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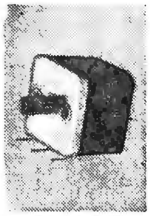
and so Mullard brings you more interesting details of *What's New in the New Sets*—new devices, new developments, and the latest production techniques in Mullard's unceasing contribution to better radio, television and sound reproduction.

MINIATURE TUNING CAPACITOR



Tuning capacitors for transistor portables must be small and sturdy and must possess stable electrical properties. The Mullard variable capacitor type AC1033 is a very compact unit which is characterised by a low noise level and an absence of microphony. The stator and rotor of this component are mounted securely on a square base, and the vanes are separated by thin discs of synthetic foil. The whole is encased in a plastic moulding through which the trimmers (which are fitted to both aerial and oscillator sections) are accessible. Three tags are provided for connection to printed circuit boards. The electrical and physical properties of this Mullard component and its easy adjustment are such that it amply satisfies all the requirements of present-day portables.

A TRANSISTOR FOR PORTABLES

In more and more new portable receivers, the Mullard AF117 is appearing in place of the earlier types of r.f. transistor. This alloy-diffused type is especially suited for the r.f. and i.f. stages of a.m. receivers, offering an increase in r.f. gain without the need for neutralising and an improvement in sensitivity. These advantages are translated into terms of radio receivers as less complex circuit designs and improved standards of performance.

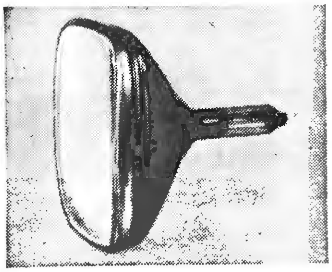
P.P.C. Cathodes for Rectifiers

The manufacture of cathodes for Mullard rectifiers is undergoing a complete change: a new technique is being adopted for producing the emissive coating. At present, the new technique is used in the manufacture of the PY33—which has an output some 11V higher than that of comparable rectifiers with conventional cathodes—and the technique is soon to be employed for other types of Mullard rectifier.

The new coatings use the normal emissive oxides, but they are prepared in such a way that the oxides are in a very dense form and a hard shiny surface is achieved. The internal resistance of the coating produced by the new process is low, which reduces local heating, and the smooth surface is free from high spots. Consequently, the likelihood of flashover occurring is minimised, and the damage suffered by the coating even if flashover does occur is much less than with conventional cathodes. Also, because of the toughness of the coating, particles are unlikely to become detached from the surface, and sputtering is less likely to occur. With these improvements it has been possible to reduce the spacing between electrodes, with a resultant increase in output voltage.

This entirely new concept of cathode manufacture opens the door to more efficient production and even better quality with Mullard rectifiers.

AW21-11 $8\frac{1}{2}$ in. tube for portable television



Compactness and low battery consumption in a portable transistor television receiver are made possible with the Mullard AW21—11 tube by virtue of its $8\frac{1}{2}$ in. screen diagonal and 90° deflection angle. A car battery can be used as the power supply because the heater voltage of the tube is 11.5V.

The new shortened unipotential gun retains the excellent flat focusing characteristics of unipotential guns, and also contributes to compactness. The drive requirements of the short gun are compatible with the performance of present-day video output transistors without the need to shorten the grid base. A gun with a high e.h.t. maximum rating and exceptional insulation properties has been chosen to lessen the likelihood of flashover occurring.

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Co-operative Research

SPEAKING recently at the annual dinner of the radio and electronics industry Earl Mountbatten emphasized the need for research on a scale not hitherto contemplated in peace time if we are to achieve industrial success in space communications and in other electronic fields in which international competition is keen. While recognizing the substantial contributions to research made by the Government departments and the larger segments of industry he strongly recommended an intensification of effort in some form of "Combined Operations." Specifically he recommended that "the Radio and Electronics Industry Council should be regarded and used as a Combined Operations Headquarters for the whole of this nationally important industry," and he suggested that it "should investigate the desirability of promoting a radio and electronic industries research association."

In responding to this leadership we trust that the Radio Industry Council and the Electronics Industry Council will not overlook Earl Mountbatten's use of the singular when referring to them and that in their future activities something stronger than formal liaison may be applied to heal the rift which appeared in 1959 between the consumer and capital goods sides of the industry. If they can break bread together in a combined annual dinner this should not be too difficult.

What form should a research association take, and what should be its functions?

By accumulating funds it can build and equip new laboratories to supplement the resources of individual firms and groups in turning over the new ground which today is being opened up at an exponential rate. Modern research has this in common with criminal investigation that there is an enormous amount of spadework and "routine inquiries" which must be carried out with patience and thoroughness in order that no vital clue shall be overlooked. Any increase in the facilities for this kind of work is all to the good, even if, as we suspect sometimes happens, the research association gets the crumbs while the member firms keep the plums.

We hope that when the radio and electronics research association comes into being it will be something more than a token to which industrial organizations pay lip service and an annual contribution by banker's order, tossing it from time to time a harmless and uninteresting problem to keep it occupied. Rather should it be a confluence of the vital bloodstreams of its member firms, giving the strength to tackle undertakings which have so far proved beyond the resources of even the biggest units. A radically new and cheaper display device for colour television, for example, would powerfully augment our export potential and at the same time provide greater financial returns to members of the association than if they had each undertaken expensive and probably overlapping research programmes. It goes without saying that satellite communications is a project calling for association—indeed of collaboration with other bodies, e.g., the G.P.O. and D.S.I.R.

Quite apart from the physical contributions to research and development (the dividing line is hard to draw in any industrial organization) one of the principal functions of a research association should be to facilitate cross-fertilization of trains of thought in different parts of the industry. To some extent this already takes place through the publication of papers and by discussion between scientists and technologists at the meetings of our great Institutions; but commercial interest sets a limit to what may be publicly disclosed. Greater freedom of discussion in the national interest is possible within the framework of an industrial association.

Finally, a research association should not be so highly organized or so wholly absorbed in the problems of the moment that it has no time to seek out and examine fresh proposals from outside. Many good ideas have remained hidden in the archives for years, and the community would have benefited earlier had it been more willing to give a hearing to Marconi and Heaviside and, in the field of flying, to F. W. Lanchester. Success in a competitive world depends not only on being first to recognize an intrinsically new idea, but on the speed with which it can be developed and produced. By the time it is in production the next project should be well under way. The Government fully recognizes this principle and has established the National Research Development Council to give it effect. No research association can afford to ignore what the conventionally-minded might describe as the "lunatic fringe."

Black Level in Television

THEORY AND PRACTICE OF D.C. RESTORATION AND CLAMPING

By H. V. SIMS*, Assoc.I.E.E., M.Brit.I.R.E.

IN a television picture signal the reference datum is black level. In the complete television waveform the synchronizing signals (of constant amplitude) lie on one side of this datum and the picture signals (of varying amplitude) lie on the other side.

In order to reproduce the various contrast tones of a picture correctly it is necessary to maintain black level at a constant voltage value at the grid or the cathode of the picture tube—in fact at the "cut-off" voltage of the tube. As picture signals always represent tones which can never be darker than black, they virtually consist of a unidirectional current whose instantaneous value varies according to picture detail and whose mean value varies in accordance with mean picture brightness.

When such a waveform is passed through an a.c. coupling (for instance an ordinary resistance-capacitance coupling) the unidirectional nature of the signal will be lost; its mean value will be fixed at zero and black level will vary (instead of the mean value) with signal amplitude.

If this signal is applied to the input of a picture tube all pictures will tend to be reproduced with the same mean brightness and black level will vary instead of mean brightness, with resultant distortion of brightness values†.

Under these conditions continuous operation of the brightness control will be necessary, otherwise bright scenes will have excessive contrast with intended detail in dark areas obscured at or below picture tube cut-off, whereas dark scenes will lack contrast because the dark areas will be too bright—although there will be no greater detail in these areas—also flyback lines may become visible unless they are specially suppressed.

*British Broadcasting Corporation.
†"The Importance of the D.C. Component," by D. C. Birkinshaw, *Journal of the Television Society*, Volume 7, No. 3 (June 1953).

As it is impracticable to use direct coupling throughout a television transmitting and receiving system, a.c. couplings are used and the unidirectional component (generally termed the d.c. component) is re-inserted (i.e. black level is made constant) when desired by means of d.c. restoration or by clamping.

D.c. restoration involves rectification of the black-going peaks of the signal; with clamping the signal must contain a line-frequency reference period which bears a constant (or partially constant) relationship to black level and, by means of an electronic switch actuated by clamp pulses, these reference periods are brought to the same voltage value to ensure that each line waveform commences from the same level.

If the output waveform direct from the television camera tube contains these line-frequency reference periods, then clamping may be used on all occasions when a fixed black level is desired; but in practice the simpler d.c. restoring circuit is also often used depending on the exact conditions required.

Development of Modern Methods

The output of some of the older types of camera tube does not contain a reliable reference period during the suppressed scanning-beam flyback and it is necessary to d.c. restore the actual picture signals. After fixing black level by d.c. restoration, line- and field-blanking pulses are added to the waveform, thereby providing the necessary reference levels for subsequent clamping.

Under these circumstances, if there is no black object in the televised scene, the darkest object would be reproduced as black and it is necessary to introduce an appropriate d.c. value into the transmitted waveform by means of a control known

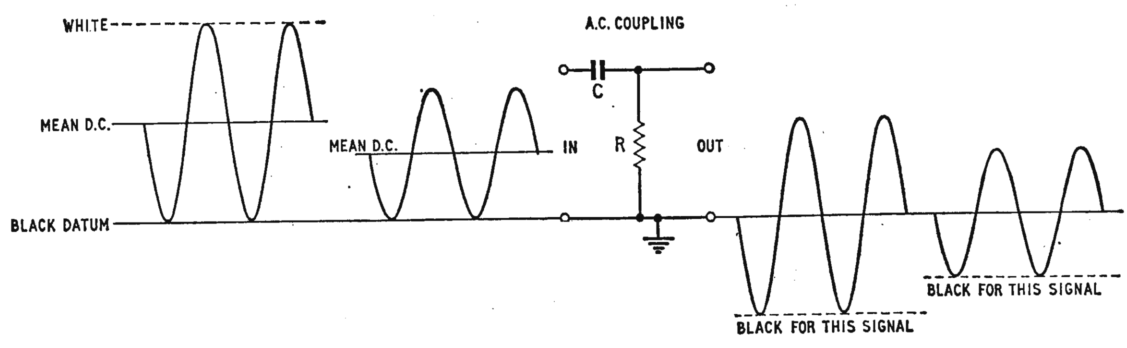


Fig. 1. This shows effect of a.c. coupling on television signals with varying d.c. components. On left is input signal with d.c. level fixed: d.c. component varies in accordance with mean brightness. On right-hand side d.c. component is missing: here the mean brightness is constant and black level varies with signal amplitude.

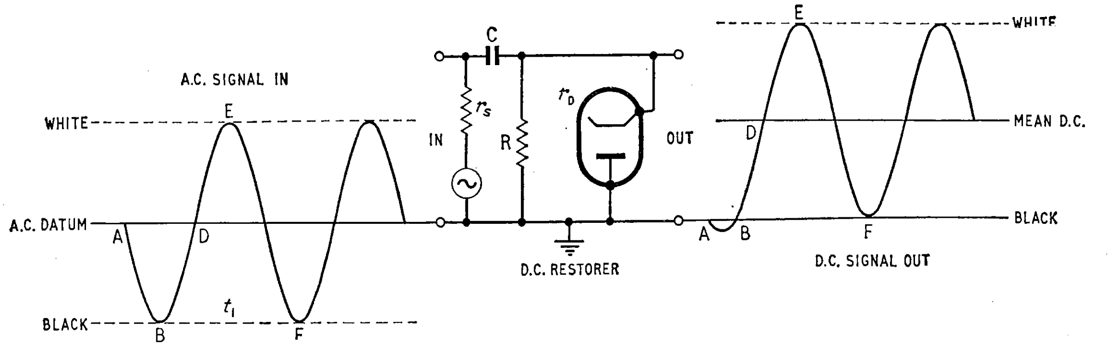


Fig. 2. D.C. restorer fitted to a.c. coupling. r_s= source resistance, r_D = resistance of diode when conducting (r_s and r_D are very much smaller than R). t_1 = time between points of conduction. C ($r_s + r_D$) = charge time constant. CR = discharge time-constant.

as " lift " which is more or less continuously operated.

An important feature in the development of modern camera tubes has been the provision of a true black-level output during the flyback periods. With this d.c. restoration becomes unnecessary, for it is possible to clamp at line frequency during these periods and so remove all low-frequency disturbances of black level.

There will be, in practically all cases, a separation between the true black output of the camera tube and the output which corresponds to black objects, for the scene lighting is so arranged that black objects do in fact reflect some light, otherwise black level in the reproduced scene will be marred by noise. The magnitude of this separation is governed by scene lighting, the lens aperture and the camera tube controls.

Action of D.C. Restorer Circuit

The effect of an a.c. coupling on two simple representative signals with d.c. components is shown in Fig. 1.

In order to d.c. restore an a.c. signal a diode is connected across the output of an a.c. coupling as shown in Fig. 2.

From A to B, the input waveform goes negative, the diode conducts and the capacitor C is charged to the peak negative value of the signal (assuming that the charge time constant is very short). During this time the output is held at almost earth potential because the resistance (r_D) of the diode, when conducting, is very low.

From B to D the input rises but C is unable to discharge as the diode ceases to conduct when its cathode is positive with respect to its anode. At E the output is positive to the extent of the peak-to-peak amplitude of the signal. Slight conduction takes place at F to replenish the charge lost from C due to leakage through the discharge resistance R.

In this way a positive direct voltage at the output is produced equal in value to the mean amplitude of the signal with the variations of the signal superimposed upon it.

The discharge resistance R is necessary to allow the mean d.c. level to fall to a lower value appropriate for a signal of lower amplitude, otherwise C would remain fully charged by the signal of largest amplitude and the mean d.c. would be incorrect for smaller signals.

The fall in mean direct voltage at the output between the points B and F must not be excessive however, otherwise shading towards black of the signals will occur.

The discharge time-constant is effectively CR (as r_s is low and the diode is non-conducting), and this time-constant should be about a hundred times t_1 (the period between the points of conduction B and F) if the mean d.c. is to be maintained adequately for video signals.

Practical Values

In most modern cases the television waveform to be d.c. restored will be complete with synchronizing signals and conduction will take place on the sync. pulse tips. The object of d.c. restoration is to hold the tips of the syncs at a fixed potential so that if the syncs are constant in amplitude, blanking level will also be fixed. (Note: blanking and black level may be regarded as the same in this discussion.)

The period between the points of conduction will be approximately 90μsec maximum and the discharge time constant would be not less than about 0.01sec, at which value the horizontal shading will be approximately 1%; that is, the brightness at the end of a line will be about 1% below its correct value. An error of this magnitude is considered to be unimportant.

The charge time-constant is $C(r_s+r_D)$ and for effective d.c. restoration this should be as short as possible. (In some circuits resistance is deliberately added in series with the diode to prevent d.c. restoration taking place on peaks of noise or sharp transients present in the signal.) In practice r_s will be the output resistance of a video amplifier and may be of the order of hundreds or thousands of ohms depending, in general, on the voltage gain. The resistance r_D varies with conduction current but a mean value of the order of 200 Ω may reasonably be expected if the diode is driven well into conduction. Crystal diodes may be used if their back resistance (which appears in parallel with R) is sufficiently high for the purpose required.

The ratio of discharge to charge time-constant $CR/C(r_s+r_D)$ should be very large and as capacitor C is common to both this means that the ratio $R/(r_s+r_D)$ should be very large.

The value of r_s can only be reduced by increasing the current capacity of the previous stage.

A finite value of r_D results in partial d.c. restoration as there will be an a.c. component developed across it which, of course, appears at the output.

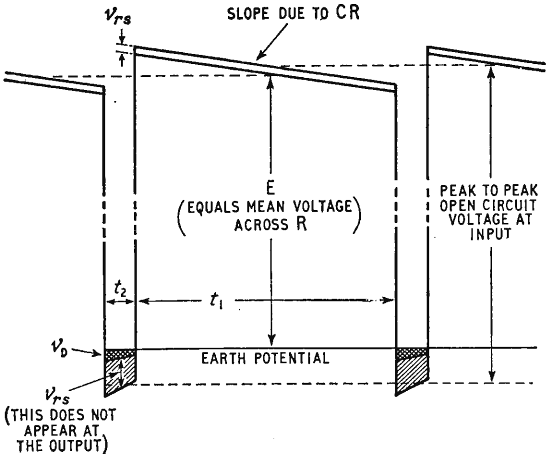


Fig. 3. Diagram showing how efficiency of d.c. restoration depends on diode and generator resistances.

The resistance R will form the grid to cathode d.c. return path of the following valve or picture tube and is therefore restricted to a value not greater than that recommended by the valve manufacturers to avoid effects due to secondary emission or gas within the valve. In parallel with R also will appear any leakage due to dust, etc., and the input resistance of the following stage.

Incomplete d.c. restoration means that black level will vary with signal amplitude and this is demonstrated in the following example.

In Fig. 3, negative-going line sync pulses are shown which have been applied to the d.c. restoring circuit of Fig. 2, with the following values of components and periods:—

R	= 200kΩ	C	= 0.05μF
r_D	= 200Ω (nominal)	t_1	= 90μsec (discharge time)
r_s	= 1.8kΩ	t_2	= 9μsec (charge time)

The discharge time constant CR is 10,000μsec (i.e. about 100 times t_1).

Under stabilized conditions let the average voltage E across R during t_1 equal 20V, when the average current flowing through it during this time will be:—

$20 \times 1{,}000/200{,}000 = 0.1\text{mA}$

This current will discharge C slightly during t_1 and during t_2 the diode will conduct to replenish the lost charge with an average conduction current of

$$(t_1/t_2) \times 0.1 = (90/9) \times 0.1 = 1.0\text{mA}$$

The charge and discharge currents flow through the generator in opposite directions and cause voltage drops in r_s during the negative and positive excursions of the waveform.

The mean loss in r_s during t_1 is $(1{,}800 \times 0.1)/1{,}000 = 0.18\text{V}$ which may be quite unimportant.

During t_2, however, the charge current of 1.0mA flows through r_s and r_D causing voltage drops of 1.8 and 0.2 respectively, and this means that the voltage for blanking level above the zero datum line is lower than it should be by a total of 2.0V (this is shown in Fig. 3). When the signal amplitude changes the voltage error due to r_s and r_D will also change—for instance, if a picture signal is added to the waveform such that the average voltage E is doubled then the discharge and charge currents will be doubled and blanking level will vary; in fact blanking level will vary with signal amplitude to the same extent as the voltages across r_s and r_D and herein lies a serious deficiency of d.c. restoration.

To minimise the variation of blanking level (and all other picture tones) the ratio of R to (r_s+r_D) should be made as high as practicable, but even so some variation is inevitable.

Use of Stabilizing Bias

When the conduction peaks are pulses of constant duration and frequency an almost constant voltage loss due to r_s and r_D may be obtained by stabilizing the discharge current through R. This is done by connecting R to a point of negative potential instead of to earth, when the discharge current through R will be largely independent of signal amplitude variations, the average signal voltage being a small proportion of the total voltage across R (see Fig. 4).

The value of R must be increased otherwise the discharge current will be excessive, resulting in a large conduction current (to replenish the charge on C) and a large constant voltage loss due to r_s and r_D. Automatically with the increase in value of R, the time-constant CR is appropriately increased—this being necessary to minimize signal shading.

It should be thoroughly understood that the fall in d.c. level during t_1 is a fixed percentage (dependent on the discharge time-constant CR) of the total voltage due to the mean signal and the applied bias. If the time-constant is not increased, the same percentage of a much larger voltage would result in an unacceptable fall in d.c. level at the output which would appear as shading from left to right on the reproduced picture.

As an example, let R be increased ten times from 200kΩ to 2.0MΩ and connected as shown in Fig. 4 to a negative supply of 180V.

With a mean signal amplitude of E = 20V the discharge current is the same as before at 0.1mA (for the total mean voltage across R is now 180+20 = 200) and the voltage across r_s+r_D during t_2 is 2.0V as before.

When the mean signal voltage is doubled (for example) so that E = 40, the total voltage across R is only increased by 10%, i.e. from 200 to 220, and the loss across r_s+r_D likewise increases by only 10%, i.e. from 2.0 to 2.2V (instead of from 2.0 to 4.0V in the first example).

This reduced variation of blanking level represents a distinct improvement and might be acceptable for some purposes, but the method employed still relies on the ratio t_1/t_2 being constant. In d.c. restoring the complete television waveform there will be variation of blanking during the field sync which provides a much longer conduction time t_2 than the line syncs (and a much shorter discharge time t_1) producing a characteristic distortion of field syncs, which may be reduced by reduction in value of r_s.

D.C. Restoration in Sync Separators

To d.c. restore a signal in which the syncs are positive the diode connections must be reversed, i.e. with its cathode earthed and its anode connected to the output (to stabilize the current through R in this case a positive bias must be applied).

With a negative-going signal, d.c. restoration may sometimes conveniently take place at the grid of a valve, when the valve becomes a d.c. amplifier suitably negatively biased by the mean d.c. which results from the rectification of the positive peaks of the applied signal.

In sync separator circuits d.c. restoration usually takes place at the grid of a separator valve whose grid base is suitably restricted by reduced screen and anode potentials. Under these conditions a high value of grid resistor may be taken up to h.t. positive because, even in the absence of signal when the grid becomes slightly positive, the anode and screen dissipation will not be high owing to the reduced potentials.

It must be understood that the real purpose of d.c restoration is to correct for the loss of very-low-frequency components which are completely removed by a.c. couplings. The input to the d.c. restorer should be substantially free from hum, l.f. distortion and disturbances down to frequencies of the order of 25 c/s, for any attempt to correct fully for these effects would require such a short discharge time-constant that serious shading during each line waveform would be produced.

Line waveform shading is not important in sync separators provided the picture on the grid is always beyond separator valve cut-off; thus a somewhat shorter discharge time constant CR may be used in the d.c. restorer than specified for the video case and this provides a useful correction of some of the disturbances of blanking level (e.g. surges, l.f. distortion, etc.) which cause a lack of synchronizing resulting in field roll and line tearing (particularly at the top of the picture).

Economy in Providing Fixed Blanking Level

The peak-to-peak amplitude of a television waveform is considerably greater when the d.c. component is absent than when blanking level is fixed and in view of this d.c. restoration is sometimes used simply as an economy measure.

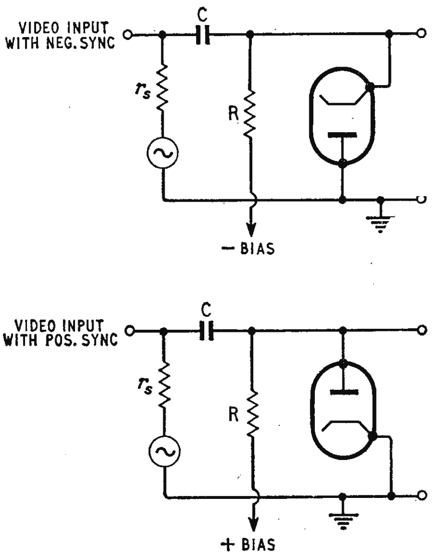


Fig. 4. D.C. restorer circuits with negative and positive bias to stabilize discharge current through R.

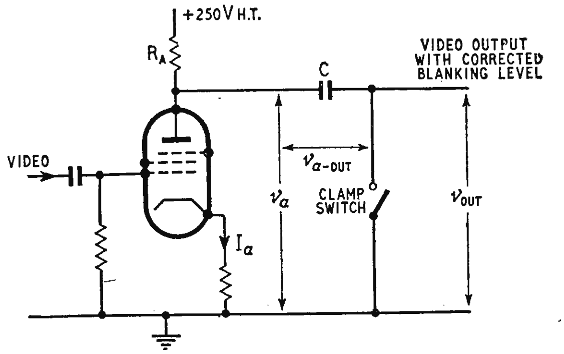


Fig. 5. Clamping circuit with clamp switch represented by ordinary switch.

It is found that with average television-picture signals the ratio of peak-to-peak amplitudes in the two cases may be of the order of 1.4/1, therefore a valve handling the a.c. signal will require a power capacity of twice that of a valve handling the signal when blanking level is fixed. This is very important in transmitters where kilowatts are involved.

Action of Clamping

Clamping is carried out by closing an electronic switch for a few microseconds during each line-blanking reference period, thereby adjusting the charge on a coupling capacitor (and hence the voltage across it) to obtain a line-frequency correction of the output voltage representing blanking level.

Clamping ensures that blanking level prior to each line waveform is maintained at a substantially constant value. The waveform must contain during blanking line-frequency reference periods which bear a constant or partially constant relationship to blanking or to black level. By the action of clamping these line-frequency references are brought to a definite horizontal datum, thereby re-inserting the d.c. component, fixing blanking level and reducing all distortions of the waveform which are substantially below line frequency.

A clamp circuit is shown in Fig. 5 with the clamp switch represented simply by a contact which closes for a few microseconds (for a time t) during each line-blanking period.

Whilst the switch is closed the output voltage v_{out} to the grid of the next stage is zero and this is the value chosen (in this case) for blanking level. During the time t the coupling capacitor C charges up and the voltage across it ($v_a - {}_{out}$) will be equal to v_a which is the anode voltage for blanking level decided by the valve current I_a.

When the clamp switch is opened v_{out} will remain (apart from a slight error) at zero until v_a changes with variations of the signal. When the clamp switch closes again any change in v_a for blanking level will either charge or discharge C through the anode load resistance R_A and the resistance of the clamp switch (which for the present is assumed to be zero). In parallel with R_A will appear the a.c. resistance of the valve r_a, but this may be ignored as its value is so much higher than R_A.

The effective charge and discharge time-constant will thus be CR_A, and if the output is to remain at zero for blanking level when the switch is opened

CR_A must be short in comparison with the time t for which the switch is closed, in fact C will be charged or discharged to within $\exp-(t/CR_A)$ of the required value.

In practice t may be of the order of 2 to 5µsec; in this instance let $t=5\mu$sec, then with $R_A=5k\Omega$ and C=333pF, $t/CR_A=3$ and exp−3=0.05, i.e. 5%.

To illustrate clamp action let the starting conditions for blanking level be as follows:—

I_a = 10mA (this is a function of the input signal)

then v_a = 200V
and v_{a-out} = 200V
Therefore v_{out} = 200−200 = 0V.

Let some change occur in the input signal so that blanking level is slightly less positive at the grid of the first valve, then just before the clamp switch closes, for blanking level

I_a becomes 9mA
v_a = 205V
but v_{a-out} remains at 200V
so that v_{out} = 205−200V=+5V.

This is the error in blanking level immediately before the clamp switch closes.

Now close the clamp switch for 5µsec. v_a immediately falls to 200V, the current through R_A increases to 10mA, the valve continues to take 9mA, the extra 1mA being used to charge up C.

After 5µsec the current entering C falls to 5% of 1mA, i.e. 0.05mA; the current through R_A falls to 9.05mA; the voltage across R_A being 45.25, v_a is 250−45.25=204.75V; v_{a-out} is also 204.75V.

The clamp switch is now opened and v_a immediately rises from 204.75V to 205V, because the current into C ceases and the valve still takes 9mA,

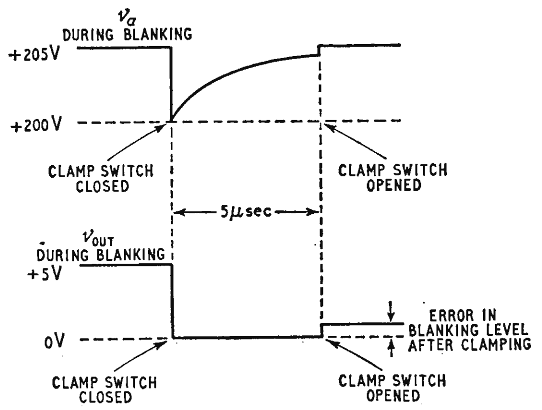


Fig. 6. Voltage changes on circuit of Fig. 5 during clamping.

but v_{a-out} remains at 204.75V therefore v_{out}=205 −204.75=+0.25V.

This is the error in blanking level after one clamping action, thus the original error of +5V is reduced to +0.25V, i.e. is reduced to 5%.

If there is no further change in blanking level during the next line this error will be further reduced to 5% of 5%, i.e. to 0.25%, and so on.

It can be seen that the clamp action is very powerful, reducing all variations of blanking level which occur reasonably below line frequency.

Voltage changes during clamping are shown in Fig. 6 and it will be noted that evidence of blanking-level correction will always be left on the waveform.

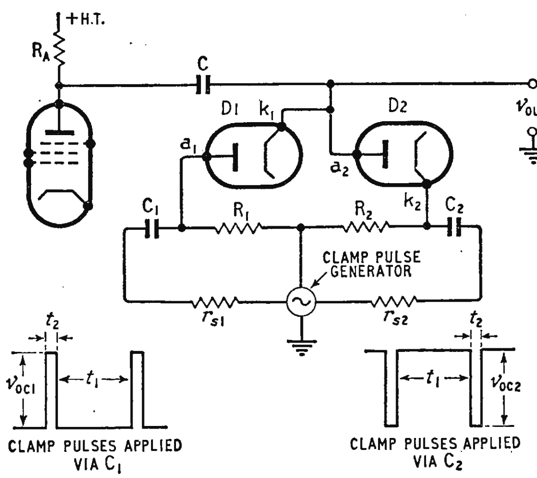


Fig. 7. Two-diode clamp switch.

The capacitor C must be much smaller in value than is usual for video couplings and therefore the input resistance of the following stage must be very high to provide a suitable coupling time-constant for line frequency. In most cases the grid leak for the following valve is omitted with no ill effect as the grid potential is established once in each line by the clamp; but with large valves internal gas may be a problem and this can set a lower limit for the value of C.

So far it has been assumed that the clamp switch when closed has zero resistance but in practice this will not be the case. Any clamp switch resistance (R_{cs}) will increase the charge and discharge time-constant which now becomes $C(R_A+R_{cs})$ and the effectiveness of the clamp is dependent on the ratio $t/C(R_A+R_{cs})$. If $R_A=3k\Omega$ and $R_{cs}=2k\Omega$, the error after clamping will be the same percentage as before (assuming no other component is changed) although the gain of the first stage will, of course, be reduced.

Two-diode Clamp Switch

The circuit of the simplest form of clamp switch is shown in Fig. 7 Semiconductor diodes may be used instead of thermionic devices provided that their back resistances are sufficiently high to maintain the coupling time-constant.

Correctly timed clamp pulses of the appropriate duration and polarity are applied to the two diodes, D1 and D2, via the capacitors C_1 and C_2.

The pulses are d.c. restored by the diodes and C_1 and C_2 are charged so that the potentials at a_1 and k_2 are negative and positive respectively during the discharge time t_1.

During t_2 the outputs of the clamp pulse generator are in series opposition to the voltages across C_1 and C_2, causing the diodes to conduct and to replenish charges lost through R_1 and R_2 during t_1.

When the diodes conduct the junction point of k_1 and a_2 (which is also connected to the output) is brought to the required clamping potential, which under balanced conditions, will be earth potential.

During t_1 the capacitors C_1 and C_2 discharge

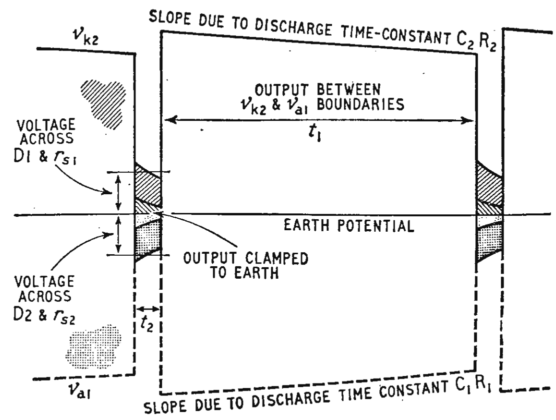


Fig. 8. Action of two-diode clamp switch (Fig. 6) working under balanced conditions.

slightly through R_1 and R_2, the diodes are biased to non-conduction, and the junction point is free to move in potential within the potential boundaries of a_1 and k_2, as shown in Fig. 8.

The amplitude of the clamp pulses must be sufficient to ensure that the video signal will not drive the diodes into conduction, otherwise severe distortion will result due to the shortening of the coupling time-constant by the low-resistance path to earth.

If the circuit and pulses are perfectly balanced the output is clamped to earth but if the symmetry of the circuit is disturbed or if the clamp pulses are unequal in amplitude, it will be clamped to a potential either positive or negative with respect to earth, depending on the severity and nature of the unbalance.

Calculation of Clamping Potential

It is useful to be able to calculate the potential to which the output is clamped under practical conditions of slight unbalance due to circuit and pulse tolerances, or deliberate unbalances designed to achieve the required bias for the following stage.

Assuming in the first instance that blanking level is correct (i.e. that no correction current is flowing through the switch) and that stable operation has been reached, two principles will be apparent:—

(1) that charge currents through the diodes will be equal (because the diodes are in series)

(2) the discharge currents through R_1 and R_2 will be equal (otherwise the charge currents would be unequal).

Let e = mean voltage across $R_1 + R_2$ during t_1, when the discharge current will be

$$I_{discharge} = e/(R_1 + R_2)$$

The charge current which flows during t_2 to replenish the charge lost during t_1 will be

$$I_{charge} = I_{discharge} \times t_1/t_2 = [e/(R_1 + R_2)]t_1/t_2$$

Referring to Figs. 7 and 9, adding up the voltages around the circuit and equating them to peak-to-peak outputs of the clamp-pulse generator, we have

$$v_{OC1} + v_{OC2} = e + [e/(R_1 + R_2)]\,(t_1/t_2)\,(r_{s1} + r_{s2} + r_{D1} + r_{D2}) + [e/(R_1 + R_2)]\,(r_{s1} + r_{s2}) \quad .. \quad (1)$$

Where v_{OC1} and v_{OC2} are the open-circuit peak-to-peak voltages from the clamp-pulse generator, $[e/(R_1 + R_2)]\,(t_1/t_2)\,(r_{s1} + r_{s2} + r_{D1} + r_{D2})$ = voltage lost during t_2 in generator and diode resistance and $[e/(R_1 + R_2)](r_{s1} + r_{s2})$ = voltage lost in generator resistance during t_1. Now let

$$(t_1/t_2)(r_{s1} + r_{s2} + r_{D1} + r_{D2}) + r_{s1} + r_{s2} = a$$

when Eqn. 1 becomes

$$v_{OC1} + v_{OC2} = e + e.a/(R_1 + R_2) \quad .. \quad .. \quad (2)$$

Let $e = e_1 + e_2$ where e_1 = voltage across R_1 during t_1 and e_2 = voltage across R_2 during t_1, then

$$e/(R_1 + R_2) = e_1/R_1 = e_2/R_2$$

and $e_2 = e_1.R_2/R_1$.

