES

1.—Practical Design Procedure for Series-Valve Types

By
M. G. SCROGGIE,
B.Sc., M.I.E.E.

ALTHOUGH voltage stabilized power units have been fairly widely employed for some years, it seems that there are still many who do not fully realize how useful they are, or who have insufficient information about their working and design. As regards the first point, anyone who has once become accustomed to using a stabilized power unit will probably confirm that it is practically indispensable. As to the second, this article may be a partial answer.

At one time the need for sources of steady D.C. was met by secondary batteries, in spite of their high cost and maintenance troubles, because the alternative—the rectified A.C. power unit—had a comparatively high internal impedance and consequently bad "regulation." That is to say, the output voltage varied considerably with the current drawn. An additional cause of substantial voltage variations came when power stations, in order to avoid the more drastic operation of load-shedding, began to practise frequency and voltage reduction. In the meantime, requirements for low ripple and noise content have become increasingly stringent. The development of stabilization technique, however, has now reached a state at which it is possible to dispense with batteries for even the most exacting requirements[1].

Of the several distinct methods that have been adopted, the most popular and generally useful, and the only one to be considered here, is that shown in principle in Fig. 1[2].

The whole load current passes through V1, which is made to absorb any voltage variations, whether slow or rapid, so that the output is constant and steady. V1 may also, if required, be made to serve the additional purpose of reducing the voltage of the source to any desired level within certain limits of adjustment.

The remainder of the circuit is designed to control the voltage drop in V1 in order to fulfil the purposes just mentioned. This it does by comparing a known fraction $\left(\frac{R_2}{R_1 + R_2}\right)$ of the output voltage (V_0) with a fixed reference voltage, usually (but not always) provided by the drop across a neon tube, N. The difference in voltage is amplified by V2 and applied as grid bias to V1 in the correct polarity to oppose any change in V_0.

The device is closely analogous to the governor of an engine, and is an example of D.C. negative feedback—a sort of amplified cathode follower. Obviously one of the prime objects in design is to make the voltage amplification so large that the change in V_0 necessary to neutralize (via V2) any fluctuations in source voltage is negligibly small. At zero frequency the feedback is reduced by the potential divider R_1 R_2, but this reduction can be avoided at hum frequencies by short-circuiting R_1 with a capacitor.

If the gain, reckoned from the junction of R_1 and R_2, is made so large that any variations in voltage across R_2 needed for feedback are less than, say, 1 per cent., and the reference standard is also very constant and accurately known, the current through R_2 is correspondingly constant and V_0 is directly proportional (within the working limits of the valves) to $R_1 + R_2$. R_1 can therefore be calibrated in volts to an accuracy equal to or better than that of a B.S. 1st Grade voltmeter. A notable example is the Tinsley Precision D.C. Stabilizer, in which the reference voltage is a standard cell and the amplifier a reflecting galvanometer and photo-cell. Any voltage from 20 to 600 can be selected, to an accuracy of 1 in 10,000.

However great the gain, some change in output voltage is necessary to effect the stabilization; but such change can be reduced to zero, or even reversed, by compensation for changes in input voltage and output current. By the use of such devices it is possible to make the power unit approximate very closely, over a wide range of working conditions, to a generator of constant zero-frequency voltage with zero internal impedance.

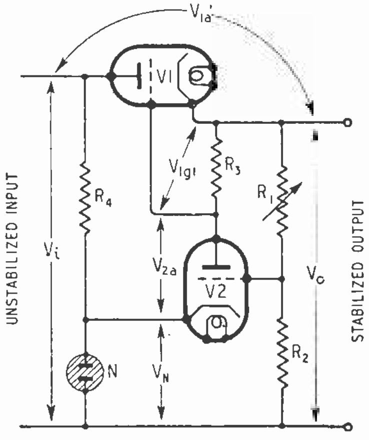


Fig. 1. Basic circuit of series-valve stabilizer, in which the output voltage V_0 is adjusted by varying R_1. N is the voltage reference standard, and V2 the negative feedback amplifier.

The practical design of stabilized power supplies on these lines was discussed in an excellent article by F. L. Hogg[3]. The present writer acknowledges that what follows is largely an extension of Mr. Hogg's work.

[1] "Electro-Encephalograph Amplifier," D. L. Johnston, *Wireless Engineer*, Aug. and Sept. 1947. (Includes details of highly stable power supply with very low ripple content.)

[2] For the alternative shunt system see "Shunt Voltage Stabilizers." J. McG. Sowerby, *Wireless World*, June 1948.

[3] "Electronic Voltage Regulators," F. L. Hogg, *Wireless World*, Nov. and Dec. 1943.

Stabilized Power Supplies—

Considering now the design of stabilized power units in detail, there is first the question of requirements. The design problem is very much eased if only a fixed output voltage is needed, or one variable within narrow limits; and similarly if the current load is more or less constant, as it often is in built-in power sources. One has then only to provide against minor variations in load, and variations in A.C. supply. The latter can, if necessary, be brought within narrower limits by one of the special transformers sold for the purpose. The residual fluctuations can then be dealt with by valves and other components working on fixed adjustments very close to optimum conditions, and a very high degree of stabilization obtained without much trouble.

It will therefore be more instructive to tackle the relatively difficult case of a unit for general laboratory use, in which the output voltage is required to be variable within wide limits, and the load may be anything from zero to a stated maximum. The procedure for most other specifications should then be more or less obvious.

The design will of course be influenced by whether the most important thing is to stabilize against input voltage fluctuations, or load current fluctuations, or to reduce hum and noise to a very low level, or a combination of these. They correspond respectively, in the theoretical equivalent generator, to constancy of generator voltage, smallness of generator impedance, and absence of any generator frequency appreciably above zero. The length of time over which a specified performance in these respects must be maintained is also a factor to be considered. If an accurate output voltage calibration is wanted, that is yet another.

Let us assume as an objective the best all-round performance obtainable with a reasonably simple system capable of coping with wide voltage and current ranges. Its achievement can best be illustrated by an example. Suppose the maximum output is to be 100 mA at 400 V, with the mains voltage liable to vary + 4 per cent and − 8 per cent from normal. The easiest and most instructive procedure is to make a voltage/load-current diagram (Fig. 2). Neglecting current through V1 other than the load current I_0, point A represents maximum output, and the horizontal line through it is the working line at 400 V for all load currents down to zero, assuming perfect stabilization.

Now consider the drop in the series valve V1. It can be allowed to reach its minimum under the condition of maximum output and mains 8 per cent low, and that minimum should of course be as small as possible. The limit is imposed by the start of grid current; to be on the safe side, the minimum bias may be assumed to be $-1\frac{1}{2}$ V. The shape of a tetrode (or pentode) characteristic gives it a low V_a for a given high I_a, but there is a constant screen voltage to provide. For simplicity let us assume a triode, in which the clue to a low voltage drop is low r_a. At the same time we want μ to be as high as possible in order to maximize the stabilization. There is thus no doubt that high g_m is needed. The best allocation of r_a and μ for a given g_m will be seen more clearly later in any particular case, but in general economy calls for a low r_a.

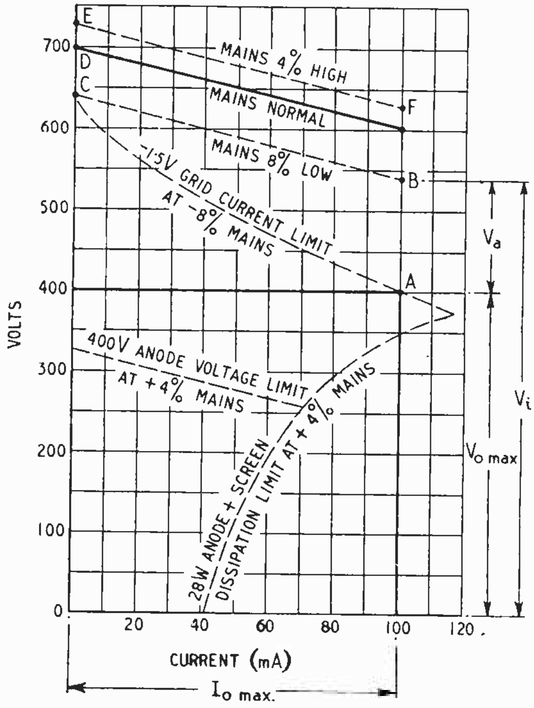


Fig. 2. Voltage/current design diagram for a series-valve stabilizer.

As a start, take a triode-connected Mullard EL37, which is typical of a number of similar valves. Fig. 3 shows the I_k/V_a characteristics. From these, at $I_k = 100$ and $V_{g1} = -1\frac{1}{2}$, V_a is seen to be 140 V. This must be added to $V_{0\,max}$ in Fig 2 to give point B, the unstabilized voltage of the source, V_i. From the data relating to a suitable power supply, the regulation curve BC can then be drawn in. Normally it droops slightly between B and C, but a straight line is generally near enough. This line is the lowest allowable, so it relates to 92 per cent of normal mains voltage. Assuming V_i at zero current to be proportional to mains input, points D and E can be marked in at 100 per cent and 104 per cent. Lines through them, parallel to CB, represent approximately the regulation curves for normal and maximum mains.

If desired, point A can be extended into a complete curve showing the minimum drop in V1 at any load current. It is got by (so to speak) hanging the $V_{g1} = -1\frac{1}{2}$ V curve of Fig. 3 from the line CB. One could, in fact, transfer the whole family of curves from Fig. 3 to Fig. 2; but it would be rather confusing to do so for each different mains voltage.

The most important limit is the maximum anode (actually $a + g_2$) dissipation, in this case 28 W. It should be hung from the *maximum* mains line, EF, as shown. (The vertical distance between it and EF at any point is

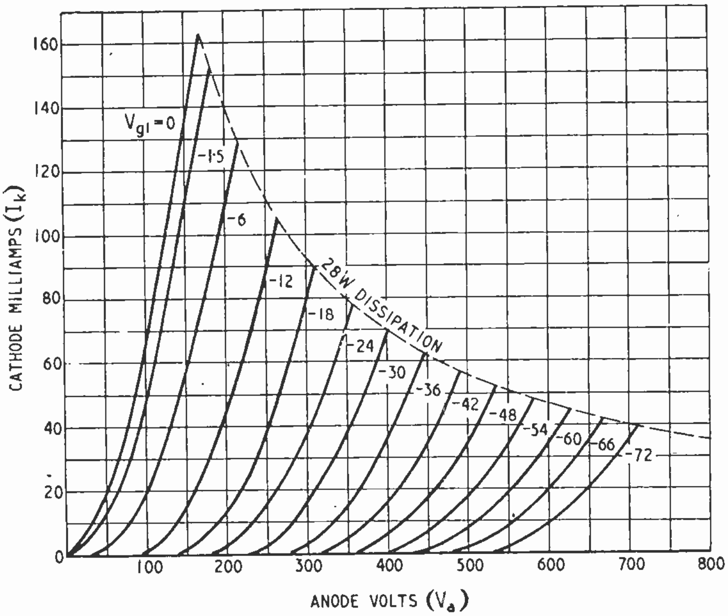


Fig. 3. Characteristic curves for triode-connected EL37 valve for V1 duty.

reckoned, of course, by dividing 28 by the current in amperes at that point). The maximum rated V_a, triode connected, is 400 V, and should be drawn at that distance below EF. The maximum current rating, 200 mA, is not in the picture at all.

