VOL. 22 NO. 6

THE
RADIO CONSTRUCTOR

RADIO · TELEVISION · ELECTRONICS · AUDIO

JANUARY 1969
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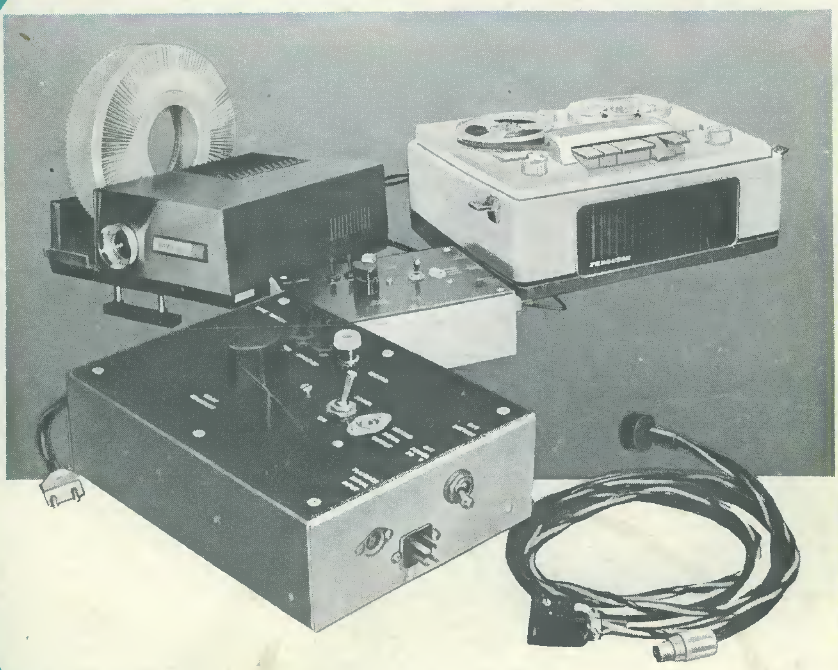
A DATA PUBLICATION



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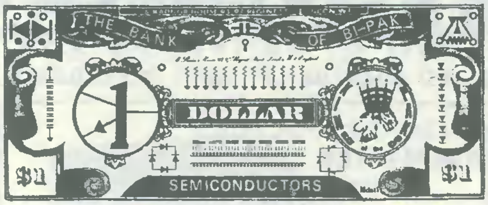

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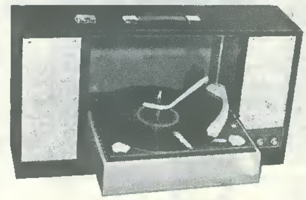

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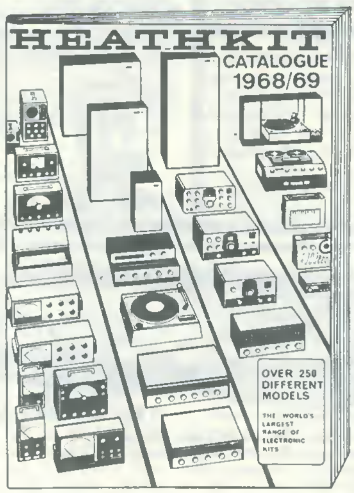

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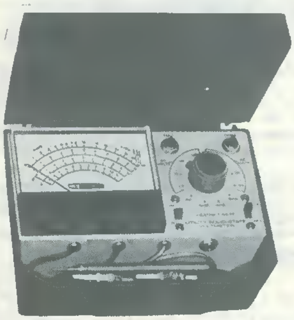

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2G308	6/9	ASY26	5/8	OA5	3/8	OC82D	3/-	MJ481	27/-
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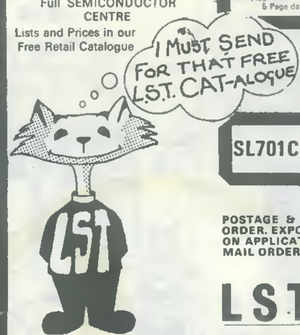

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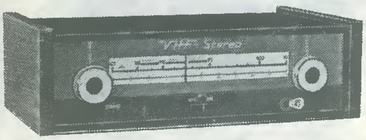

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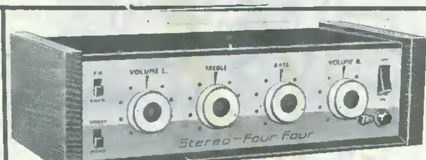

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GENERAL PURPOSE HIGH-GAIN AMPLIFIER

by A. FOORD

The usual approach towards developing amplifiers consists of designing them for the specific function they are intended to provide. In this article, however, our contributor describes an alternative technique. A basic amplifier (which is simple to construct) is first assembled, after which it can be made to carry out a very wide variety of applications by merely adding external components to its terminals

There are often times when a multi-purpose amplifier is required, for functions such as acting as a scratch filter or meter amplifier, or for boosting the output of a tuner or preamplifier.

In the present instance a single amplifier capable, with suitable additional components, of carrying out a wide range of functions was constructed, this taking advantage of readily available inexpensive silicon transistors. The circuit of the basic amplifier is shown in Fig. 1, and it consists of a differential pair input stage, TR_1 and TR_2, followed by a common emitter stage, TR_3, and emitter follower output, TR_4. D.C. conditions are arranged so that inputs and outputs are at earth potential, and external negative feedback can be used from the output back to the inverting input to set gain and d.c. conditions. Since the amplifier has unity gain at 10 Mc/s it is advisable to decouple the supply lines at the board (or chassis) on which it is assembled with both ceramic and electrolytic capacitors. The nominal 6V positive supply can be fed from a zener diode and should lie between 6V and 7.5V positive. TR_1 and TR_2 each pass about 100μA, and TR_3 passes 1mA.

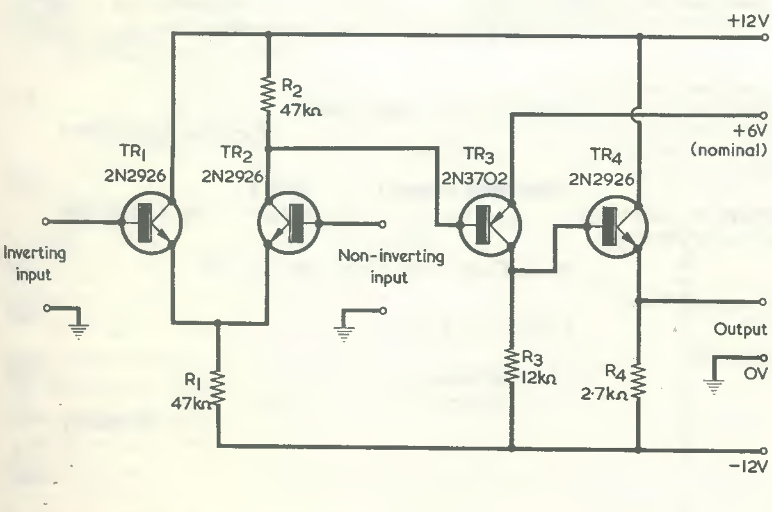


Fig. 1. The basic amplifier circuit diagram

PRACTICAL AMPLIFIER

The practical version of Fig. 1 is shown in Fig. 2, and this incorporates the nominal 6V supply and decoupling components just mentioned. All the circuits which follow in this article are based on the amplifier of Fig. 2. It will be noted that a single 12V supply is required, and that this is "floating" with respect to earth. Total consumption from the 12V supply is of the order of 5mA.

The collector of TR_2 is taken out to terminal 5 so that additional components can be added to this point, if necessary, to modify the frequency response. This facility would be required for instance in a meter amplifier, where an audio response might prove embarrassing.

The open loop gain (i.e. gain without feedback) is shown in Fig. 3, and was measured with a low source impedance. The gain/frequency characteristic is flat up to about 10 kc/s and then falls at 6dB per octave until 4 Mc/s, where the second break point occurs and the slope changes to 12dB per octave. The first break point at 10 kc/s is due to TR_1 and TR_2 operating at low current, and the second break point at 4 Mc/s is due to TR_3 (which operates at 1mA). Since TR_4 is an emitter follower it has no effect on frequency response up to 20 or 30 Mc/s, and we need not concern ourselves with it at all.

Typical performance figures for the amplifier of Fig. 2 are:—

Open loop gain = 68dB
Input impedance = 6kΩ
Output impedance = less than 100Ω
Maximum output = 4V p-p into 1kΩ load, or 8V p-p into open circuit load.