Substituting in Eqn. 2,

$$v_{OC1}+v_{OC2} = e_1+e_2+e_1.a/R_1 = e_1[1+((R_2+a)/R_1)]$$

and $e_1 = (v_{OC1} + v_{OC2})/[1 + ((R_2 + a)/R_1)] \quad .. \quad (3)$

Similarly it may be shown that

$$e_2 = (v_{OC1} + v_{OC2})/[1 + ((R_1 + a)/R_2)] \quad .. \quad .. \quad (4)$$

From Fig. 9 (which shows how the output is clamped by the overlapping clamp pulses) the voltage v_{out}, between the output and earth, may be calculated by summation of the voltages as follows:—

$$v_{out} = -e_1 - (v_{rs1} \text{ during } t_1) + v_{OC1} - (v_{rs1} + v_{rD1} \text{ during } t_2)$$

where v_{rs1} = voltage across r_{s1} and v_{rD1} = voltage across r_{D1}

$$= -e_1 - (e_1 r_{s1}/R_1) + v_{OC1} - (e_1 t_1/R_1 t_2) \times (r_{s1} + r_{D1})$$

substituting from Eqn. 3 for e_1 and manipulating slightly

$$v_{out} = v_{OC1} - [(v_{OC1} + v_{OC2})/(R_1 + R_2 + a)]\,[R_1 + r_{s1} + (t_1/t_2)\,(r_{s1} + r_{D1})] \quad .. \quad (5)$$

Similarly substituting from Eqn. 4 for e_2, it may be shown that

$$v_{out} = -v_{OC2} + [(v_{OC1} + v_{OC2})/(R_1 + R_2 + a)]\,[R_2 + r_{s2} + (t_1/t_2)\,(r_{s2} + r_{D2})] \quad .. \quad (6)$$

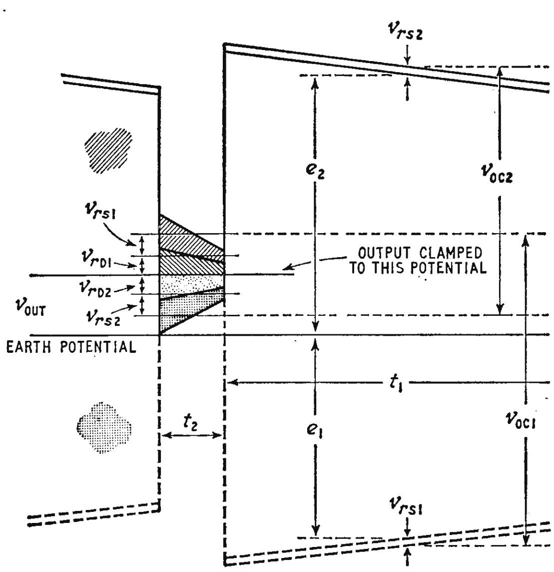


Fig. 9. Illustration of calculation of clamping potential with two-diode clamp switch.

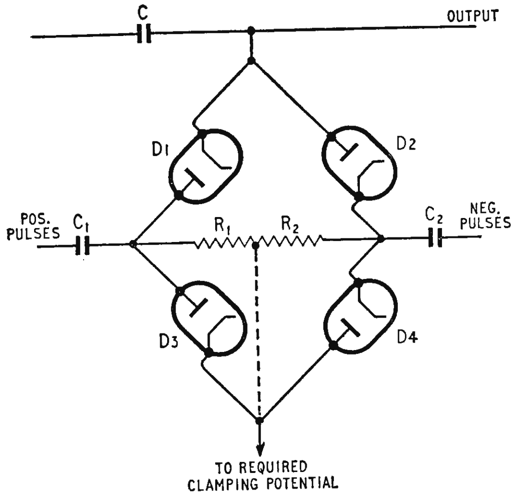


Fig. 10. Four-diode clamp switch. Dotted connection may be omitted.

These two expressions will obviously give the same result and thereby provide a convenient and useful check in calculation.

Example:—

Let $R_1 = 110\text{k}\Omega$, $R_2 = 90\text{k}\Omega$, $r_{s1} = 1.5\text{k}\Omega$, $r_{s2} = 2.5\text{k}\Omega$,

$r_{D1} = 300\Omega$, $r_{D2} = 700\Omega$,
$v_{OC1} = 30\text{V}$ peak-to-peak,
$v_{OC2} = 20\text{V}$ peak-to-peak,
$t_1 = 94\mu\text{sec}$, $t_2 = 4.7\mu\text{sec}$
(Note: $t_1 + t_2 = 98.7\mu\text{sec}$ = total line period)

$t_1/t_2 = 94/4.7 = 20/1.$

$$a = 20(1{,}500 + 2{,}500 + 300 + 700) + 1{,}500 + 2{,}500$$
$$= 104{,}000.$$
$$v_{out} = 30 - (50/304{,}000)(110{,}000 + 1{,}500 + 36{,}000)$$
$$= 30 - 24.26$$
$$= +5.74\text{V}.$$

Check using expression (6).

$$v_{out} = -20 + (50/304{,}000)\ (90{,}000 + 2{,}500 + 64{,}000)$$
$$= -20 + 25.74$$
$$= +5.74\text{V}.$$

These results indicate the dependence of v_{out} on the balance of circuit values, component values and clamp pulse amplitudes.

The simple clamp switch described has the very important facility of providing a positive or negative value for v_{out} and this in some circumstances may obviate the necessity for either a positive bias potentiometer or a negative supply to ensure the required potential for the grid of the following stage.

This adjustment of v_{out} (either preset or variable) is often obtained by varying the effective ratio of R_1 and R_2, by interposing a potentiometer between these two resistors, with the variable connection earthed (or taken to a further potential—fixed or variable as desired).

Another method, particularly useful in automatic blanking-level control circuits, is to vary the ratio of clamp-pulse amplitudes.

In some cases unwanted changes of v_{out} may be caused by inadvertent variations of the ratios mentioned and may represent a severe disadvantage of the simple two-diode clamp switch. For example hum may be clamped in if the ratio of clamp-pulse amplitudes varies at hum frequency.

Effective Clamp-switch Resistance

Another aspect to be considered is the effective clamp-switch resistance during clamping time. When the charge on the coupling capacitor C is to be increased the output point becomes slightly positive with a resultant increase of current through D2, C_2, and r_{s2}, and a decrease of current through D1, C_1 and r_{s1}. Similarly when capacitor C is discharged the output point becomes slightly

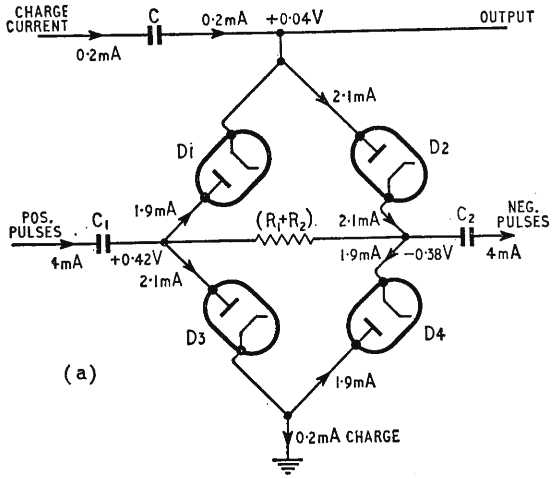


Fig. 11. Mean voltage and current values when C is charging

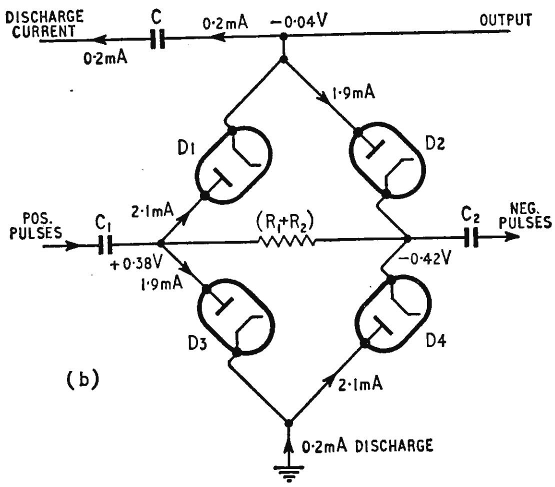


Fig. 12. Mean voltages and currents when C is discharging.

negative and the current through D1, C_1 and r_{s1} increases whilst that through D2, C_2 and r_{s2} decreases. Thus the two branches of the clamp switch are in parallel and its effective mean resistance is $(r_{D1} + r_{s1})$ in parallel with $(r_{D2} + r_{s2})$.

R_1 and R_2 are ignored because their values are large in comparison with r_{s1} and r_{s2} and C_1 and C_2 need not be considered in the calculations because mean values of current and voltage have been used (not peak values). Provided C_1 and C_2 are nearly equal in value (variations of $\pm 20\%$ would be hardly noticeable) and many times greater than the coupling capacitor C, it is unnecessary to take them into account.

Using the values given for the previous example:— $r_{s1} = 1.5\text{k}\Omega$, $r_{s2} = 2.5\text{k}\Omega$, $r_{D1} = 300\,\Omega$, $r_{D2} = 700\,\Omega$, effective mean resistance during clamping time $= (1{,}800 \times 3{,}200)/(1{,}800 + 3{,}200) = 1{,}152\,\Omega$. This value of switch resistance may be excessive if very firm clamping action is required.

Four-diode Switch

Some of the disadvantages of the two-diode clamp switch may be avoided by using a four-diode circuit as shown in Fig. 10. It may be necessary to increase the available clamp-pulse current to ensure that all diodes are driven well into conduction (ensuring low forward resistance) but the simple addition of two diodes D3 and D4 reduces the clamp-switch resistance and renders the clamped potential v_{out} substantially independent of the ratios of clamp-pulse amplitudes, r_{s1} and r_{s2} and also of R_1 and R_2.

The effective clamp-switch resistance is reduced because r_{s1} and r_{s2} are shunted by r_{D3} and r_{D4} respectively, in fact the resistance is approximately $(r_{D1} + r_{D3})$ in parallel with $(r_{D2} + r_{D4})$.

The required clamping potential (which may be earth potential) must be supplied from a low-impedance source for the circuit to be fully effective.

During clamping time, in the absence of correction current charging or discharging the coupling capacitor C, all diode currents will be equal (assuming equal diode resistances). Any correction current flowing into or out of C unbalances these currents as shown in Figs. 11 and 12. In these examples the diodes have mean resistances of $200\,\Omega$ each (when conducting) and the mean correction current is 0.2mA. r_{s1} and r_{s2} are assumed to be high in value compared with the diode resistances and the mean conduction current is 4.0mA.

Design Features

With both two-diode and four-diode clamp switches transient breakthrough will occur, producing "whiskers" on the video waveform, if the pulses are slightly dissimilar in width or shape at the tips, if the stray capacitances of the switch circuit are unbalanced, or if the output impedances of the clamp pulse generator are dissimilar. (When a diode is conducting its chief feature is its low resistance but when it is non-conducting it behaves as if it were a small capacitor.)

Failure of the diodes to conduct simultaneously (due to the asymmetries mentioned) results in the edges of the clamp pulses becoming differentiated through the capacitance of a diode just before it conducts, thus producing the whiskers.

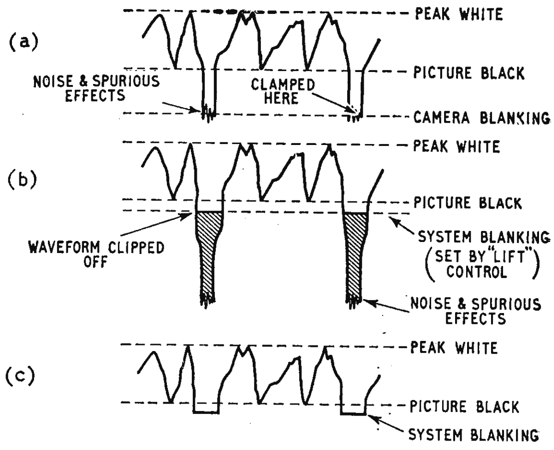


Fig. 13. Television waveforms from camera, before sync is added, showing how clamping assists the processing of a signal by holding it steady, so enabling system blanking to be inserted at a constant level. (a) Raw camera signal clamped at camera-blanking level. (b) System blanking added to push camera blanking, noise and spurious signals below clipping level. (c) Waveform after clipping: further clamping may be carried out within period to be filled by later addition of syncs; but after syncs are added clamping usually takes place during back porch.

This effect may be reduced by connecting a small differential capacitor across R_1 and R_2, with the rotor earthed, to equalize the stray capacitances. The adjustment is made for minimum breakthrough (as observed on an oscilloscope) with clamp pulses acting but with no video signal applied to the stage. Of course, when the clamp is actually correcting blanking level slight distortion of the waveform (as shown in Fig. 6) is inevitable.

The effectiveness of clamping is greatly affected by the extent and nature of noise in the reference period. To reduce the ill effects (e.g. line flashing and streaking) of clamping on peaks of noise or spurious signal it may be necessary to reduce the firmness of the clamp action ("soften" the clamp) by increasing the charge and discharge time constant in which the clamp switch resistance, the coupling capacitor and the output impedance of the previous stage are all involved.

A useful method of softening the clamp is to replace the connection between the output point and the junction of D1 and D2 with a resistance of an appropriate value (usually several thousands of ohms). This resistance serves a secondary purpose of partially isolating the stray capacitance of the switch from the video path thereby increasing the gain-bandwidth product.

In colour television, clamp circuits which handle the complete signal must be softened in a special way to avoid (a) variations of line level due to clamping on the sub-carrier burst in the back porch, and, more important, (b) distorting the sub-carrier burst by clamping on it, and so providing an inaccurate colour sync for colour receivers. One method is to connect an inductance between the output point and the junction of D1 and D2, which, in conjunction with its self-capacitance and a parallel damping resistance, inserts a high impedance at the sub-

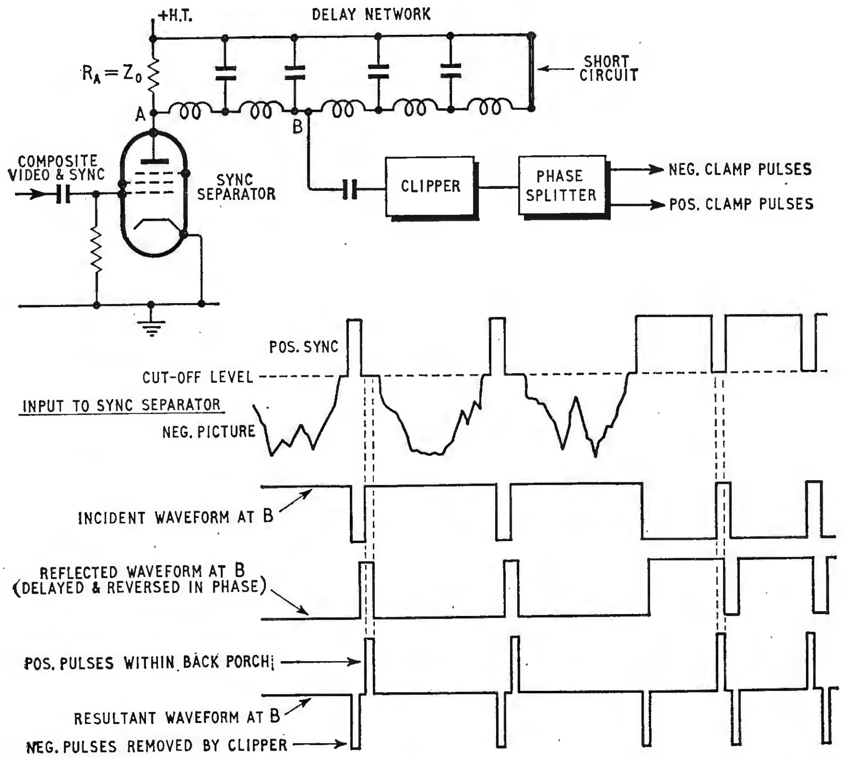


Fig. 14. Clamp-pulse generation using a tapped delay network in anode circuit of sync separator. First waveform is input to sync separator and appears as inverted sync pulses at separator anode, which appear slightly delayed at point B. Short circuit at end of line causes phase reversal so that further delayed reflected waveform adds to original at B to produce narrow spikes within back-porch interval.

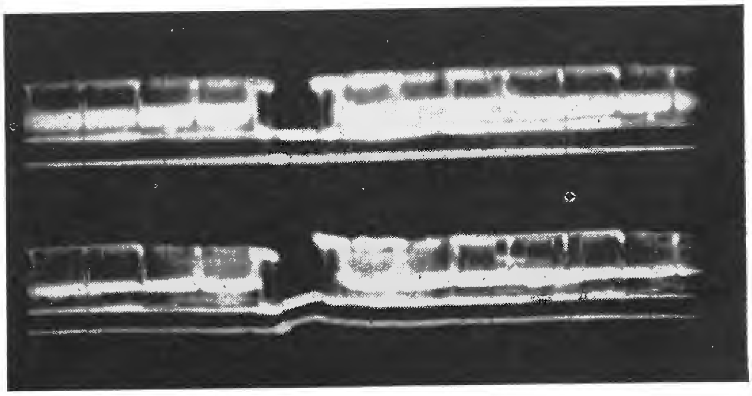


Fig. 15. Upper trace, after clamping: lower trace, before clamping, showing low-frequency distortion.

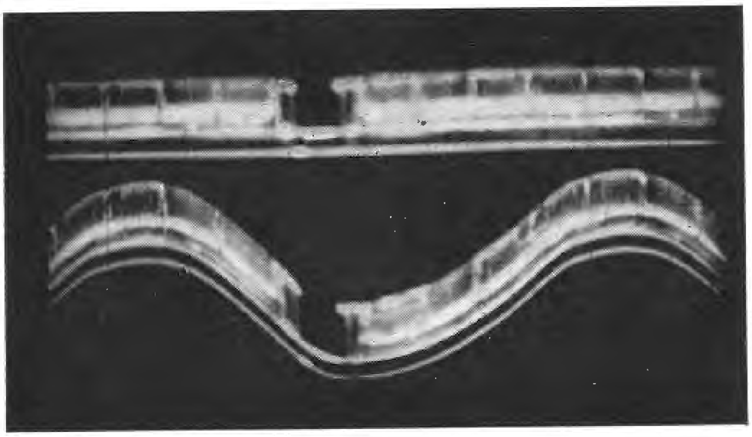


Fig. 16. Upper trace, after clamping: lower trace, before clamping, showing hum.

carrier frequency in series with the switch. The Q of this parallel circuit must be sufficiently low to avoid ringing (which would mar the signal) produced by the action of the switch.

The timing and duration of clamping is very important. The raw signal from a television camera contains camera line- and field-blanking periods of 8μsec and 400μsec respectively, in the 405-line system. It is common practice to clamp at line frequency for about 2μsec within these periods, which can contain spurious noise signals.

A short clamping time is chosen to avoid the need for great precision of pulse timing in circuits with unequalised delays and to reduce the firmness of the clamp (in addition to the method described).

Having held the reference levels of the video signal steady by clamping, system line- and field-blanking (18μsec and 1400μsec respectively in the 405-line system) is now applied, with an adjustment of its relationship to picture black by means of a control which is variously termed "lift," "pedestal," "set-up" or "black level" (see Fig. 13).

With system blanking present in the waveform, clamping may be carried out at line frequency and is timed to lie within the periods later to be occupied by syncs (as distinct from the back porch) so that any whiskers produced will appear at the bottom of the syncs (when they are inserted) and may be removed by clipping. The duration of the clamp pulses may be increased to five or six microseconds—generally not more, otherwise an increase in precision becomes necessary—and the firmness (or "hardness") may be increased as required.

In both the cases quoted the video signals are without syncs (but with camera blanking or with system blanking) and must be clamped with pulses derived from a synchronous source (usually from the line drive).

With composite video signals, i.e. with line and field syncs, clamping occurs at blanking level in the back porch and after every trailing edge in the field sync, therefore clamp pulses must be derived from the separated sync waveform and not from line drive—even if it were available—otherwise severe distortion of the field sync would occur due to sync level being raised to blanking level.

The peak-to-peak amplitude of a video signal will generally be not less than about one volt at a clamped stage, otherwise whiskers and transients may be significant in comparison. It is essential that the video signal should not drive the diodes into conduction otherwise severe differentiation will occur due to the small value of the resultant time constant of the video coupling when the output point has a low-resistance path to earth. Therefore, to ensure that the d.c. restored clamp pulses hold the diodes in a state of non-conduction during active line time, in spite of major changes of blanking levels due to surges etc., the amplitude of the pulses should be several times greater than the video signal. This represents a difficulty in the case of clamping (as opposed to d.c. restoration) in receivers.

If clamp pulses are derived from line flybacks, they will be at line frequency and therefore unsuitable for reasons before mentioned unless totally suppressed by some means during field syncs; also the time constants C_1 R_1 and C_2 R_2 must be sufficiently long otherwise the diodes will not be biased into non-conduction during this time.

Clamp pulses may be easily derived from the separated sync waveform. The usual method is to use a short-circuited tapped delay network in the anode circuit of the sync-separator valve followed by a clipper and phase splitter as shown in Fig. 14.

The clamp pulses should be free from impulsive noise, of constant mark-space ratio and reasonably well shaped at the tips. Provided the pulses are symmetrical and of sufficient amplitude, the waveshape during non-conducting periods may be surprisingly poor without ill effect, but hum and low-frequency disturbances which are unbalanced (i.e. are not complementary on the two sets of pulses) will imprint their defects on the video signal.

Effectiveness of Clamping

Clamping greatly attenuates effects due to hum, l.f. microphony, h.t. surges, gain-control d.c. changes, switching, fading, mixing and cutting (in the control of programmes), l.f. distortion and all disturbances reasonably below line frequency, provided the signal is not actually modulated by these effects. For example, the superimposed component of hum due to the use of a.c. for television lighting is greatly reduced.

In television transmission the amplifiers following the insertion of the line-frequency reference periods need not respond fully to lower frequencies: low frequency distortion, which causes a variation of blanking level, is largely corrected by clamping provided any circuits used are not overloaded and will accommodate the video-signal amplitude without modulation of the signal due to non-linearity.

In addition to a residue of distortion or hum remaining after clamping, as shown in Fig. 6, there is also the uncorrected portion of distortion or hum which occurs during each line time. For example, assuming a perfect clamping action, with 50-c/s hum, the line coincident with the region of greatest rate of change in the hum cycle will be shaded (i.e. will vary in amplitude) to the extent of $v_{hum} \sin(360°/202.5)$ V (v_{hum} = peak hum voltage). The other lines will be shaded to a varying lesser degree until at the peak of the hum cycle the shading will be negligible, assuming linear circuits.

Figs. 15 and 16 are photographs of field waveforms displayed on a double beam oscilloscope, showing the degree of correction, obtainable by clamping, of low frequency distortion and hum.

The four-diode switch circuit may be used for sampling as well as clamping. The coupling capacitor C is increased in value and the junction of D3 and D4 is taken to earth through a capacitor, whose charge will then vary with the level existing in the signal at the times during which the switch is closed. If normal clamp pulses are used, the voltage which appears across the capacitor may be amplified and used as negative feedback to an earlier stage (or a video side chain) to reduce blanking level variations. A resistance across the capacitor provides a suitable discharge time constant.

The circuits described throughout this discussion have been used in television transmission for many years and the author is not aware of their origin but would like to emphasize that he is not responsible for their design.

The author would like to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

WORLD OF WIRELESS

Project OSCAR

BY the time this note appears in print OSCAR—Orbiting Satellite Carrying Amateur Radio—will have been in orbit a fortnight. The 10lb satellite, which is sponsored by the American Radio Relay League, was launched from a Discoverer rocket on December 12th. It carries a 0.1 watt c.w. transmitter which operates on 145Mc/s and is keyed with the morse letters HI; information from the satellite being transmitted by variations in the number of HIs sent in ten seconds.

The main object of the exercise is "to arouse amateur interest in the new age of space communications" and to enable amateurs throughout the world to submit reception reports from which it is hoped to obtain useful information on propagation, Doppler shift, etc.

The co-ordinator for U.K. participation is W. H. Allen (G2UJ) of 24 Arundel Road, Tunbridge Wells, Kent, from whom further details are obtainable. Enquirers are asked to send a stamped addressed envelope.

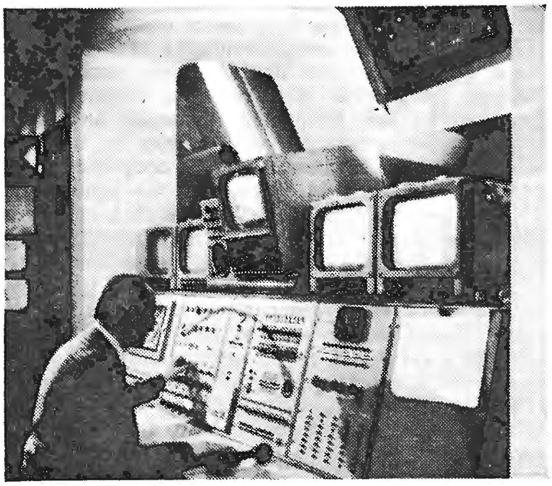
BMEWS

THE training of staff for the installation and operation of the Fylingdales centre of the Ballistic Missile Early Warning System has been entrusted to RCA Great Britain who have established a school for the purpose at their Sunbury-on-Thames headquarters.

In all nearly 400 technicians will be required to man the station, which is the third in the BMEWS network; the others being in Greenland and Alaska.

The training manager of the school is Wing Cdr. F. C. Lowe, who was until recently the head of the Air Ministry's Radio Training Branch. He has a staff of 22 instructors, recruited from industry and research establishments, who recently returned from the U.S.A. where they underwent 13 months' training. The two leading instructors are G. G. Boyt, formerly with International Computers and Tabulators, and R. G. Morris, formerly with the Electrical Research Association.

Some 30 different courses, ranging from one month to nine months' duration and covering advanced radar, data processing and high-speed computer technology and associated maintenance, are planned.



I.T.N. Re-equipped.*—Control desk in the central apparatus room of the rebuilt suite of Independent Television News at Television House, London, W.C.2. The desk provides control facilities for vision and sound circuits, sync pulses and intercom. The illuminated panel above the desk gives a visual picture of the various video sources and destinations.*

Satellite Communications.—A Study Group of the Conference of European Postal and Telecommunication Administrations had a three-day meeting in London at the end of November to consider various problems that might arise in the field of telecommunications via artificial earth satellites. It was attended by representatives from twelve European countries and Capt. C. F. Booth, of the G.P.O., was chairman. The U.K. delegation comprised J. T. Baldry, W. J. Bray, J. W. Grady and J. E. Golothan.

Space Communications Project.—An active repeater communication satellite to be launched later in 1962 by the U.S.A. authorities will enable tests to be conducted on television transmissions and two-way speech communication between Goonhilly Down, Cornwall, and the American station at Rumford, Maine. S.T.C. are to supply the G.P.O. with a transmitter, which will be installed in a room built into the 85ft diameter steerable aerial now being erected at Goonhilly Down. The transmitter will operate in the region of 2,000Mc/s, and will deliver a f.m. output of 10kW.

Pay TV.—A permanent three-programme pay-television demonstration has been mounted by British Telemeter Home Viewing at its new headquarters at 1 Albemarle Street, London, W.1. For the demonstration a film is transmitted over a microwave link from Highgate, a second film from telecine equipment in the building and the third "service", consisting of street scenes over a closed-circuit link, is a "free" programme. With the standard domestic receivers used for the demonstration the B.B.C. and I.T.A. transmissions are also receivable.

Scientific Research in Schools.—Over sixty separate scientific investigations are being administered by the Royal Society's Committee on Scientific Research in Schools. Recent or current research projects in the radio field include "The measurements of ionospheric drifts" at the County Secondary School, Tregaran, Cardiganshire; "Whistler atmospherics" at Ipswich School, Suffolk; and "Radio astronomy" at Westminster School, London. The Committee looks forward both to receiving further requests from science teachers, and to the continued support of the Fellows of the Royal Society and others, in acting as advisers and assistants in the extension of its activities.

Dip. Tech.—The first students to receive the Diploma in Technology after taking a specialist electronics course are included in the latest list of passes issued by the National Council for Technological Awards. They are nine students from the Northern Polytechnic, London, who completed a 4-year sandwich course in the physics and technology of electronics, and are, incidentally, the first "Northern" students to receive the award. The recipients are: A. R. Lee (first class honours), G. Pye, W. K. Chapman, K. Piper, D. G. Wells and D. A. Partridge, all of S.T.C.; and E. B. Castling, D. M. Horley and B. Raine of Thorn Electrical Industries. The total number of Dip. Tech. awards is now 685 including 10 to women.

R.S.G.B.—For the fifth successive year the Radio Society of Great Britain records an increase in its membership. The total at the end of June was 10,644, compared with 10,036 the year before. Of this number 5,558 held U.K. amateur transmitting licences; approximately 54% of this country's total of 10,237 licence holders. The total number of licences includes 83 amateur television transmitters.

Electronic Aids to Banking is the subject of a symposium, which is being organized by the Institution of Electrical Engineers, to be held at Savoy Place, London, W.C.2, on January 17th and 18th. Object of the symposium is to bring together bankers and designers of electronic data handling machines so that problems, users' needs and latest developments can be discussed.

Time Signals transmitted by GBR, Rugby, on 16kc/s are now radiated four times a day instead of twice as in the past. Since December 1st the signals, which are provided by the Royal Greenwich Observatory, are transmitted at 0300, 0900, 1500 and 2100 GMT. The 0900 and 2100 signals are also radiated by the following short-wave transmitters GAY25, 5807kc/s; GPB30, 10332.5kc/s and GIC37, 17685kc/s.

West Indies TV.—The Trinidad government has granted a licence to operate the West Indies' first television station to a new company, Trinidad and Tobago Television Service Ltd., in which the majority shareholding is held jointly by Rediffusion and Scottish Television. The Columbia Broadcasting System of America is also a shareholder. The service, which is planned to start in November 1962, will include commercial programmes.

Immediate task of the South African Broadcasting Corporation is to complete its v.h.f. sound broadcasting network to give a 17-hour-a-day service in nine languages—English, Afrikaans and seven Bantu dialects. Although there are no plans for the introduction, in the near future, of a television service (as reported in the last issue), the masts for the v.h.f. system could accommodate TV aerials "if and when" television commenced in South Africa.

Amsterdam Firato.—The organizers of the Amsterdam international radio show have advised us that there will not be an exhibition this year. The next Firato will be in 1963.

Television For Singapore.—According to the Finance Minister, Dr. Goh Keng Swee, Singapore can expect to have a television service by the end of 1962, as plans for its inauguration have reached an advanced stage.

Radar weather forecasts are available by telephone to farms in central Sweden from Arlanda, Stockholm's new international airport. The forecasts cover 9 hours a day, from 1 p.m. to 10 p.m. This weather radar installation is the first and only one in private use in Sweden.

Worldwide Broadcasting Services is the title adopted for a new company set up jointly by E.M.I. and Pearl & Dean, the advertising specialists, to provide sound and/or television broadcasting services—equipment, staff and programme material—anywhere in the world but especially in the "emergent countries". The managing director of the company, which has its headquarters at 33 Dover Street, London, W.1, is A. J. Mathers who was for ten years with Overseas Rediffusion and was responsible for the "physical establishment, administration and operation" of television in Western Nigeria.

B.E.A.M.A. Directory.—Prepared and published by the British Electrical & Allied Manufacturers' Association in its golden jubilee year, the first edition of a new B.E.A.M.A. Directory, lists more than 1,000 different electrical and allied products made in Britain by member firms and includes a reference section in German, Spanish, French, Portuguese and Russian. More than 15,000 copies are being distributed to buyers all over the world. Copies are available from the Association at 36 Kingsway, London, W.C.2, price £3 (10 dollars) each.

E.I.B.A. Year Book.—The 1961 edition of the Year Book of the Electrical Industries Benevolent Association, now published, shows that 1,166 people applied to it for help during the year—an increase of 8% on the previous year. Income went up by only 6%, and the Association emphasizes the need for still further income in order to finance the extension which is being made to Broome Park, its home in Surrey for old people. The year's donors include the B.B.C., B.R.E.M.A., B.V.A., R.E.C.M.F., R.T.R.A., the Radio Industries Club and many radio and electronics manufacturers.

F.B.I. Register 1962.—A comprehensive guide to a substantial cross section of U.K. industry, the "F.B.I. Register of British Manufacturers—1962," contains lists of the products and services of over 8,000 member firms together with information on trade associations, trade marks, etc. There are French, German and Spanish glossaries. Published for the F.B.I. by Kelly's Directories Ltd. and Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1, at 50s, post free.

Euradio, a federation of European radio and TV retailers with headquarters in Copenhagen, Denmark, has been formed. Its aim is to promote an intensive exchange of trade and business information between member countries, which include Denmark, Sweden, Holland, France, Austria and West Germany. At present the U.K. is not represented though the Radio and Television Retailers' Association is understood to have the question of participation under review.

Marconi Historical Exhibition, commemorating the diamond jubilee of the first transatlantic wireless signal, is being held at the Science Museum, South Kensington, London, from December 13th to January 25th.

WHAT THEY SAY

All-Industry Committee.—"These are difficult times for the radio and television retailer. One of the things that is so worrying is that the Government has seen fit to reduce the initial payment for television rentals, but has not done the same in the hire-purchase field. . . . This discrimination is both unfair and unjust. We, in the industry, intend to tackle this for the first time by forming a committee, representing all sections—manufacturers, wholesalers, retailers, co-ops.—which can speak with one voice and whose purpose will be to examine problems of this kind and find the best solution."—*R. J. Piercy, president of the Radio & Television Retailers' Association, speaking at the annual dinner of the Association's Birmingham Centre.*

Personalities

Sir Edward Appleton, F.R.S., principal and vice-chancellor University of Edinburgh, is to receive the 1962 Medal of Honour of the Institute of Radio Engineers "for his distinguished pioneer work in investigating the ionosphere by means of radio waves." The medal, which is the Institute's highest annual technical award, will be presented at the I.R.E. International Convention in New York City on March 28th. Sir Edward, who is 69 and has been at Edinburgh University since 1949, was secretary of the Department of Scientific and Industrial Research for 10 years from 1939, prior to which he was for three years Jacksonian Professor of Natural Philosophy at Cambridge University.

W. A. S. Butement, C.B.E., B.Sc., D.Sc. (Adelaide), who was a member of Sir Robert Watson-Watts' original radar team and is now chief scientist in the Australian Department of Supply, has been elected a Fellow of the Institution of Radio Engineers (Australia). When appointed chief scientist in 1949, at the age of 45, he was also given executive charge of what is now known as the Australian Defence Scientific Service, which includes the Woomera Range. Dr. Butement, who during the latter part of the war was Assistant Director of Scientific Research in the U.K. Ministry of Supply, received an award from the Government for "his contribution to the development of radar installations" which included the "split" method of d.f. and a fire control system using echoes from shell splashes.

Dr. F. C. Williams, C.B.E., F.R.S., Professor of Electrical Engineering in the University of Manchester, has been elected a member of the Council of the Royal Society. He was a lecturer at Manchester University before the war and after seven years in the Scientific Civil Service, he returned to the University in 1947 as professor of electrotechnics and director of the electrotechnical laboratories. During the war Professor Williams was concerned with radar circuitry and in recognition of his work on the development of I.F.F. (Identification, Friend or Foe) he recently received the American John Scott award.

C. W. Sowton, O.B.E., M.Sc., A.C.G.I., A.M.I.E.E., was recently appointed staff engineer in the Overseas Radio Planning and Provision Branch of the G.P.O. Since 1951 he has been concerned with the technical aspects of the sound and television broadcasting services in this country and especially on questions of frequency allocation. He has served on many national and international radio committees and is secretary of the technical sub-committee of the Television Advisory Committee. Mr. Sowton's most recent assignment was as U.K. representative on the panel of experts appointed by the Geneva conference to investigate ways of relieving pressure in the h.f. band.

R. L. Higgin, A.M.I.E.E., who joined the Plessey Company in March, 1959, as group commercial executive of the Components Group, has been appointed general manager of the group which operates factories at Ilford, Towcester, Sheffield and Havant.

Patrick E. Haggerty, president and director of Texas Instruments Inc., whose U.K. associates are Texas Instruments Ltd., has been elected president for 1962 of the Institute of Radio Engineers, which has a membership of 93,000. He succeeds **Lloyd V. Berkner,** who is president of the Graduate Research Center of the Southwest, Dallas, Texas.

L. D. Kreps recently joined Telequipment as chief development engineer. He had previously been engaged on oscilloscope development with E.M.I. Electronics and Marconi Instruments.

D. A. Bell, M.A., B.Sc., Ph.D., M.I.E.E., for the past 12 years on the teaching staff of the University of Birmingham, has been appointed director of the recently established research laboratory set up at Blounts Court, Sonning Common, Reading, by AMF Ltd., the U.K. subsidiary of American Machine & Foundry Company, which has a wide range of interests in applied physics, chemistry, electronics and automation. Dr. Bell, who has frequently contributed to *Wireless World* and our sister journal *Electronic Technology,* is a graduate of Oxford University and received his Ph.D. degree from Birmingham University for work on fluctuations of electric current in conductors and semiconductors. He was with Cossors for some years until 1946, when he joined British Telecommunications Research Ltd., where he stayed until 1949 when he was appointed lecturer in electrical engineering at Birmingham. He subsequently became supervisor of graduate courses in information theory.