We can now see that keeping strictly within these limits we could get any current up to 115 mA at 370 V; that at any current up to 100 mA the V_0 could be varied from 350 to 400; that at a fixed output of 70 mA, stabilization against mains voltages from −8 per cent to +4 per cent is possible over a range of V_0 from 260 to 450; while if $I_{0\,max}$ were restricted to 40 mA, and the V_{a+g2} limit were ignored, V_0 could be varied from 0 to 500 V.

Study of this diagram should make it a simple matter to decide on a suitable power source and V1 to meet stated requirements. To obtain more than a very small range of V_0 at a 100 mA rating, it is clear that a higher anode dissipation and/or lower r_a is needed. One solution is to use two or more valves in parallel. This is quite feasible, but it is necessary to make sure the valves are well matched, and wise to design a little more conservatively to allow for inequality. To avoid failure of all valves if one of them goes, individual fuses, or better still a differential relay, may be worth while.

Using a pair of EL37's in parallel, making $2I_{k\,max}$ = 110 mA to allow for the drain in R_1 R_2, etc., (I_k being the cathode current per valve), and reducing the p_{a+g2} rating per valve to 26 W, we get Fig. 4. The dissipation boundary has almost disappeared; but if one still strictly observes the $V_{a+g2\,max}$ rating at +4 per cent mains and $2I_{k\,min}$ (say 10 mA) the range of V_0 adjustment cannot be extended below 290 V_{min}. To obtain a wider range, one can assume the valves will not mind the possibility of occasional breaches of this limit at low currents, or else use valves with a higher rating, such as Osram PX25 triode (500 V) or Mazda 12E1 tetrode (700 V); or cover the full range of V_0 in steps, reducing the source voltage and R_1 simultaneously with a switch.

Before going into this more closely, we should consider V2 and its appurtenances. It is clear from Fig. 1 that V_0 has to be not less than the reference voltage (V_N), plus the anode voltage for V2 (V_{2a}*), plus the bias for V1 (V_{1g1}). There is therefore a practical minimum V_0 with this circuit. V_N is determined by the characteristics of available tubes, and in any case there are disadvantages in its being a very small fraction of $V_{0\,max}$—the overall feedback is reduced in the ratio $\frac{R_a}{R_1 + R_2}$, and the "error" ($V_N - V_{R2}$) is relatively serious. The table on the following page gives data for some suitable tubes.

V_{2a} cannot be reduced too far or the gain will fall off; gradually with a triode and suddenly with a pentode. As for V_{1g1}, when V_0 and I_0 are least it must be at its greatest. Supposing the lowest V_0 to be provided is 200 V, and

* Where the BS. 1409 standard nomenclature for valve voltages, etc., is elaborated by prefixing a number to the subscript, it is to identify the valve concerned.

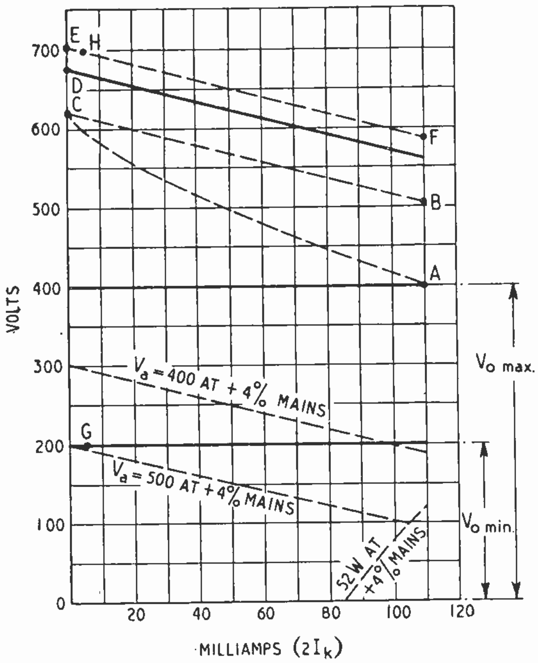


Fig. 4. Design diagram for a 200-400 V unit using two EL37's in parallel for V1.

Stabilized Power Supplies—

$2I_{k\,mi}$ is 5 mA, this condition is represented by point G in Fig. 4, which is practically 500 V below V_i with mains 4 per cent high. From Fig. 3 the bias required is −65 V. That leaves 135 V for N and V2, which is sufficient for a tube running up to about 100 V, in series with a pentode. With a G50/1G tube $V_{0\,min}$ can be reduced to about 125 V.

The advantage of a high μ in V1 when a wide range of V_0 is wanted is now clear.

Voltage gain (call it m) is the chief criterion for V2, and the most generally useful characteristic is a graph of g_m against I_a, as in Fig. 5. Multiplying both scales by R_3 converts it into a graph of approximate stage gain against output voltage†. Now the required range of output voltage is known; it is from 1½ to 65 V in our example. Whatever value of R_3 is chosen, Fig. 5 shows that if it is fed from the cathode of V1 as in Fig. 1 the gain will vary enormously. Using an EF42 with 0.3 MΩ, it ranges from about 6 at $V_{1g1} = -1\frac{1}{2}$ to 230 at $V_{1g1} = -65$.

It is clear that m can be made much more nearly constant and at the same time its average level increased by feeding R_3 from a more positive point. It could be fed from the anode of V1; but unfortunately the potential of that point shifts in such a way that the output required from V2 when V_i varies is multiplied by $\mu_1 + 1$. Looked at another way, it is equivalent to multiplying R_i by $\mu_1 + 1$ (see Appendix in subsequent instalment, Eqn. 11b).

The solution is to use another stabilizing tube, N2, as in Fig. 6. Its running voltage must be substantially less than the minimum drop across V1 (V_{1a}) in order that the ratio of maximum to minimum drop across R_5 does not exceed the working current ratio for the tube, and at the same time to ensure that the current is always less than that taken by R_1 and any other permanent drains.

In our example, the limits of V_{1a} are 105 V (A to B in Fig. 4) and 495 V (G to H). Using a G.120/1B for N2, the range across R_5 is thus 50 V to 440 V, and the corresponding current in R_3 (if 0.3 MΩ) is 0.19 mA and 0.40 mA. Limiting the current through N2 to 4 mA say, the total maximum through R_5 at 440 V is 4.4 mA, so R_5 should be 100 kΩ, 2 W. The minimum current through N2 is then $\frac{50}{100} - 0.19 = 0.31$ mA. This is below the working range for N2, but since appreciable fluctuation of voltage across it can be tolerated that does not matter. If anything, R_5 might be increased, because the current through N2 tends to impair stabilization at low I_0, for it is not controlled by the feedback. It is a function of V_{1a} and could be allowed for by a modification of Fig. 4, but normally it should not be large enough to be worth this extra complication.

The voltage across R_2 is equal to that across N_1 less V_{2g1}. V_{N1} is (we hope) constant, and V_{2g1} ought not to vary much if the unit is doing its job. Its mean value may be difficult to find, since valve makers rarely show the working region—below 0.5 mA—very clearly; so unless one plots this part oneself it may be a case of making as good an estimate as possible. With V_{2g2} about 80–100 V, V_{2g1} averages −1.5 V for the EF42 and −3 V

TABLE

Maker	Type	Vn at I_{opt}	I_{min} mA	I_{opt} mA	I_{max} mA	Approx. A.C. resistance (Ω)
Standard T. & C.	G120/1B	55	2	—	30	110
	G50/1G	50	—	—	—	100
Mullard ...	85A1	85.5	1	4.5	8	290 (at I_{opt})
	7475	96	1	4	8	300
American ...	VR.75-30	75	5	—	30	—
	VR.105-30	105	5	—	30	—
	VR.150-30	150	5	—	30	—

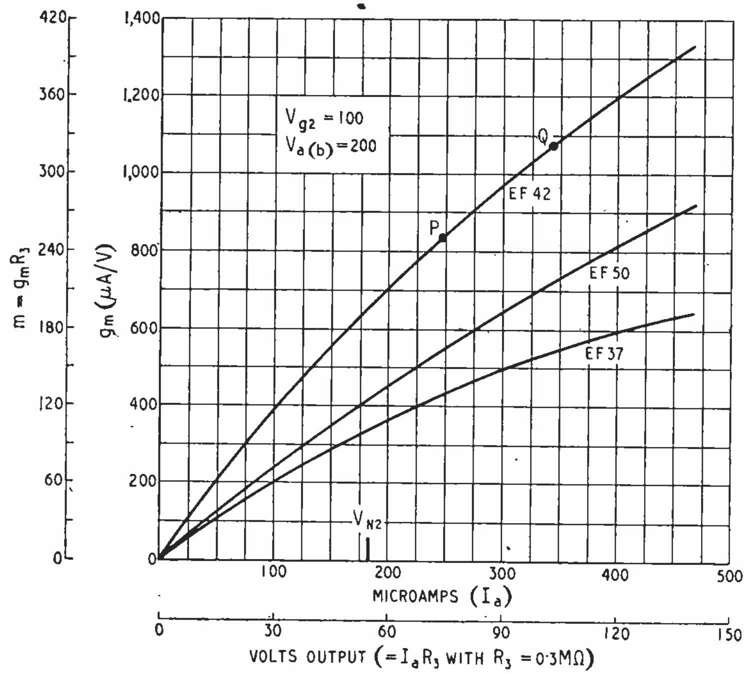


Fig. 5. Slope/anode-current or gain/output curves for three types of valve for V2 duty. V_{N2} is the zero V_{1g1} point using a G.120/1B for N2.

† In Fig. 5 the gains shown were actually measured data, using 0.3 MΩ anode coupling, R_3, and the g_m scale was derived from it on the assumption $m = g_m R_3$.

for the EF36 or EF37. Using an 85A1 and EF42 therefore makes V_{R_2} 84 V. The value of R_2 can then be chosen to pass a suitable current, say 5 mA. The exact value is more conveniently related to R_1, however, because part of it (R_{1b}) is the voltage control and may have to be a value that is available. Stability of R_1R_2 is most essential, and good wire-wound components must be used throughout. The range of voltage control in our example is 200 V, so if a 50 kΩ rheostat is used the current is 4 mA. R_2 must then be $\frac{84}{4}$ = 21 kΩ, and R_{1a} (which must drop 200–84 = 116 V) is 29 kΩ. Maximum total 100 kΩ; at 4 mA, 400 V, which is the designed maximum, so correct.