GAIN SETTING

Gain and d.c. conditions are set by negative feedback from output (3) back to the inverting input (1), and we can apply our signal to (1) to obtain an inverting amplifier or to (2) for a non-inverting amplifier, as we require. These points are dealt with in the application details, given later. The use of negative feedback to give a predictable mid-band gain and to reduce distortion is well known, and the general management is shown in Fig. 4.

In this diagram a fraction, β, of the output is fed back to the input in such a way as to reduce the overall gain, so that $\frac{V_o}{V_1}$ is less than A. For such an

COMPONENTS

Resistors
(All resistors $\frac{1}{10}$ watt 10%)

R_1	47kΩ
R_2	47kΩ
R_3	12kΩ
R_4	2.7kΩ
R_5	1.2kΩ

Capacitors

C_1	10μF electrolytic, 15V wkg.
C_2	0.01μF ceramic
C_3	10μF electrolytic, 15V wkg.
C_4	0.01μF ceramic
C_5	0.01μF ceramic

Semiconductors

TR_1	2N2926, green spot (Amatronix)
TR_2	2N2926, green spot (Amatronix)
TR_3	2N3702, high gain version (Electrovalue, 6 Mansfield Place, Ascot, Berkshire)
TR_4	2N2926, orange spot (Amatronix)
ZD_1	5.6V zener diode (5mA rating), SX56 or OAZ201

Battery
12-volt battery

arrangement the overall gain is given by:

$$\frac{V_o}{V_1} = {}'G$$

$$= -\frac{A}{1 + A\beta}$$

The minus sign indicates the phase reversal between input and output. A is the forward or open loop gain (about 68dB in our case), and β is the fraction of the output fed back to the input. If we take an example where A = 1,000 times and β = 0.1 then,

$$'G = -\frac{1{,}000}{1 + 1{,}000 \times 0.1}$$

$$= -\frac{1{,}000}{1 + 100}$$

$$\therefore\ 'G \approx -\frac{1{,}000}{100}$$

$$\approx -10 \text{ times}$$

We can see that ‘G is approximately $\frac{1}{\beta}$, so that we can see that the gain with feedback is given by

$$'G = -\frac{1}{\beta}.$$

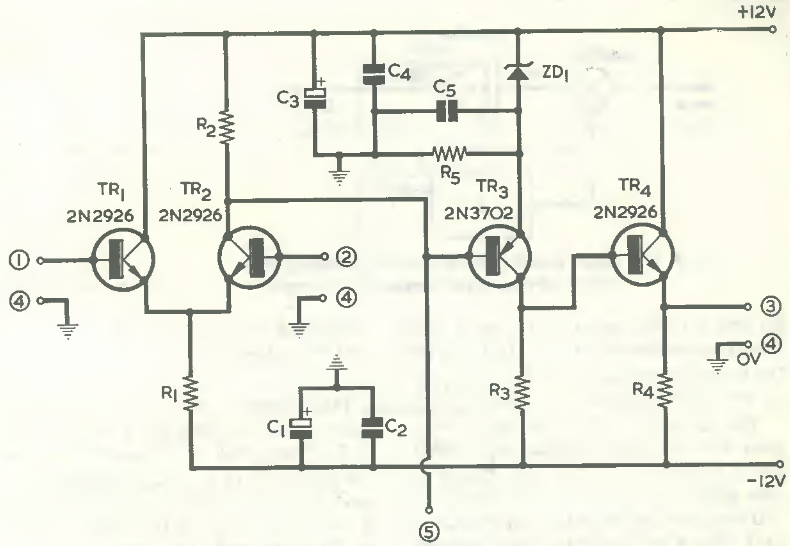


Fig. 2. The complete practical circuit for the amplifier. This is the diagram referred to in subsequent amplifier circuit arrangements

This will be so provided that the gain we aim for is much less than the open loop gain −A.*

In our case the feedback network will take the form of a voltage divider to the inverting input, and Fig. 5 shows the arrangements for (a) inverting amplifiers, (b) non-inverting amplifiers, and (c) differential amplifiers. In each instance the amplifier of Fig. 2 is indicated by the amplifier block symbol, the numbers in the block indicating the connections to terminals (1), (2), (3) and (4).

In the inverting arrangement of Fig. 5 (*a*), gain is $\frac{R_2}{R_1}$ and input impedance is R_1. Fig. 5 (*b*) shows the non-inverting arrangement and gain is $\frac{R_2}{R_1} + 1$. The differential input amplifier arrangement of Fig. 5 (*c*) gives a gain of $\frac{R_2}{R_1}$.

*This relationship was explained, in detail, in "Understanding Radio" in the issue for December, 1967.—Editor.

PRACTICAL APPLICATIONS

We can now take some practical applications, starting with inverting amplifiers.

A whole range of inverting amplifiers appears in Fig. 6. That in Fig. 6 (*a*) gives a gain of 100 times and has an input impedance of 1kΩ. The bandwidth is 100 kc/s. Both the amplifiers of Figs. 6

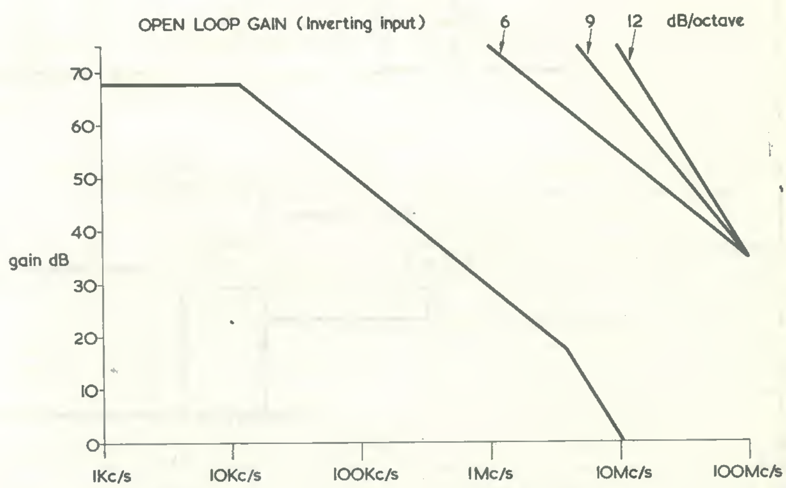


Fig. 3. Open loop gain of the amplifier of Fig. 2. Also shown are slopes for 6, 9 and 12dB per octave

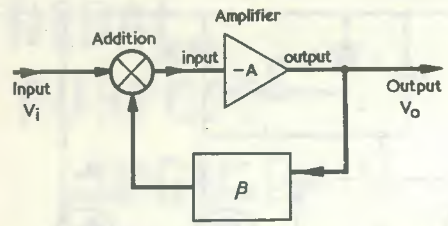


Fig. 4. The basic block diagram demonstrating the effect of negative feedback

(*b*) and (*c*) offer gains of 10 times and have bandwidths of 500 kc/s. In Fig. 6 (*b*) the input impedance is 1kΩ, and in Fig. (*c*) the input impedance is 10kΩ.

The amplifier of Fig. 6 (*d*) offers unity gain with an input impedance of 10kΩ and a bandwidth of 500 kc/s. Fig. 6 (*e*) also gives unity gain at a bandwidth of 500 kc/s, and has an input impedance of 1kΩ. The 47pF capacitor was included in the arrangement of Fig. 6 (*e*) as a precaution against instability, but it was not in fact found to be necessary with the amplifiers constructed by the writer.

Because of the feedback, all the amplifiers of Fig. 6 have low output impedance.

Non-inverting amplifiers are illustrated in Fig. 7. That in Fig. 7 (*a*) has a gain of 100 times and that in Fig. 7 (*b*) a gain of 11 times. The bandwidth in Fig. 7 (*a*) is 100 kc/s, and in Fig. 7 (*b*) it is greater than 100 kc/s.

DIFFERENTIAL METER AMPLIFIER

Fig. 8 gives a circuit for a differential meter amplifier. This has a current gain of 100 times, and can be used to increase the sensitivity of a 1mA f.s.d. meter from 1kΩ per volt to 100kΩ per volt. On the 0–1V range there is a very small change in balance with the input open or short-circuit (less than 20μA change on the 1mA scale) so this range should be used with the balance control set up under short-circuit conditions. Accuracy is limited by the meter movement rather than by amplifier non-linearity.