Dr. D. A. Bell

K. G. Huntley

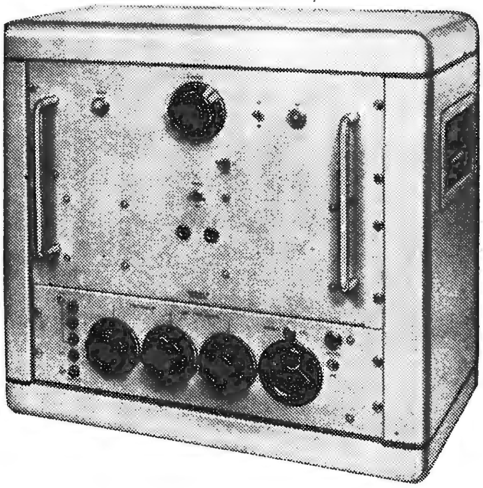
Keith G. Huntley has joined Adrema Ltd., as chief electronics engineer and will be responsible for the formation of a Data Processing Division at the Company's new factory at Cosham, Portsmouth. After war service with the Royal Signals as a Wireless Officer he joined E.M.I. Research Laboratories in 1947 and was associated with the development of television studio equipment and classified projects for the Admiralty. Since 1956, Mr. Huntley, who is 38, has been chief electronics engineer to Rank Precision Industries.

D. L. Oldroyd, B.Sc., Ph.D., recently apointed Head of the Research Division of Ampex Electronics Ltd., at Reading, Berkshire, will direct research programmes in data storage and retrieval. After graduating from the University of Glasgow with a B.Sc. degree in physics, Dr. Oldroyd joined the Post Office Research Station at Dollis Hill. During the war he was at the Telecommunications Research Establishment. In 1948 he returned to the Physics Department of the University of Glasgow as a research student and Fellow. He obtained his Ph.D. degree there before leaving in 1955 to join CERN (the European Organization for Nuclear Research). Since 1959 he has been with the U.K.A.E.A.

Harold D. Garland has joined Magnavox Electronics Ltd. as chief engineer with responsibility also for design. After an apprenticeship with Peto Scott, followed by service with R.E.M.E., he joined the Ferguson Radio Corporation. In 1953 he was appointed chief radio and audio engineer by Philco (Overseas) Ltd. After Philco were absorbed into the Thorn Group, he was appointed chief export radio engineer to the group. He is 35.

Vortexion quality equipment

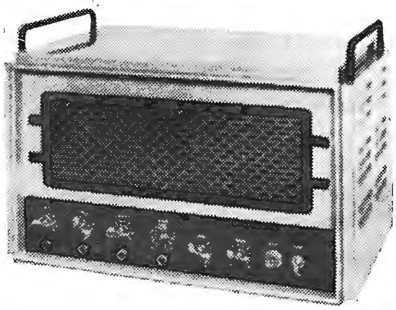
120/200 WATT AMPLIFIER



Will deliver 120 watts continuous signal and over 200 watts peak Audio. It is completely stable with any type of load and may be used to drive motors or other devices to over 120 watts at frequencies from 20,000 down to 30 cps in standard form or other frequencies to order. The distortion is less than 0.2% and the noise level —95 dB. A floating series parallel output is provided for 100-120 V. or 200-250 V. and this cool running amplifier occupies 12¼ inches of standard rack space by 11 inches deep. Weight 60lb.

30/50 WATT AMPLIFIER

Gives 30 watts continuous signal and 50 watts peak Audio. With voice coil feedback distortion is under 0.1% and when arranged for tertiary feedback and 100 volt line it is under 0.15%. The hum and noise is better than —85 dB referred to 30 watt.



It is available in our standard steel case with Baxendale tone controls and up to 4 mixed inputs, which may be balanced line 30 ohm microphones or equalised P.U.s to choice.

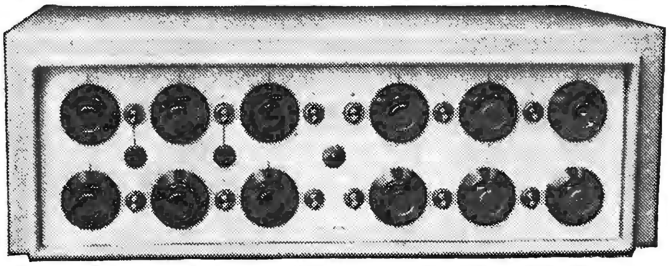
ELECTRONIC MIXER/AMPLIFIER

This high fidelity 10/15 watt Ultra Linear Amplifier has a built-in mixer and Baxendale tone controls. The standard model has 4 inputs, two for balanced 30 ohm microphones, one for pick-up C.C.I.R. compensated and one for tape or radio input. Alternative or additional inputs are available to special order. A feed direct out from the mixer is standard and output impedances of 4-8-16 ohms or 100 volt line are to choice. All inputs and outputs are at the rear and it has been designed for cool continuous operation either on 19 x 7in. rack panel form or in standard ventilated steel case.

Size 18 x 7½ x 9½in. deep.

Price of standard model **£49.**

12-WAY ELECTRONIC MIXER



The 12-way electronic mixer has facilities for mixing 12 balanced line microphones. Each of the 12 lines has its own potted mumetal shielded microphone transformer and input valve, each control is hermetically sealed. Muting switches are normally fitted on each channel and the unit is fed from its own mumetal shielded mains transformer and metal rectifier.

Also 3-way mixers and Peak Programme Meters. 4-way mixers and 2 x 5-way stereo mixers with outputs for echo chambers, etc. Details on request.

Full details and prices of the above on request

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3 **Telegrams: "Vortexion, Wimble, London"**

DON'T CUT THE TOP OFF

A tape recorder is only as good as its microphone. If you cut a top note off in the mike, you can't blame the recorder if the note isn't there. If there's distortion at the start, there'll be a din in the end. Give your recorder a fair chance. Give it a balanced, wide-frequency input. Give it a good microphone. Give it an Acos microphone.

USE AN ACOS MICROPHONE

MIC 39

A crystal hand microphone of exceptionally attractive appearance. Extended frequency response; noise-free cable and die-cast liner to minimise hum and ensure excellent signal-to-noise ratio. Available with table-stands and floor stand adaptor. U.K. Retail price 3 gns. Other Acos microphones include the famous fold-away MIC 40 (35/-) the MIC 28 Lapel Microphone (50/-) and a superb new stereo microphone (£6.6.0)

Acos microphones are standard equipment with most British high-quality tape recorders.

acos ARE also DOING THINGS IN STYLI

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News from Industry

H.M.V. Distribution Change.—Record players and tape recorders bearing the trade marks "His Master's Voice" and Marconiphone are now solely distributed by the British Radio Corporation, following a revised agreement between Electric & Musical Industries Ltd. and Thorn Electrical Industries Ltd. B.R.C. was created under an agreement whereby E.M.I. ceased direct manufacture of television and radio sets, but has subsequently made sound-reproducing equipment. This revised arrangement means that B.R.C. now handle, in Great Britain and Northern Ireland, all domestic sound products, including TV, radio and radio-grams, carrying these two brand names. E.M.I. announce that their domestic sound products and components will continue to be available, mainly under the E.M.I. trade mark, for the home and export markets. The present E.M.I. range which includes the Glyndebourne Mk. IV Stereogram, a range of record players, the Voicemaster 65A tape recorder, and the EPU 100 pickup, will continue to be made and sold by E.M.I. under marks other than H.M.V. and Marconiphone.

Hewlett-Packard, the American manufacturer of precision electronic instruments, has formed a British subsidiary company, Hewlett-Packard Ltd., with factory premises at Dallas Road, Bedford. Initial emphasis at the plant will be on manufacturing a range of counting and measuring instruments, but new products will be developed in the near future, it is stated. U.K. selling agents for the new company are Livingston Laboratories Ltd., 31 Camden Road, London, N.W.1 (Tel.: Gulliver 8501), who are also sole representatives for the whole range of imported Hewlett-Packard instruments.

Hellermann-Deutsch Link.—The Connectors Division of Hellermann Ltd. is being absorbed into a new company—Hellermann Deutsch Ltd.—which has been set up jointly by Bowthorpe Holdings Ltd. (parent of Hellermann) and the Deutsch Company, of Banning, California. Bowthorpe have a 51% interest. A new factory is to be built at East Grinstead, Sussex, where both Hellermann and Deutsch connectors will be produced. Enquiries should temporarily be addressed to the new company at Gatwick Road, Crawley, Sussex.

Walter Instruments Ltd., the tape recorder and component manufacturers of Garth Road, Morden, Surrey, have gone into voluntary liquidation. A statement of affairs lists liabilities amounting to £256,292 and assets estimated to produce £120,446. At a recent meeting of creditors C. E. M. Emmerson, of 28 King Street, London, E.C.2, and H. W. Pitt, of 100 Park Street, London, W.1, were appointed joint liquidators. Walter Headquarters Service Centre Ltd., 154 Merton Hall Road, London, S.W.9, is a new company formed to provide servicing facilities for existing Walter tape recorders. Stocks of spare parts are also held.

Decca's chairman, Sir Edward Lewis, reports that steady expansion in their Navigator marine business continues and marine contracts at home and abroad now total over 7,000. A new Decca marine service depot has been opened in Grimsby. Hi-Fix, Decca's lightweight survey equipment, has now been in use in thirty different areas throughout the world, and the latest version of the Danish Arkas automatic pilot, which the company has helped to develop, has already been taken up by 30 British shipping companies. In the civil aviation field, Decca have developed an aid to help solve the traffic problem in the upper air space. The system is named HARCO (Hyperbolic Area Coverage) and is an improvement on Standard Mark X Decca and compatible with it.

Microwave & Semiconductor Devices Ltd., is the title of a new British company, formed to exploit the microwave applications of semiconductor devices. Managing director is Dr. James T. Kendall, previously with Texas Instruments and Plessey. M.S.D. have premises at Skimpot Trading Estate, Luton, Beds., and besides producing varactor and mixer diodes, will also offer the range of microwave components manufactured by Microwave Associates Inc., Burlington, Massachusetts, with whom the company is closely associated. The range includes waveguide components and test equipment, magnetrons, ferrites and solid state devices. M.D.S. executive directors are R. G. Hibberd (chief engineer), M. S. Alderson (technical) and J. J. Tither (sales); all three were previously with Texas Instruments.

M.I.P. Repair Service.—In addition to full after-sales service for all instruments of their own make, Measuring Instruments (Pullin) Ltd. have expanded their repair service to cover other manufacturers' products and are now able to undertake the repair and servicing of all types of moving-coil, moving-iron and electro-mechanical measuring instruments of both precision and industrial grades. The Service Department is located at 73 Avenue Road, Acton, London, W.3.

Shipton Automation are now manufacturing and marketing the Gate telephone answering machine, following the acquisition of the former Gate Electronics factory at Hemel Hempstead, Herts. Shipton have also recently opened a new showroom centre in Africa House, 64-78 Kingsway, London, W.C.2, to display a range of communications equipment. Closed-circuit television equipment by Siemens & Halske, which Shipton market in this country, is also on view.

New Ferranti electronics laboratory, opened recently at Silverknowes, Edinburgh, cost £175,000 to build and will employ about 200 people. Approximately 35,000 sq ft of floor space is allocated to laboratories; a drawing office; an installation bay; a development workshop; and an administrative area.

A Scientific Instrument Centre is being built by Pye on a site in Cambridge. C. O. Stanley, Pye group chairman, in his report to shareholders, stated that "the Centre would do justice both to the standard of work we are producing and to the expansion we hope for in the years to come. Building has been going on for nearly two years. The premises are only partially occupied, but before the end of the financial year [March 31st next] we hope to have an official opening in Cambridge of what will be the Scientific Instrument Centre of the City of Cambridge."

Gas Purification & Chemical Co. Ltd.—"An unsatisfactory trading year for the group," says chairman D. D. Mathieson, reviewing results for the twelve months to June 30th, when there was a trading deficit of £14,872 against the previous year's profit of £811,034. Dealing with the individual companies of the group, of Grundig (Great Britain) Ltd., he states: "This company was expected to contribute substantially to our profits but the trading figures are extremely disappointing and are, in the main, responsible for the adverse results of the Group."

Aerialite Ltd.—Group net profits decreased from £159,542 for 1959/60 to £81,129 in the year to May 31st last. L. S. Hargreaves, chairman, feels that the downward trend in profits has been halted and that the company can look forward to raising profit levels.

Radio & Television Trust Ltd., announce that the unaudited group trading profit before providing for taxation for the six months to September 30th last, amounts to £191,723. This figure, which does not include any profit from Thermionic Products (Electronics), Ltd., acquired on September 30th, compares with £265,782 for the full year to March 31st, 1961.

British Insulated Callender's Cables report that group net trading profit for the first half of 1961 was £3,321,000, an improvement of 18% over the first six months of 1960, and of 17% over the second half of that year. Sir William McFadzean, chairman, states that on the basis of current figures, the indications are that the improvement should at least have been maintained during the second half of 1961.

Plessey Co. Ltd.—Consolidated profit on trading during the year to June 30th last was £3,422,659 as compared with £4,227,597 for the preceding twelve months. Net profit was £1,712,886 (£1,907,850).

Brush Crystal Company, of Hythe, Southampton, manufacturers of electronic components, announces that Treasury consent has been given to a scheme whereby control of the company is transferred from its major shareholder, Charterhouse Industrial Holdings, to Clevite Corporation, of Cleveland, Ohio, U.S.A.

Solartron have received an order for three magnetic-tape recorders which will be used by the Department of Scientific and Industrial Research observing stations for recording data, telemetered from instrumentation satellites. One machine has already been delivered to the Falkland Isles. The second machine will be used in Singapore, and the third in association with the Minitrack installation operated by the Radio Research Station at Winkfield.

Telefis Eireann, the Irish television service, have taken delivery of a mobile four-channel outside broadcast vehicle equipped by E.M.I. Electronics Ltd. A microwave link has been included so that pictures can be transmitted back to the Dublin studio from up to 50 miles away.

Kemet Solid Tantalum Capacitors are now being marketed in the U.K. by the Kemet Division of Union Carbide Ltd. At present these capacitors are made in the U.S.A., but home production is planned for early next summer at the company's Aycliffe, Co. Durham, factory.

Amphenol-Borg Ltd., advise that their Amphenol Electronics Division is now located at new factory premises at Thanet Way, Tankerton, Whitstable, Kent (Tel.: Whitstable 4345). The new development affords three times the area of the original Burgess Hill site, as well as room for future expansion.

British Communications Corporation, a subsidiary of Radio & Television Trust Ltd., have moved their administrative headquarters, development division and sales department, from High Wycombe to Neasden Lane, London, N.W.10 (Tel.: Dollis Hill 8511).

Gardners Radio Ltd., the transformer manufacturers of Somerford, Christchurch, Hants, advise us of a change of name to Gardners Transformers Ltd., as from January 1st.

Pamphonic Reproducers Ltd., have moved from 17 Stratton Street, London, W.1, to new premises at Westmorland Road, Colindale, N.W.9 (Tel.: Colindale 7131).

I.S.B. Transmitters.—Value of an Admiralty order for Marconi NT204 independent sideband communication transmitters is £900,000 and not £90,000 as quoted in the last issue.

S.T.C. News.—Standard Telephones & Cables has taken occupation of a 50,000 sq ft building at Monkstown, near Belfast, to provide facilities for training factory operatives to start production on equipment called for under the G.P.O.'s telephone development programme. S.T.C. has also acquired the share capital of Phœnix Internal Telephone Systems Ltd. and the Private Telephone & Electric Co. Ltd., both previously owned by the Phœnix Telephone & Electric Works Ltd., The Hyde, London, N.W.9. The S.T.C. Valve Division advise that it is now acting as agents for the British Isles for a range of products including travelling-wave tubes and direct-viewing storage tubes, made by International Telephone & Telegraph Corporation, U.S.A.

Armstrong Whitworth Equipment, of Gloucester, have concluded an agreement with Penny & Giles, of Christchurch, Hants, whereby A.W.E. will place their sales and publicity organization at the disposal of the smaller firm. A.W.E. are to market Penny & Giles' extensive range of precision stabilisers, pressure transducers and their aircraft crash recorder throughout the world within the Hawker Siddeley Group framework.

Microwave Instruments Ltd., a member of the Hilger & Watts Group, is establishing a London sales office at 98 St. Pancras Way, N.W.1 (Tel.: Gulliver 5636) on January 1st, with M. F. Collings as representative.

Tape Heads Ltd. (formerly Bradmatic Productions Ltd. and now a member of the B.S.R. group) has moved to High Street, Wollaston, Stourbridge, Worcs. (Tel.: Stourbridge 6021).

OVERSEAS TRADE

U.K. exports of electrical and allied engineering products amounted to £238M for the first nine months of 1961, which is a record and represents a 10% increase on the corresponding period of 1960. These figures indicate an annual rate of £316M. A large increase came from the electronics sector which rose from £50M to £60M. The most spectacular increases were made in the exports to the Common Market. For January-September 1961 a total of £34M was exported to the Common Market countries, an increase of 45% over the January-September period, 1960.

Japanese Agents.—The Solartron Electronic Group have appointed the Kyokuto Boeki Kaisha organization of Tokyo as exclusive agents in Japan.

Solartron have manufactured a 50-channel data logger to meet a requirement of the Polish Electricity Generating Authority. It is designed to monitor and record information concerning temperatures, pressures and flow.

Meters for Indonesia.—Avo, a company in the Metal Industries Group, has been awarded a contract to supply 1,000 Multiminor Model 2 measuring instruments to Indonesia.

Marconi radio communications equipment for a transmitting station near Ankara was presented by the British Government to Turkey as part of its programme of technical assistance to member countries of the Central Treaty Organisation.

E.M.I. Television Cameras for Poland.—Following a successful demonstration of equipment in Warsaw earlier this year, two E.M.I. vidicon camera channels have been ordered on behalf of Polskie Radio, Poland.

Hong Kong's new passenger terminal at Kai-Tak International Airport is equipped with Pye closed-circuit television and the public address system is by Westrex.

Transistor Inverters: a Single View

1.—DERIVATION OF THE NEGATIVE RESISTANCE CHARACTERISTIC

By THOMAS RODDAM

THERE is nothing which gives more pleasure to a young engineer than the devising of a new circuit which he can call his own. You will recognize this as a gross error, for most young engineers show a healthy interest in wine (Chateau Burton) and music, and their passions are easily aroused if anything comes between their wine and their song. Their training is often such as to fix in their minds the idea that all these circuits are, somehow, different. Colpitts, Hartley, Meissner, Clapp, Pierce, Cobley (O. U. T. Cobley, of course) are all inventors of separate oscillator circuits. No doubt this makes it easy to plan examination papers and it certainly helps to pad out the textbooks. It may even help to keep the patent lawyers busy although if you have ever taken counsel's opinion on a patent problem you may wonder why they should be kept busy.

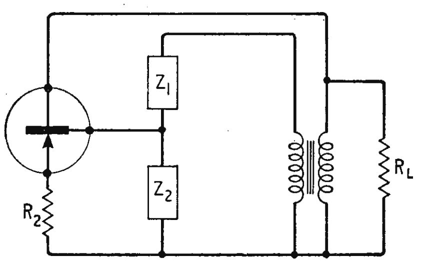

Fig. 1. Basic inverter circuit.

The same proliferation of elegant variations, which is by no means confined to oscillator circuits, is appearing among the transistor inverters. I have no intention of listing the various types of circuits here: I intend to do something quite different. I intend, indeed, to examine the common ground from which all these variants appear. It must be noted that there is some purpose in describing the individual circuits in detail for the benefit of circuit designers but unless attention is concentrated on the special design features of a particular circuit it seems to be much easier to consider it merely as a case of a general system. Curiously enough it is the more elementary texts which overlook this principle completely and reproduce what are virtually the same generalities about each special case in turn, thus squeezing out the really interesting information about what makes each special case so special.

A transistor inverter is a power oscillator of some kind, designed usually to operate at the highest possible efficiency, without too much regard for waveform, except so far as this is related to efficiency, or frequency stability. Enough circuits have been published in *Wireless World* for me to save myself the trouble of drawing a typical one. In general we can say that we shall have one or two transistors connected as a single-stage amplifier with the load in the collector or emitter lead and a signal fed back with a phase reversal to the base. The feedback to the base will be taken through a series impedance of some kind and the base may be returned to the emitter in some way through another impedance.

Negative Resistance Characteristic

Although the most interesting circuits are the push-pull inverters, their essential symmetry makes it possible for us to make a cut along the axis of symmetry and consider only one transistor. Neglecting the battery supply the basic circuit becomes that shown in Fig. 1 which shows a transformer feeding back a fraction k of the signal which appears across the load R_L. Do not worry about the characteristics of the transformer, because we are not going that far through the circuit. All we need to consider is the circuit shown in Fig. 2. Across CB we will impose a Voltage $-$ V which produces a voltage kV across AB. As it happens, Fig. 2 is too difficult for me and so I have made use of Thévenin's theorem to translate it into Fig. 3, in which we have an input across A′B of $kVZ_2/(Z_1 + Z_2)$ and a source impedance of $Z = Z_1Z_2/(Z_1 + Z_2)$. Now we can treat the transistor amplifier.

The emitter current is taken to be I, so that the emitter stands at IR_2. I propose to neglect the base resistance and to consider the internal emitter resistance as part of R_2. Then we have a current I_1

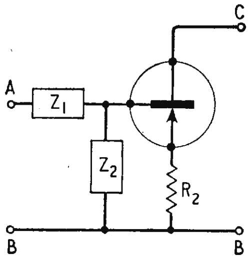

Fig. 2. Active part of the circuit of Fig. 1.

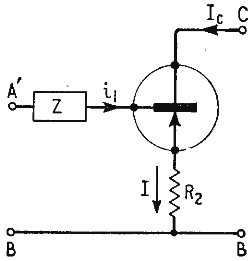

Fig. 3. After using Thévenin's Theorem on Fig. 2 we can consider only this simple circuit.

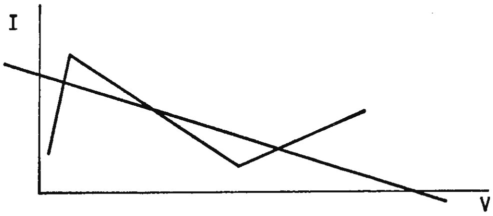

Fig. 4. Short-circuit stable negative resistance characteristic with a resistive load line.

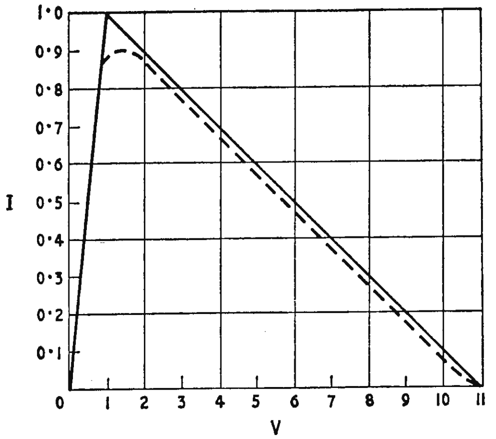

Fig. 5. Idealized and semi-practical negative resistance characteristic, looking in at CB in Fig 3.

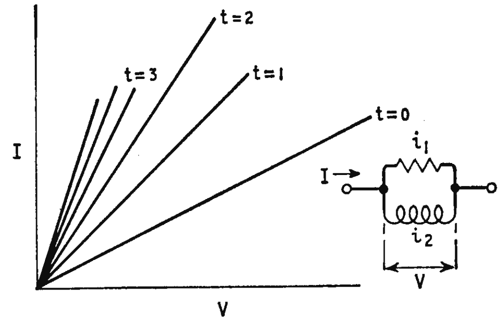

Fig. 6. Time-dependent load line of an LR circuit.

which we know is $(1 - \alpha)$ I driven through Z and we can write

$$(kV' - IR_2) = Zi_1 = (1 - \alpha)ZI$$

or

$$kV' = [R_2 + (1 - \alpha)Z]I$$

but

$$kV' = kVZ_2/(Z_1 + Z_2)$$

so that

$$V/I = \frac{1}{k}\left(\frac{Z_1 + Z_2}{Z_2}\right)[R_2 + (1 - \alpha)Z]$$

$$= \frac{1}{k}\left(\frac{Z_1 + Z_2}{Z_2}\right)\left[R_2 + (1 - \alpha)\frac{Z_1 Z_2}{Z_1 + Z_2}\right]$$

Finally, putting $I_c = \alpha I$ and rearranging slightly,

$$\frac{V}{I_c} = \frac{1}{k}\left[\frac{Z_1 R_2}{Z_2 \alpha} + \frac{R_2}{\alpha} + \frac{Z_1(1 - \alpha)}{\alpha}\right] = R$$

You will remember that we began by imposing a voltage $-V$ across the terminals CB and that I_c is a consequence of this. The impedance seen when looking in at CB will be $-V/I_c$ and this is therefore equal to $-R$.

To make matters a little easier at this stage let us take $Z_2 \to \infty$ and $Z_1 = R_1$. We then have

$$R = \frac{1}{k}\left[\frac{R_2}{\alpha} + \frac{R_1(1 - \alpha)}{\alpha}\right]$$

In this case there is no doubt about it at all: R is just an ordinary resistance and $-R$ is a negative resistance, as ordinary as negative resistances come. The only thing we need to know is whether it is short-circuit stable or open-circuit stable. There cannot be much doubt about this because we need to have a voltage $-V$ across the terminals and we cannot get that if the terminals are short-circuited. The current/voltage characteristic is then of one N-form shown in Fig. 4, with the turnover points defined by positions at which the parameters have changed sufficiently to make $|R|$ rise to infinity.

The characteristics of negative resistance circuits have been described before in these columns.* We can see that if we connect a positive or conventional resistance R across terminals C and B the total loop impedance will be zero and current will flow through R. We can apply a load line to the characteristic curve in Fig. 4 and see that if the resistance is greater than R there are three intersection points. For the centre one conditions are unstable but the two extremes are stable so that in a circuit of this kind the working point will move off to one or other of the stable intersections.

In the simplified form we see that the turn-over points can only be obtained by making either $k = 0$ or $\alpha = 0$. If we can make the system stable at the left-hand end and then in some way cause the intersection points to slide upwards the circuit will be forced to snap over to the right. There are two basic methods of achieving this result. We can displace, and if necessary, deform, the load line upwards or we can displace and deform the characteristic downwards. It is not impossible that we should do both. To get back from the right-hand stable point we need either of two mechanisms which are essentially similar but opposite in direction.

In the full form for R we see that we can send R off to infinity by the means already described, making $\alpha = 0$ or $k = 0$, by making Z_2 go to zero or by making Z_1 go to infinity. I think that it can be taken for granted that if the impedance is infinite it does not much matter whether it is resistive or reactive so that we can send R off in a complex direction, as we shall if either of the Z's contains reactance, without being too worried. The proof of this statement is related analytically to the proof of Nyquist's Rule.

We have talked about the negative resistance going off to infinity, but in practice we are only concerned with it rising (in numerical value) above the load resistance R_L. There is one more possible mechanism for shaping the characteristic, and that is an increase in R_2. This must not be overlooked because R_2 includes the internal emitter resistance of the transistor which we know to be current-dependent.

It might be as well at this stage to construct a typical characteristic to replace the rather general negative squiggle of Fig. 4. Let us take a transistor having $\alpha = 0.9$, which will make $(1 - \alpha)/\alpha = 1/9$ and $R_1 = 90$ ohms. To get a first approximation we shall

* "Ohm's Law and Negative Resistance," by "Cathode Ray," July 1960, p. 343.

(*Continued on page 19*)

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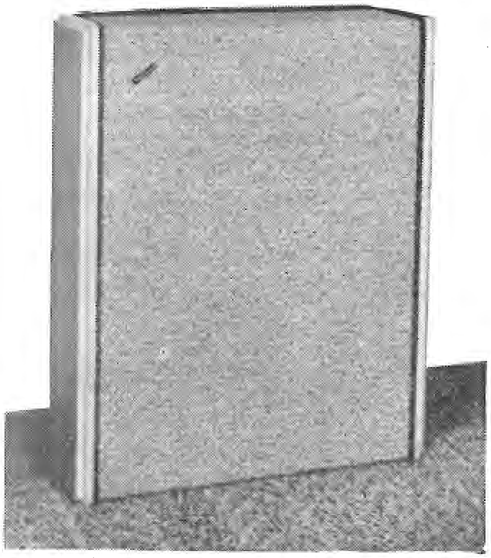

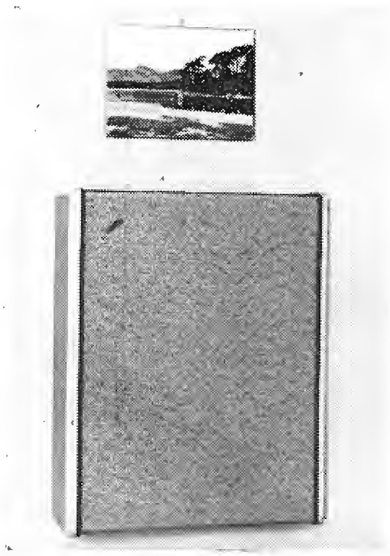

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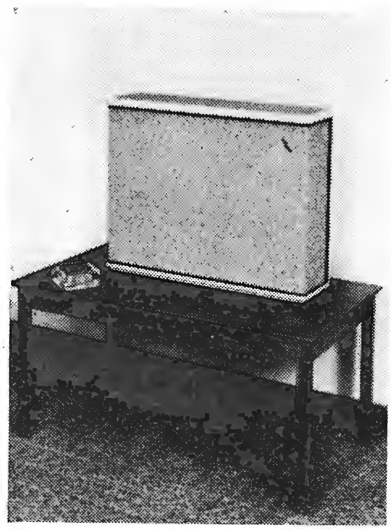

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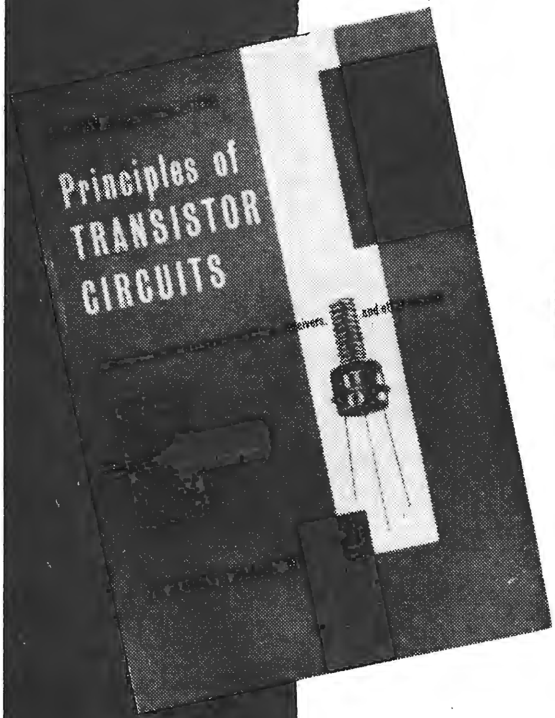

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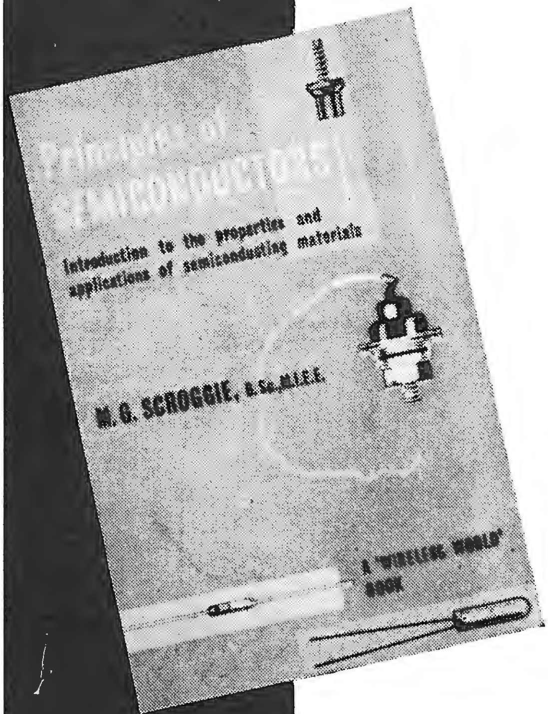

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take $R_2 = 0$ and $k = 1$, which gives us $R = 10$ ohms. We must now place the -10 ohm slope on a V−I plot. Let us now put in the battery, which we take to be 11 volts. If the characteristic extends above this level the current cannot reverse, so that (11V, 0A) is a point on the characteristic. We also assume that when there is only 1 volt across the transistor it bottoms sharply and below this value the graph makes its way back to the point (0, 0). The result is shown in Fig. 5. It does not look like the sort of characteristic we see in real life only because of its very sharp corner. Otherwise it is a very typical transistor negative resistance characteristic such as I described in these columns for the point-type transistor, in, I think, 1953.†

At low values of current we know (from, for example, the Mullard Reference Manual of Transistor Circuits, p. 75) that the internal emitter resistance is, roughly, $25/I_e$ ohms, where I_e is in milliamps. This will give us a slight softening of the corner round the point (11, 0), a softening which would be much more noticeable if we had taken $k = 0.1$ and $R_1 = 9$ ohms to get the same value of R. For the example I have chosen, however, the most significant rounding effect will come from the reduced value of α at low currents and low voltages, which will produce the roundings-off shown in the dotted curve of Fig. 5.

We are all so obsessed by the idea of sinusoidal waves and Fourier analysis that we find it very easy to overlook one very important thing: at any instant there is a current flowing through a reactance and there is a voltage across it and the ratio of these two factors is a number. Because it is not a constant we search for a concept which will enable us to identify the network element by a single constant, but, for a quick look, volts/current is given a number with a history. If we know the value of this number for Z_1 and Z_2 we can draw a characteristic which must be broadly similar to Fig. 5, but with a lower slope, to represent the general expression at a particular instant of time.

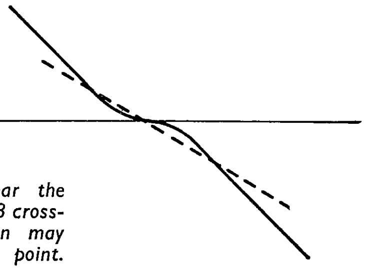

Fig. 9. Near the origin of Fig. 8 cross-over distortion may give a stable point.

Time, like an ever-rolling stream, must not have a stop. Let us keep out these $j\omega$ terms which can so easily please us. For an inductance we have

$$V = L\,dI/dt$$
$$\text{or } I = Vt/L \text{ if V is constant.}$$
$$\text{or } V/I = L/t$$

and for capacitance

$$I = C dV/dt \text{ if I is constant}$$
$$\text{giving } V/I = t/C.$$

We see that the voltage/current ratio is just a number which depends on the length of time a situation has existed. I have chosen the simplest conditions and thrown away constants of integration because the results look clearer that way. As it happens these rather simple forms suit almost all inverter circuits.

Let us consider the circuit shown as an inset in Fig. 6. For the resistance we get a current $i_1 = V/R$ and for the inductance a current $i_2 = Vt/L$, making the total current $I = V\left(\frac{1}{R} + \frac{t}{L}\right)$. For various values of t we can draw the characteristic shown in the main part of the figure. This is very important and very simple, although a small sample test I have carried out suggests that there is initially some sort of built-in mechanism in the mind which refuses to grasp the meaning of the figure. Curves which can be derived from it are familiar, however, and it may help you, if you cannot accept it as it stands, to take V = constant and plot out I as a function of t, which will have a shape which you should recognize. You must come to grips with Fig. 6 in the end, because it is this moving characteristic which determines the switching mechanism of the inverter.

For the present we shall continue to study the simplified transistor circuit in which $Z_2 = \infty$ and $Z_1 = R_1$ so that the value of R does not contain any reactive elements and is therefore time-invariant. Now we take the approximate characteristic and apply to it a load line in the form shown in Fig. 7. The load line is BAC and this will give us the choice of two stable positions, B or C. Since point A corresponds to the supply voltage the only stable situation will be at B. Now we take the load to consist of an inductance and a resistance in parallel. As time passes the load line will swing round, first to CB′ and then to CB″. When it reaches CB″ there is only one stable intersection point, C, so that the working point must jump there.