With $2I_{1k}$ as low as 4 mA, R_5 ought definitely to be raised, say to 150 kΩ, to ensure that I_{N2} is always less.

The extreme range of V_{2g1} can be deduced from Fig. 5. The mean gain in our example, using EF42, is about 280; so a range of 63.5 V output necessitates about 0.23 V at the grid, which is ± 0.136 per cent of the 84 V across R_2 and therefore the same percentage of V_0. This can be analyzed with the aid of Figs. 4 and 3 into the variations due to mains fluctuations and to load current. For example, at 300 V output with normal mains, change of load from zero to 100 mA (neglecting I_{R1}–I_{N2}) necessitates a change in V_{1g1} from – 48 V to – 19 V, represented by P to Q in Fig. 5. Dividing the voltage change, 29, by the mean gain, 290, gives 0.1 V as the change in 84 V, and so 0.36 V in 300, corresponding to a mean internal resistance of 0.36/0.1 = 3.6 Ω. The value varies considerably over the range of I_0, owing to variation in I_{1a}, being higher when I_0 is small and vice versa.

Similarly the V_0 variation corresponding to ± 4 per cent mains variation from normal at 300 V 100 mA output can be shown to be ± 0.0143 per cent, or a stabilization ratio of 280 : 1.

Formulæ for these parameters will be derived in the Appendix.

In the above calculations it is assumed that I_{2a} is not appreciably affected by variations in the potential of any electrode other than g_1. The gain *m* is reckoned on this basis. Reasonable constancy of anode feed voltage has been ensured by N2. But what about the cathode and g_2? It seems to be generally assumed by writers on the subject that N1 keeps the cathode steady against any variations in the voltage of the source feeding it. That is by no means true. The A.C. resistance of N1 at its optimum current is usually of the order of 300 Ω, and it is possible for the voltage drop to vary sufficiently to upset completely the performance calculated as above. Even though the feed resistance R_4 may be, say,

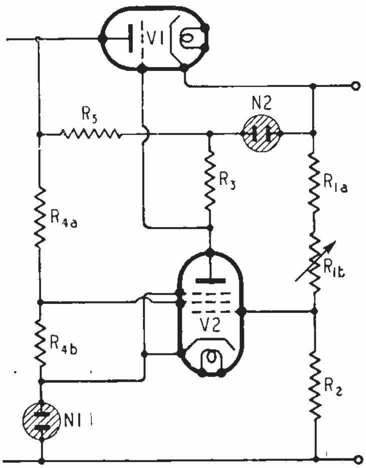


Fig. 6. Modified feeds for V2 to ensure higher and more uniform gain.

500 times as great, so that source variations are reduced in the ratio 501 : 1, it must be remembered that they are then multiplied by the total feedback gain, $\mu_1 m$, which may be of the order of 2500.

So to preserve the stabilization it is desirable (and to use N1 as a voltage standard it is essential) to feed N1 from a stabilized source. If V_0 is fixed, it is the obvious source. Keeping the current constant in this way, the best use can be made of a good tube. The makers of the 85A1 claim that its short-term stability is within ± 0.1 per cent, and long-term stability ± 0.2 per cent, so that it can be used as an accurate voltage standard. For this purpose it is desirable to use a circuit in which V_{N1} is applied to the grid of a valve, to avoid current changes in N1 via the valve; but for power supply purposes such changes are generally negligible.

If I_{N1} is kept constant in this way, g_2 can be tapped off the feed resistance, R_4, at about 100 V. R_4 itself is chosen to pass about 4 mA, compared with which I_{2a} and I_{2g2} are small.

The same arrangement will do if V_0 is variable over a moderate range, but it may then be desirable to substitute a regulator tube for R_{4b}, the part of R_4 between g_2 and *k*.

For a wide range of V_0 control it would be necessary to gang R_{4a} with R_{1b}, which would be rather a nuisance. It is therefore usual in a unit such as we are considering to feed N1 from the anode side of V1. Here the range of voltage variation is relatively small, but, unlike the variations of V_0, which occur only while it is being adjusted, they are "stabilization" variations, in opposition to those provided by V2. It will be shown in the Appendix (Eqn. 10a) that the effect is as if the source resistance, R_i, were increased by a factor equal to the total gain round the loop R_4N1 V2 V1, that is to say $\mu_1 m r_{N1}/R_4$, which may mean a several-fold increase in apparent R_i, and a corresponding loss in stabilization.

A very convenient way out of this trouble is to adjust the resistance across which V_{2g2} is obtained (R_{4b}) so that its variations neutralize those in V_{N1}. Neglecting the I_{2g2} variations, the correct value of R_{4b} is thus $\mu_{2g2} r_{N1}$, where μ_{2g2} is the amplification factor between g_1 and g_2 in V2. In the EF42 it is 85; but since I_{2g2} variations add to those in N1 the result is as if it were somewhat lower, in a measured example about 65. The value of R_{4b} to fulfil this requirement is not necessarily suitable as regards the standing V_{2g2}; but in our case it is, for with r_{N1} at 300 Ω, effective μ_{2g2} say 65, and IR_{4b} at 4 mA, we have 78 V, which is quite a satisfactory screen voltage.

Having neutralized the apparent extra R_i in this way, one may well ask why the real R_i should not be neutralized too. As the Appendix will show (Eqn. 9a), this operation is equivalent to neutralizing an

Stabilized Power Supplies—
added resistance in N1 equal to $R_4/\mu_1 m$. In our example, the mean V_i is about 600 V (Fig. 4); less V_{N1} this is 515 V, so, to pass 4 mA, R_4 should be about 130 kΩ. Taking $\mu_1 m$ as 2000, the extra R_{4b} required is 4.2 kΩ.

When R_{4b} is correctly adjusted, then, the unit behaves as if R_i were zero; and, what is more, stabilization as regards variations in mains voltage is theoretically perfect. It is accomplished solely via the screen grid of V2, output feedback via the control grid being unnecessary, and variations in V_0 nil. In practice it does not work out quite like that, because certain of the factors, notably m, are not constant. The slightest departure from exact adjustment of R_{4b} would, if there were no output feedback, make the stabilization fall right off. The designer should therefore aim at the greatest possible basic stabilization by output feedback, which does not depend on critical adjustments; and then any unavoidable variations in the further improvement conferred by input feedback will be of minor importance.

For this reason it is not altogether recommended that input feedback be used to neutralize the large apparent increase in source resistance that would be produced if R_3 were fed from the input side of V1, although it could do so, and would save N2 and R5 and the uncontrolled current around V1.

By increasing R_{4b} beyond that necessary to neutralize R_i, it can be made to neutralize r_{1a} also, with the result that R_0 (the resistance of the unit as a whole) is zero, and the output voltage is —subject to variations in m and r_{1a}—entirely unaffected by changes in load current. At this setting of R_{4b} the unit is somewhat overcompensated for mains fluctuations. In practice one would adjust R_{4b} to give a compromise depending on the relative importance of mains voltage and load current changes. It is practicable in this way to improve on the basic stabilization in both respects.

(To be continued)

SHORT-WAVE CONDITIONS

August in Retrospect : Forecast for October

By T. W. BENNINGTON and L. J. PRECHNER (Engineering Division, B.B.C.)

DURING August, while the average daytime maximum usable frequencies for these latitudes were much higher than in July, the night-time MUFs were considerably lower than during that month. This was in accordance with the normal seasonal trend, and it may be expected that the MUFs will now continue to vary in that manner towards the winter. One should note, however, that the conditions were very disturbed in the first two weeks of August.

Although communication on frequencies higher than 35 Mc/s was rather infrequent, yet, owing to the rapid increase in the average maximum usable frequencies, many contacts have been made. Frequencies below 14 Mc/s for distances exceeding 3,000 miles were not often usable at night.

The rate of incidence of Sporadic E was still very high, in accordance with the seasonal trend.

Sunspot activity in August was somewhat greater than in July, and may have had some connection with the exceptionally disturbed conditions in early August. Ionospheric storms were observed on 1st-3rd, 4th-5th, 7th-13th, 20th-21st and 29th-31st.

Not very many "Dellinger" fadeouts have been recorded in August, but those on 6th and 9th were fairly severe.

Forecast.—Although the daytime MUFs should continue to increase in October and reach very high values, these should be below the 1947 values, having regard to the fact that sunspot activity has decreased since last year. Long-distance communication on very high frequencies should therefore be frequently possible in all directions from this country. The 28-Mc/s amateur band, for example, should be regularly usable at the suitable time of the day, and frequencies considerably higher than this should also become workable over certain circuits. Night-time working frequencies will probably decrease somewhat as compared with September. Frequencies as low as 9 Mc/s will become the optimum for many night-time circuits, though frequencies lower than this will not be often necessary.

As the E and F_1 layers will not control transmission for any distance in these latitudes, and as Sporadic E is not likely to be much in evidence, medium distance communication on high frequencies will seldom be possible.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during October for four long-distance circuits running in different directions from this country. *All times in this article are GMT.* In addition, a figure in brackets is given for the use of those whose primary interest is the exploitation of certain frequency bands, and this indicates the highest frequency likely to be usable for about 25 per cent of the time:—

Montreal :	0000	9 Mc/s	(15 Mc/s
	0400	7 ,,	(11 ,,)
	0800	9 ,,	(14 ,,)
	0900	11 ,,	(19 ,,)
	1000	15 ,,	(24 ,,)
	1100	17 ,,	(27 ,,)
	1200	21 ,,	(30 ,,)
	1400	26 ,,	(35 ,,)
	1900	21 ,,	(32 ,,)
	2000	17 ,,	(26 ,,)
	2100	15 ,,	(22 ,,)
	2200	11 ,,	(18 ,,)
	2300	9 ,,	(16 ,,)
Beunos Aires :	0000	11 Mc/s	(18 Mc/s)
	0400	9 ,,	(16 ,,)
	0600	11 ,,	(17 ,,)
	0700	15 ,,	(20 ,,)
	0800	17 ,,	(25 ,,)
	0900	21 ,,	(32 ,,)
	1000	26 ,,	(40 ,,)
	2000	21 ,,	(32 ,,)
	2100	17 ,,	(26 ,,)
	2200	15 ,,	(22 ,,)
Cape Town :	0000	11 Mc/s	(19 Mc/s)
	0200	9 ,,	(16 ,,)
	0500	11 ,,	(18 ,,)
	0600	21 ,,	(30 ,,)
	0700	26 ,,	(38 ,,)
	1900	21 ,,	(31 ,,)
	2000	17 ,,	(26 ,,)
	2200	15 ,,	(22 ,,)
Chungking :	0000	7 Mc/s	(12 Mc/s)
	0400	9 ,,	(16 ,,)
	0500	15 ,,	(24 ,,)
	0600	17 ,,	(28 ,,)
	0700	21 ,,	(30 ,,)
	0800	26 ,,	(38 ,,)
	1300	21 ,,	(28 ,,)
	1400	17 ,,	(22 ,,)
	1600	15 ,,	(20 ,,)
	1700	11 ,,	(17 ,,)
	1900	9 ,,	(14 ,,)

October is often a fairly stormy month, and some periods of poor communication are therefore to be expected. At the time of writing it would appear that such disturbances are more likely to occur within the periods 1st-5th, 14th-16th, 20th-22nd and 28th-31st than on the other days of the month.