Note that use is made in this circuit of terminal (5) of the amplifier. The 1.5μF capacitor connecting this terminal to earth limits the frequency response of the amplifier. Since this capacitor is in the collector of TR_2 it should be a low leakage type, preferably tantalum.

INTEGRATING AMPLIFIER

An integrating amplifier is shown in Fig. 9. This can be used to produce s sawtooth from a square wave. It is particularly useful for checking cross-over distortion in Class B output stages, since the distortion is very evident on a linear ramp.

SCRATCH FILTER

The basic arrangement for a scratch filter, or low pass filter, is given in Fig. 10 (*a*). The frequency at which roll off commences is given, in c/s, by

$$f = \frac{1}{2\pi CR}.$$

Note that all three resistors have the same value, R, and that one capacitor has a value of 3C and the other one of $\frac{C}{3}$. Thus the two capacitors should have a ratio of 9:1, or 10:1 in a practical circuit. Roll off is at 12dB per octave.

A practical version appears, with component values, in Fig. 10 (*b*). This is ideally suited to removing surface noise from old recordings and gives the 12dB per octave roll off above 7.8 kc/s. The gain is unity up to this frequency, apart from a 1.5dB peak just below the roll off point. The turnover frequency can be altered by changing the capacitors (whilst still maintaining the 10:1 ratio) or the resistors, working from the equation just given.

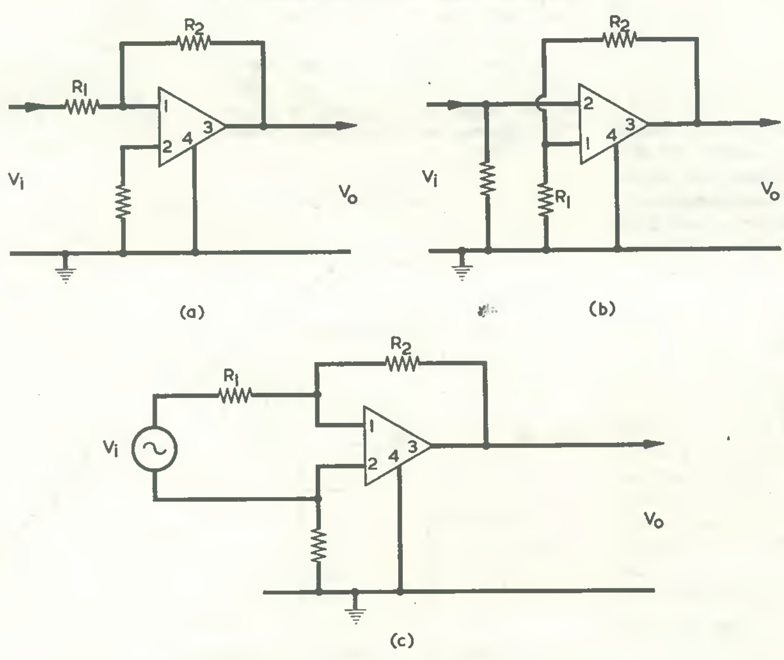


Fig. 5 (a). Inverting amplifier circuit (b). Non-inverting amplifier circuit (c). Differential input amplifier

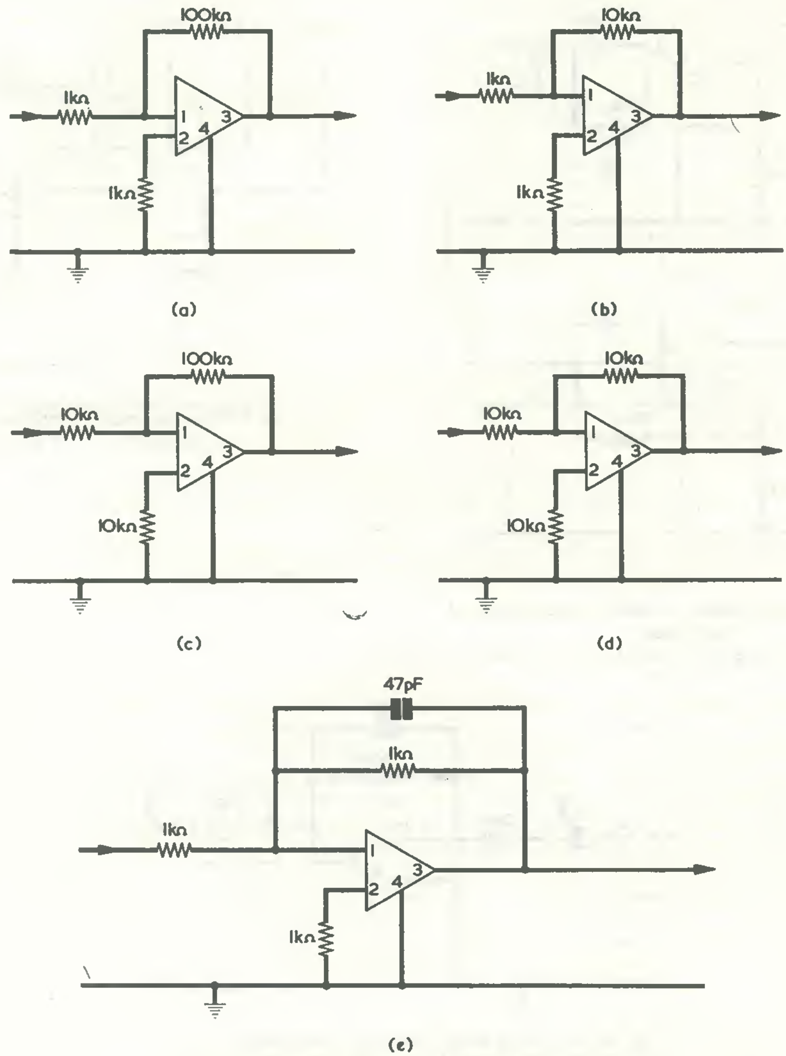


Fig. 6. A group of five inverting amplifiers with different external feedback circuits. Their performance is discussed in the text

PARALLEL-T SINE WAVE OSCILLATOR

The amplifier may also be employed as a sine wave oscillator in conjunction with a parallel-T network. Although this is more often employed as a notch filter it provides 180° phase shift at the notch frequency (and a large signal attenuation) so that the amplifier can be used to complete the oscillator, as in Fig. 11 (*a*).

Here, positive feedback occurs by way of the network, whilst negative feedback via the silicon diode limits the gain to provide an output level of about 0.5V p-p. Because of the high Q of the network the output is a good sine wave.

The frequency of oscillation, in c/s, is

$$f = \frac{1}{2\pi CR}$$

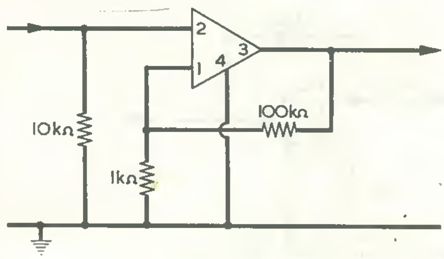
using the component values of Fig. 11 (*a*). This type of oscillator is more suitable for fixed frequency operation, because the 2:1 ratio of component values makes variable frequency operation difficult.

A practical circuit for 1 kc/s is given in Fig. 11 (*b*). The 10kΩ potentiometer in this diagram acts as variable damping on the circuit, and should be adjusted from maximum towards minimum resistance until the circuit oscillates reliably. In this particular version the diode is tapped down the output to increase the output to 1V p-p. 0.5V p-p is still maintained across the diode.

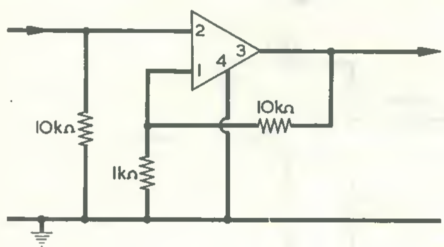
CONCLUSION

For the a.c. amplifier applications, no input or output coupling capacitors have been shown. These can be added, if desired, remembering that both the inputs and the output are nominally at earth potential, and that electrolytic capacitors should be connected up with the corresponding polarity.