When this happens the voltage across the inductance falls to zero and the load line starts to swing back until it is in the B′ region again. The transition back may be, and I suspect always is, produced by bringing C to the left of AD when only one transistor is involved. In the push-pull case we can set up a composite load characteristic of the form shown in Fig. 8. Here the triggering at B″ on one side produces

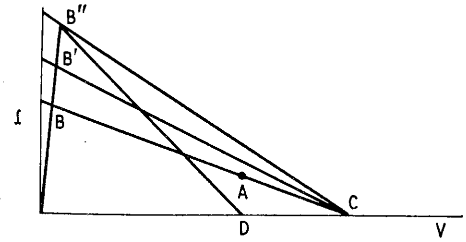

Fig. 7. Negative resistance characteristic with moving load line.

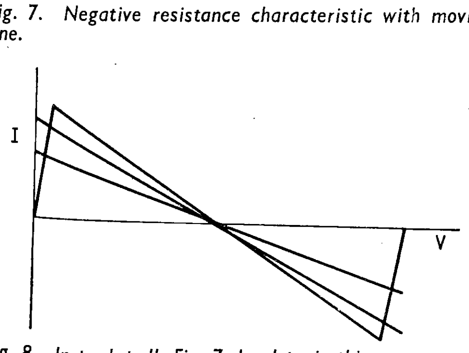

Fig. 8. In push-pull, Fig. 7 develops in this way.

† "Transistors", February-December, 1953.

a very large shift in C and thus pulls the other side right down to the B region. Critical examination of the cross-over region is needed, as you can see from the enlarged view in Fig. 9. Here there is a stable centre point and the system may rest symmetrically. One of the practical design problems is to make sure that this cannot happen.

We are getting perilously near some practical design, something I wish to avoid until the foundations are properly laid. Let us leave this for the moment and go back to the general form for the negative resistance. This, if you look back, contains terms in Z_1 and $1/Z_2$. We have seen that if the circuit elements are reactive we must regard them as numbers which change with time. We can look more closely and see that if Z_1 increases or Z_2 decreases with time the effect will be to increase the value of R. A resistive load line can now be drawn in Fig. 10 which shows the progressive movement of the negative resistance characteristic from CB to CB′ to CB″, where a transition must take place. This is the pattern we shall observe if Z_1 is capacitive and Z_2 resistive or if Z_1 is resistive and Z_2 inductive. Again we can develop a push-pull characteristic so that triggering is always at the B end and not at the D end.

Single-ended systems raise a problem which I feel at the moment is too difficult for an elementary treatment. It is this: if the starting state is at point A, what is it that decides whether a stable state will be sought at B or D? The answer is tied up with the way in which the system will behave at very high frequencies and the way it is tackled has been relegated to an appendix. There is always in single-ended systems a second mechanism, a storage mechanism, at work. When D is reached the storage system takes over and holds the conditions on a drift path from D down to C and then away towards A. Once in the neighbourhood of A the stable condition at B will be sought.

Near the beginning of this article, when the negative resistance characteristic first appeared, I referred to some long-lost articles on the negative resistance characteristics of point contact transistors. Now we have quite a family of devices which have

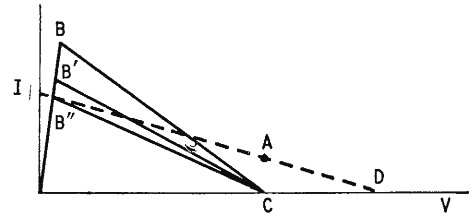

Fig. 10. Load line is fixed, but the negative resistance characteristic is time-dependent.

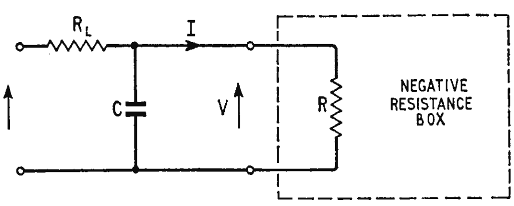

Fig. 11. To determine the trajectories we must include a stray capacitance C.

built-in, as it were, the feedback mechanism we have been studying and which can be represented in general terms by Fig. 4. Avalanche transistors, tunnel diodes and silicon controlled rectifiers are three classes which come to mind. Although I do not propose to discuss the ways in which they can be used for inverters it is necessary to mention them here because in circuits used with these devices you will often find a commutating capacitor used as an extinguishing path. The purpose of this is to drive the load-line sharply downwards so that there is no intersection in the positive B region, after which the working point swings up along the zero-current axis to the D region. This is only a very rough statement of what happens and is mentioned here purely as an aside.

At this stage we can pause for recapitulation. By leaving out everything which is not needed in a theoretical study of inverter circuits we have reduced the system for investigation to a fairly simple one which turns out to produce a short-circuit stable negative resistance facing the load. We have then shown how a time-varying element either in the load or the amplifier system can cause the stable working point to be displaced in such a way that triggering takes place and the second stable state is sought.

When we look back at the expressions for the negative resistance we see that two of the terms contain α while the third is $Z_1(1-\alpha)/\alpha$ which we might write as Z_1/β or Z_1/α'. This term is obviously much more dependent on the frequency characteristics of one transistor than the other and it is worth considering it more closely. We can write

$$\alpha' = \alpha_0'/(1 + j\omega/\omega_0')$$

where ω_0' is the cut-off frequency in the common emitter connection. Let us now take Z_1 as made of a parallel combination of resistance R_1 and capacitance C_1, so that $Z_1 = R_1/(1 + j\omega C_1 R_1)$, which will make the term we are considering,

$$\frac{Z_1(1-\alpha)}{\alpha} = \frac{R_1}{\alpha_0'} \cdot \frac{1 + j\omega/\omega_0'}{1 + j\omega C_1 R_1}.$$

Now we choose C_1 so that $\omega_0' C_1 R_1 = 1$, and this reduces to simply R_1/α_0'. We have, in effect, moved our frequency dependence up to the alpha cut-off frequency, a very substantial improvement indeed. This is a result of considerable practical importance.

We must now turn to the question of the practical inverter circuits and examine how they are derived from this common basis. We may also see how unwanted effects can appear.

APPENDIX

The problem is to determine which of the two stable points will be sought if a negative resistance system is released at some arbitrary point in the (V, I) plane. For a sufficiently simple example the problem is not too intractable. If we take a very special case of the circuit we have considered and put $Z_2 \to \infty$, $R_2 = 0$ we have simply

$$R = R_1/k\beta = (R_1/k\beta_0)(1 + j\omega/\omega_0)$$

in which we now write

$$(R_1/k\beta_0) = R_n \text{ and } (R_1/k\beta_0\omega_0) = L_n,$$

giving us

$$R = R_n + j\omega L_n.$$

Now we take note of a very important fact: the circuit in a transient state is only aware of the negative resistance region of the characteristic. Although we talk of seeking one stable point or the other this is not true, because the stable regions are produced by characteristic non-linearities, like the cut-off, which do not influence the linear region. Like the lemmings, the working point heads off

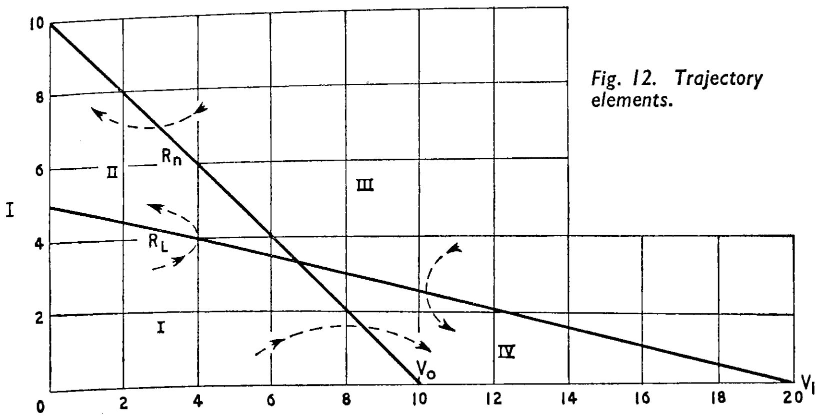

Fig. 12. Trajectory elements.

in the right direction until, near the corner, the changing value of R corresponding to the rounding-off produced by the non-linear region brings the trajectory swinging round to converge on the stable points. For a simple analysis we can forget about this and simply find out what happens in the linear region: the rest is just more mathematics.

We are concerned then, with a characteristic having a slope of $-R$, and passing through a point $(V_0, 0)$, so that it must satisfy the equation

$$V = V_0 - (R_n + j\omega L_n)I$$

which is better written

$$V = V_0 - R_nI - LdI/dt$$

Suppose that we are feeding this system through a load resistance R_L and there is a stray capacitance C, as shown in Fig. 11. Then for this circuit

$$V_1 = (1 + j\omega CR_L)V + R_LI$$
$$= V + R_LI + CR_L\, dV/dt.$$

We therefore have:

$$\frac{dV}{dt} = \frac{V_1 - V - R_LI}{CR_L}$$

and

$$\frac{dI}{dt} = \frac{V_0 - V - R_nI}{L}$$

so that

$$\frac{dI}{dV} = \frac{V_0 - V - R_nI}{V_1 - V - R_LI} \cdot \frac{CR_L}{L}$$

We can take a typical characteristic like the one shown in Fig. 12, for which $V_0 = 10$, $V_1 = 20$, $R_n = 1$ and $R_L = 4$ which would be fairly representative of a 75 watt inverter running below full load. Then

$$\frac{dI}{dV} = \frac{10 - (V + I)}{20 - (V + 4I)} \cdot \frac{4C}{L}$$

The plane is divided into four areas. In areas I and II we have $10 - (V + I)$ positive while this term is negative in areas III and IV. In areas I and IV the term $20 - (V + 4I)$ is positive and it is negative in the other two areas. Thus in areas I and III the value of dI/dV is positive, while in II and IV it is negative.

Furthermore, in crossing the line $10 - (V + I) = 0$, dI/dV goes to zero, while in crossing the line $20-(V+4I) = 0$, dI/dV goes through infinity. We can therefore put in the four dashed typical trajectories shown. Which way do we travel along them? We can see this from the expression

$$\frac{dV}{dt} = \frac{20 - (V + 4I)}{4C}$$

which is positive below the R_L line. The arrows are now added to Fig. 12. It is now apparent which stable point will be sought, provided that you know the starting point and follow out the trajectory. The boundary line will depend on the values of L and C and can be identified as passing through the junction of R_L and R_n. This general principle can be applied to more complex systems.

NATO V.L.F. STATION AT SOLWAY

To augment the communications facilities of the North Atlantic Treaty Organization and to ensure the greatest possible immunity from ionospheric disturbances, work has just started on building a high-power, very-low-frequency (v.l.f.) radio-telegraph station on the coast of Solway Firth, Cumberland.

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The transmitter will be located at the centre of the site, and the aerial, which will consist of six radial rhombic-shaped sections suspended from thirteen masts 600-740 ft high, will cover practically the whole site. This arrangement of the aerial will enable each section to be lowered to the ground for maintenance without fouling mast stays or any other obstructions. The aerial will be built of cadmium-copper conductors about one inch in diameter, to enable it to withstand the working voltage (120 kV) without perceptible corona under adverse weather conditions, and also to be strong enough to support a heavy coating of ice. Should the ice loading on the conductors increase beyond the designed maximum value, halyard-tension-limiting gear will cause the winches to lower the aerial and prevent the conductors and supporting structures being overstressed.

The aerial will be tuned by a fixed helical inductor in series with a variometer. The latter will be automatically controlled to compensate for variations in aerial capacitance due to weather effects. These inductors will be accommodated in a copper-lined room in the transmitter building and the lead-out to the aerial will be taken via a large bushing in the roof of the inductor room. An aerial circuit efficiency of 30% is expected.

The transmitter will comprise a 50 mW drive stage followed by five stages of amplification, and at its normal working frequency of 19 kc/s it will be capable of delivering a peak power of 500 kW into the aerial. A frequency stability within 1 part in 10^8 has been specified.

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The power supply will normally be taken from the mains, but two 600-kW emergency generators will be provided, each of which will be so connected as to supply one half of the transmitter and the miscellaneous loads.

Competitive bidding by member countries of NATO to a specification issued by the Post Office has resulted in the contract for the design and provision of this station being placed with Continental Electronics Systems Inc. of Dallas, Texas, whose British associates are Redifon Ltd. Under sub-contracts, the masts and aerials will be supplied and erected by British Insulated Callender's Construction Co. Ltd. and the power plant by English Electric Co. Ltd.

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THIS title is now a misnomer, for it is officially called the "Annual Exhibition of the Institute of Physics and the Physical Society," since the amalgamation of the two organizations, but it is likely to continue to be known colloquially as the Physical Society Exhibition. The 46th exhibition, which opens for five days at the Royal Horticultural Society's Halls, London, S.W.1, on January 15th, will retain the "unique nature of these annual exhibitions as scientific occasions rather than as opportunities for displays of ordinary commercial products."

Admission to the exhibition is by ticket obtainable free from exhibitors or from 47 Belgrave Square, London, S.W.1. Applicants are asked to enclose a stamped addressed envelope to take the tickets measuring $4\frac{1}{2} \times$ 3in. The exhibition opens at 10.30 on the first day and 10.0 on the following days. Admission is restricted to members of the Institute and Society until 2.0 on the opening day. The closing time is 7.0 except on the 16th (9.0) and 19th (1.0).

In addition to the research organizations and manufacturers listed, a number of publishers and journals, including *Wireless World* and *Electronic Technology,* have taken space.

The Handbook, containing descriptions of the exhibits, which is a useful reference book, is obtainable, price 6s (postage 2s), from the organizers.

A feature of the exhibition is the series of annual lectures. This year, on the 16th Dr. C. A. Taylor will speak on "A physicist looks at music," and on the 18th Prof. R. V. Jones' paper is entitled "The uses of elasticity in instrument design." Lectures begin at 5.45.

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Edwards High Vacuum
Ekco Electronics
Electronic Instruments
Electronic Tubes
Elliott Brothers
English Electric Valve Co.
Ericsson Telephones
Evans Electroselenium

Ferranti
Flann Microwave Instruments
Fleming Radio

G.E.C.
General Radiological
Genevac
Griffin & George
Grubb Parsons & Co.

Harrison, W.
Hatfield Instruments
Hilger & Watts

I.C.T. (Engineering)
Imperial College of Science
International Nickel Co.
Isotope Developments

Kent, George

Labgear
Levell Electronics
London, King's College
London, University College
Lucas, Joseph

Manchester, University of
Marshall of Cambridge
Megatron
Mervyn Instruments
Metals Research
Meteorological Office
Ministry of Aviation
Ministry of Power
Mullard

N.G.N. Electrical
Nagard
Nash & Thompson
National Inst. for Medical Res.
National Inst. of Agricultural Eng.
National Inst. of Oceanography
National Research Dev. Corp.
New Electronic Products
Newcastle, King's College
Newport Instruments
North Wales, University College
Nuclear Enterprises

Optical Works

Panax Equipment
Paton Hawksley Electronics
Perkin-Elmer
Planer, G. V.
Plessey Co.
Pye, W. G., & Co.

Racal Instruments
Rank Cintel
Reading, University of
Royal College of Surgeons
Royal Meteorological Society
Royston Instruments

Sanders, W. H. (Electronics)
Semiconductor Thermoelements
Shackman, D., & Sons
"Shell" Research
Singer Instrument Co.
Smiths' Industrial Division
Southampton, University of
Stanton Instruments
Sunbury Glass Works

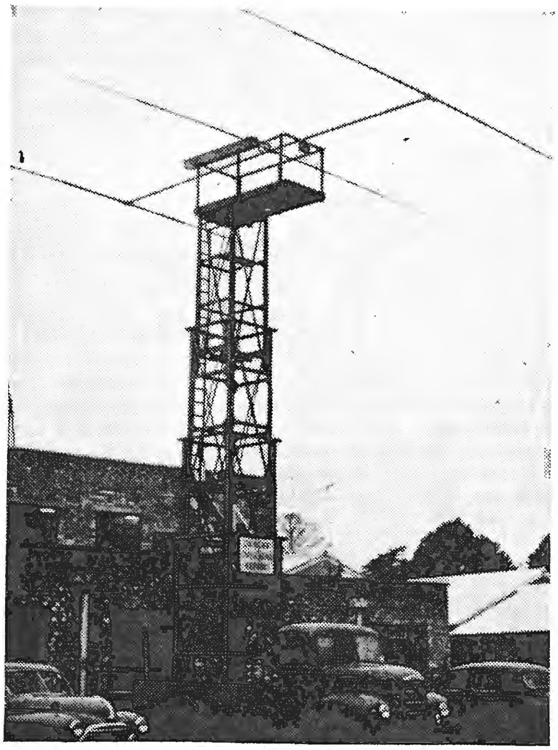
Techne (Cambridge)
Telcon Metals
Texas Instruments
Thompson, J. Langham
Thorn Electrical
Tinsley, H., & Co.
20th Century Electronics

U.K.A.E.A.
Ultrasonoscope Co.
Unicam Instruments
University College Hospital Medical School

Venner

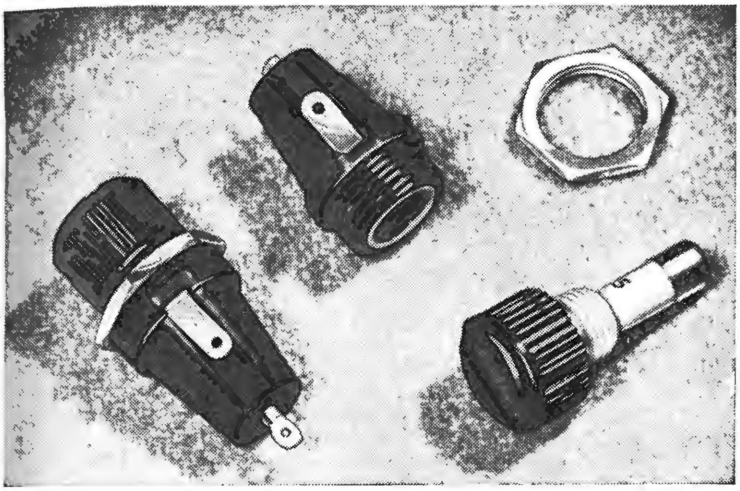
Watson, W., & Sons
Wayne Kerr Laboratories

TAPERED-TUBE AERIAL



SHOWN in the photograph is a 16-Mc/s three element Yagi array made recently by J-Beam Aerials. The overall length of each element is 30ft, each 15ft section consisting of a continuous length of tube with three steps of diameter, each 5ft long, the respective outer diameters of each step being 1.5in, 1.125in and 0.75in. This method of construction was found to reduce sag, the deflection at each end of the element being only 1.5in. A single tube of adequate diameter sags considerably more than this, and a second advantage is a reduction of wind resistance. The material used was aluminium to specification BA25Wp, supplied by the British Aluminium Company Limited.

"Belling-Lee" PANEL FUSEHOLDERS



This is a miniature version (shown approximately one and a half times full size) of the well-known standard fuseholder L.1348 below. Designed originally for a Services' requirement, this component has been type-approved for many years, and is now in use in equipment throughout the world. For miniature fuse-links $\frac{5}{8}''$ x $\frac{3}{16}''$ diameter such as L.562 and L.754 series. Fuseholders of this type occupy very little panel space, and give front access to the fuse-links for testing and replacement.

MINIATURE PANEL FUSEHOLDER L.575

Specification: R.C.S. 262.

Current rating: 2·5 amp.

Max. working volts: 250 V. a.c., 230 V. d.c.

Breakdown voltage: Between side tag and panel, 2,500 V. (r.m.s.).

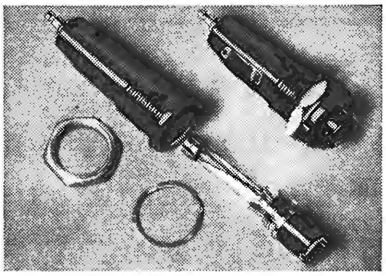
Size: 00 (for $\frac{5}{8}$ in. x $\frac{3}{16}$ in. dia. fuse-links).

STANDARD PANEL FUSEHOLDER L.1348

Current rating: 5 amp.

Max. working volts: 250 V. a.c.

Size: 0 (for $1\frac{1}{4}$ in. x $\frac{1}{4}$ in. fuse-links).



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Aerials for higher definition and colour television.

We are often asked what kind of receiving aerials will be required for colour television, and for a higher definition service, e.g., 625 lines. The first consideration, of course, is the transmission frequency to be used, but reflection effects, particularly with colour, will be a more serious problem than with present services. However, the B.B.C. has for a long time been radiating test programmes in colour in the London area, using its regular Band I channel, and these are received perfectly satisfactorily by many people by means of normal television aerials.

But if present services are to be maintained so that existing receivers shall not become redundant, any new service will probably have to be radiated in a higher frequency band, because those now in use are already handling nearly as much traffic as they can accommodate without serious mutual interference. Even if the existing services were discontinued, the present transmission bands are not wide enough to contain a sufficient number of channels of the increased width that would be necessary for a higher definition carrier.

The next higher bands available for public entertainment services are IV and V, covering frequencies from 470–585 Mc/s and 610–960 Mc/s, respectively. At these frequencies, transmission is almost confined to line-of-sight paths, since diffraction effects are reduced and, also, most solid objects are more or less opaque. Moreover, although very high radiated powers can be expected, perhaps around 1,000 kW, the amount of signal picked up by a receiving aerial is related to its physical size, which for these bands, with the wavelengths lying between 65 and 30 cm. approximately, is fairly small. This means, too, that there are many more objects in the landscape which are large enough to act as reflectors, so that "ghosting" conditions are more severe, with effects that are less tolerable—particularly with colour.

A new look in aerials is therefore likely, combining high gain with very sharp directional properties. These requirements can be met by stacking Yagi arrays, which can be effected compactly and economically at these frequencies. Such arrays have in fact already been designed and made by "Belling-Lee" some years ago, and thoroughly tested on the B.B.C. experimental transmissions, and have been used by the B.B.C. and other authorities.

Part 9 of "Some mechanical aspects of design" will appear next month.

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ffolkes

Collectors Upwards or Positive Upwards?

By P. J. BAXANDALL,* B.Sc. (Eng.)

THE subject of transistor graphical symbols and transistor circuit diagram drawing has aroused much controversy.[1, 2, 3]

Like all my colleagues in the Circuits Research Division at R.R.E., I have favoured, ever since starting work on transistor circuits, the symbol shown in Fig. 1(a) for an ordinary p-n-p junction transistor. The symbol shown at (b), originally devised to represent a point-contact transistor, seems to me to be quite inappropriate for a junction transistor. I feel strongly that a good symbol should bear as direct a relationship to the nature of the device it represents as is consistent with simplicity. Symbol (a) satisfies this requirement well—it represents a thin slice of semiconductor material with an emitter on one side and a collector on the other; (b) does not do this.

At the moment the official British Interservices symbol for a p-n-p junction transistor is that shown in Fig. 1(c). I have no quarrel with this, except that the sloping lines seem to be an unnecessary elaboration and make the symbol considerably more trouble to draw.

Unfortunately there seems to be a very large trend throughout most of the world towards symbol (b); I think this is regrettable, and personally I shall continue to use symbol (a).

Two Schools of Thought

However, the main concern in this article is not transistor symbols as such, but the issue of whether or not one should always draw a transistor circuit diagram with the most positive supply line at the top and the most negative at the bottom. This is, I feel, a much more important issue than that of the transistor symbol itself. There are two schools of thought:—

(a) The school which maintains that transistor circuits should be drawn so that they resemble as closely as possible their valve counterparts. Since most valve circuits have been drawn with the earth line along the bottom and the anodes at the top of the valve symbols, this school chooses, for example, to draw a simple two-stage amplifier using p-n-p transistors in the manner shown in Fig. 2. This makes it look superficially like the valve amplifier of Fig. 3. With n-p-n transistors it would be arranged as in Fig. 4.

(b) The school of thought (to which I belong) which says one should always have the most positive supply line at the top and the most negative at the bottom. This school would draw the two-stage amplifier with p-n-p transistors as in Fig. 5. This has the appearance of being upside down compared with a valve circuit and may well give an initial impression of unfamiliarity to some people. Why, then, do I favour drawing it in this way?

* Royal Radar Establishment.

In Support of "Positive Up"

If simple amplifier applications such as that in the above example were the only ones to which transistors were applied, I might possibly be tempted

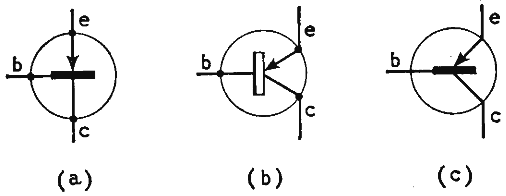


Fig. 1. Some transistor symbols in common use.

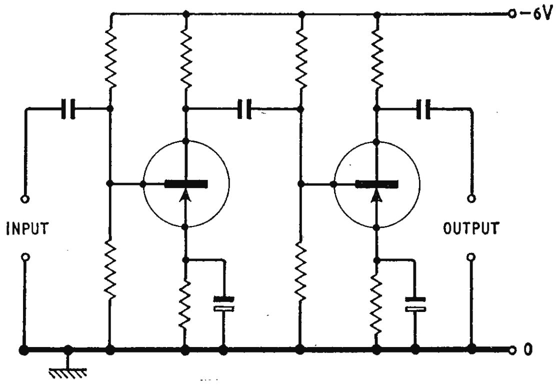


Fig. 2. Simple two-stage transistor amplifier with p-n-p transistors.

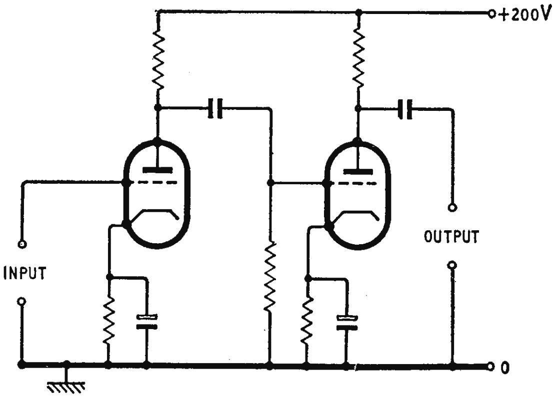


Fig. 3. Valve equivalent to circuit of Fig. 2.

to agree with the Fig. 2 school of thought. However, the really decisive argument in favour of drawing circuits with the positive line at the top arises, in my opinion, when one comes to consider non-linear circuits, such as time-bases, blocking oscillators, television pattern generators, etc.

Leaving aside such complex-waveform circuits for the moment, it is worth pointing out that, even in the field of linear amplifiers, difficulties can arise if one does not adopt the positive-upwards philosophy. Thus, consider the circuit shown in Fig. 6, which is part of an amplifier I designed some time ago. The special feature is the use of an n-p-n emitter-follower stage, the earlier stages employing p-n-p transistors. By this means, with simple direct coupling between the stages shown, one can get the major portion of the supply voltage across the load resistors of both stages, thereby minimizing harmonic distortion and increasing the available output into a fairly low impedance load. Since the amplifier has 50 dB of feedback, it was desirable, in the interests of stability, to avoid an a.c. coupling between the stages.

When confronted with a circuit such as this, school (a) must decide whether the rule is simply that the earth line must be drawn at the bottom, or whether it is that the collectors must be drawn uppermost. If the former, then the decision will just be to draw Fig. 6 the other way up. If the latter rule is to apply, then a difficulty arises, since, whichever way up the circuit is drawn, one or other of the transistors will be the wrong way up. A possible solution is shown in Fig. 7, but is hardly elegant, I feel.

Consider now the circuit shown in Fig. 8—a two-stage amplifier consisting of a common-emitter stage feeding an emitter follower. The unconventional feature is that the emitter bypass capacitor, instead of being connected, as in normal practice, across the emitter resistor, is connected as shown. This arrangement, first proposed, as far as I know, by K. Holford of Mullard, Ltd.,[4] has very real advantages in some circumstances—one capacitor is made to provide a measure of supply decoupling as well as functioning as an emitted bypass capacitor. (I have used this principle in various circuit designs, described in the *Journal of the British Sound Recording Association*, November, 1961, and I am left with the feeling that it is a scheme we ought to have thought of years ago but did not!)

Would school (a) draw the circuit as in Fig. 8, which follows the rule that the earth line should be along the bottom, or would they invert the circuit, thereby satisfying the "collectors uppermost" rule but moving the earth line up to the top?

The above may, perhaps, have made some members of the "other school" feel that their case is not quite as straightforward as they had imagined —maybe not. However, as already stated, the really strong case for having the positive line at the top arises, in my view, when one considers non-linear waveform circuits.

Now a special attitude of mind is required in order to be good at non-linear waveform circuit work—a rather similar attitude to that possessed by the ingenious mechanical engineer who can rapidly and intuitively fathom out how complicated mechanisms work and how to adjust them correctly or modify their design.

In thinking about the functioning of non-linear waveform circuits, either as a designer or merely for the purpose of understanding some existing circuit, one is forever thinking about "points moving up or down in potential," and one really does mentally visualize these effects as up or down movements while looking at the circuit diagram. The plain fact is that unless one has the positive supply line at the top and the negative at the bottom, one will be frequently confronted with the situation that if the potential of a point on the circuit moves nearer to the potential at the top of the circuit, then this will be represented as a downward movement on the waveform and will appear as a downward movement on any normal oscilloscope.

The convention of plotting graphs on a "positive upwards, negative downwards" basis is much older than the science of electronics, and is almost, if not quite, universally accepted. Since no reasonable person would, I imagine, suggest changing *this* convention, the only sensible way to draw circuit diagrams seems to me to be the positive-upwards one, so that the movements one visualizes when looking at the diagram are in the same direction as on the corresponding waveforms, and one does not have to keep doing a mental inversion. The argument about it being desirable for transistor circuits to look superficially like valve circuits is, I suggest, of quite trivial importance compared with this argument.

On looking at some part of a new waveform circuit, whether it uses valves, transistor, relays or any other active devices of the future, one is likely, before

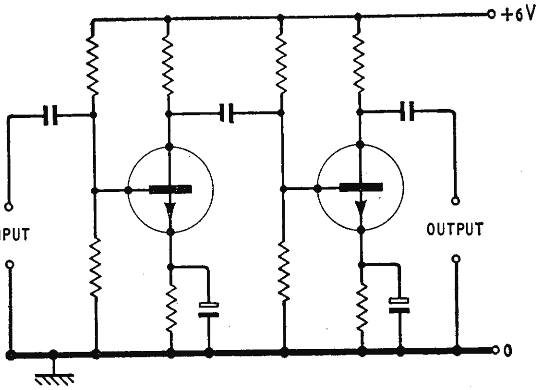


Fig. 4. Circuit of Fig. 2, but with n-p-n transistors.

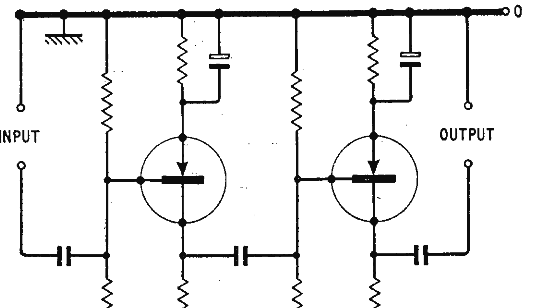


Fig. 5. Circuit of Fig. 2 redrawn with "positive up."

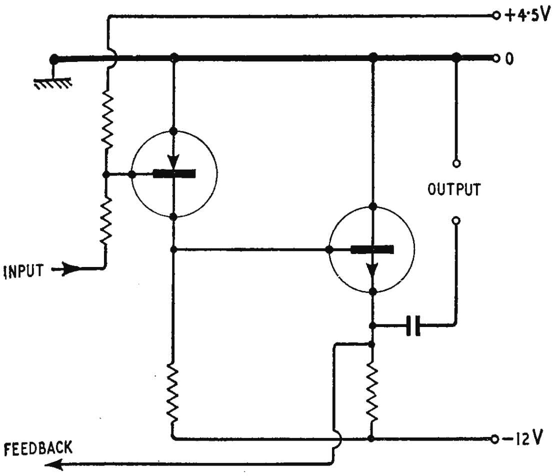


Fig. 6. Direct-coupled amplifier with p-n-p and n-p-n transistors.

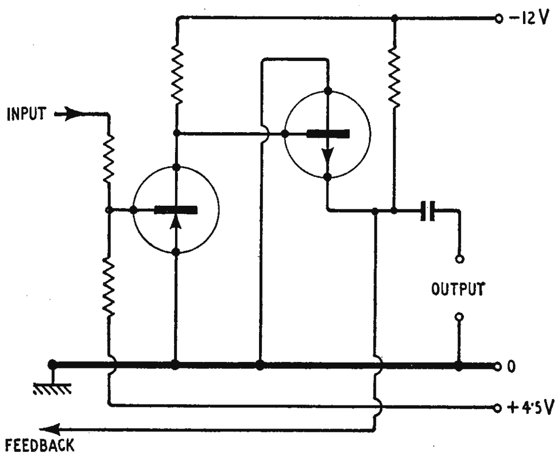


Fig. 7. Circuit of Fig. 6 redrawn with "collectors up."

long, to say to oneself (see Fig. 9) "what happens to the voltage at the point P when the active device is turned on?" Before deciding whether it will go positive or go negative, one has to digress to consider whether the top supply line is positive or negative to the bottom one; and if the top one is negative, one has, in effect, to say to oneself "when the device comes on, P will move down to earth, but this will appear as an upward movement on the waveform."

If, on the other hand, one sticks to having the positive line at the top and the negative at the bottom in all diagrams, then one never has to digress in this manner to consider the supply polarity—one knows it will always be such that the movements one visualizes on the diagram will coincide with those seen on the waveform.

Some people have said that since supply polarity is largely a mere practical detail it should not be allowed to influence the drawing of the circuit diagram any more than necessary, and that always having the collectors uppermost achieves this aim. I maintain that the way to keep supply polarity details as far into the background as possible is to adopt the positive-upwards convention in *all* circuit diagrams. This produces, in my opinion, a far closer unification

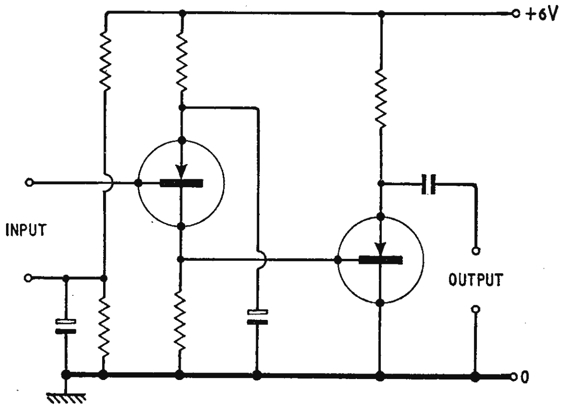


Fig. 8. Amplifier with common-emitter stage feeding an emitter-follower.

of circuits of all types than does the collectors-upwards convention.

In the Circuits Research Division at R.R.E., in the days of valve circuits, we were always careful to draw the most positive supply line at the top of a diagram and the most negative at the bottom, *in order to facilitate thinking about waveforms.* It seemed obvious to all of us that we would continue doing this when transistors arrived. I must confess that I often find it worth while redrawing diagrams in published articles, when not drawn on the positive-upwards basis, before thinking in detail about how the circuits work.

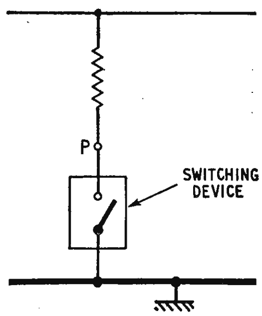
Of course, it may be argued that the point of view I have been taking is only important in non-linear waveform circuits, and that ordinary amplifier circuits could equally well, or even preferably, be drawn on a collectors-uppermost basis.