ELECTRONIC CIRCUITRY

Selections from a Designer's Notebook

J. McG. SOWERBY
(Cinema Television Ltd.)

Time Delay Flip-flop Circuits

THE time delay flip-flop is a circuit possessing one stable and one unstable state. Normally in the stable state, on the receipt of a short pulse it can be forced into the unstable state where it remains for a period, t_0, determined by its own time constant. The leading edge of the resultant rectangular waveform is obviously coincident with the triggering impulse, and a second pulse can be obtained from the trailing edge (by a differentiator circuit for example) after a time t_0, as shown in Fig. 1. Alternatively the rectangular

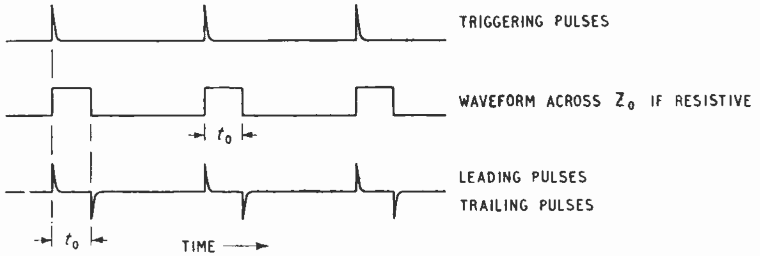


Fig. 1. Waveforms in the flip-flop circuit.

waveform itself can be used as a pulse of known duration, or for any other purpose. The time t_0 may be given any value between about 2 microseconds and 30 seconds without using extreme values of resistance or capacitance, so that this type of circuit can be put to a wide variety of uses.

Several time delay flip-flop circuits are described by O. S. Puckle in his book "Time Bases," and many readers will be familiar with the circuit of Fig. 2. Quite often the input time constant R_1C_1 is made short (a differentiator) to obtain the triggering pulses of Fig. 1 from a rectangular waveform. Initially in the stable state V_2 is conducting, since it is at zero bias, and R_c is large enough to permit V_1 to be cut off.

On the receipt of a positive pulse V_1 conducts and its anode moves negatively and cuts off V_2 via R_2C_2. Provided the triggering pulse is very short, V_1 is then left conducting with a current determined by R_c operating as a normal cathode bias resistor. The resultant voltage drop across R_L is applied to R_2C_2 and keeps V_2 cut off until most of the charge on C_2 has leaked away through R_2 and R_L in series. At some point on this discharge cycle V_2 begins to conduct again and to reduce the current in V_1. This action is cumulative and the circuit returns to its stable state again; in doing so C_2 is re-charged partially through R_2, but prin-

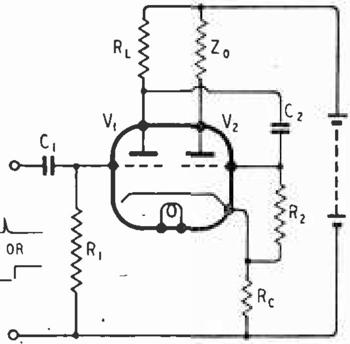


Fig. 2. Simple time delay flip-flop. Typical values :—R_1 = 100kΩ, R_2 = 1MΩ, R_L = 100kΩ, R_c = 1000Ω, Z_o = required load, C_1 = 100pF, C_2 according to required t_0, E = 200 volts, V_1 V_2 = ECC32 or 6N7.

cipally through R_L and the grid-cathode path of V_2 in series. The circuit therefore requires a little time to recover before it is ready to accept another triggering pulse.

The period t_0 during which the unstable state persists is generally of the order of $5R_2C_2$ depending

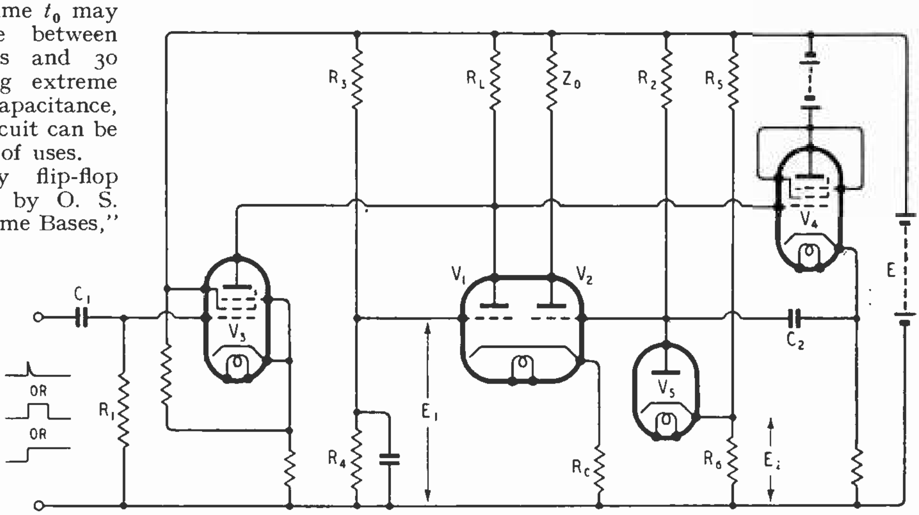


Fig. 3. Improved flip-flop circuit. Typical values :— R_1 = 100kΩ, R_2 = 100kΩ – 3MΩ, R_6 = 6.8kΩ, R_L = 8.2kΩ, R_c = 4kΩ, C_1 = 100pF, C_2 according to required t_0, E_1 = 40V, E_2 = 55V, E = 250V volts, V_1 V_2 = ECC32 or 6N7, V_4 = V_3 = EF50, V_5 = EA50. N.B. For $t_o < 10\mu$sec miniature valves would be desirable.

Electronic Circuitry—
on the particular circuit details.

For short times an improved circuit has recently been published[1] and is shown in Fig. 3. As before, V_1 and V_2 together with R_2C_2 form the time delay flip-flop. The anode of V_1 is here coupled to the grid of V_2 by the cathode follower V_4, and the diode V_5 holds the grid of V_2 at the potential E_2 which is determined by R_5 and R_6. The triggering pulse is fed into the anode of V_1 (rather than the grid as in Fig. 2) by V_3 which is normally cut off.

Initially in the stable state V_2 is conducting because E_2 is always greater than E_1, and V_1 is cut off. When a short positive pulse is applied to the grid of V_3 through R_1C_1, the grid of V_4 (and hence of V_2) is driven negative, so that V_2 is cut off and V_1 is left conducting with a current of approximately E_1/R_c. The resultant voltage drop across R_L is applied to R_2C_2, and C_2 begins to leak away through R_2. Since the voltage across R_2 approximates to the full H.T. potential, this leakage is rapid, and the grid of V_2 moves positively. Eventually V_2 begins to conduct and to reduce the current in V_1. This action is cumulative so that V_1 is abruptly cut off again, and the consequent voltage change across R_L attempts —via V_4—to drive the grid of V_2 positive. However V_5 now conducts and C_2 is restored to its initial state of charge relatively rapidly as R_6 is low compared with R_2. Hence the recovery time of the circuit after returning to the stable state is very short, so that it is quickly able to accept another triggering pulse.

The period for which the unstable state persists is given approximately by

$$t_0 = 2.3\, R_2C_2 \left[\log\left(1 + \alpha\frac{R_L}{R_c} - \beta\right) - \log(1 - \alpha)\right]$$

where $\alpha = R_4/(R_3 + R_4)$ and $\beta = R_6/(R_5 + R_6)$.

It is useful to realise that t_0 can be varied over quite a wide range by the adjustment of E_1 (i.e. α in the equation). The main advantages of this circuit are (i) delay times down to 2 microseconds are obtainable, (ii) the circuit has a short recovery time so that it can spend most of its time in the unstable state if desired, and (iii) the time delay is controllable and constant within a few per cent.

[1] Scheuch, D. R. and Cowan, F. P. *Rev. Sci. Inst.* Vol. 17, No. 6, p. 223. (June, 1936.)

Relay Operation by Valves

ONE of the uses of the time delay flip-flop is to energise (or more usually de-energise) a relay for a predetermined period, t_0. It is not always remembered that a relay represents an inductive load, so that if switched by a valve as shown in Fig. 4 quite large peak potentials of several hundred volts or more can easily exist across the relay coil at the instant of switching off (or on). These peaks tend to stray into undesired places in the usual annoying way and cause trouble, so it is often desirable to reduce them.

This reduction can be effected by a shunt resistor across the relay coil, but this is wasteful of anode current. A better solution is to shunt the relay coil (of resistance R and inductance L) with a resistance nR and a capacitance C in series as shown dotted in the figure. The peak voltage at the anode is then $E_p = I_a nR$, where I_a is the anode current of the valve. By suitable choice of n it is obviously possible to give E_p any value we like. However, C must be chosen correctly or damped oscillations—also undesirable—will appear. The correct value is

$$C = \frac{4L}{(n + 1)^2R^2}$$

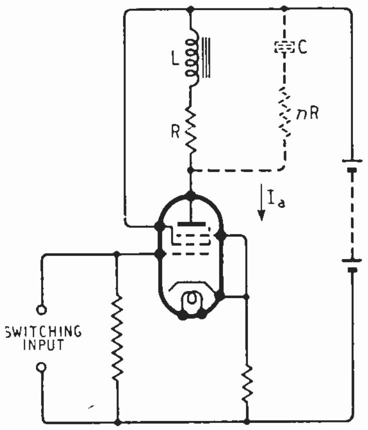


Fig. 4. Valve-controlled relay with surge suppressor shown dotted.

As long as n is greater than one, the current through the relay coil will rise to I_a in a finite time—t'—and we may regard this time as the lag between switching the grid of the valve and the coil current reaching its operating value—because I_a is not generally much in excess of the minimum operating relay current for reasons of economy. The time taken for the relay current to rise to its operating value (actually I_a) is, then

$$t' = \frac{2L}{(n - 1)R}$$

and this lag is the penalty to be paid for the reduction in the peak voltage across the coil.