If it is desired to use two of the amplifiers in cascade with a direct coupling between them a difficulty may arise since, although the output of the first amplifier will be nominally at earth potential, it could still have a small



(a)



(b)

Fig. 7 (a). A non-inverting amplifier with a gain of 100 times
(b). Altering the feedback values gives a gain of 11 times

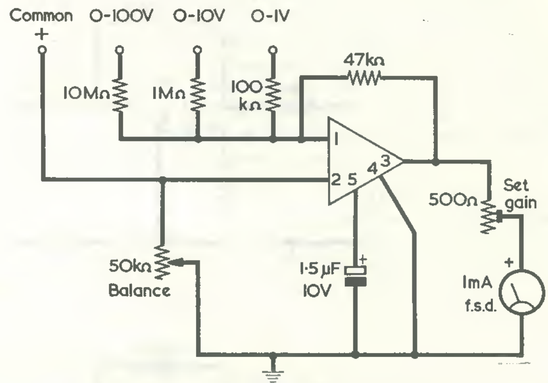


Fig. 8. Differential meter amplifier. This circuit has a sensitivity of 100kΩ per volt

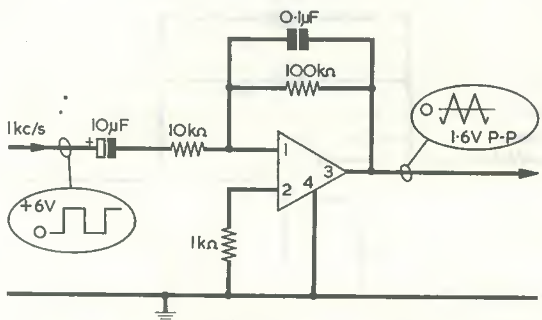
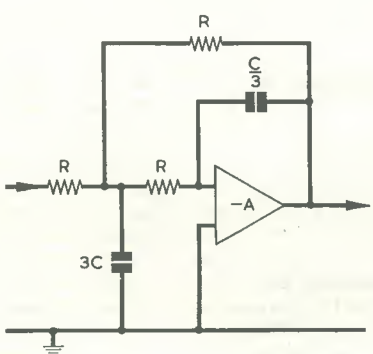
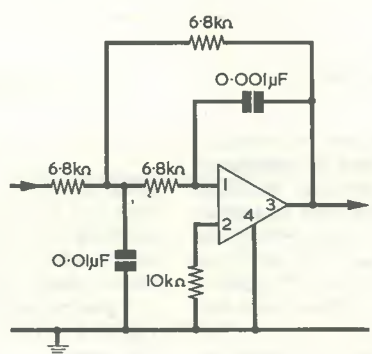


Fig. 9. An integrating amplifier. Amongst other applications this may be used to check for cross-over distortion in Class B a.f. output stages



(a)



(b)

Fig. 10 (a). Basic requirements for a low pass filter
(b). A practical version which is intended for use as a scratch filter for record reproduction

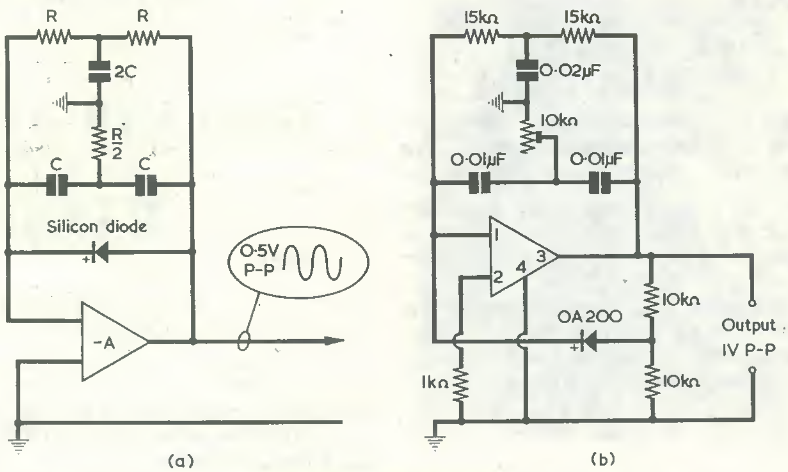


Fig. 11 (a). Adding a parallel-T network from output to input allows the amplifier to function as an oscillator giving a sine wave of good waveform
(b). A practical parallel-T sine wave oscillator circuit with worked component values. Oscillator frequency is 1 kc/s

offset (i.e. difference from earth potential) which may be sufficient to bias the second amplifier into cut-off or saturation. A solution here is to balance the first amplifier in the manner that was shown in Fig. 8. Thus, the input could be applied to terminal (1) of the first amplifier and a variable balance resistor connected between terminal (2) and earth. The balance resistor is adjusted until the output terminal of the second amplifier has zero offset.

A possible alternative approach could be to apply a bias which can be varied from positive to negative of earth to the input terminal of the first amplifier. This bias could be applied via a resistor having a value considerably higher than the amplifier input impedance. The bias would then be adjusted for zero offset at the output terminal of the following amplifier.

The acompanying photograph shows an amplifier made up to the circuit of Fig. 2, the components being mounted on a Paxolin board. This amplifier was actually fitted inside an old Carpenter Relay case, and the board is approximately 2in long and $1\frac{3}{8}$in wide.

MARCONI COLOUR CONVERSION FOR TYNE TEES

Tyne Tees Television, the Independent television contractor for North East England, will shortly have their existing black and white Marconi outside broadcast vehicle converted to full colour operation by The Marconi Company. Tyne Tees, major users of Marconi television equipment at their headquarters in Newcastle upon Tyne, took delivery of the O.B. unit in October 1967. Marconi originally supplied the van to a design based on the premise that a colour conversion would follow, and this has now materialised under a contract worth nearly £100,000.

The four existing Marconi Mark V black and white cameras will be replaced by a similar number of colour camera channels comprising a Mark VII camera, a camera control unit and an operational control panel. The Mark VII, with the famous Marconi 'hands-off'' operation, is highly stable and therefore particularly suitable for outside broadcast work. Other modifications to the van include the introduction of colour balance controls and vertical aperture correctors, a dual synchronising generator, genlock and colour lock units, and colour synchronising equipment. The existing vision mixing equipment will be modified to enable the switching and fading of colour signals with separate preview facilities, and will include an output processing amplifier and a PAL colour caption module.

OHM'S LAW READY RECKONER

by R. M. BLACKALL

A diagram which enables any one of voltage, current and resistance to be found when the remaining two are known

The accompanying diagram has been designed primarily for use with valve circuits, but it can be easily modified for lower voltages and lower or higher currents.