My view is that, since I think there is an overwhelming case in favour of positive-uppermost diagrams for non-linear waveform circuits, one had better be consistent and use this same convention for all circuits—otherwise awkward situations will arise when non-linear circuits and linear amplifiers appear on the same diagram, or in borderline cases when it is not obvious whether a particular circuit should be put in one class or the other.

Even in an amplifier circuit, where one is usually thinking in terms of small-signal amplitudes, loop gain, etc., occasions can arise when one may think more along the lines of waveform circuitry; when, for example, one is trying to reason out why, on overloading the amplifier, an unexpected type of distortion appears on the waveform.

I suspect that the strongest opposition to the posi-

Fig. 9. Simple switching circuit.



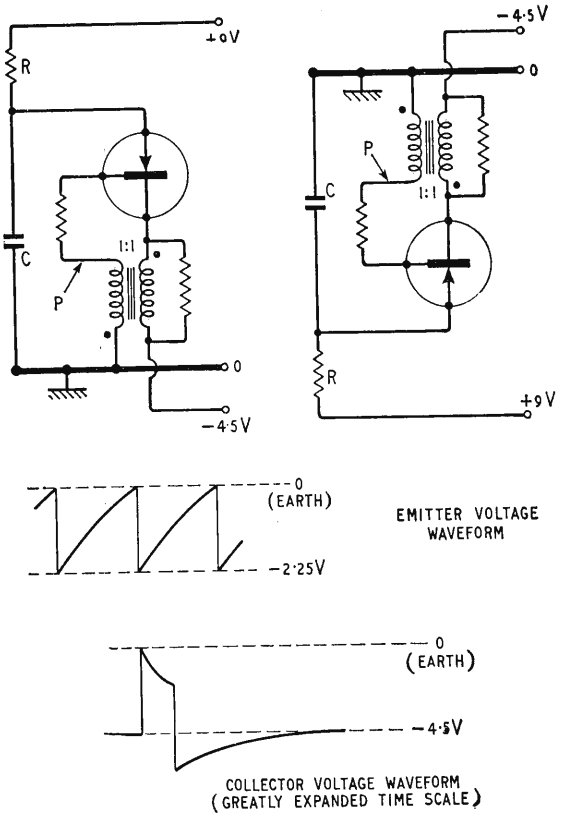


Fig. 10. Simple sawtooth generator circuit drawn to both conventions, and suggested as an exercise in correlation with waveforms.

tive-upwards scheme will come from people whose association with transistor circuits is mainly as users, and who seldom have occasion to consider in much detail what happens inside the circuit blocks. But should we base our circuit-drawing conventions on the views of people who are not experts on the circuits themselves?

I am convinced that by adopting the positive-upwards convention we shall, in the long run, make it easier for people, even those employed in quite a junior capacity, to think clearly about how circuits work—it may even increase the likelihood of bright new ideas occurring!

Try it Yourself

In conclusion, Fig. 10 shows the circuit of a simple but very satisfactory sawtooth generating circuit. The same circuit has been drawn in two different ways, according to the ideas discussed in this article. I invite readers to reason out for themselves just why the waveforms are as shown, first using one version of the diagram and then the other. (It will be sufficiently accurate for the present purpose to regard the transistor as a simple switching device, which is an open circuit when point P is positive to the emitter and a short circuit, i.e. "bottomed," when the point P is negative to the emitter. In the latter state, all three transistor electrodes may be regarded as being, nearly enough, at the same potential. In the practical circuit, the resistor shown in the base lead may be omitted, the parameter $r_{bb'}$ of the transistor functioning in place of it. A typical value would be 100 ohms, so that quite a large base current flows during most of the time the transistor is on.)

How would you draw the circuit if an n-p-n transistor were used?

REFERENCES

(1) "Transistor Graphical Symbols" by "Cathode Ray," *Wireless World*, April, 1957.

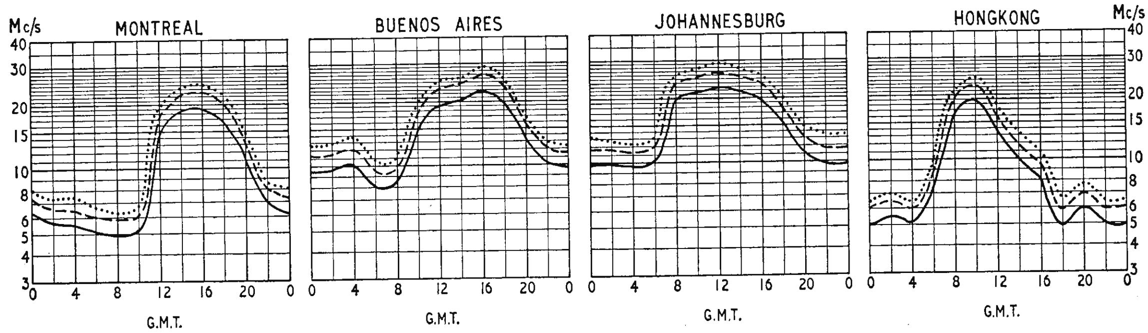
(2) "Transistor Circuit Symbols" by E. H. Cooke-Yarborough, *Wireless World*, July, 1957.

(3) "Semiconductor Symbols" by P. M. Thompson and J. Bateson, *Wireless World*, November, 1957.

(4) "Decoupling Capacitors in Grounded-Emitter Amplifier and Oscillator Stages" by K. Holford, *Mullard Technical Communications*, Vol. 5 No. 43, April, 1960.

SHORT-WAVE CONDITIONS

Prediction for January



THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during January.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

FUNDAMENTALS OF FEEDBACK DESIGN

1.—THE FEEDBACK CONCEPT

By G. EDWIN

AN engineer's life can be regarded as being concerned with two aspects of his problems. There are, however, several different ways in which the cut can be made. He is concerned with both the idea and the hardware, the theoretical system and its realization: he is concerned with passive network elements and active network elements: he is largely engaged by the distinction between the ideal element and its practical, non-ideal, form. He may also be convinced that the numerate need not be illiterate although the literate are too often innumerate. It may not be surprising that the reproduction rate of engineers is low.

Active devices are at the very heart of engineering. The network theorist may consider this to be the rankest heresy, but there is no network which will respond to a lump of coal: network theory can only be a way of establishing rules for connecting or applying active devices. The superior look of the mathematician turned engineer must not be allowed to discourage the more practical man who knows that he is working to enable coal from Newcastle to produce sound in Southampton or to print information in Pimlico. There was a tutor of Peterhouse who held that the only career for a gentleman was to enter the Diplomatic: politics, which might bring you to be Foreign Secretary, was quite unsuitable. Consider for a moment whether the Second Law of Thermodynamics does not apply in an embassy (Gresham's Law is leading to the disappearance of legations).

Active elements suffer from the very serious defect that they are so imperfect. Passive elements are also imperfect, but their imperfection can be regarded as simple and uniform whereas all active elements differ to some extent from each other and change both with time and with excitation. It is tempting to suggest that they must be treated only by statistical methods, but the practical engineer knows that he cannot tell a user that he has a 90% chance that the system will work: that attitude is reserved for the motor industry.

A Slow Start

James Watt is usually regarded as the first person to come to grips with this troublesome characteristic of active devices. His device, the steam engine, must have had parameters depending very sensitively on the stoking history while the user demanded a constant speed. The invention of the governor represents the first conscious use of the feedback principle which is the subject of this study. Applications in our own field were limited and on a rather *ad hoc* basis until the publication of H. S. Black's paper in the January 1934 issues of the *Bell System Technical Journal* and *Electrical Engineering*, and the general acceptance of the feedback principle then took a time which now seems to have been incredibly long. Systematic analysis based on the concept of closed feedback loops can liberate us from the most serious limitations of active devices; we see the appearance of close tolerance unit circuits as the basic step towards the mass production of systems, just as accurate machining was the basic step towards the interchangeability needed for mass production of machine guns and motor cars.

Feedback theory is essentially a practical study. Just as the playwright is concerned with the broken personal relationship and the probation officer is concerned with the broken social relationship, so the feedback designer is concerned with the defects which impede him in the realization of a design. The end of his road must be a happy ending with a piece of hardware functioning reliably: this is true even when the hardware is simple. Without a really full study of the literature it is impossible to be certain, but a rather cursory search suggests that between the few pages in the handbook and the full dress volume treating the most complex systems there is a gap where many engineers are left to struggle on their own.

Any study of feedback principles begins with the same diagram, shown here as Fig. 1. It consists of two portions, the forward path, which is usually the

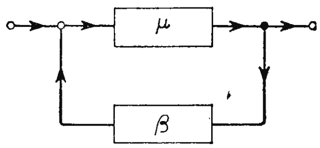


Fig. 1. Basic feedback diagram.

amplifier and which has a gain, however defined, of μ times, and the feedback path which has a gain of β, usually less than unity. The actual input to the forward path is obtained by combining the system input with the output from the feedback path, and the usual convention is that this should be an addition. The arithmetic of this system is easily performed. Unit input to the amplifier produces a system output μ and this results in an output from the feedback path of $\mu\beta$. The system input is such that when $\mu\beta$ is added to it we get unity, and is thus $(1-\mu\beta)$. The overall gain of the system is thus output/input $= \mu/(1-\mu\beta)$. Let us call this μ_f. We can now consider some of the significance of this. In general all the active elements will be in the amplifier μ, and β will be a purely passive system. (μ and β are used as names as well as for the characteristics of the boxes bearing these names.) Although μ is a varying, distortion-producing unit, the passive system β can be regarded as almost free of these defects. What happens if μ changes? We have:—

$$\mu_f = \mu/(1-\mu\beta)$$

so that $$\partial\mu_f/\partial\mu = 1/(1-\mu\beta)^2$$

or, $$\frac{\delta\mu_f}{\mu_f} = \frac{1}{1-\mu\beta} \cdot \frac{\delta\mu}{\mu}$$

This means that if μ changes by some fraction $\delta\mu/\mu$

the change in μ_f will be in a different proportion, $\delta\mu_f/\mu_f$ given by the relationship above. We shall for this purpose consider β to be negative, μ positive and $(1-\mu\beta)$ to be a fair degree larger than unity: a value of 10 for $(1-\mu\beta)$ is not unusual. Any change in μ is thus reduced by a substantial factor. It is often necessary to calculate just how much feedback is needed to give a particular gain tolerance. Let us suppose that we want μ_f to be 10, and that we expect μ to vary by a factor of 1 : 2. With $\beta = 0$, no feedback, μ_f will vary from 10 to 20. Now let us take μ larger, varying from 100 to 200, but $\beta = -0.09$. Then μ_f varies from 10 to 200/19, which is about 10.5. The next step might be μ ranging from 1,000 to 2,000, with $\beta = -0.099$, so that μ_f ranges from 10 to 2,000/199 or about 10.05. No attempt has been made to work these deviations out exactly because the problem has quietly lost its reality. The operation of increasing the amplifier gain will usually involve adding extra active elements, or operating the active elements in a more sensitive way. The last step above might well bring us to a range for μ of 1,000 to 8,000 and we can more easily establish limits by a slightly different approach. We can write $\mu_f = [-\mu\beta/(1-\mu\beta)](-1/\beta)$. When μ is allowed to become infinite this reduces to $\mu_f = -1/\beta$, and the performance of the system is completely dominated by β. A practical system with a finite value of β deviates from this by a factor $-\mu\beta/(1-\mu\beta)$, known as the $\mu\beta$ factor. Now we can begin again with our call for μ_f to equal 10 and make $\beta = -1/10$. If μ_f must not fall below some number $10x$ where x is just less than unity, we must have $x = (\mu/10)/(1+\mu/10) = 1/(1+10/\mu)$. It is then a straightforward operation to find the minimum value of μ which will provide the required gain stability for variations of μ of any amount upwards. There is no need to worry about the range, provided that μ exceeds this minimum value.

We can apply the same reasoning to variations of μ due to the signal itself, as we shall see when we come to consider distortion and intermodulation problems. Already, however, we have prepared the digging of a pit and we must turn to consider the basic problem in the application of negative feedback, the stability of the system.

Stability

It will be apparent that if we have $\mu\beta=1$ the gain with feedback, μ_f, becomes infinite. For any input, no matter how small, we shall have an output determined only by internal overloading of the system. This condition will be reached with μ negative. But although we have chosen to make μ positive in the region of the signals we are considering, we cannot maintain this condition at all frequencies. Eliminate all parasitic elements and we shall still find that at a sufficiently high frequency the time of travel of a signal over the finite distance from input to output will represent a phase shift of 180°, so that an input of $e \cos\omega t$ appears as an output of $\mu e \cos(\omega t+180°) = -\mu e \cos\omega t$. In practical circuits coupling and parasitic reactances produce this effect at frequencies in or near the signal band and it is the analysis of these effects which forms the basis of most of the writing on negative-feedback circuits.

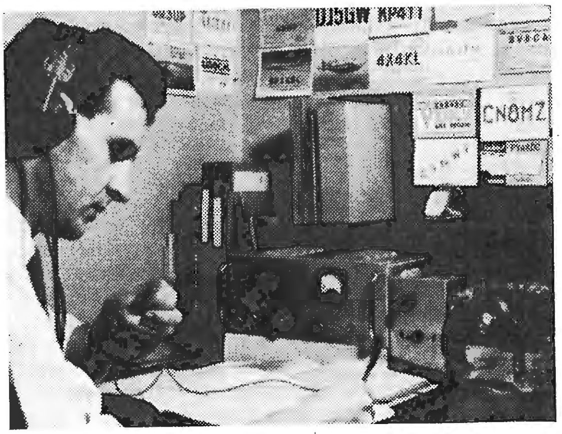
The analysis of circuits operating at fairly low frequencies is sometimes tedious but rarely difficult. When reasonable amounts of negative feedback are to be used it is always worthwhile. Simple approximate techniques can often be applied to indicate the kind of change needed to make an unstable system into a stable one and to give a fair approximation to the magnitude of the elements which must be changed or added. This is a frank statement that the second-best is better than nothing and is based on the author's experience that no matter what they write in the examination room, many young engineers are content to think with a soldering iron when they are working. The justification for the treatment you are now reading is that the more advanced texts do seem to have left us with too many hopeful experimenters at a level where thought is actually easier.

Since we have already raised the possibility of μ containing a phase shift we might now introduce this explicitly. Since we can also have a phase shift in the β path and since the ideal is when $\mu_f = -1/\beta$ so that $|\mu_f|\angle\theta = |1/\beta|\angle\theta$, we need only consider the $\mu\beta$ effect. This is particularly convenient because a calculating device has been designed to work with this factor and descriptions of its use will be given later. In the terminology we shall use, which is that used for the calculator, we can write

$$M\angle\phi = \frac{-|\mu\beta|\angle\theta}{1-|\mu\beta|\angle\theta}$$

Where now θ is the total phase shift of the amplifier and feedback path. Usually we do not have any phase shift in the feedback path and β is a constant. This expression then enables us to calculate the response of a practical system, particularly in the awkward regions at the edges of the band where the feedback is becoming positive. We shall see that this is by no means the only application of this extremely useful calculator. Before we can discuss how to use it to see how safe the stability of a system is, we must turn our attention to the basic rules which establish the stability and the way in which practical circuits are brought into conflict with them.

Transistor Transmitter



G3NWF (Mr. M. Bond of Chislehurst, Kent) has built and is using a 10-W 7-Mc/s RT transmitter that is fully transistorized. Using for the output stage a pair of S.T.C. silicon power transistors, Type TK202A, in push-pull, the transmitter has a crystal-controlled oscillator employing a Type TK252A. Contacts achieved include stations in Bulgaria, Denmark, Finland, Germany and Norway.

NEW FRAME-GRID CASCODE AMPLIFIER

MAZDA 30L17

The 30L17 is a high gain low noise double triode valve of frame grid construction designed for use as a cascode RF stage in VHF television tuners.

Excellent stability with high gain has been achieved by giving considerable attention to the arrangement of internal screening and connections. Each section of the valve has a slope of 15 mA/volt at an anode current of 15 mA and the variable-mu characteristic results in good signal handling with low cross-modulation.

Compared with the 30L15 at 200 Mc/s a gain improvement of about 5 dB with a tuner noise factor of 6 dB is possible.

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	7.2

MAXIMUM DESIGN CENTRE RATINGS

Anode Dissipation, either section (watts)	$P_{a(max)}$	1.6
Anode Current, per section (mA)	$I_{a(max)}$	18
Anode Voltage (volts)	$V_{a(max)}$	150
Negative Grid Voltage (volts)	$V_{g(max)}$	−50
Grid to Cathode Resistance, section 1 (MΩ)		1
Grid to Cathode Resistance, section 2 (kΩ)		22*
Effective Grid to Earth Resistance, section 2(kΩ)		150†

*Grid current bias.
†With potentiometer bias from HT line.

INTER-ELECTRODE CAPACITANCES‡ (PF)

Input as Cascode	c_{in}	4.3
Output as Cascode	c_{out}	3.1
Anode′ to Cathode′, Heater, Shield	$c_{a'-k',h,s}$	1.8
Cathode″ to Grid″, Heater, Shield	$c_{k''-g'',h,s}$	6.6
Anode′ to Grid′	$c_{a'-g'}$	1.5
Anode″ to Cathode″	$c_{a''-k''}$	.18
Anode′ to Anode″	$c_{a'-a''}$	.002
Grid′ to Anode″	$c_{g'-a''}$	.0025

‡Measured in fully shielded pocket, with cylindrical screening can.

CHARACTERISTICS (EACH SECTION)

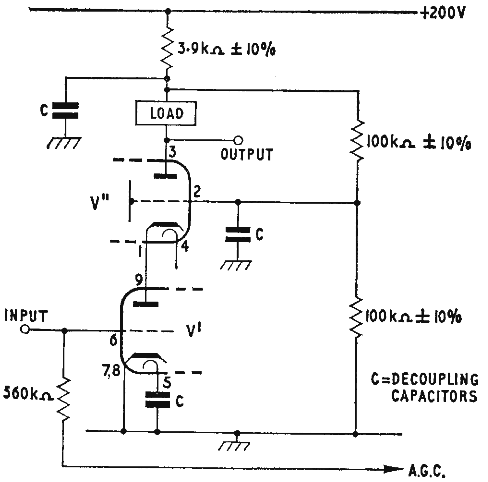
Anode Voltage (volts)	75
Anode Current (mA)	15
Mutual Conductance (mA/V)	16.5
Approximate Grid Voltage to give g_m = 165 μA/V (volts)	−6

TYPICAL CASCODE OPERATION

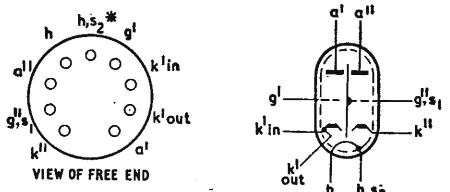
Grid current bias circuit, as shown below.

Anode supply voltage (volts)	200
Anode decoupling resistor, section 2 (kΩ)	3.9
Grid current bias resistor, section 1 (kΩ)	560
Anode current (mA)	15.8
Combined mutual conductance ($\Delta i_a/\Delta v_{g1}$) (mA/V)	18.3
Approximate bias voltage to give combined mutual conductance 100 : 1 reduction (volts)	−8.2

Typical Circuit With Valve Section 1, Grid Current Bias



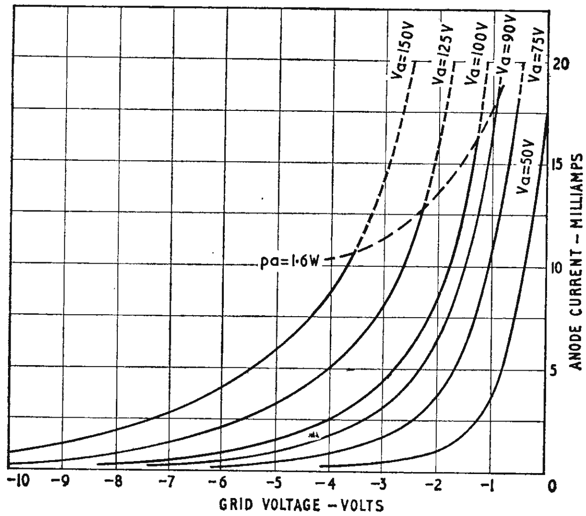
Mounting Position: Unrestricted
Base: B9A (Noval)
Connections:

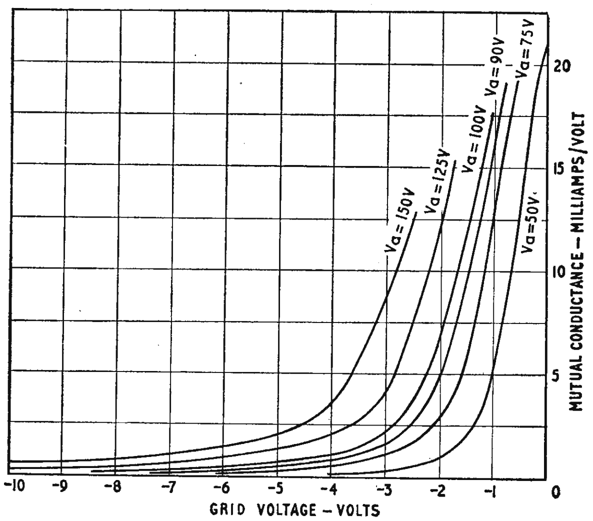


* In operation this pin must be earthed through a capacitor to chassis.(C_{h-E}>500pF)

MAXIMUM DIMENSIONS (mm)

Overall length	56
Seated Height	49
Diameter	22.2





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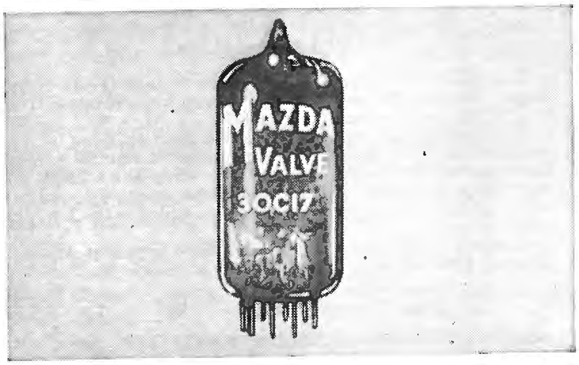
EDISWAN EXPORT DIVISION Thorn House, Upper St Martin's Lane, WC2 Telex: 21521 Thorn London

THORN-AEI RADIO VALVES & TUBES LTD

NEW VHF FRAME GRID FREQUENCY CHANGER

MAZDA 30C17

DESIGNED FOR AGC OPERATION



The 30C17 is a new VHF high gain triode pentode frequency changer for television tuners. The pentode section has variable mu characteristics enabling its gain to be controlled from the AGC line.

The application of gain control to the frequency changer stage of a television tuner will greatly ease the cross-modulation requirements of the IF valve since the output from the tuner can be kept lower when two stages are controlled. This leads to improvements in the AGC and cross-modulation performance of the whole receiver. To give the utmost control AGC can be applied to three stages, RF, Frequency Changer and Common Variable-mu IF. Alternatively it offers the possibility of controlling the two tuner valves only and using a straight IF amplifier with its attendant advantage of extra IF gain.

Heater Current (amps)	I_h	0·3
Heater Voltage (volts)	V_h	7·4

TENTATIVE RATINGS AND DATA

Maximum Design Centre Ratings

		Triode	Pentode
Anode Dissipation (watts)	$p_{a(max)}$	2	1·7
Screen Dissipation (watts)	$p_{g2(max)}$	–	0·5
Anode Voltage (volts)	$V_{a(max)}$	250	250
Screen voltage (volts)	$V_{g2(max)}$	–	230
Heater to Cathode Voltage (volts rms)	$V_{h-k(max)rms}$	200	200
Cathode Current (mA)	$I_{k(max)}$	18	18

Inter-Electrode Capacitances* (pF)

		Triode	Pentode
Input	c_{in}	3·5	6·6
Output	c_{out}	2·1	3·1
Control Grid to Anode	c_{g-a}	1·8	0·008
Grid Triode to Grid 1 Pentode	c_{gt-g1}	0·01	
Anode Triode to Anode Pentode	c_{at-ap}	0·01	
Grid Triode to Anode Pentode	c_{gt-ap}	0·002	
Anode Triode to Grid 1 Pentode	c_{at-g1}	0·005	

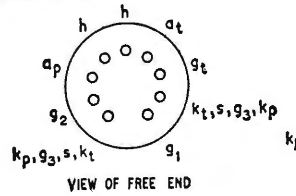
*Measured in fully shielded socket with can.

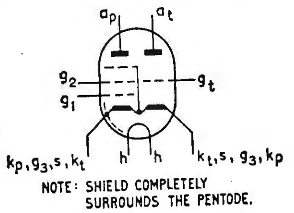
Triode Characteristics

Anode Voltage (volts)	V_a	100
Anode Current (mA)	I_a	15
Mutual Conductance (mA/V)	g_m	8·5
Amplification Factor	μ	20

Base: B9A (Noval) **Mounting Position:** Unrestricted

Connections





Maximum Dimensions (mm)

Overall Length	56
Seated Height	49
Diameter	22·2

TYPICAL OPERATION AT 200 Mc/s WITH CATHODE BIAS

For operation with cathode bias where it is intended to apply AGC to the frequency changer. The oscillator voltage is applied to the pentode control grid.

Pentode

Supply Voltage (volts)	V_b	200
Anode Voltage (approx.) (Decoupling Resistance, R_a=4·7 kΩ) (volts)	V_a	170
Screen Voltage (approx.) (R_{g2}=22 kΩ) (volts)	V_{g2}	155
Cathode Bias Resistance (Ω)	R_k	100
g_1 Resistance (MΩ)	R_{g1}	4·7
g_1 Current (μA)	I_{g1}	0·6
Anode Current (approx.) (mA)	I_a	6·4
Screen Current (approx.) (mA)	I_{g2}	2·0
Conversion Conductance at 1 Mc/s (mA/V)	g_c	4·9
Grid Voltage for Conversion Conductance reduction 10 : 1 (volts)		−6·7

Triode

Anode Voltage (volts)	V_a	100
Anode Current (mA)	I_a	5

TYPICAL OPERATION AT 200 Mc/s WITH GRID CURRENT BIAS

Operation with grid current bias is suitable for the 30C17 in existing tuners not provided with AGC on the frequency changer. The oscillator voltage is applied to the pentode control grid.

Pentode

Supply Voltage (volts)	V_b	200
Anode Voltage (approx.) (Decoupling Resistance, R_a=5·6 kΩ) (volts)	V_a	148
Screen Voltage (approx.) (R_{g2}=33 kΩ) (volts)	V_{g2}	108
g_1 Resistance (MΩ)	R_{g1}	0·1
g_1 Current (μA)	I_{g1}	24
Anode Current (approx.) (mA)	I_a	9·2
Screen Current (approx.) (mA)	I_{g2}	2·8
Conversion Conductance at 1 Mc/s ($V_{het(pk)}$=2·6 V) (mA/V)	g_c	5·2

Triode

Anode Voltage (volts)	V_a	100
Anode Current (mA)	I_a	5

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THORN-AEI RADIO VALVES & TUBES LTD

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

"Over the Hump"

I VENTURE to doubt whether Marconi's historic feat of 1901 in getting signals across the Atlantic in daylight can be fully explained by the favourable propagation conditions then existing.

When the next sunspot minimum period came in 1912 radio communication was still predominantly by means of spark transmitters and non-amplifying receivers, though techniques had been greatly refined. Night-time ranges of 2,000 miles were not uncommon but, in spite of improvements, there appears to be no record of daylight communication during the period at such distances on frequencies of the order thought to have been used by Marconi in the original experiments. Estimates vary, but the frequency is generally given as something well above 100kc/s.

It seems plausible to suggest that the frequency actually used may have been much lower; perhaps as low as 45-50kc/s, a value used very successfully during the 1912 sunspot minimum for the Clifden–Glace Bay transatlantic circuit.

Chichester. H. F. SMITH.

Electronic Ignition

A FEW weeks ago the motoring journals carried a brief description of an electronic ignition system, using transistors, developed by Joseph Lucas Ltd. Reduced to its essentials, the system comprised a high-power blocking oscillator (the spark generator), triggered by a pulse-shaping amplifier. The timing pulse was generated electromagnetically by a small transducer having one fixed element (e.g., a coil on a magnetic core) and one moving element (a magnet or magnetic yoke) carried on the engine flywheel.

It occurred to the writer that an alternative approach might be to employ a silicon-controlled rectifier, (SCR), in a pulse circuit of the type used in the modulator stage of some of the older types of radar transmitters, or that used more recently for spark machining of hard materials. In principle, a capacitor is charged through a high resistance from a d.c. source and is then discharged, by means of an electronic switch, through the load, which may be the primary winding of a pulse transformer.

The idea was tested in the arrangement shown in Fig. 1. The capacitor C is charged from a high-voltage d.c. source through the resistance R and the primary

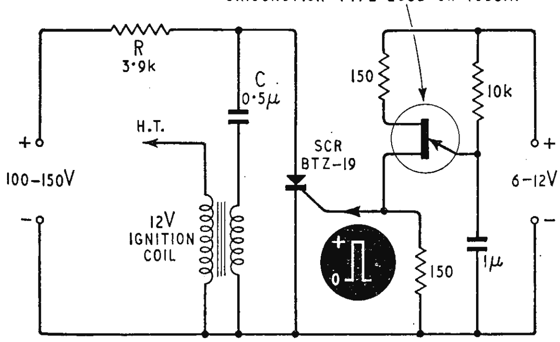


Fig. 1

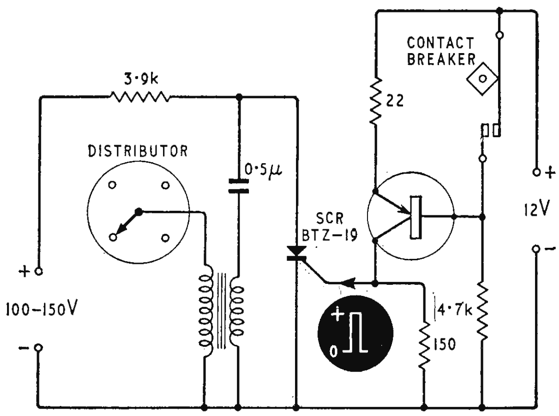


Fig. 2

winding of a standard 12-volt oil-filled ignition coil. On firing the controlled rectifier by means of a short positive gating pulse, the capacitor is discharged through the SCR and the primary winding of the ignition coil, producing a spark in the secondary circuit

The controlled rectifier ceases to conduct when the discharge current through it falls below some critical value or when the voltage across it is reversed or reduced to zero. It will not conduct again until a new firing pulse is applied to its gate electrode. The capacitor discharge tends to be oscillatory since it takes place through an LCR series circuit and in practice the SCR appears to cut off reliably at the end of the forward half-cycle of the discharge current, provided only that the firing pulse is of very short duration.

For test purposes a silicon unijunction device makes a convenient pulse generator. Suitable types include the (American) General Electric units 2G5B or 4JD5A1. Referring to Fig. 1, the 1μF capacitor is charged through a 10kΩ resistance. When the capacitor voltage reaches a critical value the device fires and a brief current pulse is drawn from the 6-12V supply. This develops a corresponding voltage across the 150Ω load resistance which is in the gate circuit of the controlled rectifier. With the component values shown the pulse repetition frequency is about 400c/s. This spark frequency corresponds to the requirements of a 6-cylinder engine running at 8,000 r.p.m. or a 4-cylinder motor turning at 12,000 r.p.m. Although high, these figures are nowhere near the limiting switching speed of a controlled rectifier, which could easily run a 16-cylinder engine at over 12,000 r.p.m. With a pulse frequency of 400c/s the circuit of Fig. 1 draws 5mA from a 100-V supply when the h.t. spark gap is set to $\frac{1}{8}$ inch. If a sparking plug is used instead of a pointed wire gap, the current rises to 10mA, presumably because of a heavier discharge current. With a 150-V d.c. supply a very intense spark is produced. A conventional car radio h.t. supply would provide this high-voltage d.c. supply with little risk of overloading since the current drawn is quite small. Alternatively a low-power transistor inverter could be used in conjunction with a simple rectifier-filter system.

Running tests on an actual engine have not been made, but it should not be difficult to modify a standard ignition system to test the principle. A possible arrangement is shown in Fig. 2. Here the normal contact breaker is used to generate a firing pulse by using it to open or short-circuit the base-to-emitter terminals of a silicon p-n-p transistor amplifier. With the contacts closed there is no forward bias on the transistor, which is therefore cut off and draws no collector current. When the contacts open, base bias is applied through the 4.7kΩ resistance and the resulting pulse of collector current develops a voltage across the 150Ω collector load resistance. This is sufficient to turn on the controlled rectifier. A possible weakness of this arrangement is that the duration of the gate firing pulse to the SCR may be too long. If so, the controlled rectifier will not cut off reliably at the end of the first half-cycle of the primary discharge current or, if cut off momentarily, it may re-strike to give multiple spark discharges. The remedy for this is to introduce pulse-shaping circuits between the contact breaker and the gate firing circuit of the SCR.

On British cars the positive side of the electrical supply is usually grounded to the chassis, but Fig. 2 requires a negative earth (normal American practice). To try out the circuit it is best to use a separate battery and to disconnect existing wiring from coil and contact breaker, re-wiring as in Fig. 2. The capacitor normally shunting the contact breaker points should also be removed.

A fully developed version of the system would not use a contact breaker at all but would rely on a firing pulse generator of the type used in the Lucas equipment. Even if it were retained in an otherwise entirely electronic ignition system the contact breaker would have an abnormally long life since it is only required to open a circuit carrying a few milliamperes instead of several amperes as in the standard system used today.

If a high-voltage d.c. source is used the controlled rectifier should have a correspondingly high inverse voltage rating. The Mullard BTZ 19 is a 400-V device. Its current rating is unnecessarily large for the present application and a much smaller unit would serve the purpose just as well.

The writer would welcome comments on the proposed scheme and would be particularly glad to hear from anyone bold enough to try it in practice.

Cheltenham. F. BUTLER.

Preferred Values

BROWSING through some old bound copies of *Wireless World* the other day, I came across an article by "Cathode Ray" (1952) entitled "Why 47." In this, he explains the reason for the standard preferred values of resistor. I thought I was going to find in this the answer to a problem which I was trying to solve, but alas, he did not go deep enough.

Taking the 20 per cent range of values, he rightly explains that their purpose is to divide each decade into six logarithmically equal parts. Put another way, the values form a geometric series with six terms per decade and containing all the exact powers of 10. On this basis, the values for the decade 1 to 10 should be:—

$$10^0, 10^{1/6}, 10^{1/3}, 10^{1/2}, 10^{2/3}, 10^{5/6}, 10^1$$

and these, evaluated with 4-figure tables, produce:—

1, 1.468, 2.153, 3.162, 4.641, 6.813, 10

Now, one may well ask "Why 47?" Why was 4.641 rounded up to 4.7 and not down to 4.6? And if this is splitting hairs, one may ask with a little more conviction why 3.162 was rounded up to 3.3?

I have tried to justify the standard figures from all possible angles, but although I can explain some of the discrepancies, I cannot find one approach which satisfies all. Unless you can offer me an explanation, I should be most grateful if you would publish this letter in the hope that the gentleman who originally derived the figures may read it and come forward with the answer.

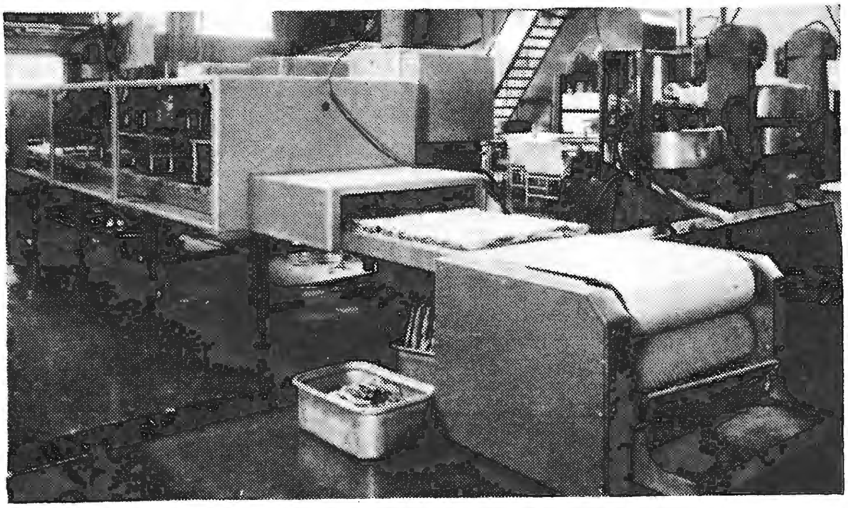
London, N.20. A. B. COOPER.