A relay of the usual P.O. type measured by the writer recently has a resistance of 1,000 ohms and an inductance of 3.5 henrys. The energising current (I_a) was made 15 mA, and n was made 2.7 giving a peak voltage of 40 volts at the instant of switching on or off. Using the above equations, the shunt impedance was made 2.7 kΩ in series with a condenser of 2 μF and this yielded a satisfactory result since t' worked out to be 4 milliseconds which, of course, was much less than the inherent mechanical lag of the contact assembly, etc.

OUR COVER

C-R D-F—The illustration on this month's cover shows the cathode-ray direction-finder used at the Central Forecasting Office (Meteorological Office), Dunstable, for the location of thunderstorms. The equipment, which was made by the Plessey Co., operates on a frequency of about 10 kc/s.

BOOKS RECEIVED

Glossary of Terms used in Waveguide Technique. This is supplement No. 1 (1948) to B.S.204:1943 (Glossary of Terms used in Telecommunication). British Standards Institution, 28, Victoria Street, London, S.W.1. Price 2s.

One Story of Radar. By A. P. Rowe. An account, largely non-technical, of the wartime development of radar at Telecommunications Research Establishment, by a former Chief Superintendent. Pp. 208; many illustrations. Cambridge University Press, 200, Euston Road, London, N.W.1. Price 8s 6d.

TELEVISION STANDARDS

The Case for 405 Lines

IN the early part of 1937 the present British television standards were adopted after some months of experimental transmissions, carried out alternately with the present and with another system. Since then there has been a daily public service of television which was interrupted only during the war years.

It is the oldest regular service in the world and more experience has been gained with it than with any other. It also has the fewest scanning lines of any existing television system. Since it is generally believed that the picture definition obtainable is a direct function of the number of lines there has been a good deal of pressure put on the television authorities for an increase.

This pressure was most marked immediately after the war because the resumption of the service after a six-year break was unquestionably the ideal time for introducing any change of standards. Most existing receivers required overhauling after their spell of idleness and changes to suit them to new standards could have been made at the same time.

However, it was decided to adhere to the 405-lines standard, but ever since there have been rumours that this was to be only an interim measure and that a drastic alteration was to be expected in a few years' time. Such rumours did considerable harm to the television industry, for although they were assessed at their true worth—nothing—by the industry itself, they tended to discourage the non-technical public from buying television apparatus.

The recent statement that the present standard is to be maintained indefinitely and certainly for many years is thus particularly welcome. It may come as a surprise, however, to those who believe that the 405-line standard is an obsolete one and point to the American use of 525 lines and to their experiments with colour.

The number of scanning lines has become something of a fetish and is often taken as a direct measure of the picture quality. In fact, however, it is nothing of the sort. It indicates merely one limit to definition. In fact, under some quite common practical conditions an increase in the number of lines may well *reduce* the picture quality. This matter is so important and has been so little discussed in the past, that it is advisable to go into it in some detail.

The number of lines used primarily governs the definition only in the direction at right angles to the scan; that is, vertically with all current systems. The lines divide the picture into narrow strips and it is obvious that the more strips there are the better until the limit set by the size of the scanning spot is reached. If there are too many lines for the size of the spot they will overlap and no advantage is then gained from increasing their number.

The spot size obtainable in practice depends on the design of the cathode-ray tube, the design of the deflecting system and upon the voltage at which the tube is operated. In general, the attainment of a minimum spot size demands high-voltage operation and the use of a deflection system of rather low efficiency. Both factors increase the power needed for scanning and consequently make the cost of a receiver greater.

Horizontal Definition

In the direction of scan—horizontally—the number of lines has no direct influence on the definition, which is actually governed only by the overall bandwidth and the size of the scanning spot. The bandwidth limits the maximum rate at which the light intensity of the spot can change. When the spot in the transmitting camera passes across a hard edge—say the edge of a vertical column in the scene being televised—it is required for perfect definition that the light intensity of the spot on the receiving tube shall change instantaneously from one light value to another.

Due to the finite bandwidth of the circuits between the camera and receiving tubes, this cannot occur and a finite time is taken to

Television Standards—

accomplish the change. The usual 9-inch receiving tube gives a picture 19 cm wide, and with the British system the spot travels across it with a velocity of 2.28mm/μsec. If the system has an overall bandwidth such that a change of light intensity cannot be completed in less than 0.2 μsec the spot must travel $2.28 \times 0.2 = 0.456$ mm while the light is changing. The result is a blurred, instead of a hard, edge.

With a given number of lines, any increase of bandwidth reduces this transition time and so increases the horizontal definition. With the standard 405 lines and a bandwidth of 2.5–3 Mc/s, the vertical and horizontal definitions are roughly equal. Increasing the bandwidth to some 4–5 Mc/s results in very noticeably higher definition without changing the number of lines. The horizontal definition is then better than the vertical, but the result is an improved picture.

Now if the 2.5-Mc/s bandwidth is retained and the number of lines is increased the vertical definition is improved but the horizontal definition is *decreased*. With more lines the scanning velocity is increased and as the rate of change of light intensity is unaltered the distance travelled by the spot during the change is increased. To maintain the horizontal definition unaltered it is necessary to increase the bandwidth in proportion to the number of lines. To improve both horizontal and vertical definition at the same rate, the bandwidth must be proportional to the square of the number of lines.

The size of the scanning spot exercises an effect very similar to that of a finite bandwidth and must be reduced as the bandwidth is increased if it is not to become a limiting factor.

It is clear from this that if the overall bandwidth is limited for any reason there is an optimum number of scanning lines which will result in the best picture. This optimum is roughly the number which results in equal vertical and horizontal definition, but it is not critical. The choice of the number of lines for a television system is, therefore, dictated by the bandwidth which it is practicable to adopt.

It must also be pointed out that the power needed in the receiver for carrying out the horizontal scan is proportional to the number of lines. As scanning generators for 405 lines consume some 20-50 watts, according to their design, any large increase in the number of lines is likely very appreciably to increase the cost of a receiver. Bearing this in mind it may be preferable to use a number of lines slightly less than the optimum. In other words, it may be desirable to obtain a given picture standard by increasing the horizontal definition at the expense of the vertical since by so doing a cheaper scanning circuit can be used in the receiver.

Bandwidth

We have now to consider what factors limit the usable bandwidth in practice. The limitations are more economic than technical, but there are practical limits to what can be achieved in the way of reducing the size of the scanning spot in the receiver tube. However, even these are mainly economic.

As the bandwidth is increased the receiver stage gain falls off and more stages of amplification become necessary. The attainment of a smaller spot, while retaining normal brightness, demands a higher operating voltage for the tube and this, in turn, necessitates an increase of scanning power, over and above that needed directly to produce a higher-velocity scan. It is obvious that receiver costs must increase with the number of lines.

It is difficult to find any definite relation between the number of lines and the cost of a receiver but the increase of the one with the other is likely to be considerable. Matters are not helped by the natural tendency for the reduced production rates of higher-priced equipment to be reflected in still higher production costs.

Apart from the receiver there are two factors which materially limit the practical bandwidth. The first is the usual one set by the need for avoiding mutual interference between transmitters operating in a limited frequency spectrum. With the present 405-line standards there is room for only about five clear channels in the European television band of some 40-70 Mc/s. In a general European service, sharing of channels must be adopted, which means that the transmitters must be widely separated geographically.

However, the fact that the normal range of such stations is about 50-70 miles does not mean that interference will not be found between stations much more widely separated. The British station has been received on occasion in South Africa and in the U.S.A., in the latter case with sufficient intensity for a picture to be resolved.

The use of any appreciably greater number of lines would so increase the bandwidth as to make the problem of frequency allocation in the 40-70 Mc/s band an insoluble one. The use of higher frequencies brings its own problems in its train. The range of the transmitter is reduced and this makes it exceedingly hard to cover rural areas economically. In urban districts, buildings produce reflections which cause serious interference. This is very evident in the American high-frequency transmissions and aerial siting for their avoidance seems to be the major problem of receiver installation.

Because of this trouble from reflections, the use of higher power is not the answer to obtaining increased coverage. The need is for more stations. This in its turn increases the cost of feeding the stations with programme material. To provide each station with its own studio and independent programmes is prohibitively costly. It is necessary to have a very few central studios and programmes and to relay the signals to the transmitters by cable or radio links.

One of the most important programme items in television consists of sporting events, and these usually take place remote from a transmitter. Mobile equipment is used and is linked to the main transmitter hy cable or radio.

Relay Links

In any general television scheme, therefore, great use of cables or radio links must be made for conveying the signals to the transmitters. It is the bandwidth economically obtainable in such links which forms the major practical limitation to the number of lines which can be usefully employed.

If we compare two systems, such as the British 405-line and the American 525-line, we may expect that the American will give higher definition when the programme originates in a studio near the transmitter, but that it will give poorer definition than the British when the programme originates from a remote point and must be conveyed by a link of only 2-2.5-Mc/s bandwidth. If such remote programme sources are to be used to any extent, therefore, it is clear that the advantage lies with the British system of fewer lines. This is especially the case when the lower cost of receivers, the greater service area of each transmitter, and the simple installation problems are taken into account.

This question of the bandwidth practicable for television relaying is the crux of the matter. In the case of permanent links for uniting a studio in the heart of a town with a transmitter a few miles away there is no serious difficulty in providing almost any bandwidth. For permanent links of a hundred miles or more a bandwidth of 2-2.5 Mc/s is probably the most that can be economically achieved with a cable. Radio links with a chain of relay stations offer better hope of greater bandwidth, but are as yet largely untried. One is being erected between London and Birmingham and more will be known of its capabilities when it is in operation. The practicability of such a link, of course, depends much upon the nature of the intervening country.

For the relaying of sporting events, which occupy a large proportion of programme time, it is feasible to install special cable only at a few places from which relays are frequent. In most cases portable equipment must be used with cables of rather narrow bandwidth. The radio link is not always practicable inside a town on account of the difficulty of placing the transmitting aerial suitably. The B.B.C. uses a 'fire-escape' to carry the aerial, but very often it employs the ordinary telephone system! It has been found practicable to equalize such lines up to some 1.5-2 Mc/s provided only a very few miles is involved.

In view of all this it may fairly be stated that the present 405-line system is the best suited to the realities of television. If more lines were used better pictures could be obtained from studio transmissions, for there is then little bandwidth difficulty. However, outside broadcasts would usually be poorer than with 405 lines. Outside broadcasts are of great importance in popularizing television, and it is clearly wrong to increase the number of lines if by so doing poorer pictures are obtained on such broadcasts, especially if the change is reflected in increased receiver prices.

Optimum Lines

Now what does all this mean in practice? Two facts are clear. If the bandwidth is limited there is an optimum number of scanning lines for the best definition. Receiver prices increase with an increase in the number of lines. Clearly under ideal conditions there is a practical limit to the bandwidth set by receiver costs. What this limit is has not yet been determined, but it is possible that quite a considerable increase would be practicable.