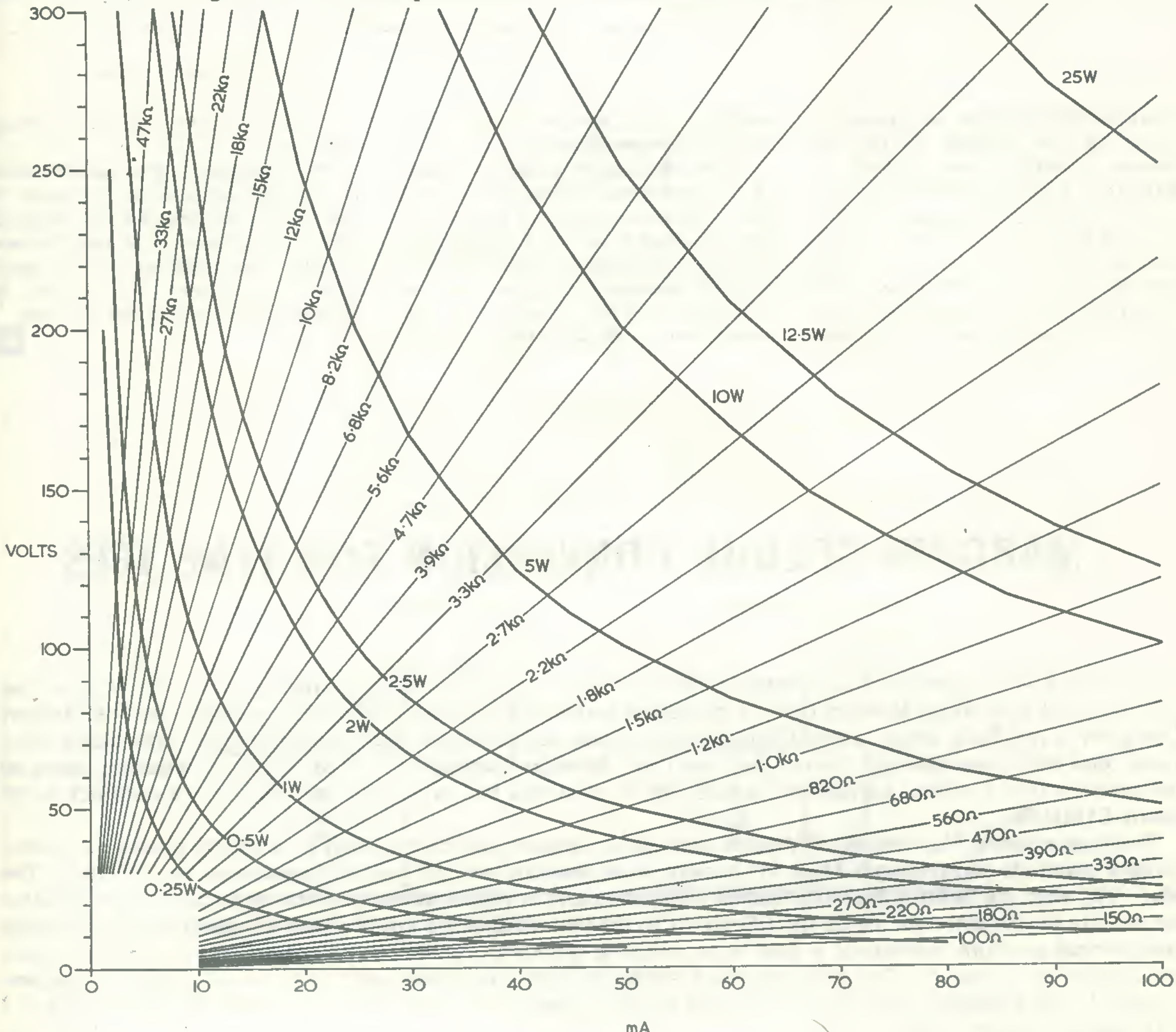
Given any two of voltage, current and resistance, the diagram immediately gives the third as well as the wattage dissipated. This is *not* the wattage rating the resistor should exhibit—the resistor should have a higher wattage rating than the figure indicated. The diagram will be found particularly useful in designing potential dividers and voltage droppers.

To take an example, let us assume that we wish to drop 100 volts at 50mA. These two quantities cross at a point central between the 1·8kΩ and 2·2kΩ lines, indicating that the resistance should be 2kΩ. Also, the quantities cross on the 5 watt line, showing that this is the dissipation that will occur in the 2kΩ resistor.

The Table gives conversion factors for voltages and currents other than those shown in the diagram. If, for instance, we want to use a voltage scale of 0–30 (instead of 0–300) and a current scale of 0–10mA (instead of 0–100) the Table indicates that R values remain the same but that watts are multiplied by 10^{-2} (i.e. divided by 100). Thus, the 2 watt line now corresponds to 0·02 watts, the 5 watt line to 0·05 watts, and so on. Again, for 0–300 volts and a current scale of 0–1 amp, the watts are multiplied by 10 whilst resistance is multiplied by 10^{-1} (i.e. divided by 10).

CONVERSION TABLE

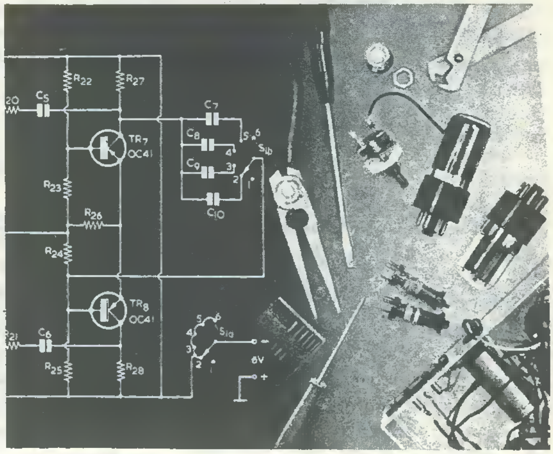
	0–30 volts	0–300 volts
0–10mA	R × 1 Watts × 10^{-2}	R × 10 Watts × 10^{-1}
1–100mA	R × 10^{-1} Watts × 10^{-1}	R × 1 Watts × 1
0–1 Amp	R × 10^{-2} Watts × 1	R × 10^{-1} Watts × 10



SUGGESTED CIRCUIT No. 218

VARIABLE VOLTAGE POWER SUPPLY

by G. A. FRENCH



FOR EXPERIMENTAL AND constructional work with transistor equipment it is frequently desirable to have available a power supply whose d.c. output voltage is continuously variable. This output may then be set at any desired level as required. It is also possible for the output of a variable voltage power supply to be initially set to zero when using it with newly constructed and untested equipment, the output voltage then being gradually increased to the final design level whilst monitoring the output current by a suitable meter. This procedure ensures that any tendency, due to fault conditions, for the new equipment to draw excess current can be discovered at an early stage, and without the risk of damage to components.

Frequently, variable voltage power supplies incorporate voltage stabilising circuits which neccessitate the use of a large quantity of components and a complex circuit. This month's "Suggested Circuit" is for a power supply whose output voltage, whilst still being variable, is *not* stabilised. Nevertheless, the supply offers good voltage regulation and should be adequate for most applications which can be envisaged. In the interests of circuit simplicity and economy in components the power supply employs half-wave rectification only. Because of this, a small ripple is present on the output at the higher voltages and currents. The ripple may be easily removed by a simple filter following the output terminals but in most cases such a filter should not be necessary. Even if the power supply is employed with an a.f. amplifier the ripple will probably be cleared before the supply voltage reaches the earlier stages, which are those most likely to be affected, due to the a.f. decoupling in the amplifier itself.

The power supply to be described offers an output voltage continuously variable from zero to more than 15 volts at currents up to 300mA.

BASIC CIRCUIT

To appreciate the operation of the complete unit it will be of assistance to examine, first of all, the basic power supply circuit shown in Fig. 1.

In this diagram the upper terminal of a mains transformer secondary offering between 12 and 15 volts r.m.s. is applied to the "cathode" of D_1, a silicon rectifier type DD000. Alternate negative half-cycles appear at the "anode" of D_1 and are applied to the top end of potentiometer R_1 and to the collectors of p.n.p. transistors TR_1 and TR_2. TR_1 and TR_2 are in a compound emitter follower circuit offering a high degree of current amplification whereupon (assuming the requisite negative collector potential) the voltage at the emitter of TR_2 is the same as that at the base of TR_1 less the small voltage dropped in the base-emitter junctions of the two transistors. R_1 is the output voltage control for the power supply circuit.

The voltage at the emitter of TR_2 is next applied to limiter resistor R_4 and thence to the negative plate of the large value capacitor C_1. R_5, connected across C_1, is included merely to ensure that the voltage across this component reduces quickly when, with no external load, R_5 slider is set for a lower output voltage. Without R_5 the supply across C_1 falls slowly, and this can be irritating when work with the supply is in progress.

Let us examine circuit operation when the slider of R_1 is at a mid-way position on its track. For the moment, we shall assume that C_1 is out of circuit. During a positive half-cycle at the upper end of T_1 secondary diode D_1 does not conduct, and the components which follow it are inactive. As soon as a negative half-cycle appears at the upper end of the secondary a correspondingly lower negative voltage is passed, via the slider of R_1, to the base of TR_1, and a similar voltage (less the voltage drop in the base-emitter junctions of the two transistors) appears

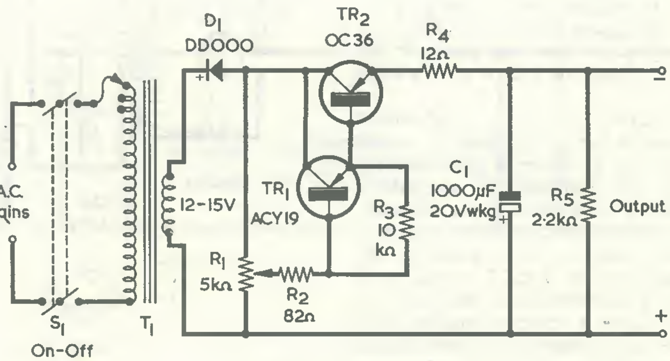


Fig. 1. Basic circuit employed in the power supply

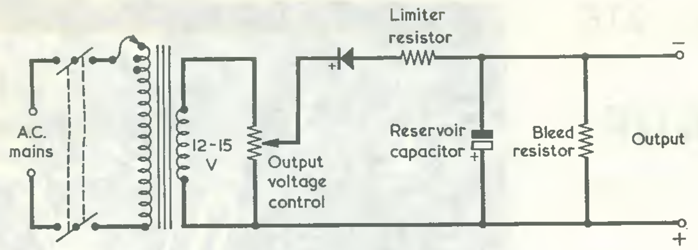


Fig. 2. The circuit of Fig. 1 functions effectively in the manner shown here

at the emitter of TR_2. As the amplitude of the negative half-cycle increases, so also does the voltage at R_1 slider and at TR_2 emitter. When the half-cycle amplitude is at its peak the same happens with the voltage at TR_2 emitter, and when the half-cycle amplitude commences to fall so also does the voltage at TR_2 emitter.