RAPID THAWING OF FISH

TO allow a longer, and thus more economical, fishing trip modern practice is for the catch to be deep-frozen at sea and then thawed again on landing. The thawing of the resulting large blocks of frozen fish has been carried out by warm air or water; but the process is slow, sometimes taking several days: fish on the outside of the block can deteriorate whilst the inside is still frozen and forceful separation of fish causes damage.

Pye have recently installed an r.f. heating system at Grimsby for Ross Foods. In this plant three tunnel ovens are employed, the slabs of frozen fish passing through all three on a 36-ft conveyor belt. Each oven is fitted with a 12-kW industrial r.f. generator (frequency 27.12Mc/s) connected to an electrically balanced pair of electrodes, one above the conveyor, one below, which form part of the final tuned circuit.

Good results are claimed—a 10lb slab of herring initially at −20 to −30°F passes through the ovens in 12min and emerges just below freezing point with less than 1°F difference in temperature between various parts of the slab, and maximum handling capacity of the installation as arranged at present is about 1ton/hr.



General view of defrosting plant showing three consecutive ovens.

FORMANTS

By "CATHODE RAY"

IF you are interested in sound reproduction—and most readers of *Wireless World* seem to be—your thirst for knowledge is likely to face you, sooner or later, with the word *formant*. If your experience is anything like mine, your encounters with it may be somewhat confusing. Perhaps I have failed to find the clear and informative definition that exists somewhere. Or perhaps there just isn't one. Anyway, the impression I gained was of something rather complicated and mysterious, when in fact it seems to be quite simple.

Come to think of it, when is a thing simple? I suppose, when one happens to know it. That makes all the difference. The obvious has been defined as something one learnt yesterday. Human nature being what it is, one then tends to look down on those who won't know it until tomorrow. Not long ago, if a "What do you know?" team had failed to give the atomic weight of a radioactive isotope of strontium, they would have had every sympathy, but nowadays even Members of Parliament might deride such ignorance, for is it not mentioned almost daily in the House whenever there is a fall-out scare?

Similarly, people who don't happen to have been brought up on radio are not necessarily morons because they look blank when one says that formants are just local resonances causing peaks in the frequency characteristic. To us, that may be all that need be said. (For fear it isn't, I'm going to say quite a lot more!) We enjoy special knowledge that can be drawn upon to explain an analogous effect, whereas others must start from scratch and may well find the unfamiliar subject hard to grasp. I suspect that some of those who wrote about formants in their books hadn't really grasped it when they did so.

If sounds of certain frequencies are unduly accentuated by equipment such as loudspeakers, microphones, pickups and amplifiers, we ascribe it to resonances—and try to get rid of them. Why have a different word for the same thing in musical instruments and the human voice? One reason, presumably, is that in musical and even acoustical circles "resonance" means something different—more like what we call "reverberation." Another reason, perhaps, is that in general our resonances are undesirable, whereas resonances in musical instruments may be helpful, and in speaking are absolutely essential. But the basic distinction, surely, is that musical instruments and people actually produce the sounds, whereas our equipment just passes them on. A sound producer is entitled to some control over the shapes of its sounds, whereas a reproducer is expected to say what it's told without addition, subtraction or modification.

A moving-coil loudspeaker is a mechanical device having mass and stiffness and therefore a natural frequency of resonance, usually in the region 40-100c/s. The effect of this is to emphasize all sounds at that frequency, as we well know. So we try to damp the resonance out as much as possible, by such means as negative feedback. The air enclosed in the cabinet resonates at certain frequencies determined by its dimensions, and there again the idea is to damp the resonances out by lining the enclosure with sound-absorbing materials.

Musical instruments consist essentially of stretched strings or air enclosures having definite natural frequencies, and they are played by hitting or plucking or blowing into them in such a way as to set up transient or continuous oscillation at one or more of those frequencies. Just as with our electrical oscillators, there is some output at exact multiples of the fundamental frequency—in one word, harmonics. The characteristic quality or timbre of the particular instrument is due mainly to its harmonic structure. With some instruments, such as the oboe, the harmonics are actually stronger than the fundamental. Fortunately our sense of hearing is so arranged that we automatically identify the fundamental frequency, even if it is entirely absent! Another interesting feature of hearing is that if the harmonics of a continuous note are phase-shifted relatively to one another, it makes no difference to the sound as heard, even though the waveform may thereby be altered drastically. It is only the relative amplitudes of the harmonics that count.

Musicians' Tone Control

Even in a single instrument the harmonic structure may vary considerably with the pitch of the note played, and with its loudness and (in stringed instruments, for example) exactly where it is attacked. Some instruments played at the extremes of their frequency ranges can be quite difficult to identify. But on the whole each type of instrument has a recognizable tone quality due to the relative amplitudes of its harmonics.

Bowed string tone, for example. But while a violin and a viola both produce such tone, it is not exactly the same tone even when they play the same note. That is where formants come in. The sounds produced by bowing the strings are considerably amplified by the bodies of the instruments, which are forced into vibration. The bodies have natural resonances which amplify some frequencies more than others. Because a viola is larger than a violin, its resonances are lower pitched, so its sounds are somewhat different, rather as the sounds from various loudspeakers reproducing the same programme are different. (But whereas a composer can get the effect he wants by choosing to score a tune for a viola rather than a violin, the effect produced by a loudspeaker "formant" is inflicted on all his music, willy nilly!)

The important point is that the frequencies affected by a formant are the same, no matter what the frequency of the note played. So its effect on the harmonic structure depends on the note.

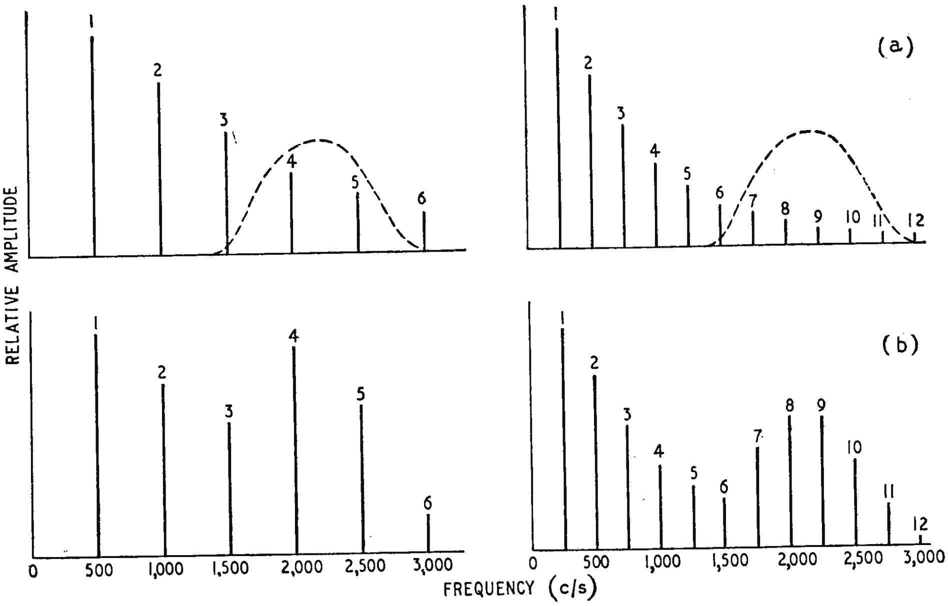


Fig. 1 (a). Unmodified harmonic structures for notes produced by an imaginary musical instrument at 500 c/s and 250 c/s. (The frequency scale is linear, instead of the usual logarithmic one as in Fig. 2, to suit the harmonics, which occur at equal intervals of frequency.) If the instrument has a formant at 2,200 c/s, as shown dotted, its output is modified as at (b).

Suppose the nature of some unspecified instrument without formants is to generate a full train of harmonics declining steadily with amplitude, as shown in Fig. 1(a) for a note of 500 c/s and for one an octave lower (250 c/s). Next, suppose it has a formant in the region of 2,200 c/s, shown as a dotted resonance curve. Below, at (b), are the relative amplitudes as modified by this formant. Whereas the high note has its fourth and fifth harmonics brought into prominence, these are relatively weak in the low note, which is likely to sound rather harsh on account of the emphasized upper harmonics. Incidentally, the writers I criticized earlier include those who say, or at least convey the impression, that such an instrument produces tones in the region of 2,200 c/s, unrelated to the frequencies of the notes played. In fact, of course, formants don't produce sounds; they only modify those produced by other means.

One can guess that favoured musical instruments are unlikely to have formants in the shape of prominent isolated peaks.* Such peaks would tend to make the tone quality of an instrument vary too much from note to note in the musical scale. The human voice is quite a different matter, even if we leave consonants out of account and consider only vowels, which are comparable with sustainable musical tones. Although the English alphabet has only five vowels, the English language has at least fifteen different vowel sounds that are readily distinguishable when spoken by a competent voice at any reasonable pitch. How is this possible? What is the essential difference between the various vowel sounds?

By uttering sustained vowels one can easily check that what one does to change from one to another is to alter the shape and size of the space inside the mouth. To say "ah" one has to open it up and bring the tongue well forward—which is why the doctor tells you to do this when he wants to look at the throat. For "ee" one has to reduce the opening and push the tongue back.

The basic sound of any vowel is generated by modulating the air stream coming up through the throat by vibrating the vocal cords at the frequency needed to pitch the desired note. As in a musical instrument, this sound contains numerous harmonics of the fundamental frequency. The relative amplitudes of these are modified by the resonances of the semi-enclosed spaces in the mouth before they emerge into the open air. (I would call them—in radio parlance—cavity resonances if this were not liable to suggest dental decay.) There is sometimes an alternative route through the nose, which has its own characteristic resonances. If this is blocked by a cold, or by pinching the nose, it causes a characteristic change in the voice, commonly described as nasal or "talking through the nose," though it is the precise opposite of that.

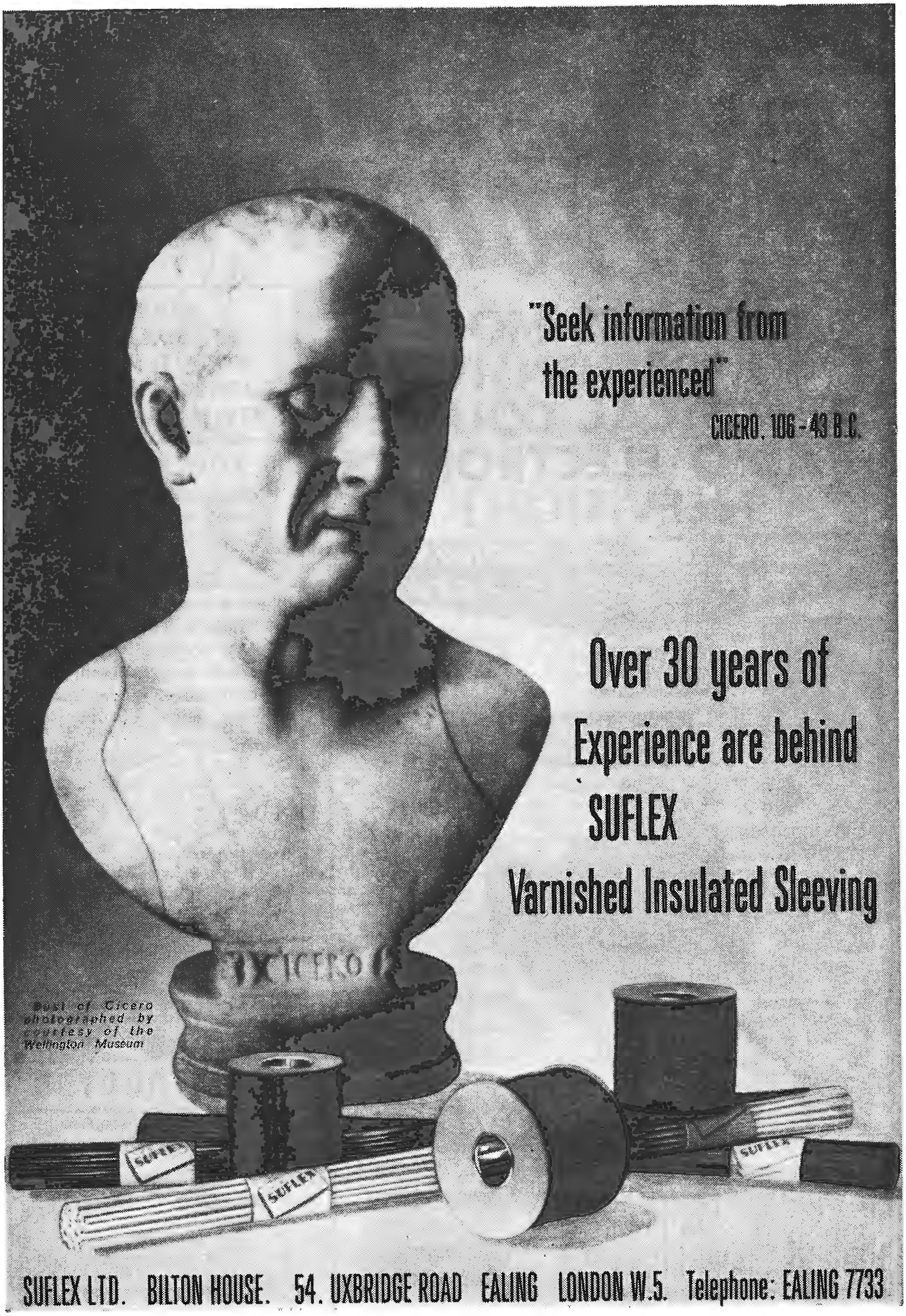
The interesting thing is that the particular vowel uttered depends only on the frequency or frequencies of these formants, which are roughly constant for all individuals and all frequencies of the vocal sound. Fig. 2 shows those corresponding to the principal vowel sounds. One series has a single prominent hump; the other, two. Recent investigators say that there are really three vowel formants, but one or two of these are less noticeable.

That altering the formant frequencies alters the vowel sounds can be demonstrated by playing recorded speech at the wrong frequency. Playing at half speed lowers the tones an octave, as well as halving the speed of utterance; but the vowels, too, are altered, so the result is not the same as the original speaker intoning an octave lower and half as fast.

Another consequence of the formant mechanism is that "oo," which has a low formant frequency, is harder to sing on a high note than "ah," and when it is done the result doesn't sound a very good "oo." This is one reason against singing a translated version of a song. A reputable composer would

(*Continued on page* 33)

* "Favoured by whom?" the younger readers may ask; "Squares?" The question is, perhaps, pertinent, since it would hardly be true to suggest that the role of formants is inconspicuous in certain jazz instruments.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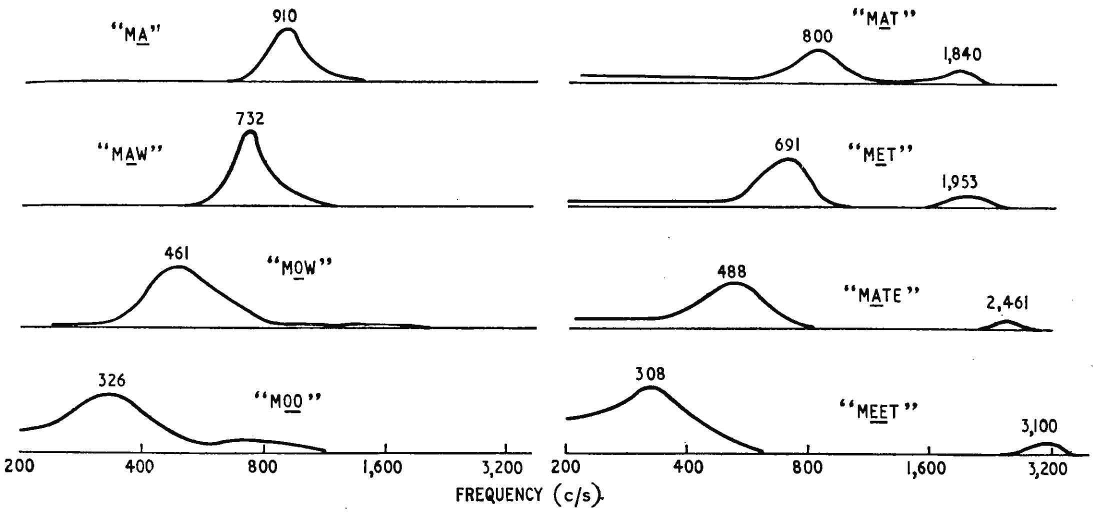


Fig. 2. Vowel formants, as measured by D. C. Miller (The Science of Musical Sounds).

instinctively avoid awkward combinations of pitch and vowel sound, but it would be asking rather a lot of a translater to expect him to find words to comply with this requirement as well as make sense and fit the metre.

You may be wondering about whispered speech. The difference with this is that the vocal cords are inoperative, so the stream of air is unmodulated at any frequency. Instead, it generates a sort of "white noise"—containing all frequencies at random. The relative strengths of these are modified by the mouth formants, just as if they were an infinite train of harmonics; and so distinctive vowel sounds are produced. But if you try to alter the pitch of a whispered vowel sound you find you cannot without altering the vowel too, for the formant frequencies are the only variable ones. You can, however, whisper a tune, so long as you abandon the words. It is easiest done by generating a strong white noise—between a "h" and a "sh"—and varying the size of the mouth space so as to make it resonate at the appropriate frequencies. The semi-consonant noise tends to drown the varying vowel sounds corresponding to these frequencies, which would otherwise tend to divert attention from the varying pitch.

Transient white noise can be generated by clicking or tapping, and this is used instead of breath by those irritating people who tap on their teeth with a pencil while varying the size of their mouth cavity to resonate with the notes of a tune.

Turning from this misguided virtuosity to orthodox speech, we next consider the fact that we can distinguish not only different vowels and pitches but also between different people saying the same vowel at the same pitch. The frequency of vibration of the vocal cords determines the pitch; the frequencies of the formants determine the vowel; what parameters are left to account for voice recognition? Presumably they are recordable, if the H.M.V. motif has any validity.

I'm sticking my neck out here, because frankly I don't know. But until someone writes in with a better story, mine is going to be as follows.

I suspect that if different people did utter *exactly* the same vowels at exactly the same pitches it would be quite difficult to tell one from another. To identify people by voice, we rely a good deal on pitch, and still more on individual renderings of supposedly the same sounds. To take an extreme example, if a person pronounced "top" in much the same way as we say "tap," we would at least have a clue to his nationality! Even if the inquiry is confined to the British Isles, wide variations in vowel sounds will be heard. That is true of "steady state" vowels, but from the output of many speakers —notably Londoners—these would be almost non-existent, there being a continuous transition from one sound to another. When we take into account the combinations of different forms of "attack" for all the vowels, and then add the differences in rendering consonants, and all the varied breath and tongue noises and individual pitch outlines in phrases and sentences, the chance of any two voices being wholly alike can be seen to be remote, without the need to look for any other basic parameters. We know, too, that a slight change in a familiar person's speech formants, caused by the presence of a sweet or other foreign body, is usually quite enough to have a noticeable effect on his talking.

For much the same reason, even if you were to enter your house in the dark, noisily, you would probably notice at once if someone had removed a settee or even an easy chair. The "formants" of the room would thereby be subject to less damping. Incidentally, in connection with rooms a third term is sometimes used instead of "resonances" or "formants"—"eigentones." But there seems to be no real need to import a German word when we have two of our own.

All this may seem to be rather off the subject in *Wireless World*. But, as I said at the beginning, nothing to do with sound production is off our subject; and to obtain the hi-est fi it helps if one knows the characteristics of what one is trying to produce. If it is known that a resonant peak at a particular frequency is enough to give a recognizable vowel tone to an otherwise neutral sound, the importance of avoiding such peaks anywhere in the reproducing system is clearer.

RADIO HOBBIES EXHIBITION

TRANSISTORS FOR V.H.F. AND COLOUR TV

ON looking round the amateur exhibits on the Radio Society of Great Britain stands the immediate impression was that transistors are now capable of supplying the needs of practically any receiver whether for m.f. or v.h.f. In this field it would seem that the amateur has regained the lead he held over the professional in years gone by, for in particular the V.H.F.-Group exhibits showed that transistors are in use by amateurs for reception of frequencies that are still almost exclusively the province of valve equipment in the commercial world. A typical example from the equipment here was a 2-m crystal-controlled converter made by J. Gazely using Type 2N1742 transistors.

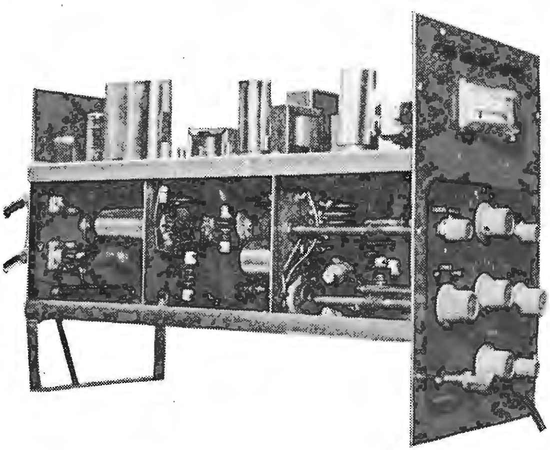
Of particular note on the R.S.G.B. stand was A. H. Mynett's (G3HBW) transistor communications receiver, which won this year's Silver Plaque Award for the most outstanding piece of amateur-built equipment. Using over thirty transistors, this set has facilities usually found only on professional equipment of the highest grade. The receiver tunes over the usual six amateur bands (160m to 10m) and also includes coverage of the 144 to 146Mc/s band, using an individual wide-band r.f. stage and mixer with crystal control of the local oscillator (noise factor better than 4.5dB). This, of course, ensures a high degree of frequency stability as the selection is carried out over the 1.8-2.2Mc/s band. Double conversion is employed on the other bands too, with another individual circuit for 28 to 30Mc/s. The a.g.c. system, in particular, is elaborate: separate amplification at i.f. being followed by a detector with a fast (5msec) rise time and switched selection of decay times of 50msec for a.m. reception or 1sec for s.s.b. and c.w. operation. Other features are an adjustable noise limiter and a two-transistor bridge circuit for the S-meter. To avoid the possibility of damage to such a large number of transistors, should the supply be inadvertently reversed, diodes are fitted in each supply lead. Power consumption is about 80mA at 12V: a surprisingly small amount in view of the complexity of the set.

Another item that caught our eye on the R.S.G.B. stand was a transmitter for mobile use having a 30-W transistor modulation amplifier and a transistor-converter power supply unit for the transmitter, which covers the amateur bands from 160 down to 10m. This equipment, made by C. J. Salvage (G3HRO) is the companion transmitter to last year's group-award-winning transistor communications receiver*. The transmitter "chain" uses four valves, starting off with a v.f.o. for the three l.f. bands. The next two stages operate either as buffers or doublers feeding the final 5B257M stage to which anode and screen modulation is applied. The power-supply develops 600V and 250V, the power input to the final stage being 60W.

This year's best group entry was a 2-m triple-conversion crystal-controlled receiver entered by the Enfield Club. This 17-transistor set was made by John Gazely, who received the Freeman Trophy for it, the first award of this prize.

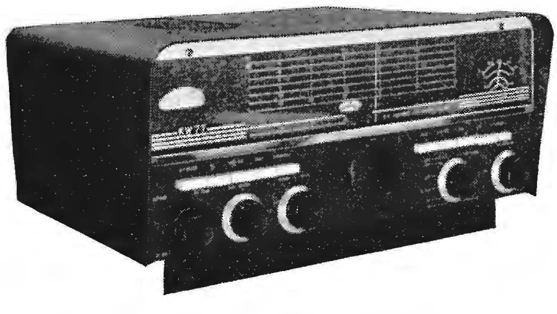
Transistors are making their debut also in the "ready-made" field; for instance Stratton's newest "Eddystone" receiver (prototype) uses twelve transistors and covers the m.w. broadcast band and 2.2 to 30Mc/s. This set uses a single conversion to a 465-kc/s i.f. and employs amplified a.g.c. Powered by eight "U2" cells, the set

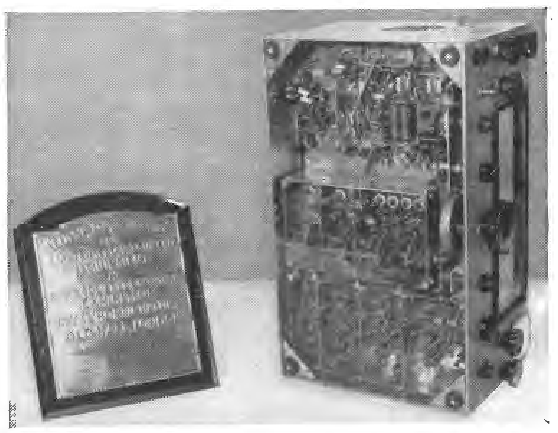
* "All-Band Transistor Communications Receiver", by C. J. Salvage, *Wireless World*, December 1961, p. 626.



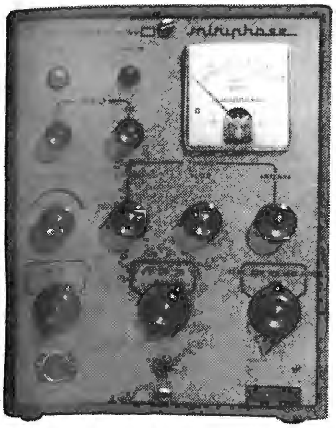
Single-sideband adapter by Heathkit.

KW77 communications receiver using valves (K.W. Electronics).

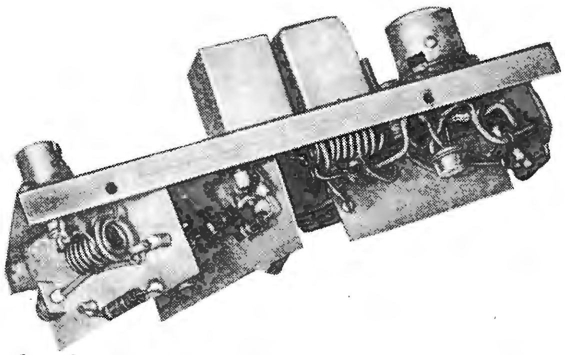




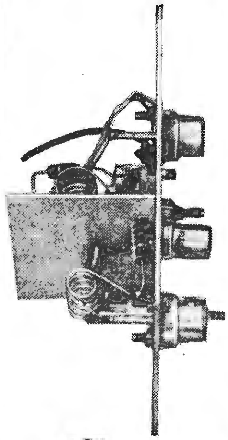
A. H. Mynett's award-winning transistor receiver and Silver Plaque.



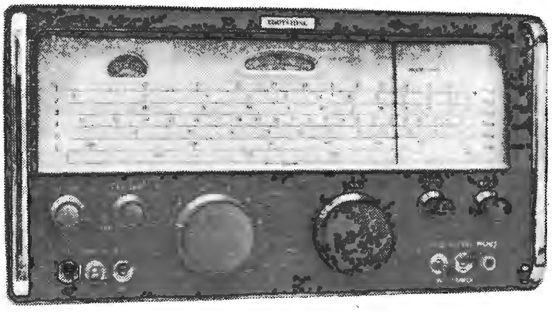
Left: Minimitter "Miniphase" single-sideband exciter using sheet-beam valves in an out-phasing circuit.



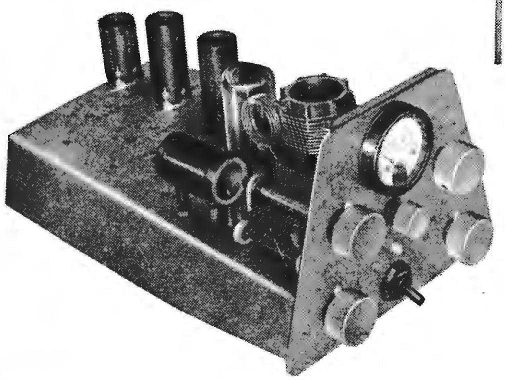
Crystal-controlled transistor 2-m converter shown by J. Gazeley in R.S.G.B. V.H.F.-Group display.



Right: Withers 2-m pre-amplifier using "Nuvistor" valve (to right of screening partition).



Prototype of "Eddystone" transistor communications receiver by Stratton.



Transmitter section of mobile equipment (C. J. Salvage, G3HRO).

incorporates a crystal filter and has a sensitivity of 3μV, falling to 6μV at the highest frequency.

From K.W. Electronics comes a new receiver, the KW77, using valves. This, like Mynett's receiver, has a fixed-tune crystal-controlled front end, all bands being converted first to 80m, where tuning is carried out. Then a further conversion takes the signal down to 455kc/s, then again to 50kc/s, with a fine tuning facility at 455kc/s. A 100kc/s crystal calibrator is built in, as is a crystal filter.

Developments in v.h.f. techniques are not confined to transistors, though. J. Withers were showing converters and amplifiers for the 2 and 4-m bands employing the 6CW4 "Nuvistor"—one of the miniature metal-and-ceramic valves made by R.C.A.—which, due to its small internal inductances and capacitances coupled with high slope allows the realization of about 20dB of gain at a very good noise factor. Another item of special interest shown in Withers' range was a 2-m v.f.o. with a basic output at 72Mc/s (to feed a doubler). On c.w. operation a "clickless" keying action is obtained by triggering a neon tube which passes current through a winding on part of the magnetic circuit of the oscillator coil. This moves the frequency by about 200kc/s and cut-off bias is applied to the amplifier stages in the key-up position.

Interest in single-sideband operation on the lower frequencies continues to grow, and three new exciter units were found. Two of these use the new sheet-beam valves* in the balanced-modulator circuit, where their use overcomes that old bugbear of a balanced-modulator stage: that is, the problem of maintaining a long-term stable cancellation of the carrier. In the Minimitter "Miniphase", two R.C.A. 7360 valves are used, cross-connected, with quadrature r.f. applied to their control grids. In the absence of modulation the output is brought to zero by adjustment of the deflector-electrode potentials: application of quadrature a.f. signals to the deflectors then unbalances the stage to produce an s.s.b. output. The Copp Communications Co.'s 5BJ exciter uses a single 7360 as a balanced modulator at 9Mc/s, its d.s.b. suppressed-carrier output being passed into a "McCoy" crystal filter which selects the wanted sideband. The advantage of the sheet-beam valve is that the parameters on which proper balance of the modulator depend are controlled solely by the applied potentials. Thus the use of these valves allows the construction of very stable exciters.

Daystrom introduced their SB-106 s.s.b. adapter designed primarily for their "Apache" transmitter, but capable of operation with any suitable design, such as the DX 100U.

An idea to help the man short of space on his "aerial farm" comes from Minimitter, who were showing wire aerials loaded with ferrite beads at the centre. This technique reduces the length of a 3.5-Mc/s $\lambda/2$ dipole (about 130ft) to 86ft and another advantage claimed is that, when running as a harmonic aerial on high-frequency bands, the shortened middle section changes the phase relationships of the remote parts. The effect is to maintain a single-lobe radiation pattern, instead of giving the figure-of-eight characteristic of a "harmonic" aerial.

The aerial æsthete should be interested in a new

* "First Colour TV Receivers", Technical Notebook, *Wireless World*, December 1961, p. 611.

mast from Sound Vision Services (Electrical). Built from steel tube, this is a triangular-section telescopic tower with tilt-over facilities and is 48ft high when fully extended. The fittings include the S.V.S. grease-less nylon bearings and mountings for a rotator motor.

Components on the Electroniques (Felixstowe) stand included some items that could, with justice, be said to "fulfil a long-felt want" (85- and 100-kc/s i.f. transformers, for instance). The 85-kc/s types give a 2-kc/s passband at −6dB and 3-kc/s at −20dB. Electroniques new coilpacks are designed for amateur-band or general coverage and employ the EF183 frame-grid valve in the r.f. stage. Incidentally, it is worth noting that the demand for the "Pathfinder" top-band transmitter shown last year has been so great that Copp Communications are to produce it for Electroniques.

Another component that should find approbation is a "potted" a.f. phase-shift network for s.s.b., made by Minimitter. Conveniently mounted on an octal base, this assembly uses the popular "bridge" C-R type of circuit and produces from two antiphase sources two signals within 2° of quadrature over the band 200 to 3.000c/s.

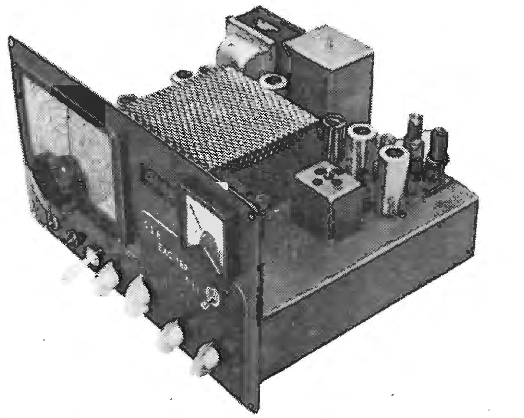
Test equipment is, of course, an essential for the amateur of today, and of particular interest was the Dartronic Type 381 oscilloscope*. An unusual circuit feature of this design is the method of feeding the h.t. to the first *y*-amplifier stage and the pair of cathode followers driving the *y*-plates. Each of these requires about half the h.t. potential available, so they are simply connected in series across the supply, component values and potentials being adjusted so that the d.c. performance is not impaired.

Last, but definitely not least, must come the magnificent polychrome machinations of the Colour Group of the British Amateur Television Club. Their display consisted of a mechanical frame-sequential colour camera (John Tanner, G3NDT-T) and a caption scanner which were used to provide signals to displays on the stand, the major part of which was taken up by three shadow-mask units. One of these had been seen before (John Ware's original amateur-built off-the-air N.T.S.C. receiver) but two were newcomers—another unit by John Ware (using a c.r.t. found in a salvage yard!) and the third and newest built by D. H. McLelland, using a new (paid for) tube. Tanner's camera uses an image-orthicon tube and has a 12-segment disc running at 250rev/min, a servo system ensuring that the change of filters is phased so that it follows the beam, to reduce desaturation due to storage effects. A small display with a 3-segment disc running at 1,000rev/min showed the picture "as produced"; but the sequential signals were gated out by a three-phase flip-flop opening and closing four-diode gates to form R, G and B for display on the shadow-mask tubes. N.T.S.C. signals, by courtesy of the B.B.C., were decoded and fed out also by the same transistor amplifiers (built by Michael Cox). These consist of a long-tailed pair of OC170s feeding a GT43 output stage: to set gain and ensure good tracking, negative feedback, taken from the output, is fed into the unused base of the long-tailed pair.

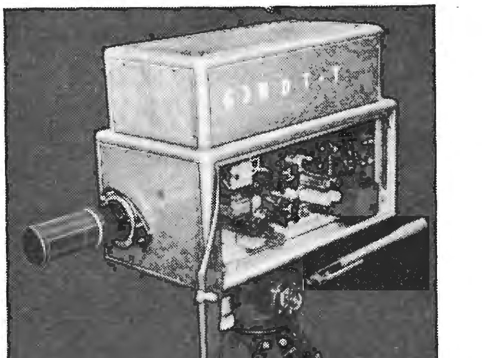
The caption scanner allowed, by suitable cross connections, the production of primary-coloured lettering on a coloured background, which could be shaded both in colour and brightness by adding "time-base" waveforms to the vision signal.

Our congratulations must go to this group for their display which was of a complexity and enterprise hitherto attempted only by large organizations with the full backing of almost unlimited research and technical facilities. The B.A.T.C. has shown what it can do with "something old, something new, something borrowed and something blue." If the responsible authorities don't look to their laurels they may find the amateur in the lead in this field, too!

* See "Manufacturers' Products", *Wireless World*, December 1961, p. 648.



"5BJ" s.s.b. exciter using sheet-beam valve and crystal filter (Copp Communications).