Other bandwidth limitations depend very largely on the distribution of the population in a country. If the bulk of the population is concentrated into a few large towns separated by great distances of sparsely inhabited country, any attempt at complete coverage is impracticable in the present state of the art. Each town must have its own independent television system with a central transmitter and its own studios. Outside broadcasts would never originate at, perhaps, more than five miles from the transmitter. There is then little or no difficulty in providing large bandwidth. Systems of some 600 lines become practicable and desirable.

On the other hand in more densely inhabited countries like Britain and much of the Continent, large towns are separated by 50 miles or less and the rural areas are relatively densely populated. Coverage over a much larger total area is needed and it is impracticable on economic grounds to provide each of the transmitters required with its own independent local programme.

Cable and radio links of 50-100 miles are needed to feed the outlying transmitters, and in the not distant future, longer links will be necessary. The cost of such links increases enormously when the bandwidth exceeds about 2.5 Mc/s, and so there is a definite limit to the number of scanning lines which is desirable.

All transmitters on such a linked system must operate on the same basic standards, and so we find that for the general requirements of a television service in Britain and the Continent a number of lines around the present 405 is about the optimum.

Television Standards—

Because of the need for common standards in any area over which a common programme is to be distributed it is rather important that neighbouring countries should consider their services jointly. Near their frontiers the stations of their neighbours may be receivable and provide alternative programmes. Then with common standards international relays become practicable. Britain must be considered as a part of the Continent for this purpose, since the English Channel is no barrier to a radio link and the interchange of British and French programmes is within the realms of the practicable, provided only that the standards are common and that they do not call for an excessive bandwidth.

Because it is considered that under British conditions an increase in the number of lines is undesirable it should not be concluded that there is no scope for improvement and that British television is a static thing. This is far from being the case. It has already been pointed out that a greater bandwidth with the present standard will give higher definition, and if the difficulties of frequency allocation can be overcome such a change can be effected at any time without in any way affecting existing receivers. It would give better pictures from studio transmissions without affecting outside broadcasts.

Of even greater importance, however, is the attainment of a greater depth of focus in the transmitting camera. This entails the use of a lens of smaller aperture and so requires a more sensitive camera tube. The more sensitive tube also has obvious advantages for outside broadcasts under poor conditions of lighting. Such a tube is already in existence in the C.P.S. Emitron. It has not yet been put into service on a large scale, but it was used for relays during the Olympic Games, and the increased depth of focus and detail were remarkable and set a new standard of picture quality.

MANUFACTURERS' PRODUCTS

Television Aerials

AN inductively-loaded dipole in which the dimensions have been reduced to approximately ¼ wavelength has been developed by Antiference Ltd., 67, Bryanston Street, London, W.1. It is used in conjunction with a low-impedance stub section which is designed to compensate for variations in the aerial reactance. The impedance is said to be substantially resistive over the television band and is adjusted to 70Ω.

It is intended for indoor use and under average conditions satisfactory reception is claimed up to a range of 10 miles.

The overall length of the aerial is 5ft 6in and the price is £2 10s.

Export Battery Receiver

A NEW all-wave bandspread superheterodyne (Model 92) operating from a 6-volt battery has been introduced for the export market by Invicta Radio, Parkhurst Road, London, N.7. The consumption is 3½A at 6V and the four-valve circuit covers wavelengths of 11-25, 25-60, 60-200 and 200-550 metres. There is bandspread tuning on 16, 19, 25, and 31 metres. A heavy-duty 10in loudspeaker is used and the set is designed to operate under adverse climatic conditions.

Cabinet Loudspeaker

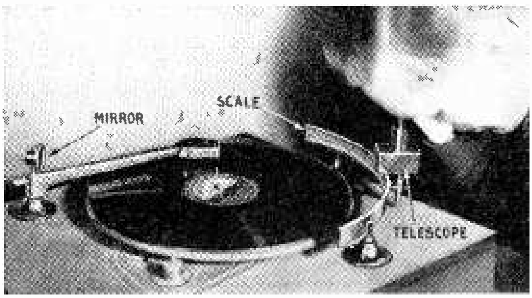
TO meet the demand for a loudspeaker which will fit in the angle between two walls, Richard Allen Radio, Caledonia Road, Battery, Yorks, have introduced a "Bafflette Console" model incorporating their Type 810 loudspeaker. The cabinet is of polished walnut on a black plinth and measures 26in × 17in × 6in. The price is £6 15s, or £7 3s 6d with output transformer.

Record Groove Indicator

FOR identifying and selecting particular passages in a gramophone record, Wilkins and Wright, Holyhead Road, Birmingham, 21, have evolved a groove indicator which does not impose any extra load on the pickup and which gives a high magnification without backlash.

Designed for use with their "Coil" pickup, the Type O indicator consists of a curved graduated scale which is screwed to the motor board and viewed through a mirror attached to the tone arm pivot, and a telescope fitted with cross wires. The scale is divided into 100 divisions and approximately three revolutions of the record are equivalent to a division. Precise placing of the needle to the nearest groove is easy, provided that the record is concentric; with eccentric records a little more skill is required. The indicator is also useful in gauging the height of the needle above the record, since the magnification of vertical movement is comparable with that of the horizontal.

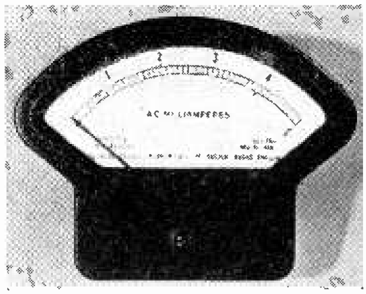
The price of the complete outfit is £4 6s 8d, including purchase tax.



Wilkins and Wright optical record groove indicator Type O.

Wide Scale Meters

A NEW range of wide-scale, moving-coil meters (Series 415) has been introduced by Taylor Electrical Instruments, 419-424, Montrose Avenue, Slough. D.C. instruments with ranges of 0-10 μA and 0-5mV upwards are available, and also rectifier types with ranges of 0-25 μA and 0-1V upwards. The range will shortly be extended to include moving-iron and thermocouple types.



Series 415 sector type meter by Taylor Electrical Instruments.

"QUIET HIGH-GAIN AMPLIFIER": A CORRECTION

In this article, the value of R_{31} was incorrectly given (p. 209, June, 1948, issue) as 22Ω. It should have been 220Ω.

LETTERS TO THE EDITOR

Series Capacitor Circuits ✦ Television Receiver Selectivity ✦ Discriminator Alignment

Series Capacitor Heater Circuits

IT is rather surprising to read in this otherwise excellent article in your Sept. issue, that "dial lights gradually attain their full brilliance, taking several seconds in the process." Mr. Stanley evidently has not tried this, or he would have noticed the brilliant flashes often obtained at the instant of switching on, and the high probability of lamp burn-out.

Actually the instantaneous current in the circuit at t seconds after the E.M.F. wave has passed through zero, is

$$i = I_m[\sin(2\pi ft + \phi) - \epsilon^{(t_1 - t)/RC}\sin(2\pi ft_1 + \phi)]$$

where $I_m = E_m / \sqrt{(R^2 - 1/4\pi^2 f^2 C^2)}$

t_1 = value of t when switch is closed

ϕ = phase angle = $\tan^{-1} 1/2\pi fCR$

The first term within the bracket corresponds to steady-state conditions and the second to the transient. The latter is zero when $2\pi ft_1 = -\phi$; i.e., if the switch is closed at the instant during the E.M.F. wave when the steady-state current would have been zero.

This transient current does not harm ordinary indirectly heated valves because of their thermal inertia, but the thermal time constant of the typical dial light is short compared with the first few cycles during which the transient current is appreciable.*

Two ways of overcoming the difficulty are (1) to have another switch short-circuiting the dial light and open this not less than, say, ¼ second after the main switch is closed, and (2) to arrange the main switch to short-circuit the heater chain plus dial light when it is desired to switch off. The latter method reduces switching to a single operation but leaves the series capacitor permanently across the mains when the set is out of use; however, negligible power is drawn, the set will remain cool, and no consequent rotation of the watt-hour meter should occur.

G. S. LIGHT.

Feltham, Middx.

* "Condensers in Series-Heater Circuits," *Electronic Engineering*, April, 1945.

THIRTY years of experience with radio components prompts me to raise friendly issue with A. W. Stanley in reference to his article.

Like many others, he would appear to confuse the A.C. working voltage of a capacitor with its D.C. rating by thinking of the former in terms of the latter.

I would suggest an empirical formula for his consideration: "In any capacitor rated for D.C. operation the safe maximum A.C. voltage that can be applied is one-half the D.C. rating or 250 V A.C., whichever is less.

When one considers the severe mechanical stresses that a capacitor has to meet under A.C. conditions it can be readily appreciated that for use on A.C. capacitors (strictly speaking) should be designed for that purpose. The better manufacturers do, in fact, supply components to meet this need.

The question of standard capacity tolerance of ±20 per cent appears to have been overlooked, and although the regulation of the arrangement shown by Mr. Stanley is excellent, it is doubtful whether it would permit the adoption of capacitors whose capacity just falls within the limits prescribed.

Bearing the foregoing in mind, I would suggest that the arrangement is not entirely foolproof.

J. PARKINSON

Uxbridge, Middx.

The author replies:—

I have used a series capacitor circuit in a number of A.C. mains receivers and these have been in continuous use for more than two years without a single dial light failure which could be attributed to the initial transient current when switching on. In all cases the heater circuits were rated at 0.2 A and the dial lights were 6.3-V, 0.3-A types. It is a fact that the bulbs appear to warm up more slowly in such circuits than when a constant voltage is applied, but I admit, on reflection, that my "several seconds duration" is a slight exaggeration.

It is possible that the explanation of our differing experiences may lie in the different ratios of bulb to circuit current rating. It is well known that 6.3-V bulbs last longer than 4-V types on a 4-V R.M.S. A.C. circuit, and it seems reasonable to suppose that 0.3-A bulbs would last longer than 0.2-A ones on a 0.2-A R.M.S. circuit. My bulbs had a current rating 1.5 times the R.M.S. heater current; Mr. Light used 0.35-A bulbs on a 0.3-A R.M.S. circuit for which the ratio is less than 1.2.

From the expression given by Mr.

Letters to the Editor—

Light it is interesting to calculate the rate of decay of the transient current. In my receivers the heater circuit has a cold resistance of 60 ohms and the series capacitor is 3μF. This gives a time constant of less than 1/5,000th second and the transient current has fallen to 1/1,000th second. The question to be settled is whether such a brief pulse of greater than normal current can damage a bulb filament. Mr. Light has found that it can; I have had no trouble from this cause. Probably it depends on the thermal inertia of the bulbs used and, as suggested above, on the ratio of bulb to circuit current rating. It would be very interesting to hear about the experiences of other users of the series-capacitor heater circuit.