It may thus be seen that the voltage at TR_2 emitter consists of a half-cycle having the same sine wave form as that from T_1 secondary but with a reduced voltage amplitude. Indeed, the output at TR_2 emitter is that which would be given by a half-wave rectifier coupled to a transformer secondary giving a lower voltage than does the secondary of T_1. It is obvious that, if we now set the slider of R_1 higher, the output at TR_2 emitter will still consist of sine wave half-cycles but that these will have a correspondingly greater amplitude. Thus, R_1 functions as an output voltage control and can vary the voltage amplitude of the half-cycles at TR_2 emitter from zero to very nearly the full voltage available from D_1. It might be thought that when R_1 slider is at the top of its track there would be insufficient base-collector voltage for TR_1 and TR_2 to operate satisfactorily. In practice, however, TR_2 presents about the same output impedance for this setting of R_1 as it does for lower settings.

If we now re-introduce C_1 we will find that this functions in the same manner as does the reservoir capacitor in any half-wave rectifier circuit, charging on peaks from the emitter of TR_2 and discharging between these peaks. In the interests of regulation C_1 is given a large value.

The circuit of Fig. 1 effectively functions in the same manner as would that in Fig. 2, where a potentiometer across the transformer secondary supplies a half-wave diode directly. However, to enable the same degree of voltage regulation to be achieved, the potentiometer in Fig. 2 would need to have a very low value, whereupon it would draw a proportionately high current and dissipate a considerable amount of heat. In Fig. 1 the high current amplification offered by TR_1 and TR_2 in tandem enables the actual voltage control used to have the comfortably high value of 5kΩ.

LIMITING RESISTORS

Returning to Fig. 1 it will be seen that the transistor specified for TR_2 is an OC36. This is a power transistor capable of operating at collector currents up to 8 amps and is considerably under-run in the present application. The fact that it is under-run represents no great disadvantage as it still provides the low output impedance required of the circuit; also, the fact that it is a fairly large and bulky transistor is counterbalanced by the point that other components in the circuit—the mains transformer and reservoir capacitor—are similarly of a bulky nature. The main reason for using the OC36 is that it has the high maximum reverse base-emitter voltage rating of 40 volts. A high reverse base-emitter voltage rating is necessary because, if R_1 slider were suddenly moved from the upper to the lower end of its track, the reverse base-emitter voltage applied to TR_2 could approach 21 volts. This would occur with no load connected and C_1 charged to peak potential from a 15 volt transformer secondary.

The transistor specified for TR_1, an ACY19, has the more commonly encountered (with germanium transistors) reverse base-emitter voltage rating of 12 volts. Resistor R_3 is connected across its base and emitter to ensure that, in the circumstances just described, most of the reverse voltage appears across the base-emitter junction of TR_2. R_3 serves no other function.

Resistor R_2 is a limiting resistor, and it limits base current in TR_1 to a safe value should the power supply be switched on with R_1 slider at the top of its track and C_1 fully discharged. Resistor R_4 is also a limiting resistor and, for the same circumstances, limits the forward current in D_1 and the initial charging current in C_1.

As it stands, the basic supply circuit of Fig. 1 is quite practicable, but it suffers from poor regulation due to the presence of R_4. If R_4 is short-circuited the regulation improves considerably but there is then the risk of excessive surge current when initially switching on.

As a matter of interest R_4 *could* be short-circuited provided that the slider of R_1 was *always* at the bottom end of its track when the mains input was switched on. After switching on there would then be no initial surge and R_1 could be adjusted for whatever output voltage was required. The writer did, in fact, toy with the idea of ganging on-off switch S_1 with R_1 such that R_1 slider would automatically be at the lower end of its track when switching on, whereupon R_4 could be short-circuited and taken out of circuit. Although attractive at first sight, this method of operation cannot be recommended as

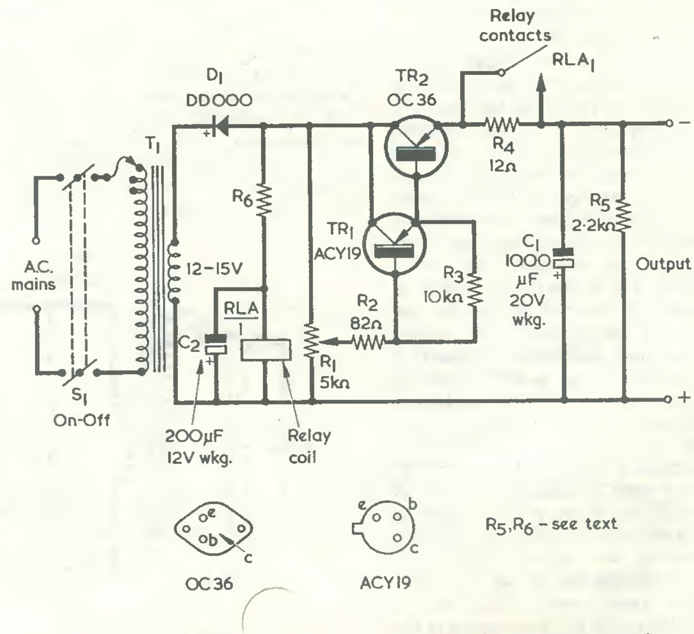


Fig. 3. The complete circuit of the variable voltage power supply

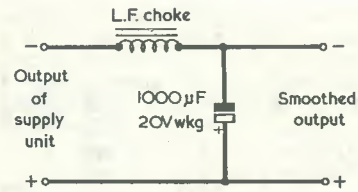


Fig. 4. A simple filter which may be added to remove ripple

there is always the risk of the mains supply to the power unit being broken and then reconnected externally, say by the removal and reinsertion of the mains plug in its socket. Damage could then occur to D_1 or C_1 under this condition.

FINAL CIRCUIT

The final arrangement, and that which forms this month's "Suggested Circuit", appears in Fig. 3. This is the same as Fig. 1 with the exception that R_6, C_2 and relay RLA have been added.

When, now, the mains supply is switched on the basic power supply circuit functions as before and causes C_1 to be charged to a voltage depending on the setting of R_1. At the same time, capacitor C_2 commences to charge via R_6 with the result that, after a short period, relay RLA energises. Its normally-open contacts, RLA1, then short-circuit R_4, enabling the circuit to provide good regulation.

Even if R_1 slider is initially at the top end of its track when the mains supply is switched on, the momentary surge in the D_1C_1 circuit when, later, contacts RLA1 close is that associated with an a.c. supply of several volts only. It is far lower than would occur if the short-circuiting of R_4 were not delayed.

The accompanying table shows results obtained with the prototype circuit and indicates the regulation achieved. In general there is a drop of about 2 volts for a current of 300mA, thereby indicating a regulation resistance of some 6 to 7Ω. The uppermost line of figures in the Table corresponds to the slider of R_1 being right at the top of its track.

A ripple of about 0·4 volts peak-to-peak was given when the supply was checked at maximum output voltage at an output current of 150mA. This reduced to negligible proportions for output voltages below around 10 volts. It also reduced with lower output currents at the higher voltages. If the ripple is troublesome it can be readily cleared by adding the simple filter shown in Fig. 4. An inductance of only 1H in the choke (giving a reactance of 628Ω at 100 c/s) should be adequate.

If desired, a voltmeter could be permanently connected across the output terminals and a milliameter in series, as in Fig. 5 (*a*). The milliameter could have a full-scale deflection corresponding to the range of currents (up to 300mA) it is intended that the power supply should provide. No short-circuit protection is given with the circuit of Fig. 3. Again if desired, a 500mA fuse could be added, *after* C_1, as in Fig. 5 (*b*).