John Tanner's frame-sequential colour camera.

Commercial Literature

"Tape Recording is Fun"—hints and tips on tape recording and a guide to Simon equipment for tape recording are given in the latest edition of this 15-page booklet, which is free from Simon Equipment Ltd., Recorder House, 48, George Street, London, W.1, or through local Simon dealers throughout the country.

Valve Reliability: ARINC Report No. 411 "Investigation of Electron Tube Reliability in Commercial Airlines Applications" carries details of recent tests made and statistics collected from six U.S. and Canadian airlines over a period of three years, totally over 10M valve hours and $\frac{1}{2}$M equipment hours. Copies price $1 from Aeronautical Radio Inc., 1700 K Street, N.W. Washington 6, D.C.

Copper Tape, applied longitudinally under the copper braid on a coaxial cable improves cable performance considerably, reducing both attenuation and radiation. Leaflet on such cables from Aerialite Ltd., Castle Works, Stalybridge, Cheshire.

Valve Type ECL86, a combined a.f. amplifier triode and output pentode, offers improved sensitivity and higher power output than its predecessor ECL82. Circuits and constructional details for stereo amplifiers from 3W to 10W are given in Mullard leaflet number TP456 from Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

Data for the Brush Crystal Company's range of semiconductor components, including new transistors Types OC700 to OC704 and variable capacitance diodes. Brush Crystal Company Limited, Hythe, Southampton.

"All-Band" Transistor Communications Receiver, by C. J. Salvage, *Wireless World,* Dec. 1961, p. 626. The primary inductance of the output transformer T_7 (p. 629) should be 50mH.

Non-Destructive Testing

TECHNIQUES DISCUSSED AT THE I.E.E. CONFERENCE

THE testing of materials and components in a manner that does not involve the destruction of any part of the object under test is a process which calls for perhaps more ingenuity than any other process in electrical engineering. Destructive testing, where the whole, or part, of a component or piece of material is dismantled and measured is costly and wasteful, and does not necessarily represent the standard of the rest of the piece or batch. Statistically, the method may be accurate, but where even one failure during life could be disastrously expensive, some method which leaves the tested specimen available for use must be employed. Non-destructive testing is, therefore, the subject of much attention, and new methods are constantly being developed.

Some of the processes and instruments described in papers submitted to the conference are concerned with work in other spheres of activity, but will be described for their use of electronics. For instance, the paper by J. A. Betts and J. P. Newsome describes a tentative method of measuring the depth of surface hardness in flame-hardened steels, using a ferrite-cored coil. A cup-core is used, the machined surface of the test specimen completing the magnetic circuit. The product of resistivity and surface permeability (electrical surface factor) modifies the impedance of the search coil, which is evaluated by means of a Maxwell bridge and tuned detector in the range 5-10kc/s. The electrical surface factor varies with depth of hardness, and the process is therefore a possible method of measurement.

Wires and Cables

The enamel insulation on wire is considerably reduced in efficiency if any pinholes are present in the enamel. A method of detecting these is proposed in a paper by K. W. ffitch and P. Graneau, who consider that the B.S. method of testing is a destructive one, as it involves passing the wire through a mercury bath which, the authors claim, tends to contaminate the enamel. The method proposed is to pass the wire through a tube with a high voltage on it, which is just high enough to initiate corona when a pin hole passes through the tube. The pulses are counted and used to formulate a pass/reject decision.

The diameter of polythene extruded on a conductor must be checked as soon after the operation as possible, to enable correcting action to be taken if necessary. In apparatus for this purpose described by A. C. Lynch and E. A. Speight the time taken for a moving beam of light to cross the cable is measured photoelectrically. As the measurement is solely that of time, the calibration is independent of lamp voltage, photocell sensitivity and gain stability of the associated amplifying circuitry.

Sealed electronic components, such as transistors, may have the efficacy of their seal checked by a method developed by P. F. Berry and J. F. Cameron, in which leakage in or out of components is measured with the aid of radioactive gas. Leakage into a component is checked by immersing it in krypton^{85} at a pressure of 50lb/in^2. After a time, the component is removed and the amount of gas inside it measured with a scintillation counter. Alternatively, the component can be filled prior to sealing with a little krypton^{85} and the amount of gas leaking out into a vacuum chamber measured. Leaks as small as 10^{-11} ml/sec can be measured in this way.

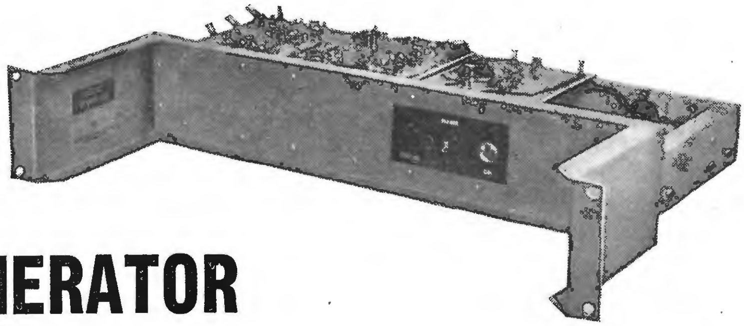
When mechanisms such as relays are contained in sealed enclosures, or potted in a resin compound, the normal visual stroboscopic method of vibration inspection becomes impossible, and an X-ray method is described in a paper by L. W. D. Pittendrigh. Contra-rotating shutters modulate the X-ray beam from a 150kV tube, at a controllable frequency, and the specimen, situated in front of an image intensifier, is vibrated up to a maximum frequency of 150c/s. Remote handling gear is provided for all electrical controls and specimen location, and the whole is enclosed in a shielded cabinet. Afterglow effects in the image intensifier are nullified by keeping the difference frequency down to a few cycles.

Profile Checking

The use of microwaves for the determination of the profile of a rotating body is described in a paper by P. B. Barber and J. S. T. Looms, which has several advantages over the capacitive and optical systems. No electrical connections to the rotating body are required, non-conducting bodies may be measured, and only a small, pressure-tight window need be provided. A klystron oscillator supplies power, via a waveguide, to the surface of the rotating body. Reflected power, dependent in amplitude on the distance in wavelengths and parts of a wavelength of the surface of the body from the window, plus direct signal from the klystron, is detected by a crystal, and the envelope used to deflect radially a cathode-ray tube spot. The circular sweep is synchronized with the rotating body, and the resultant trace is therefore related to the profile of the specimen.

The papers presented will be published in full in 1962 in Vol. 109, Part A, of the *Proceedings of the Institution of Electrical Engineers.*

Transistor Audio Power Amplifier: in Table 1 of this article in our November issue (p. 567) the values given to C1 and C2 should be interchanged.



General view of cuedot generator from front.

CUEDOT GENERATOR

TELEVISION-PICTURE SIGNALLING FOR NETWORK OPERATION

By A. J. HENK*

THE problems associated with the co-ordination of programme timings throughout the independent television network are many and complex. A detailed examination of the networking procedure is outside the scope of this article, but in order to appreciate the purpose of the unit to be described some attention to certain aspects of the system is necessary. Let us therefore concern ourselves for a while with the case of a programme which is being produced by a programme contractor in one area and which is to be broadcast simultaneously by companies in other areas, perhaps over the whole of the country. This is known as a "networked" show, and will start at a pre-arranged time. Obviously every company taking the programme must join it on time and this includes the originating company, who need, incidentally, have no more liaison with the studio than a station taking the show at the other end of the country. It is interesting to note that the studio, during a networked show, has a responsibility to the network which outweighs its responsibility even to its own company, and will start the programme on time even if its local transmitter is unable to join until later due to unforeseen circumstances.

The programme will usually contain one or more commercial breaks and the duration of each break is agreed in advance by all the interested companies who can thus allocate the right number and duration of their own commercials to be inserted locally at the appropriate points.

Whilst the precise duration of a commercial break is agreed in advance it is up to the producer of the show to choose the most satisfactory point for the commercials to be inserted, and it can be very difficult to forecast the exact time at which the natural break will occur.

The procedure used in the past was that the producer would contact each net-working company by telephone over specially-booked G.P.O. control circuits and would give a verbal cue to the whole network at the start of each break. This procedure proved tedious in the extreme and, as the number of new stations increased, the need for a different approach rapidly became apparent.

New Procedure.—A simple solution to this problem has been found in the introduction of the "electronic cuedot" which is visual information transmitted as part of the vision signal and visible on a picture monitor in a similar way to that in which a film cuedot† is visible on the cinema screen. The electronic cuedot is a small rectangle containing scintillating black and white bars and is placed at the top right-hand corner of the picture area by the operation of a switch in the studio. About one minute before the break is due to start the cuedot is switched on and its presence is a signal to networking companies to stand by with their commercials. Precisely five seconds before the break the dot is switched off and at this signal telecine projectors throughout the network are started. After the standard five-second run-up time has elapsed the first frames of the commercials are running through the projectors for insertion into the programme.

This cuedot is also used to indicate the end of a programme, being switched on at about one minute to go and switched off at precisely five seconds to go so that the Network can leave the programme tidily without the risk of fading it out inadvertently. This could occur during a dramatic pause at black, for example.

Making Composite Programmes

The advent of vision tape recording has brought similar problems, one of which concerns the case of a recorded programme which requires film inserts to be added at a later date, usually during the actual transmission, by the company originating the programme. The mixture of taped and filmed material then becomes a composite programme to be taken by all the networking companies. While the show is being recorded the producer leaves a black screen on the recording at the appropriate point during the action for the duration of the film insert, and the recording machine is kept running for the whole of this time. After the necessary interval has elapsed the studio action continues exactly as though the film had been inserted at the time. Here again a cuedot is used to cue the subsequent film insert, being switched on at about one minute to go and switched off at exactly five seconds to go. It is, of

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*Alpha Television Services (Birmingham) Ltd.

†Marks which appear (usually) in the top right-hand corner of the screen to give warning of, and indicate, a change of reel. (Ed.)

course, necessary to avoid the possibility that the networking companies will mistake this for a commercial break, and so the cuedot for cueing filmed inserts, as opposed to commercials, is placed in the top left-hand corner of the picture.

The electronic cuedot is the subject of a British Patent[1] which describes the use of a cuedot in any corner of a television picture for cueing purposes and observes that the information content of the dot need not be confined to an h.f. bar pattern. The generator to be described, however, has been designed specifically for use in British independent television and produces right- and left-hand cuedots of the type described in the foregoing paragraphs. The possible uses to which cuedots of a different type may be put together with further applications of the type of cuedot already mentioned are described elsewhere[2].

As the cuedots are small and in the extreme corners of the picture they are invisible on a domestic receiver in normal adjustment because the scanning is arranged to extend slightly beyond the curvature of the screen corners: the monitors used for observing this form of cueing require their screens to be slightly underscanned. The cuedots remain an integral part of the vision signal throughout the complete transmission chain and the right-hand one can frequently be seen on domestic receivers in which the requisite corner of the raster has been made visible by appropriate adjustment.

Design Philosophy

A prerequisite of a cuedot is that it should be unmistakably visible under all conditions of picture composition, whether against a background of white, grey or black; plain or full of detail. Furthermore it should occupy as small an area as possible so as to reduce the probability of its proving distracting on domestic receivers. These two main requirements are clearly conflicting and, at the time of writing, the specification relating to the size of an electronically produced cuedot is under review and so precise figures cannot be given. There is, however, general agreement on the condition for maximum visibility of a cuedot of fixed size. In order for the dot to be equally visible under all picture conditions the picture signal is suppressed over the area to be occupied by the dot, producing a black "hole" in the picture. The cuedot proper is a short burst of 1-Mc/s signal introduced into the blacked out area by a free-running oscillator. The result is a series of black and white bars running across the blacked out area in such a way as to produce a "twinkling" effect which is particularly eye-catching. The size of both right- and left-hand dots is typically 8 to 12 picture lines in height and 2 to 5μsec in width.

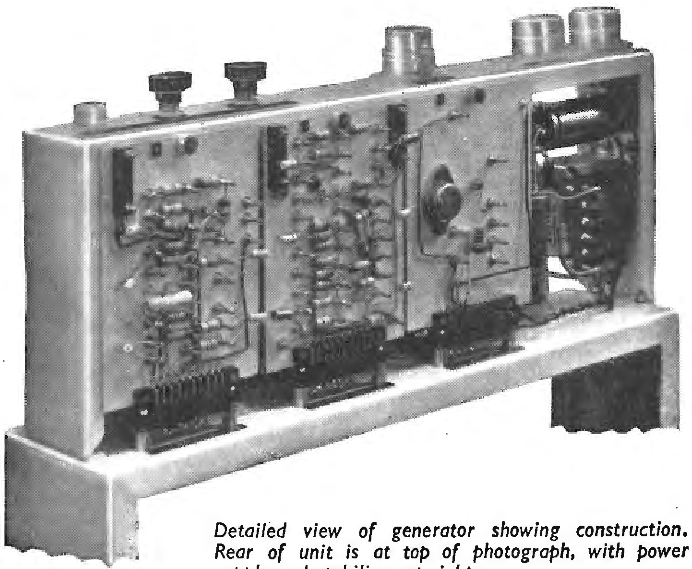
Apparatus Required

The circuitry required to insert a black "hole" into a vision signal is complex, necessitating black-level-clamping and clipping stages in which any drifting of component characteristics could result in undesirable changes of black level in the final signal. In order to avoid these difficulties advantage has been taken of existing studio apparatus which already incorporates the kind of circuitry required. Studio camera channels are fed with a blanking signal which is caused to suppress picture information during the normal line- and field-suppression periods and by combining the cuedot pulses with the blanking signal the necessary area of black level can be introduced into the camera output. The 1-Mc/s signal can be resistively mixed with this blanked vision waveform to produce the final cuedot, and elaborate mixing circuits are unnecessary.

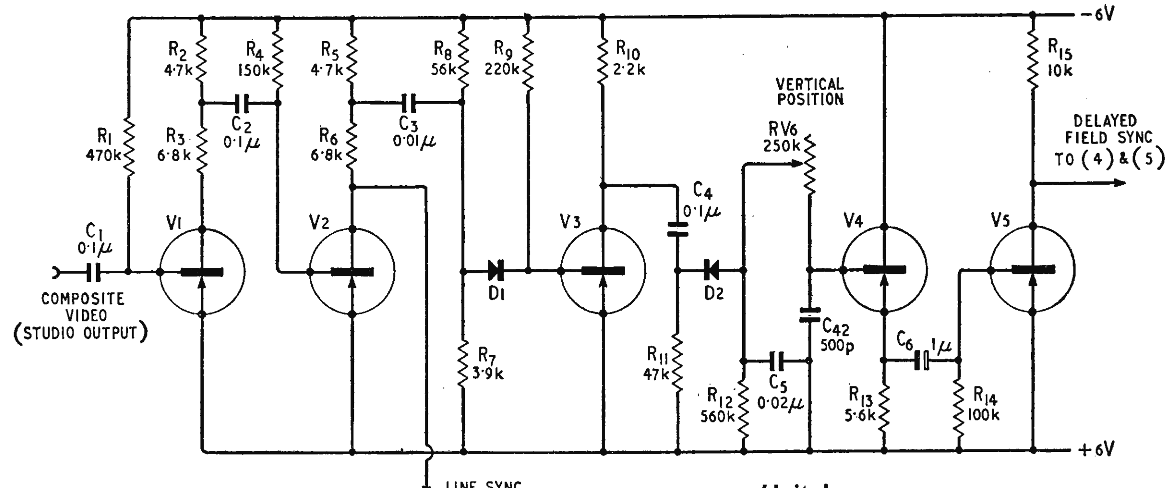
Whereas it is convenient to accommodate the cuedot generator in the same racks as the other studio equipment, the operation of selecting either dot is under the control of the producer, who sits some distance away. It is therefore advisable to use direct current to control the unit in order to avoid the necessity of passing signal frequencies on long control wires.

Automatic Recognition.—Interest is being shown by some independent television companies in the use of techniques which enable presentation and continuity operations to be carried out by automatic equipment and it is obviously desirable for such equipment to be able to recognize the presence of a cuedot on a signal and to take the necessary action. This consideration underlines the need for an easily recognizable cuedot so that the circuitry will not be triggered off by normal picture information. It is generally agreed that the information content of a given picture area is unlikely to be significantly different during odd and even fields, and if the cuedot were to be different during odd and even fields the reliability of operation of an automatic recognition system could be improved considerably. A suggested way of doing this is to apply the 1-Mc/s bars to one field of the picture only and provision is made for this within the generator.

Stability in Service.—An unusual feature of the generator is the complete absence of operational controls on the front panel. It was felt that the possibility of mis-adjustment would be



Detailed view of generator showing construction. Rear of unit is at top of photograph, with power supply and stabilizer at right.



Unit 1

materially reduced if a minimum number of front-panel controls were provided, and to this end the adjustments are all preset and accessible only from the rear of the unit which is designed to be sufficiently stable not to require re-adjustment after the initial setting-up. The only control on the front panel is the mains on/off switch.

Transistors are used throughout the unit which, in consequence, occupies very little space in the apparatus racks. For the sake of uniformity with the existing apparatus a "dish pan" chassis is used (see photo.) which occupies two $1\frac{3}{4}$-in units of rack height. It has been found convenient to assemble the transistor circuitry on a number of boards mounted horizontally on the rear of the chassis. Six boards are employed in each generator and the circuitry on each board will be described separately.

Circuit and Construction

A consideration of the points described above led to the adoption of the circuit reproduced here, which has been drawn in sections corresponding to the circuitry contained on each board.

Unit No. 1—Sync Separator and Field Delay.—First the vertical position of the cuedot is determined by setting the time "down the field" that it is to occur. For this, and the other timing operations, sync pulses are needed: these the generator extracts from the studio vision signal.

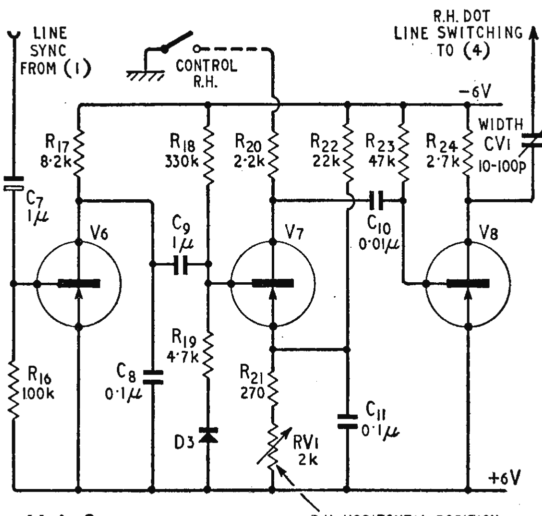
The standard composite video signal forming the studio output is applied to the base of transistor V1. The negative excursions of the sync pulses cause the transistor to saturate. Due to the d.c. restoring action of C1, R1 and the base-emitter junction of V1, the picture content of the input signal holds the base sufficiently positive with respect to the emitter to cut off the collector current. The collector-voltage waveform therefore contains positive, separated sync pulses which are fed to the phase-inverting pulse-shaping stage V2.

The negative sync pulses at V2 collector, of the order of 6V double-amplitude peak (d.a.p.), are fed to Units 2 and 3. The syncs present at the junction of R5 and R6, about 2V d.a.p., are differentiated by C3 and R7 whose time constant is chosen such that field-sync separation takes place, D1 conducting on the half-line pulses during field sync and remaining cut-off during the rest of the field.

V3 is normally saturated, thus the positive pulses occurring at its base during field sync cause negative pulses to appear at its collector. These cause D2 to conduct and C5 charges via D2, C4 and R10. As D2 is cut off for the remainder of the field, C5 discharges via RV6 into the base of V4 which amplifies the discharge current. When the discharge current has fallen to a low value, V4 and V5 cut off until the next field pulse occurs. Hence V5 collector, after a time starting at the field sync and determined mainly by the setting of RV6 and the capacitance of C5, describes a negative excursion. It is this negative excursion which determines the start of the cuedots and hence their vertical position on a monitor screen.

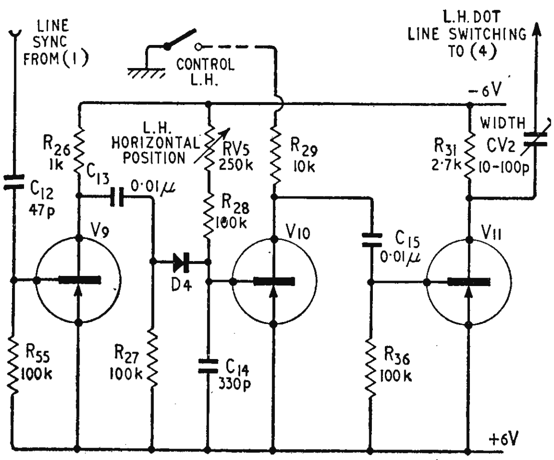
Unit No. 2—Right-hand Line Delay.—Here the delay along a picture line, governing the horizontal position of a right-hand cuedot, is set.

V6 is normally cut off and conducts on the tips of the negative line-sync pulses which are applied to its base from Unit No. 1. Conduction causes the voltage across



Unit 2

Note: Transistors, except V19 and V20 (Type XA131), are Type GT43, all diodes are Type OA86.



Unit 3

C8 to fall rapidly, C8 recharging at the end of each sync pulse so that a negative-going line-frequency sawtooth waveform is generated. D3 causes d.c. restoration to take place on the negative excursions of the signal, R19 serving to prevent distortion of the negative sawtooth peak by extending the charging time-constant of the restorer, thus reducing the peak value of the charging current. The d.c. operating point of V7 is set by RV1 so that base current flows as the sawtooth approaches its maximum negative value. If a right-hand dot is selected by the closing of the remote-control switch the collector of V7 executes a positive excursion each time current flows in V7 base (i.e., towards the end of each line period) and thus V8 produces a negative "edge" at its collector for the initiation of the line component of the right-hand cuedot. The pulse is differentiated by CV1, which forms a dot-width control, and the input impedance of the following stage, the resulting spikes being fed to Unit No. 4.

Unit No. 3—Left-hand Line Delay.—This unit does, for a left-hand cuedot, what Unit No. 2 does for a right-hand one; but, because the time delay required is very much shorter the mode of operation, and thus the circuit, is slightly different.

Briefly, when V9 conducts on receipt of a negative sync pulse, D4 switches on and C14 charges rapidly via the low-impedance path now existing: this cuts off V10. At the end of the sync pulse V9 (and hence D4) cuts off and C14 discharges at a rate determined by R28 and RV5. Therefore V10 begins to conduct again after an interval which can be adjusted by RV5. When R29 is earthed by the remote switch an output is produced by V10 cutting on towards the end of the discharge of C14.

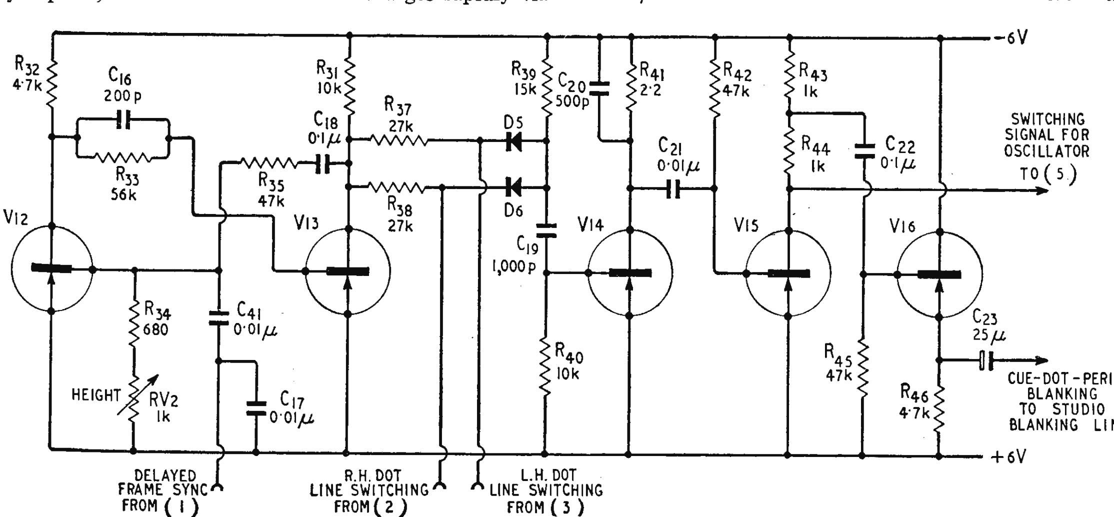
Unit No. 4—Monostable and Gating Unit.—Having produced the basic timing waveforms, these are used to produce the "hole" in the picture and switch on and off the 1-Mc/s oscillator that fills the hole with bars.

This unit is conveniently divisible into two parts: the monostable field-pulse generator incorporating V12 and V13, and the line-pulse gating circuits incorporating V14, V15 and V16.

Monostable Field-pulse Generator. V12 and V13 form a conventional monostable circuit which is stable with V12 cut off and V13 conducting to saturation. The delayed field pulse from Unit No. 1 is applied to the base of V12 to trigger the circuit which returns to the stable condition in a time set by RV2, which is the adjustment for the height of the dot. The output from V13 is a negative pulse which is used for gating-in the line-frequency components generated in Units 2 and 3.

Line-pulse Gating Circuits. The pulses applied to D5 from Unit 3 contain negative edges which correspond to the start of the line-frequency component of the left-hand cuedot. Similarly pulses applied to D6 from Unit 2 contain negative edges which correspond to the start of the right-hand cuedot. When V13 is cut off (i.e., the monostable stage has been triggered), no reverse bias is applied to D5 and D6 and so the negative "spikes" present in the input waveforms are passed to V14. Any positive spikes in the input will cause D5 and D6 to cut off further, so that the circuit only operates on negative-going information. The duration of the pulses so formed at V15 collector depends upon the width of the "spikes" fed into the unit; this, in turn, is determined by the setting of the differentiating capacitors CV1 and CV2 in Units 2 and 3. A 2- to 3-volt blanking signal is developed at the emitter of V16 and is coupled into the studio blanking circuit. As V16 is normally cut off the only extra load imposed on the 75Ω blanking feed is that due to R46, i.e., about 4.7kΩ. The 6-V d.a.p. blanking signal at the collector of V15 is fed to Unit No. 5 for the purpose of switching the 1-Mc/s signal on and off at the appropriate times.

Unit No. 5—R.f. Oscillator and Gating Unit.—The 1-Mc/s oscillations to fill the cuedot "hole" are



Unit 4

produced here and turned into an output suitable for the studio vision line. Whereas the dot blanking signal is mixed with the studio blanking before it enters the studio equipment, the gated 1-Mc/s burst is mixed with the studio vision signal after the studio equipment. Therefore any delays occurring in cables, camera channels, etc., will affect the register of the "burst" in the blanked "hole," and means have to be provided for compensation.

When automatic recognition of a cuedot is required, the 1-Mc/s running-bar pattern is applied to alternate fields only and this is achieved by gating the r.f. oscillator at 25c/s in addition to gating by the delayed dot-blanking signal.

The output from the oscillator (V18) is mixed with positive blanking pulses from V17 in L2. As the collector of V17 is normally at negative rail (earth) potential D7 is biased off and the r.f. amplitude across L2 is insufficient to cause conduction; but the positive pulses bring D7 near conduction, allowing positive r.f. half-cycles to pass to V19. V19 is normally saturated so that when D7 conducts, the r.f. output is negative pulses clipped to about 5V d.a.p.

The output stage (V20) is normally cut off that that it imposes a negligible load on the 75Ω studio-output vision line. The amplitude of input to V20 (set by RV4) causes the injection of 0.7V d.a.p. of positive half-cycles into the line, thus supplying the characteristic cross-hatch pattern into the blanked-out cuedot areas.

For synchronous arrival of the dot blanking "hole" and r.f. burst at the studio output terminal a delay in the production of the r.f. burst is necessary: this is provided by C26 and RV3. The additional gating signal for automatic recognition is supplied by the binary counter (V21 and V22) which is triggered by the field pulses from Unit No. 1. The fall in V21 collector voltage, being coupled to the supply for the r.f. oscillator V18, causes oscillation to cease.

If an r.f. burst is required on every field this 25-c/s gating facility may be disconnected by simply removing the link LK1 between D8 and R52.

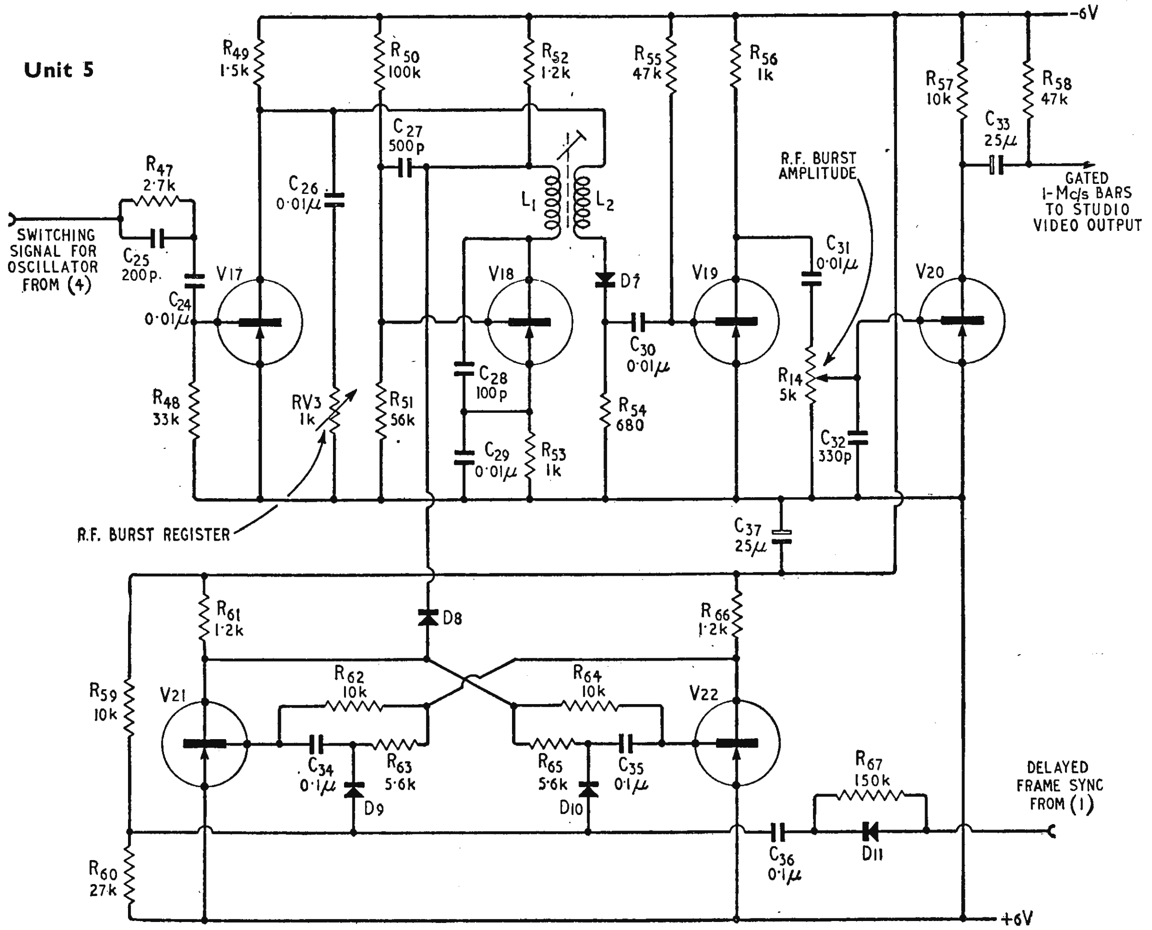
Unit No. 6—Power Supply.—A simple circuit provides a regulated 6-V supply to all sections of the equipment (diagram not shown).

Mechanical Construction.—Mention has already been made of the fact that the units are assembled on separate boards and their arrangement on the main chassis can be seen in Fig. 3.

The boards are of melamine-bonded glass fibre, a strong non-hygroscopic white material of excellent electrical properties. Each board carries a 10-way male strip connector whose female counterpart, mounted on the main chassis, serves to anchor one end of the board in addition to carrying signal and power supply wiring to and from the other boards.

A gantry extending rearwards from the chassis provides support for the other end of each board which is fixed to the gantry by means of a knurled screw. By simply releasing the appropriate screw a board can be

(*Continued on page* 43)



withdrawn from the rear of the generator for servicing and, in order to avoid unnecessary stress on the strip connector as the rear of the board is lifted clear of the gantry, the female members are mounted in such a way that they are free to move about 15° in the necessary direction.

Conclusion

Four of these generators have been in use by Alpha Television Services (Birmingham) Ltd. at the Midlands Independent Television Studios for eighteen months, and a further number have been supplied to other companies within the Independent Television Network. Although it has not been possible to keep careful observations of generators supplied to other companies, those in use at Birmingham have given trouble-free service. Their stability has come well up to expectations and amply justifies the exclusion of operational controls from the front panel.

REFERENCES

1. British Patent No. 871,238.

2. *"Sound and Vision Broadcasting"* B. Marsden:—"Electronic Cuedots", to be published in Vol. 2, No. 3 (October, 1961). Marconi's W.T. Co. Ltd., Chelmsford, Essex.)

BOOKS RECEIVED

Transistors in Radio, Television and Electronics, by Milton S. Riner. A complete grounding is given in solid-state electronics, from basic electron theory to the use of transistors and related devices in modern circuits. This is a second, revised edition, and is designed for the technician who feels the need to know more about the principles of operation and applications of transistors. Questions are set at the end of each chapter, and advice is given on the safe servicing of semiconductor equipment. Pp. 424; Figs. 338. McGraw-Hill Publishing Co., Ltd., 95, Farringdon Street, London, E.C.4. Price 44s.

How to Troubleshoot T.V. Sync. Circuits, by Ira Remer. A reference book for the television serviceman. A discussion of the features required in a synchronizing pulse and the duties it must perform is followed by descriptions of methods of sync. pulse separation and pulse shaping. A chapter is then devoted to circuit faults and suggested cures. The last two chapters describe commercial sync. pulse circuits and problems involved in colour television. The book is concerned throughout with the American video signal (positive sync.-negative picture information), although much of the text is applicable to other systems. Pp. 128; Illustrated. John F. Rider Publisher, Inc., 116, West 14th Street, New York 11, N.Y. Price $2.90.

High Fidelity Sound Engineering, by Norman H. Crowhurst. A very detailed treatise on the principles and design procedures of sound-reproducing equipment. The text is divided into sections which deal fully with a particular aspect of audio engineering, from the basic concept to complicated circuit elements. The mathematical treatment is confined to the appendix, and a list of references is given. Pp. 328; Figs. 264. George Newnes, Tower House, Southampton Street, London, W.C.2. Price 50s.

Printed-Circuits by Morris Moses. Essentially a practical book, designed to initiate the home-constructor in the preparation of printed- and etched-circuit boards. Details of simple equipment are given to illustrate the procedure, and a chapter on the servicing of printed-wiring assemblies will be of value to the service technician. Pp. 224; Figs. 249. Gernsback Library, 154, West 14th Street, New York 11, N.Y. Price $2.90 paperback, $4.60 hard covers.

Mon Magnétophone, by P. Hémardinquer, and M. Aubier. Designed to enable the amateur tape-recording enthusiast to extract the maximum of pleasure from his instrument. This very readable book describes the factors governing the choice of instrument and the way in which it should be operated to obtain the best results. A description of the operation of a recorder in conjunction with ciné apparatus is given. Pp. 158; Illustrated. Editions Chirons, 40, Rue de Seine, Paris-6e. Price 8.80 N.F.

Basic Electronic Test Procedures, by Rufus P. Turner. Methods of determining all parameters required in electronic laboratory work are fully described. The author describes the working and methods of operation of most of the instruments to be found in the general laboratory and questions are included after each chapter. Several chapters are devoted to measurements on transmitters, receivers and industrial electronic equipment. Pp. 316; Figs. 193. Technical Division, Rinehart and Company, Inc., New York. Price $6.50.

A. to Z in Audio by G. A. Briggs. A reference book for the audiophile. The encyclopædic form is used to cover the whole field of sound reproduction and associated subjects. Mr. Briggs is renowned for his lectures on audio and for his ability to write on technical subjects in a light, unaffected manner. Pp. 224; Figs. 160. Wharfedale Wireless Works Ltd., Idle, Bradford, Yorks. Price 15s 6d.