Turning to J. Parkinson's letter: I did have two breakdowns of capacitors during my experiments on the series-capacitor circuit, even though my components were rated at 400 volts peak. I put this down to bad luck, but it appears that there is more in the subject than meets the eye. Afterwards I used components rated at 1,000 volts and had no more trouble: this bears out Mr. Parkinson's observations. The capacitance tolerance was ±5 per cent, and I agree that the normal tolerance of ±20 per cent is much too wide for this circuit.

A. W. STANLEY.

Selectivity in Television Receivers

THE excellent article on selectivity in television receivers in your June issue would, I think, have been somewhat more complete if brief reference had been made to the use of a cathode parallel-resonant circuit for sound rejection, particularly as considerable space is devoted to the series-resonant rejector.

With the series circuit, a few calculations with normal component values show, as you yourself certainly imply, that adequate rejection at 9.5 Mc/s and inappreciable loss at 10 Mc/s are well nigh impossible.

If, for example, we assume for C, a value of 3pF, about the lowest physically possible, then L_1 will be 93μH. Assuming further, perhaps rather optimistically, a Q-factor of 300, we shall obtain:

at 9.5 Mc/s an attenuation of about 25 db and

at 10 Mc/s an attenuation of about 8 db.

The first figure is reasonable, the second undesirably high. At 10 Mc/s neither $\frac{\omega^2 L_1 C_1 - 1}{C_1 R_1}$, (not $\frac{(1-\omega^2 L_1 C_1)}{C_1 R_1}$), nor $\frac{2\delta f.Q.R_1}{f_x R}$ are much greater than 1. They are about 0.6, in fact. Furthermore, there does not seem much that can be done about it.

If we decide to try the parallel-tuned circuit in the cathode, we have the same demand for a high Q-factor but this time with the least possible value of L_1 instead of the highest. Let us take 1000pF as a value for C_1, which gives an L_1 of 0.28μH, and assume Q=120, probably no more difficult to achieve than the previous conditions. Then, if we tap down about 15 per cent on the coil, we shall get attenuations of about 23 db at 9.5 Mc/s and 4 db at 10 Mc/s.

These results are slightly better than those obtained with the series circuit and do not occasion more difficulty in design.

H. G. M. SPRATT.
Enfield, Middx.

Discriminator Alignment

A. G. CROCKER, in the excellent account of the practical work he has carried out, says (page 316, your Sept. issue):—

"Linearity.—The characteristic (Fig. 2) is linear up to ±125 kc/s, if linear means the distortion effect is less than 2 per cent."

Now this raises again the old question of how much distortion is "distortionless." Two per cent distortion doesn't sound very much, but inspection of Mr. Crocker's curve shows that the slope over the range quoted varies by as much as 20 per cent. This means that if in the modulation there were a strong component (corresponding to nearly maximum deviation) and also weaker components (at other audio frequencies) the strong component would modulate the weak ones by about ±10 per cent. Can the quality enthusiast accept this amount of distortion in the reception of the very high fidelity signals which F.M. promises us?

E. F. GOOD.
Malvern, Worcs.

Direct-Coupled Amplifiers

I WAS rather surprised to see the circuit of N. Bonavia Hunt's amplifier in the July issue of the *Wireless World*, as I would have thought that, to-day, a circuit of this very crude type would have been beyond the serious consideration of most readers.

I am not, however, surprised to hear that it sounds very good, since it will presumably give a maximum output of the order of 20 watts, and yet under average domestic conditions, will have to supply perhaps two or three watts. But surely what an absurdly extravagant way of obtaining such results?

I would like to know what exactly were the conditions under which comparisons were made with other amplifiers. This amplifier incorporates a tone-control circuit (in which, incidentally, one of the potentiometers varies the anode current of the last three valves as well as controlling the tone!), and, therefore, of course, for a fair comparison, any amplifier with linear frequency characteristic (e.g., D. T. N. Williamson's or my own designs, described in the *Wireless World* May, 1947 and Jan., 1948, respectively), should have been preceded by a tone-control circuit of the same characteristics. Was this done? If not, the comparison is worthless.

I hope N. Bonavia Hunt will forgive my very outspoken criticisms, but I do sincerely believe it desirable to do what one can to stop people building amplifiers of this kind.

PETER J. BAXANDALL.
Malvern, Worcs.

"Principles of Radar"

IN the September issue of *Wireless World* there appears a review of the book "Principles of Radar," by Taylor and Westcott. The reviewer makes the statement that "metre-wave types [of radar] had little or no future even in 1945." I presume by this description he means CH and CHL equipments. Admittedly, the function of CHL has been adequately fulfilled by the multifarious centremetre equipments, but as far as CH is concerned the reviewer can merely be stating his own opinion, which is by no means shared by all, including the Air Ministry, judging from their general policy at the time.

M.G.S. goes on to say that the book does not mention rocket-detecting radar. There may be security reasons for this, as when I was last actively concerned with radar, which is not so very long ago, methods of rocket-detection were still secret. Even if they are not so today, which I doubt, they may have been at the time the book was written.

In view of security requirements I can say little of the actual methods of rocket-detection, but I would inform M.G.S., if indeed he is unaware of the fact, that no small part was played in rocket-detection in 1945 by those equipments "which had little or no future."

Hertford. K. W. PEARSON.

Aircraft and Television

APPROPOS to the remarks by "Diallist" in the September issue, I should like to submit what appears to me to be the obvious explanation of the "beating" effect of aircraft on television images. As an ex-radar boffin, I have heard many theories regarding the beating of echoes from objects, but never the present one.

Taking the television effect first: the reflected wave from an aircraft or other object is not locked in phase with the transmitter, with reference to any reception point on the ground. Obviously, as the distance between aircraft and ground varies, direct and reflected signals will be in phase for an instant (adding) then out (subtracting) and so on, at a rate of variation determined by the speed and line of flight.

Regarding the radar beat and the rotating propeller thesis, I can vouch for the fact that jet aircraft, buzzbombs, and barrage balloons all beat regularly and vigorously if any movement is present. This would indicate an effect analogous to the television flutter, caused by phase differences in direct and ground- or sea-reflected paths. Indeed, this path-difference (and hence phase-difference) between the two was the essential basis of the height-finding facility of ground C.H. radar stations. The fact that an echo would beat fiercely on a high aerial and remain steady on a lower one appears to confirm the reason for the phenomenon.

It has been suggested to me that aircraft might be built of resistive material such as would present a matched load to a T.V. signal, and so prevent reflection! ("Free Grid," please note.)

DOUGLAS M. GIBSON.
Ashford, Kent.

REFERRING to "Diallist's" comments in last month's *Wireless World*, the flopping up and down effect is the only kind of interference from aircraft I experience here.

As this happens frequently with jets it cannot be due to reflections from the revolving propeller.

E. E. S. EARNSHAW WALL.
London, N.W.2.

MANUFACTURERS' LITERATURE

Technical data on low-pass filters for use in A.F. amplifiers and amateur transmitting stations from Aysgarth Manufacturing Co., 5, Aysgarth Road, Wallasey, Cheshire.

List No. 4A of ex-Government radio equipment from Clydesdale Radio Supply Co., 2, Bridge Street, Glasgow, C.5.

Technical details and prices of quality amplifiers, including *Wireless World* designs, from C. J. R. Electrical and Electronic Development, Hubert Street, Aston, Birmingham, 6.

Price list of aerials, including special television arrays, from Newhalk British Industries, 69, Hornsey Road, London, N.7.

Illustrated leaflet describing power transformers and chokes from Stewart Transformers, 1021, Finchley Road, London, N.W.11.

Catalogue of low-current tubular rectifiers (selenium) from Standard Telephones & Cables, Oakleigh Road, New Southgate, London, N.11.

Price lists of Government surplus and other components from M. Watts, 38, Chapel Avenue, Addleston, Surrey.

"M.O.S. Newsletter" No. 3, being a catalogue of Government disposal and other items in the form of a journal, from Mail Order Supply Co., 3, Robert Street, London, N.W.1.

NEWS FROM THE CLUBS

Birmingham.—Special events have been arranged by the Slade Radio Society in celebration of its twenty-first anniversary. The week's programme includes a lecture on Oct. 1st by Dr. H. A. H. Boot on the cavity magnetron which will be open to non-members. Members are to visit the B.B.C.'s Droitwich transmitter on the following day. On the 6th a demonstration of two-way working on 80 metres will be given. The society's twenty-first birthday dinner will be held on October 8th. The meetings will be held in the Parochial Hall, Slade Road, Erdington, Birmingham, 23. Sec.: C. N. Smart, 110, Woolmore Road, Birmingham, 23, Warwick.

Birmingham.—Meetings of the South Birmingham Group of the R.S.G.B. are held on the first and third Sundays of each month at 10.30 a.m. at Stirchley Institute. Regular morse classes are being held and those interested in joining are requested to communicate with T. F. Higgins, G8JI, 391, Rednal Road, Northfield, Birmingham, 31, Warwick.

Middlesbrough.—The Tees-side Amateur Radio Society has secured premises for its headquarters at 400, Linthorpe Road, Middlesbrough, where future meetings and morse classes will be held. Sec.: H. Walker, G3CBW, 9, Chester Street, Middlesbrough, Yorks.

Pontypool.—Weekly meetings of the recently formed Pontypool and District Radio Club are held in the Abersychan Technical Institute. Sec.: W. F. Chew, Bryn Cottage, Pontrepiod, Mon.

Solihull.—Meetings of the Solihull Amateur Radio Society are held on alternate Wednesdays at the club's H.Q., The Old Manor House, Solihull. Sec.: H. C. Holloway, 20, Danford Lane, Solihull, Warwick.

Tunbridge Wells.—The West Kent Radio Society, which embraces the Tunbridge Wells, Sevenoaks, Tonbridge and Southborough areas, meets on the first and third Wednesdays of each month at 7.30 at "Culverden House," Culverden Park Road, Tunbridge Wells. Sec.: R. Pluck, 9, Prospect Road, Southborough, Kent.

RANDOM RADIATIONS

By "DIALLIST"

Liverpool's Radar

THE PORT OF LIVERPOOL radar supervision system is remarkable not only for being the first of its kind in the world, but also for having one of the most ingenious display arrangements yet devised. The technical details were dealt with in last month's *W.W.* There's one application, though, that strikes me as exceptionally valuable. The 12-mile channel up the Mersey is narrow and winding and it is marked by about 60 buoys. It is obviously most important that these should be exactly in their proper positions and that movements of any kind should be spotted at once and communicated to shipping. In the past this meant hard and constant work on the part of a large staff; in foggy weather, when it is of the greatest importance, such verification must have been very difficult if not actually impossible. The checks are now made rapidly and almost automatically by the radar operator, no matter what the weather. In front of each of the screens showing a portion of the channel is a transparency on which the proper position of every buoy is marked by a green dot. The operator can see at a glance whether the spot of light on the tube corresponding to a buoy coincides with the appropriate green dot. If one of the buoys has shifted he can read off its exact position from a grid on the transparency and can thus notify shipping without delay. The British Sperry Gyroscope Company, who, with Cossors, were responsible for the design and the installation, have made the system a flexible one so that only slight modifications will be needed to make it suitable for any harbour. One doesn't need to be a prophet to foretell that this system, or others like it, will soon be applied to many others of the world's great ports, some of which are now very difficult for shipping in certain kinds of weather.