COMPONENTS AND RELAY SETTING

Many of the components of Fig. 3 have already been discussed.

As already stated, TR_2 is under-run and it hardly requires a heat-sink. Nevertheless, a heat-sink is convenient for mounting purposes, and could consist of a flat sheet of metal some 2in square. It should be remembered that the collector of TR_2 is common to its metal case.

Resistors R_2, R_3, R_4 and R_5 may be $\frac{1}{4}$ watt components, the first three of these having a tolerance of 10%. Resistor R_5 is not at all critical and could, in practice, have any value between 1·5kΩ and 4·7kΩ. R_5 may be a carbon track potentiometer of standard size.

Relay RLA should have an energising current of the order of 10 to 15mA at some 5 to 7 volts. The writer used a P.O. 3000 relay having a 500Ω coil and two sets of changeover contacts (of which only the make contacts of one set were employed), this functioning very satisfactorily. It is of course necessary to use a relay of reliable operation, such as a Post Office type, here. (P.O. 3000 relays are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon, Surrey).

The value of R_6 is found experimentally. First, the whole power supply should be completed with the exceptions that R_6 is not fitted and that the relay contacts are *not* connected across R_4. Next, using a variable resistor of some 1kΩ to 5kΩ, find a value for R_6 which causes a marked delay in the energising of the relay after S_1 is closed. Then replace the variable resistor with a fixed component of the appropriate value. The delay may be less than a second but should still be very perceptible. With the prototype it was found that the final value required in R_6 was 270Ω. If difficulty is experienced in obtaining the required delay it may be necessary to increase the value of C_2. However the writer found, with the relay used by himself, that there was an adequate delay when C_2 was 100µF only. The 200µF value specified gaves added insurance.

When relay operation is satisfactory, its normally open contacts may be connected across R_4 as shown in Fig. 3. If the output voltage for a load of some 100mA is next checked with a voltmeter whose movement is not excessively damped it will be found that, after switching on, the output voltage rises quickly to a level dependent upon the setting of R_1, then finally increases by a volt or two as the relay contacts close.

A final point with respect to components concerns mains transformer T_1. The transformer used with the prototype circuit was a standard component having two 6·3 volt windings which were connected in series to provide a nominal 12·6 volts. A number of different transformers could be employed and a suitable component would be the Radiospares "Standard" type offering a secondary voltage of 13V at 0·5 amp. This is available from Home Radio (Components) Ltd. under Cat. No. TH5D.

TABLE
POWER SUPPLY REGULATION

The table shows observed output voltages (rounded off to the nearest quarter-volt) at currents of zero, 100mA, 200mA and 300mA for three settings of R_1.

Zero Current	100mA	200mA	300mA
17·5V	16·5V	15·75V	15V
12V	11·25V	10·75V	10·25V
6V	5·0V	4·5V	4V

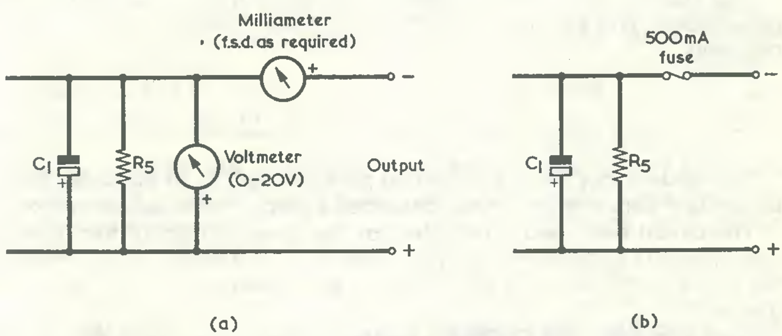


Fig. 5 (a). Either an output voltmeter and/or milliameter may be incorporated, if desired.
(b). If a fuse is fitted it should appear after C_1, and after the milliameter of (a) if this is fitted

It will be noted that no chassis connection is made, in Fig. 3, to either side of the power supply output, since in most cases it will be preferable to have the output terminals "floating". Should a chassis connection be considered desirable it may be made to either the negative or the positive output terminal.

"SUGGESTED CIRCUIT" No. 216

Before concluding this month, the writer would like to refer back to Suggested Circuit No. 216, "Low-Value Capacitance Bridge", which appeared in the last November issue. This article stated that if a charged capacitor happened to be connected to the Test terminals of the bridge an internal resistive path existed through which it would discharge. It should be pointed out that, even so, capacitors should always be discharged before being connected to the bridge described in the article as excessive voltages could otherwise be applied to the gate of TR_2.

RECENT PUBLICATIONS

RADIO COMMUNICATION HANDBOOK. 832 Pages, $7\frac{1}{2}$ x 10 in. Published by the Radio Society of Great Britain, 35 Doughty Street, London, W.C.1. Price 63/–, 6s. postage and packing.

This is the Fourth Edition of the famous British Amateur Radio Handbook published by the National Society. It is fittingly dedicated to the memory of John A. Rouse, G2AHL, who was General Manager of the RSGB and responsible for much of the prepatory work in connection with this volume and who died in May 1967.

This well known Handbook was first published in December 1938 and supplied in very large quantities to the Armed Forces during the last war where it was used as a standard training manual.

The present edition is the largest yet produced and between its covers will be found many designs for receivers, transmitters, test equipment, VHF equipment, aerials, and filters etc. The book is lavishly illustrated with circuit diagrams and included are also special fold-out sheets on which are reproduced large circuits of a receiver and transceiver respectively. The early Chapters, cover both the theory of radio and the designing of equipment.

This well-produced Handbook deals with the many varied aspects of amateur radio communications and will be found invaluable to the amateur enthusiast and professional radio engineer alike. The theory and practice of modern techniques have been blended together in a book essential to both the home constructor and the electronics student.

The Chapter titles themselves alone convey the comprehensive coverage. Principles, Valves, Semiconductors, HF Receivers, VHF/UHF Receivers, HF Transmitters, VHF/UHF Transmitters, Keying and Break-in, Modulation Systems, SSB Transmission, RTTY, Propagation, HF Aerials, VHF/UHF Aerials, Noise, Mobile Equipment, Power Supplies, Interference, Measurements, Operating Technique, Station Layout and The RSGB and the Radio Amateur.

The Handbook is bound within very substantial rich blue linen board covers having a gold blocked spine and cover, this being covered by a quality art paper dust jacket of distinctive design.

The postage charge also includes packaging of the Handbook within a tough cardboard container ensuring safe postal delivery without damage.

This Handbook is highly recommended for all those engaged in radio communication whether amateur or professional, and for those interested in the art of electronics. For those studying for the RAE, it is virtually a necessity.

Our readers may care to know that pamphlet No. 21 in the series Educational Electronic Experiments issued by Mullard Educational Service describes a simple motor speed controller using a thyristor.

The circuit described is intended for the speed control of fractional horse power, a.c. series motors of the type normally used in electric hand drills and food mixers ($\frac{1}{2}$ h.p. maximum). The controller not only enables the speed of the motor to be varied but also maintains a reasonably constant speed under varying load conditions.

Also available from Mullard Educational Service is a pamphlet entitled "Introducing Silicon Planar Transistors". Its description of how silicon planar transistors are manufactured will be of use to teachers and students of electronics, and of interest to engineers using semiconductor devices.

Copies of these two pamphlets can be obtained from Mullard Educational Service, Mullard Limited, Mullard House, Torrington Place, London, W.C.1.

QSX

by

L. SAXHAM

(All times GMT)

Topic has been held over in view of the large amount of Dx listed. The subject of receiver ancillary equipments will be dealt with next time round—March issue.

AMATEUR BANDS

Although the writer spent comparatively little time on these bands, it was noted that plenty of Dx was there provided one searched for it. Unable to operate during the recent contest times, the following were however noted on the various bands.

21 Mc/s

CW: CR6FU, 6FW, CX4CO, EL2NJ, HI3PC, KP4UW, TJ1AJ, ZS5SY, and 9X5MF/P.

SSB: CR6LX, 6YL, KP4BCL and 5H5TH.

14 Mc/s

CW: CE2PI, 9AT, CM2HA, CO2KG, 6AH, CR6AI, 6IV, LU2AEU/MM, 6FBR, 8OI, PY2DN, 4BCX, 5ASN, 5WL, 7AH, ZL2BCW, ZS1AX, 6GG, 8J and 9Y4KK.