Eliminating Man-Made Interference, by Jack Darr. The result of much experience of tracing and rectifying sources of radio interference. The author deals thoroughly with each type of noise source and its effect on domestic and car radio and television receivers. Interference caused by equipment used in aircraft, ships and industry is discussed, and there is a chapter on filter design. Pp. 160; Figs. 173. Howard W. Sams & Co., Ltd., Indianapolis, 6, Indiana. Price $2.95.

Transistor Projects, compiled by the staff of Gernsback Library. A collection of articles, which have appeared in Radio-Electronics Magazine, on the construction of radios, instruments and gadgets, all employing transistors. An introductory chapter gives general advice on the use of transistors and seeks to dispel some popular fallacies. Pp. 160; Figs. 447. Gernsback Library Inc., 154, West 14th Street, New York 11, N.Y. Price $2.90.

Television Engineers' Pocket Book, edited by J. P. Hawker. The third, enlarged edition of a useful pocket reference-book for the service engineer. Ranging from descriptions of basic circuit techniques to alignment procedures and i.f.'s of several hundred commercial receivers, the book covers the whole field of television servicing. Lists of c.r.t. and valve connections and equivalents are included. The chapter on the choice of test gear is especially useful. Pp. 272; Figs. 142. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 12s 6d.

POLYSTYRENE DIAPHRAGMS

By G. A. BRIGGS*

ABSORBING RESONANCES IN SHALLOW ENCLOSURES

THE non-resonant nature and light density of expanded polystyrene are qualities which make this modern material an attractive proposition for use in loudspeakers, but it has a serious drawback in that its absorption coefficient, which is related to the density, also varies enormously with frequency. It is hardly likely to replace completely the versatile, moulded, fibrous-paper cone.

Recent experiments indicate that polystyrene can be very helpful in obtaining satisfactory results with

*Wharfedale Wireless Works Ltd.

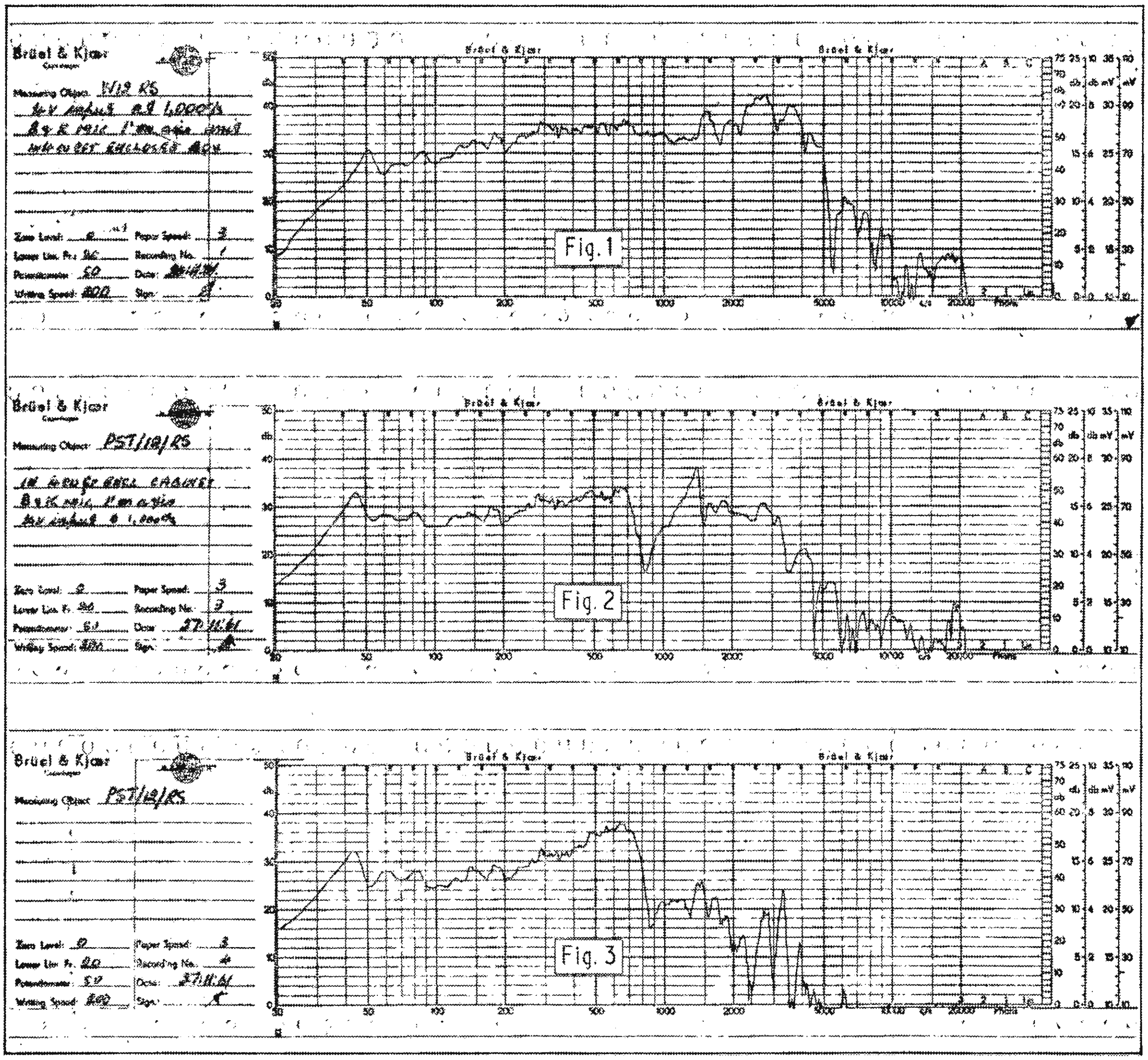


Fig. 1. Axial response of normal 12-in speaker with airtight roll surround and suitable for use in average enclosures up to about 2,000 c/s.

Fig. 2. Response curve to show the effect of adding a flat diaphragm of $\frac{3}{4}$-in thick polystyrene to the cone of Fig. 1 speaker. This model is only suitable for use at frequencies up to about 700 c/s, to avoid the junction effect between 700 c/s and 1,500 c/s.

Fig. 3. Effect of placing $\frac{3}{4}$-in thick polystyrene diaphragm in front of Fig. 2 speaker, showing sharp cut-off in response above 700 c/s.

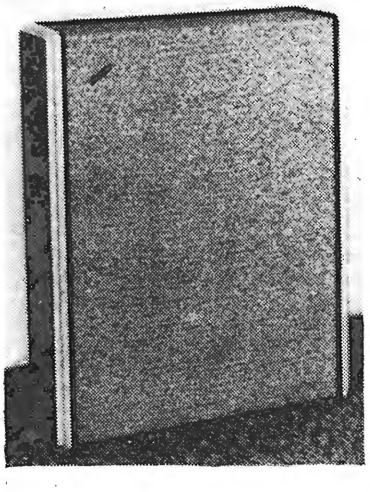
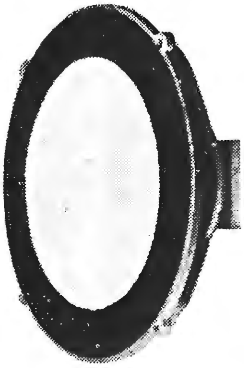
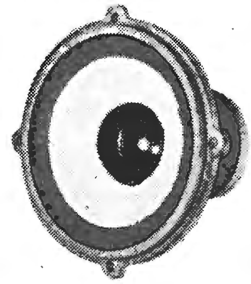


Fig. 4. New Wharfedale "Slimline 2" loudspeaker system.



Left: Fig. 5. 12-in loudspeaker with ¾-in thick flat polystyrene diaphragm added to absorb enclosure resonances.



Right: Fig. 6. 4-in loudspeaker with thin layer of polystyrene attached to damp high-frequency cone break-up.

moving-coil speakers, say 12-in and 4-in types, mounted in a cabinet only 6in deep and with only 1½ cu ft total volume.

The internal resonances with such a small enclosure are high in frequency and have a very high Q. They are heard *mainly through the cone of the 12-in unit,* the worst peaks being a main back-to-front resonance at about 1,100 c/s (due to the 6-in distance) and a second harmonic at about 700 c/s (due to 18-in width). Using a conventional paper cone the "honking" was dreadful in spite of a generous use of absorbent treatment. Incidentally, filling an enclosure with too much absorbent material can have a devastating effect on results.

Now the absorption of ¾-in thick polystyrene starts at about 700 c/s and it quite strong at high frequencies, as the accompanying response curves clearly indicate.

The effect of adding a flat polystyrene diaphragm to the 12-in cone is twofold:—

1. The egress of the internal resonances above 700 c/s is impaired and "honking" is audibly reduced.

2. The fundamental resonance is lowered by about 5 c/s and the bass output is increased.

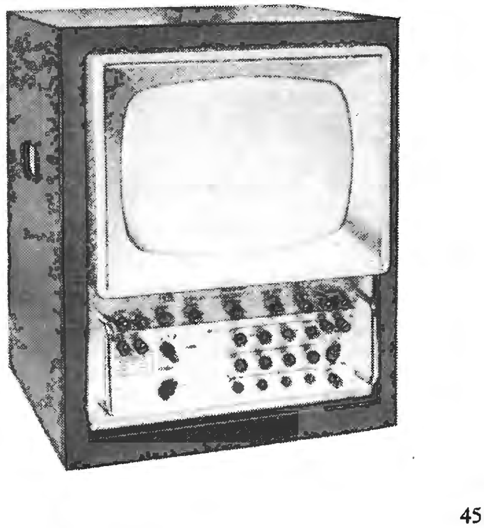
Although domestically speaking small enclosures may be a step in the right direction, I am still firmly convinced that, acoustically speaking, they are steps in the wrong direction. The polystyrene helps to bring the wayward shallow cabinet back to the straight and narrow path of acceptable listening. Nevertheless, I would not recommend this type of treatment to 12-in units in general.

In the Wharfedale "Slimline 2" (Fig. 4) a long narrow tuning vent is inserted in the top of the complete unit near the back so that low-frequency sound waves can be reflected from the wall. In fact this enclosure is rather heroic because it sounds best when it has its back to the wall. Two types of internal absorbent are used: the cabinet is loosely filled with bonded acetate fibre, and a layer of plastic foam is attached (inside) to its back.

In Fig. 5 we see a view of the 12-in speaker with added polystyrene diaphragm (PST12/RS), and Fig. 6 gives a picture of the 4-in unit (PST4), which is designed to take over from the bigger speaker around 700 c/s. In this case a thin layer of polystyrene is used to damp any cone break-up in the 5,000 to 10,000 c/s region, the response above this range being derived from the centre dome. The tweeter must, of course, be isolated from the low-frequency sound waves.

Lecture Oscilloscope

WHEN teaching or lecturing upon the practical aspects of electronics often a c.r.t. display is required; but normal c.r. oscilloscopes have an inconveniently small screen. The Airmec Type 279 is designed for just such applications with its 17-in c.r.t. and facility for four-trace working. Timebase speeds range between 1sec to 1msec pei sweep and the four traces are drawn on successive sweeps. So that the slowest speeds are useful with this four-beam arrangement a long-afterglow (30secs) c.r.t. is fitted. 3dB bandwidth claimed for the *y* channel is d.c. to 10kc/s and the minimum sensitivity is 18cm/V (peak-to-peak) with the pre-amplifiers in circuit: also the *x* amplifier can be used apart from the timebase.

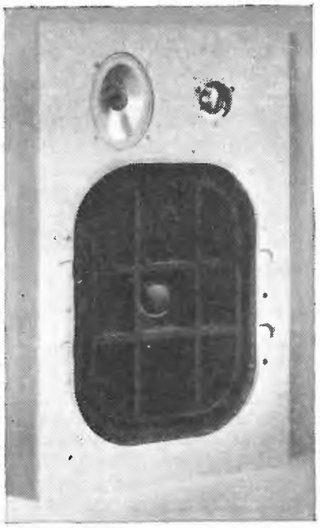


MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

New Series of Loudspeaker Systems

ALL the new KEF Electronics K1 series use the same basic three-speaker system. This has a number of unusual features. The bass loudspeaker is rectangular (16in × 12in) with rounded corners. This shape gives it an effective radiating area about twice that of a normal 12-in round loudspeaker and $1\frac{1}{2}$ times that of a 15-in speaker. The diaphragm is made from $\frac{1}{2}$-in thick expanded polystyrene, criss-cross ribbed (see illustration) for extra rigidity to reduce cone break up. Thickness vibrations of the polystyrene diaphragm are



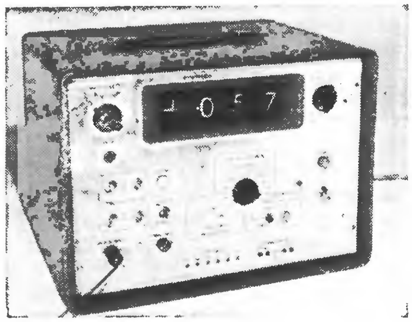
KEF Electronics K1/B loudspeaker system.

damped by an electrostatically applied Rayon fibre coating. A double diaphragm edge surround made up of cambric and cloth is used so as to combine the two advantages of positive centring provided by cambric and correct edge damping termination given by cloth. The free air resonance of this unit is around 25 c/s. The conventional chassis is eliminated by sticking the diaphragm surround directly on to the front panel, from which the magnet is supported by a heavy cast framework. The magnet is made of Feroba II ceramic and weighs 9lb. It gives a total flux of 165,000 maxwells (flux density=12,700 oersteds). The 6-in × 4-in mid-range loudspeaker again uses a diaphragm made up of expanded polystyrene, in this case only $\frac{3}{8}$-in thick and strengthened on both sides by $\frac{1}{2}$-thou skins of aluminium. It also has a Feroba II ceramic magnet. The polyether foam surround is made thicker than usual ($\frac{3}{8}$-in), and attached to the cone and chassis without compression so that it is only shear-stressed as the cone vibrates. The tweeter has a 2-thou thick Melinex convex dome cap radiator $1\frac{1}{2}$-in in diameter, the voice coil diameter being also $1\frac{1}{2}$-in. Crossover frequencies of 375 and 3000 c/s are obtained with a full half-section network: these frequencies being chosen so that, within the frequency range which it handles, each of the three units provides a wide sound dispersion. The crossover network components and three loudspeakers are all mounted on a 27-in × 17-in × $\frac{3}{4}$-in thick chipboard baffle. This assembly (K1/B) is available separately for £27. Details of home construction cabinets for this panel are available: alternatively it may be obtained already built into two alternative cabinets. At the back of each of these is a 10-in square aperture covered with wool cloth to provide resistive loading. This reduces the bass loudspeaker's impedance rise at resonance to only about 20%. With the compliance provided by the air in the cabinet it also alters the phase of the sound radiated from the aperture so that it partially adds to that radiated by the cone itself. These systems are suitable for amplifiers with output impedances in the range 8 to 16 ohms and powers up to 50 watts (peak). One cabinet—the K1/E—is only 7-in deep (× 27in × 17in): the other, K1/X, is rather larger ($39\frac{1}{2}$in × 17in × 14in). The K1/X costs £52 and the K1/E £37.

All these units are manufactured by KEF Electronics Ltd., of Tovil, Maidstone, Kent.

Digital Voltmeter-Counter

AN integrated digital voltmeter, timer, frequency-meter and clock-pulse source is introduced by Southern Instruments. The basic instrument is a 120kc/s counter, with a crystal-controlled oscillator to provide gating and clock pulses. Display is by in-line projectors, and a memory device dissociates the display from the counting operation. Voltage measurements may be made in the range 1mV-500V, and clock pulses are available at p.r.f.'s between 10 c/s and 0.1 c/s. Details may be obtained from Southern Instruments Ltd., Instrumentation Division, Frimley Road, Camberley, Surrey.



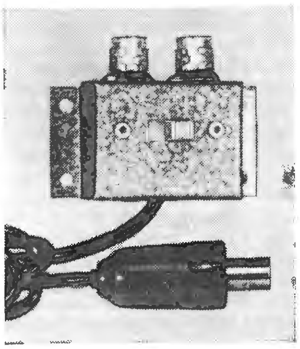
The Southern Instruments M.1155 Counter/Voltmeter.

Tape Magnetization Indicator

"INDICORD" is a suspension of fine ferromagnetic particles in a mild soap solution (provisional patent 39408/60) which by application to magnetic tape can be used to indicate the presence, position and (to some extent) the degree of magnetization on the tape. By contrast to previously used suspensions of magnetite (which is very similar in colour to the tape coating) the particles in Indicord are jet black. Indicord is sufficiently sensitive to detect the presence of signals recorded 20dB or more below saturation. Its uses include the measurement of effective erase width, and detection of recording head gap defects and poor tape contact (either with the recording or erase head). Indicord can also be used to time recorded signals. The cost of Indicord is 5s 6d for a "Standard Size" applicator bottle containing $\frac{1}{4}$oz or 9s 6d for a "Professional Size" bottle containing four times as much. It may be obtained from H. P. Freedman of 271-273 Archway Road, London, N.6.

Aerial Changeover Switch

THE areas which are fortunate (*sic*) enough to be served by several television programmes in the same band are often unfortunate in that, being fringe or poor-



Wolsey CAS aerial changeover switch

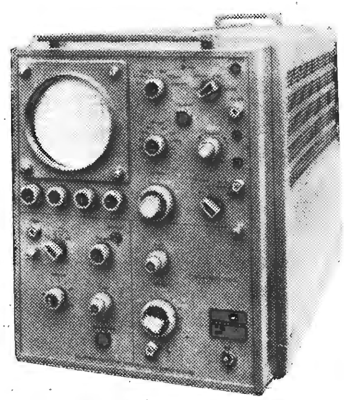
reception areas, separate arrays are required for each available channel. Naturally this leads to the intractable problem of, say, two down leads (one Band-I and III, one Band III only) and one aerial socket.

The ordinary coaxial plug and socket are certainly not designed with this hard wear in view, so Wolsey's Type CAS changeover switch should achieve popularity. Priced at 16s 6d, it consists of a small metal box carrying a switch, chosen for its low losses and low mismatch, selecting either of two coaxial sockets for connection to a 4-ft flying lead terminated in a plug for insertion in the receiver socket.

Wolsey Electronics, Ltd., Cray Avenue, St. Mary Cray, Orpington, Kent.

General-purpose Oscilloscope

WITH a frequency-response of 0-25 Mc/s, and a vertical sensitivity of 50 mV/cm, the Solartron CD1012 oscilloscope is suitable for the vast majority of applications. A wide-range time-base, working from 12sec/cm to 20nsec/cm, with all the usual operating modes, is



Solartron CD1012 general-purpose oscilloscope.

capable of uncalibrated expansion to X12, and provides the sweep and bright-up waveforms at the front panel via cathode-followers. If reduced bandwidth can be accepted, an a.c.-coupled preamplifier increases Y-sensitivity to 500 μV/cm. Time and voltage measurements are by graticule and calibration accuracy is to within $\pm 5\%$. The provisional price is £350. Further details may be obtained from Solartron Laboratory Instruments, Ltd., Cox Lane, Chessington, Surrey.

Indicating Relay

THE range of relays manufactured by the French firm A. le Boeuf et Fils is now marketed in the U.K. by L. E. Simmonds.

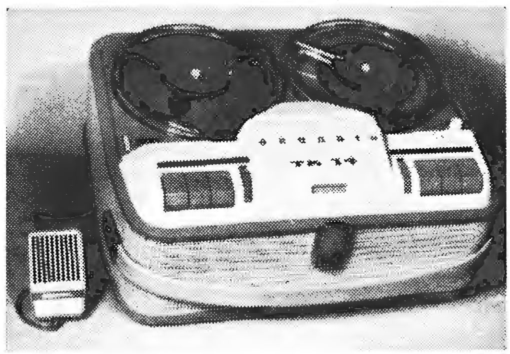
Typical examples are the SB2 and SB21, which are end- or centre-stable devices with operating currents as low as 1 μA. The SB21 relay, which is a plug-in type on an octal base, may incorporate a rectifier or thermocouple, and may employ a double-wound coil for differential deflection. The positions of the fixed contacts are adjustable, and are displayed, together with that of the moving contact, on a meter scale on the case. Currents up to 30mA and voltages up to 50V can be

A. le Boeuf et Fils relay, Type SB2. The pointers show the positions of the fixed and moving contacts.

broken, and the power handling capacity is 1W. Full details are available from L. E. Simmonds Ltd., Byron Road, Harrow.

New Tape Recorder

WITH the new Grundig TK14 recorder at $3\frac{3}{4}$in/sec, the single speed provided, the response is within $\pm$4dB from 60 to 12,000c/s, the wow and flutter 0.2% r.m.s. and the signal-to-noise ratio 50dB. Up to $5\frac{3}{4}$-in diameter reels can be used. Unusual features of this



Grundig TK14 tape recorder.

recorder are the use of a ceramic magnet loudspeaker and the "pressure tape". This latter is a flock-sprayed plastic tape which is spring loaded so as to press the tape against the head over a greater arc than is usual. This recorder weighs just under 20lb, measures $14\frac{3}{4}$in by $11\frac{1}{2}$in by $6\frac{3}{4}$in and costs 35 guineas. It is available from Grundig (Great Britain) Ltd., of Newlands Park, Sydenham, London, S.E.26.

UNBIASED

By "FREE GRID"

Audio Aces

SOME months ago I was invited to give details of my life so that I might be included in a volume of biographies of those who had achieved notability or notoriety in the world of audio. I accepted with some reluctance as I was very strictly brought up by my father, and enjoined always to be careful of the company I kept. However, I duly filled in the questionnaire which was sent to me, and waited somewhat uneasily, as I did not know who were to be my fellow biographees—if that be the correct word to use.

Now that the book has appeared, my fears have been set at rest in that direction, but uneasiness has been caused in another one, as I had no idea I was to be included among such a galaxy of talent, and my audio output is several decibels down as a result.

I must congratulate the learned author on persuading so many sonic savants to have not only the details of their lives laid bare, but also to allow their photographs to be published, "warts and all" with the same becoming modesty as Oliver Cromwell did. Actually I am surprised at the truly handsome and photogenic faces possessed by the majority of the 65 audio addicts included. Of course, there are always exceptions, and if this book of biographies finds its way to Scotland Yard, I can imagine one of the C.I.D. officers looking thoughtful as he studies it at his desk, and now and again walking across to his filing cabinet with a puzzled look on his face.

One of the most interesting features of the book is the inclusion of several ladies; these interested me very much. I was very astonished to find they had allowed their ages to be published. Mr. G. A. Briggs, the author, seems from his photo to be a kindly and tolerant sort of man, and I do seriously wonder whether the ladies have not taken advantage of his good nature by not adhering strictly to the truth in this detail. When I have had time to check at Somerset House I will let you know.

Fiat Justitia

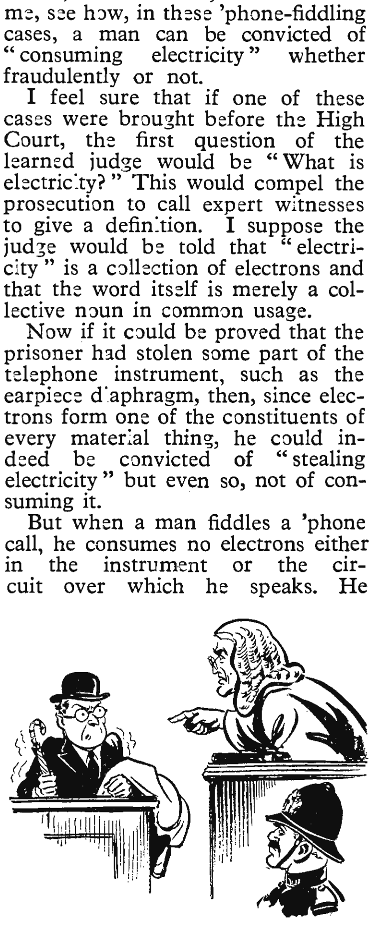
FROM time to time somebody who has managed, by some means, to make a call from a telephone box without putting the necessary coins in the slot is charged with "fraudulently consuming electricity." Usually the result is conviction and a fine. I have, on occasion, seen it stated in the press that one of these phone fiddlers has been accused of "stealing electricity," and recently I noticed that the expression "abstracting electricity" was used. But I learn on good authority that such wording is never used by the prosecution and is, therefore, I presume, due to careless reporting.

Now I am no friend of the criminal classes but I do like to see justice done even to those who have obviously transgressed the law and yet are sometimes convicted of crimes which they never committed. Surely it is a cardinal principle of our law that the prosecution must prove its case before a prisoner can be convicted, and I cannot, for the life of me, see how, in these 'phone-fiddling cases, a man can be convicted of "consuming electricity" whether fraudulently or not.

I feel sure that if one of these cases were brought before the High Court, the first question of the learned judge would be "What is electricity?" This would compel the prosecution to call expert witnesses to give a definition. I suppose the judge would be told that "electricity" is a collection of electrons and that the word itself is merely a collective noun in common usage.

Now if it could be proved that the prisoner had stolen some part of the telephone instrument, such as the earpiece diaphragm, then, since electrons form one of the constituents of every material thing, he could indeed be convicted of "stealing electricity" but even so, not of consuming it.

But when a man fiddles a 'phone call, he consumes no electrons either in the instrument or the circuit over which he speaks. He merely causes certain "loose" electrons in the circuit to shuffle along a circumscribed path. To my mind this charge is all wrong; after all if a man takes a ride in an electric train without a ticket, is he charged with "fraudulently consuming electricity"? Surely the two cases are analogous.



"What is electricity?"

To my way of thinking, people are being wrongfully convicted almost every day. The reason is partly the slackness or ignorance of the magistrates in not insisting that the prosecution prove its case, and partly the ignorance of the convictees (what a word!) concerning their rights.

I am, therefore, proposing to test the validity of this charge myself, by fiddling a 'phone call and then giving myself up at the nearest police station. At the subsequent hearing I shall, of course, conduct my own defence.

Microcymatology

WHAT a pleasant place to visit was the annual Radio Hobbies Show at Westminster where I spent a few profitable hours in November. I found technical information to be available in abundance, and every stand holder and assistant to be genuinely pleased to discuss with me esoteric questions of microcymatology and suchlike things.

It is not my purpose to discuss the exhibits, as they are dealt with elsewhere, but as I paused at the *Wireless World* stand to examine the apparatus which had been described in various issues, I was struck by its small size, and architectural severity of design.

I could not help thinking what a silent but eloquent commentary this apparatus made on radio progress since pre-war days, when the *W.W.* stand seemed to be filled with mighty engines of reception that seem well-nigh unbelievable today. The largest of these which I can call to mind was the Brobdingnagian developed by W. James, and described in *W.W.* during March 1925; a truly prodigious instrument with an outsize in frame aerials. It had, I suppose less sensitivity than the tiniest transistorette (what a word!) of today.

My only criticism of the show is its name which seems to suggest something juvenile, frivolous or lacking in dignity, like the old name Ping Pong did when it was used to describe table tennis. But I certainly cannot think of a better name; can you, I wonder?

Me Paenitet

WHAT I said in the November issue regarding hospital wireless has brought down on my head the severe strictures of a member of the staff at one of our hospitals, who asks me to refer to him as G3DUQ.

The reason for his displeasure is that I chided the hospital authorities for showing sales resistance to the manufacturers of stethoscope-type earphones who had circularized them about the advantages of their devices for giving greater comfort to patients listening to broadcasting, than is obtainable with the conventional hair-entangling type.

G3DUQ points out that he is compelled to make considerable use of the stethoscope which can make the external auditory meatus—earhole to you—quite sore. He stresses that this soreness, if caused to a patient, is an open invitation to the entry of any micro-organism left on the earpieces by a previous user.

He anticipates my obvious retort that earpieces could be sterilized after each change of patient, by telling me nurses and money are too scarce to permit this being done. It would seem that the real solution would be for each patient to bring to hospital his own earphones, just as he does his own toothbrush. If he did this he would be consuming only his own micro-organisms.

Loudspeaker Origin

MAYBE some of you noticed a few weeks ago a lively correspondence among readers of the *Daily Telegraph* about the date when the first loudspeaker was invented or, at any rate, brought into use. The correspondence was started by a reader who had the mistaken idea that the first loudspeaker used for the reproduction of broadcasting was in 1922. Actually I myself recall using one—and a moving-coil one at that—to reproduce the Melba concert from Chelmsford on June 15th, 1920, and I did not regard it as anything of a novelty even then.

In my opinion the loudspeaker became feasible as soon as the microphone was invented because it was then possible to construct a microphone amplifier and so to enable a primitive electrically driven megaphone, or loud hailer, to be constructed. Indeed Edison did just that thing in 1877 when he produced his aerophone as one of the correspondents in the national daily pointed out.

If we cut out the proviso of "electrically operated" we can of course go straight back to Sir Samuel Morland's megaphone in the seventeenth century. This is often stated to be the first megaphone but surely it must have occurred to somebody long centuries earlier to make a funnel to take the place of his cupped hands.

JANUARY MEETINGS

Tickets are required for some meetings; readers are advised, therefore, to communicate with the secretary of the society concerned.

LONDON

3rd. Brit.I.R.E.—All-day symposium on "Data transmission" at 10.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

5th. I.E.E.—Discussion on "Membranes" opened by Dr. H. Davson at 6.0 at Savoy Place, W.C.2.

9th. I.E.E.—"A linear transducer of high accuracy" by P. C. F. Wolfendale at 5.30 at Savoy Place, W.C.2.

10th. I.E.E.—"Tests of three systems of bandwidth compression of television signals" by G. F. Newell and W. K. E. Geddes at 5.30 at Savoy Place, W.C.2.

10th. Brit.I.R.E.—Discussion on "The effect of electromagnetic radiation on living tissues" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

10th. Society of Instrument Technology—"A review of digital computer control applications" by E. M. Grabbe at 7.0 at Manson House, 26 Portland Place, W.1.

11th. Radar & Electronics Association.—"Digital telemetering" by J. B. Richardson at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

11th. Television Society.—Fleming Memorial Lecture on "Bandwidth compression of television" by Prof. Colin Cherry at 7.0 at the Royal Institution, Albemarle Street, W.1.

12th. Institute of Navigation.—Discussion on "Simulators for training in the use of marine radar" at 5.30 at the Royal Institution of Naval Architects, 10 Upper Belgrave Street, S.W.1.

16th. I.E.E.—Discussion on "Electrical engineering education in the Soviet Union" opened by Prof. M. G. Say at 6.0 at Savoy Place, W.C.2.

17th. Institute of Physics and Physical Society—Symposium on "The calibration of microphones and hydrophones" at 2.0 at the Royal Horticultural Hall, S.W.1. (Joint meeting with the Brit.I.R.E.)

17th. Institute of Physics and Physical Society.—Annual general meeting of Low Temperature Group, followed by "Crystal lattices of semiconductors at lower temperatures" by Dr. D. H. Parkinson at 2.30 at 47 Belgrave Square, S.W.1.

17th. Brit.I.R.E. — "VERDAN — a miniature computer for airborne use" by P. B. Rayner and S. Morleigh at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

19th. B.S.R.A.—"Recent trends in loudspeaker design" by R. E. Cooke at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

24th. Brit.I.R.E.—"The development of a very high quality loudspeaker system" by D. A. Barlow and H. J. Leak at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

25th. Television Society.—Discussion on "Picture quality doesn't matter any more" at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

29th. I.E.E. & R.Ae.S. London Joint Group.—Discussion on "Automatic maintenance testing" at 6.0 at the Royal Aeronautical Society, 4 Hamilton Place, W.1.

31st. I.E.E.—"Storage tubes" by E. B. B. Callick and Dr. J. C. Firmin at 5.30 at Savoy Place, W.C.2.

BIRMINGHAM

2nd. I.E.E.—Faraday Lecture on "Expanding horizons in communications" by D. A. Barron at 7.0 at the Town Hall.

29th. I.E.E.—"Electronic telephone exchanges" by N. C. Smart at 6.0 at the James Watt Memorial Institute. (Joint meeting with Institution of Post Office Electrical Engineers.)

BRADFORD

23rd. I.E.E.—Discussion on "The electronics content of National Certificate courses" to be opened by Dr. G. N. Patchett at 6.30 at the Institute of Technology.

BRISTOL

25th. Institute of Physics and Physical Society.—"Recent developments in non-destructive testing" by R. S. Sharpe at 7.0 at the College of Science and Technology.

CARDIFF

10th. Brit.I.R.E.—"Test equipment for television transmission links" by L. A. Tanner at 6.30 at the Welsh College of Advanced Technology.

31st. Society of Instrument Technology.—"Computers and their application" by E. Stuart at 6.45 at the Welsh College of Advanced Technology.

CHELTENHAM

25th. I.E.E.—"Audio frequency applications of transistors" by P. J. Baxandall at 6.0 at the North Gloucestershire Technical College.

DUBLIN

18th. I.E.E.—"The Kippure mountain television transmitting station" by A. G. Tobin at 6.0 at the Physical Laboratory, Trinity College.

EDINBURGH

10th. Brit.I.R.E.—"Nuclear reactor safety circuits" by T. M. Dowell at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.

16th. I.E.E. — "Micro-miniaturization" by L. J. Ward at 7.0 at the Carlton Hotel.

23rd. I.E.E.—"The Banana-tube display system" by Dr. P. Schagen at 7.0 at the Carlton Hotel.

FARNBOROUGH

23rd. I.E.E. — "The silicon-controlled rectifier and its applications" by D. D. Jones and A. E. Jackets at 6.15 at the Technical College.

30th. Brit.I.R.E.—"Transistors in nuclear instrumentation" by D. Harrison at 7.0 at the Technical College.

GLASGOW

11th. Brit.I.R.E.—"Nuclear reactor safety circuits" by T. M. Dowell at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

15th. I.E.E. — "Micro-miniaturization" by L. J. Ward at 6.0 at the Royal College of Science and Technology.

HANLEY

4th. I.E.E.—Faraday Lecture on "Expanding horizons in communications" by D. A. Barron at 7.0 at the Victoria Hall.

LIVERPOOL

10th. Institute of Physics and Physical Society—"The physics of computer elements" by Dr. C. N. W. Litting at 7.0 at the University.

MANCHESTER

10th. I.E.E.—"Recent research in thermionics" by Dr. G. H. Metson at 6.15 at the Engineers' Club, Albert Square.

MIDDLESBROUGH

23rd. Society of Instrument Technology.—"The electrical synthesis of music" by A. Douglas at 7.30 at the Cleveland Scientific and Technical Institution.

NEWCASTLE-UPON-TYNE

8th. I.E.E.—"The changing face of electronics" by Prof. W. E. J. Farvis at 6.15 at the Rutherford College of Technology, Northumberland Road.

10th. Brit.I.R.E.—"Industrial electronic temperature measurement and control" by B. N. Ellis at 6.0 at the Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

18th. Society of Instrument Technology.—"Electronic weighing" by L. F. Cohen at 7.0 at the Conference Room, Roadway House, Oxford Street.

22nd. I.E.E.—"Air traffic control" by Dr. E. Eastwood and Dr. B. J. O'Kane at 6.15 at the Rutherford College of Technology, Northumberland Road.

NOTTINGHAM

25th. I.E.E.—Faraday Lecture on "Expanding horizons in communication" by D. A. Barron at 7.15 at the Albert Hall.

OXFORD

10th. I.E.E.—"Satellite communications" by W. J. Bray at 7.0 at the Southern Electricity Board, 37 George Street.

PRESTON

10th. I.E.E. — "Radiocommunication in the power industry" by E. H. Cox and R. E. Martin at 7.30 at the N.W.E.B. Demonstration Theatre, Friargate.

READING

15th. I.E.E.—"Global communication" by R. J. Halsey at 7.15 at the George Hotel, King Street.

SHEFFIELD

30th. I.E.E.—Faraday Lecture on "Expanding horizons in communications" by D. A. Barron at 7.30 at the City Hall.

SOUTHAMPTON

9th. I.E.E.—"Transistors in transmitters and communication receivers" by A. J. Rees at 6.30 at the University.