Just the Place

THE ELABORATE RADAR GEAR installed recently at the tip of Southend's incredibly long pier has provided some of the lay papers with a magnificent opportunity of getting hold of the wrong end of the stick. To some of them it was just another amenity for trippers. They even went so far as to describe it as "penny-in-the-slot radar" which had taken its place amongst the various fun-and-games machines on the pier. The truth is rather different. The radar installation has a serious object; it is intended primarily for research and development work. It was placed where it is simply because the Southend pier juts right out into the Thames Estuary and the radar scanner is almost as well placed for following the movements of shipping as if it were carried by a vessel in mid-channel. It would be difficult to think of a better site than the far end of that immense pier with streams of ships always passing up and down. For the time being, at any rate, a side-show for the public has been provided in the form of a repeater P.P.I. tube in a room open to all comers. That's apparently how the penny-in-the-slot notion originated. I hope the hut housing the gear has been made fairly draught-proof, for the far end of Southend pier can be pretty arctic. I remember being frozen stiff when I had to visit an A.A. gun site there during the awful winter of '40-'41.

Navigation

BRADFIELD OF T.R.E. HAS developed a short range navigational device of considerable interest. By placing his ultrasonic generator at the focal point of a paraboloid he has been able to focus the energy into a beam, and, using radar technique, he transmits pulses, which are echoed back to a receiver, the travel time being measured by a C.R.T. The fire fighting services are watching his development closely, for they see in it a likely means of enabling firemen to find their way about smoke-filled buildings. Other investigators are working on a multiplicity of possible applications of ultrasonics. Conn, of Sheffield University, takes the line that neither the crystal nor the magnetostriction generator can provide the energy needed commercially at useful frequencies. He is working on a new method of generation by a combination of electric and magnetic fields. Jacob, at Imperial College, is studying the disintegration of bacteria (particularly those of milk) by ultrasonic methods. He has destroyed such bacteria, but is still endeavouring to establish the connection between frequency and lethal effect. At Cambridge, Pinkerton is obtaining valuable data about the construction of liquids by observing the effects of the passage of ultrasonic vibrations through them. He has already established that cavitation—the formation of liquid vacuums—may be caused. This may be a very valuable line of investigation, for it has long been known that cavitation in water may cause the eventual break-up of ships' propellers. That, in outline, is some of the story of ultrasonics to-day. No one can say yet what its ultimate possibilities may be; but there can be little doubt that it is a development of first-rate industrial importance.

Television Policy

THE OFFICIAL STATEMENT on television policy in this country struck me as being eminently sound. Some people, I know, had been shy about investing in television receivers because of tales they'd been told by the irresponsible and not very knowledgeable about amazing improvements — big-screen, colour, stereoscopic images and the like—which would shortly render all present sets obsolete. It was no use telling them that such rumours were utter nonsense; they just smiled politely and didn't believe you. The official announcement that 405-line transmissions are to be continued for many years should put an end to silly talk of that sort. One hopes it will; but human nature being what it is, the people bursting with completely incorrect "inside information" will no doubt get busy again sooner or later. Lots of folk either don't or won't realize that if, say, colour television were perfected to-morrow, transmissions couldn't be made from B.B.C. stations for some years; it takes a long time to build and install new apparatus nowadays, as the history of the Sutton Coldfield station shows. In any event the receivers for colour transmission would probably be much more expensive than those now in use. It would be a case of twopence coloured, penny plain, so to speak. I fancy that the penny plain 405-line receiver will be good enough for most people for a long time to come.

Proving the Pudding

I'm not sure of the frequency range claimed for the best of the U.S.A. television receivers; nor do I know to which their normal television receivers respond adequately. But I'm open to wager the shreds of my last pre-war shirt that it must take them all their time to get more out of 525 lines than we do out of 405. I admit that I wouldn't hazard even the rags of that prized and irreplaceable garment if I weren't more or less betting on a certainty. American friends who watched events in the Olympic Games on television screens here have been lost in admiration of the steadiness and clarity of the pictures and of their depth of focus. Two other items of interest also came my way from these good friends. The first is that from the home entertainment point of view our television programmes are in the main better than theirs. Like broadcasting, television must consist over there mainly of sponsored items; I gather that Big Business is proving a little coy about taking television to its heart as an advertising medium, and that the quality of the programmes suffers accordingly. There is a surfeit of boxing and of baseball matches and so on and a sad deficiency of matter of general entertainment value. The second item is more or less a consequence of the first. Though the number of televisors in use in the States runs a good way into six figures, comparatively few of them are in private homes. The larger proportion is to be found in bars, restaurants, "hot dog stands" and so on. Some thinking Americans, I'm told, are convinced that the sponsoring system is not at all likely to provide the right sort of entertainment and are trying to find some way of making the programmes more or less independent of advertising by getting the viewer to pay for his fun by means of a receiving licence of some kind or through a subscription service.

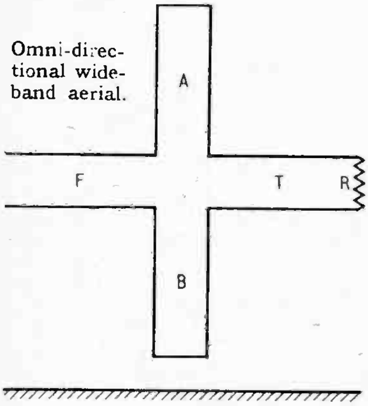
RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

Wide-band Aerials

TO be suitable either for frequency-modulated signals, or for television, an aerial should be substantially aperiodic over a band of frequencies covering a ratio of at least two to one. A common expedient is to

Omni-directional wide-band aerial.



use radiators of relatively large diameter, but this is not always convenient.

The desired impedance characteristic is also possessed by certain directional types, such as the Beverage and rhombic aerials, though at the expense of some power that is lost in the surge impedance by which they are terminated. The thin wire aerial shown is of this type, though it is modified to have an omni-directional radiation pattern, similar to that of a dipole. The two co-planar "loops" or radiators A, B are fed at one side by a two-wire line F, and are connected at the other side by a transmission line T to a matched dissipating resistance R, which is preferably located some distance away and at ground level. The aerial is stated to be the equivalent of a "rhombus of zero apex angle."

Standard Telephones and Cables, Ltd., and W. L. McPherson. Application date, May 25th, 1945. No. 594805.

Scanning Beams

A ROTATING beam aerial, particularly suitable for radar, includes a parabolic reflector which is sprayed with primary wave energy from the slotted and tilted end of a waveguide. The waveguide terminates at a point which is located below both the horizontal scanning-plane and the principal axis of the paraboloid, so that it is also offset from the focus.

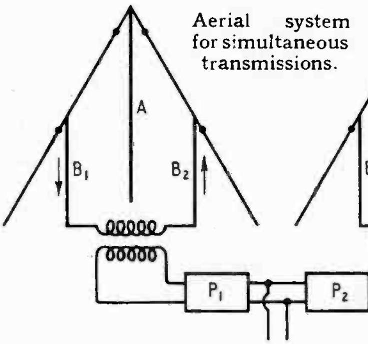
The arrangement reduces undesired secondary reflection effects and consequent distortion of the radiated and received fields. In particular, it avoids the production of large side lobes of energy and prevents the so-called "polarization splitting" common to horizontal scanning systems, where the linearized waves tend to break up into quadrature and so produce a circularly or elliptically polarized beam.

Western Electric Co., Inc. Convention date (U.S.A.), Nov. 6th, 1943. No. 595724.

Aerial Systems

THE diagram shows how two separate aerials are grouped together for the simultaneous transmissions of two broadcast programmes on different wavelengths without mutual interference. One aerial is an insulated mast A, which is connected in any suitable way to a first transmitter (not shown). The second aerial consists of four radiators B1, B2, B3, B4, supported by triatics which are arranged symmetrically around the centre mast, as illustrated by the two different aspects shown in the drawing.

The radiators of the second aerial are transformer-coupled to a second transmitter through a line comprising phase-shifting networks P1, P2, which respectively introduce a lead and lag of 45 deg. The diametrically opposite limbs B1 and B2 are accordingly fed in phase opposition, whilst the currents in adjacent limbs (such as B1 and B3 when viewed in plan) are in phase quadrature. The currents induced by the central mast A in each pair B1, B2 and B3, B4 of the outer aerials will be in phase, and will therefore cancel at the terminals of the second transmitter. The symmetry of the arrangement preserves the normal radiation pattern of both the aerials.



Aerial system for simultaneous transmissions.

The British Broadcasting Corp. and H. L. Kirke. Application date, Feb. 13th, 1945. No. 590629.

Reducing Interference

THE signal is first divided into two equal but oppositely phased counterparts by passing it through a phase splitter. An electronic switch then feeds an element, taken alternately and progressively from each of the two counterparts, to the modulator, so that the signal when radiated is "chopped" and alternately reversed in phase.

At the receiving end, the frequency imposed by the high-speed switch is first filtered from the carrier, and is applied through a separate channel to drive a similar electronic switch at the same frequency. This is used to reverse the phase of alternate sections of the rectified signal, and so restore it to its original form.

Any jamming or similar interference picked up by the receiver will also be "chopped" and reversed in phase. But, unlike the signal, the chopped elements are combined in phase opposition, and so cancel out. Suitable filter circuits are provided to protect the sound reproducer from the switching frequency.

Standard Telephones and Cables, Ltd. (assignees of N. H. Young, Jr.). Convention date (U.S.A.), April 16th, 1932. No. 594235.

Programme Selection

A RECEIVER can be set to reproduce only specially selected items from the daily programme of a given broadcasting station, provided each of the transmissions from that station is preceded by a pulsed identification signal and is followed by a pulsed "signing-off" signal.

These control signals, preferably supersonic, are filtered out in the receiver and applied to operate the selecting relay through a triggering circuit, which includes a cold-cathode discharge tube. The relay is of the stepped switch or telephone type, and is set each morning by inserting plugs into numbered apertures corresponding to the selected items. When the same contacts are bridged from the rear, by a wiper operated by the preliminary identification signal, the heaters of the A.F. amplifiers are switched on, so that the incoming item is heard. The relay is reset to zero by the "signing-off" signal, and the receiver remains mute until the transmission of the next pre-selected item.

Electrical Components, Ltd., and W. Sommer. Application date, June 15th, 1945. No. 595805.

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