SSB: CE6EW, JA2CLI, 2JKV, OA4GQ, PJ3CL, TI2CAP, 2CEF, VK1GD, 2AFB, 3VK, 5FQ, 7GK, 7RX, YV5CDK, ZL2ABY, 3LE, 3TD, 4BO, ZP3AL and 8P6CC.

7 Mc/s

CW: CE2DI, CO2BB, PY2NE, VE2UN, 7ASV, VP1GB and W4BXB.

SSB: PJØMM and YV4UA.

3·5 Mc/s

CW: VE1LX, W2SZ, 4EZ and ZL4IF.

SSB: W1EBC, 1FZJ/KP4, 3BMS and 4IHK.

1·8 Mc/s

Always the favourite haunt of the writer, especially the c.w. end, this band has certainly provided some Dx of late—

CW: DJ7YR, EI5BD, 6BC, GI3LSM, 3OIC, GM3FGJ, GW3TOW, 3XJC, OK1JIL, 1JIM, 1JOE, 1MSS, 3CHX, 3KIC, OL2AIO, 2AIQ, 2AKS, 6ACG, 6AJN, 6AJT, 7AJB, OM1AWQ, 2AJQ, 2BOL, 2DW, 3KYQ, PAØAHQ and ØPN. On SSB the only station of Dx note was EI4AL.

This completes the Amateur bands roundup and we now turn to the—

BROADCAST BANDS

3225kc/s 1952 R. St. Elwa, Liberia—with music prog. Heavy CW QRM.

3240kc/s 1910 Baghdad, Iraq—with Arabic songs.

3346kc/s 1925 Lusaka, Zambia—with African chants and drums.

3365kc/s 0424 HIRL "R. Exitos", Dominican Rep.—with identification.

3970kc/s 1955 Buea, Cameroon—with African drums and songs. Fairly clear channel at this time.

4735kc/s 0517 HCEH3 "R. El Progresso", Loja, Ecuador—taped with Latin American music, 1 chime and identification.

4760kc/s 1655 VUD Delhi, India—with sitar music in typical Indian manner. 6 'pips' at 1530 and announcements in dialect.

4772kc/s 0450 YVMW "Ondas del Caribe", Punto Fijo, Venezuala—with National Anthem and closing down at 0453.

4775kc/s 1525 AIR Gauhati, India—with songs by female singer. 6 'pips' at 1530.

4777kc/s 2055 R. Gabon, Gabon—with talk in French.

4790kc/s 0530 YVQN Puerto le Cruz, Venezuala—with Latin American music in typical manner and station identification.

4795kc/s 2145 R. Commercial de Angola—with station identification.

4800kc/s 1540 AIR Hyderabad, India—with news in English read by female announcer.

4820kc/s 0355 HRVC R. Evangelica, Honduras Rep.—with hymn singing. Channel suffers from CW QRM.

4860kc/s 0630 YVQE R. Mundo, Maracaibo, Venezuala—with station identification (every $\frac{1}{4}$ hour).

4872kc/s 0345 TGQH R. Santa Cruz, Guatemala—with station identification.

4875kc/s 2150 Dahomey, Africa—with African drums, chants and trilling female cries—most impressive!

4885kc/s 0343 HJIG "Ondas del Meta", Columbia—with identification.

4900kc/s 2040 R. Conakry, Guinea—with talk in vernacular. Clear channel at this time.

4910kc/s 0520 HCMJ1 Quito, Ecuador—with identification "Emisora Gran Columbia" and trumpet fanfares.

4920kc/s 1650 VUM Madras, India—with typical Indian music.

4925kc/s 0403 ZYV32 "R. Industrial", Brazil—with identification.

4938kc/s 1840 R. Sanaa, Yemen—with talk in Arabic.

4955kc/s 0315 HJCQ R. Nacional, Columbia—with identification.

4960kc/s 0338 YVQA "R. Sucre", Cumana, Venezuala—with Latin American music.

4976kc/s 1825 Kampala, Uganda—with talk in vernacular.

5030kc/s 0335 YVKM "R. Continente", Caracas, Venezuala—with Latin American songs.

5033kc/s 2020 CR6RW R. Clube de Cabinda, Angola—with song programme.

5041kc/s 2315 Emis. de Ginea, Bissau—with male choir.

5043kc/s 2025 CR6RF R. Clube de Benguala, Angola—with music programme.

5047kc/s 2033 Lome, Togo—with talk in dialect.

5050kc/s 0430 "R. Cultura", Venezuala—with identification.

5050kc/s 1950 Dar-es-Salaam, Tanzania—with song programme.

6145kc/s 2200 PRL9 "R. Nacional", Rio de Janeiro, Brazil—with station identification.

6160kc/s 0415 HJKJ Emisora Nueva Granada, Colombia, with news in Spanish and station identification.

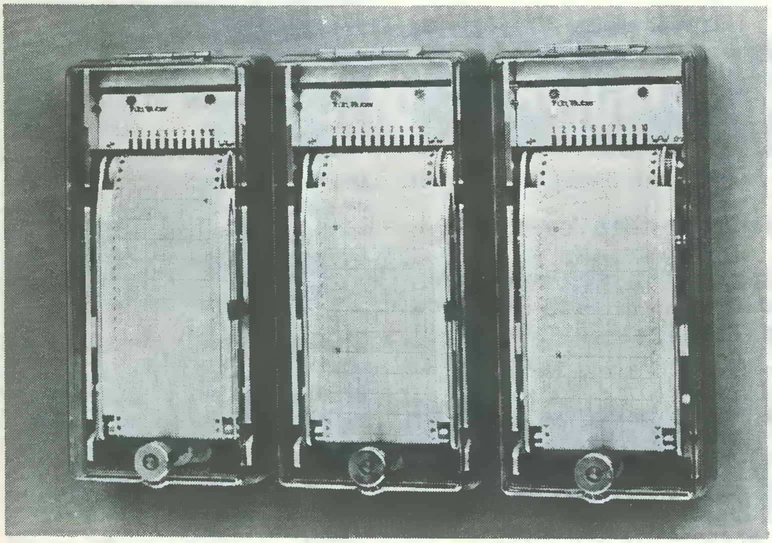
6600kc/s 2030 Pyongyang, Korea—with talk in dialect.

7180kc/s 2020 AIR Bhopal, India—with sitar music.

7215kc/s 1945 VUD Delhi, India—with English programme and identification.

NEWS . . . AND .

TEN-CHANNEL EVENT RECORDER



Trub Tauber Ten-Channel Event Recorder

Radiatron Limited announce the introduction of their new Trub Tauber ten-channel event recorder.

This compact instrument, with a front panel size of only 212mm × 96mm, is equipped with ten independently operated continuous line recording channels. Each channel can indicate two different "on" conditions by means of a pen deflection from the central position to either the right-hand or left-hand side. In addition, each channel can be provided with an extra chopper type of operation which allows each of the ten channels to record up to four different conditions simultaneously.

Recording is inkless—using a wax coated pressure sensitive recording chart.

Typical applications for this type of recorder are for the survey of switching conditions; production machines; and most types of industrial continuous processes. It also enables programming and optimisation of production.

The Trub Tauber recorder can be supplied for panel mounting or for portable applications; it is available with two-speed chart drive, built in power supply and many other special features. The signal response time of each channel is 30 milliseconds.

Further information may be obtained from Radiatron ;imited, 7 Sheen Park, Richmond, Surrey.

PRODUCTIVITY ON THE SEA-BED

Never before in world history have the leading nations of the world spent so much time or money in exploration of the bed of the world's seas. Although Britain, as compared with Russia and America has spent little in space research, she is certainly participating in the sea-bed explorations stakes.

The big need has always been for man to be able to *see* what is happening well below the surface and until the advent of underwater TV his knowledge was limited in this respect.

Hitherto problems have been that of lighting, which has to be robust to say the least and in the case of deep-water, particularly so.

However, Group 70 Limited of Manchester are now operating with lighting equipment which together with the TV camera and ancillary equipment, can be fitted quite comfortably, together with two operators, in an ordinary rowing boat!

Although the camera is diver-operated, all the essential control equipment is housed in a special unit on the surface.

Mr. Richard A. E. Young, Chairman of Group 70 Limited believes that the future Underwater TV will be channelled into:

(a) application in connection with fish farms.
(b) commercial civil engineering: the exploitation of underwater oil and gas.
(c) Oceanography work generally (i.e. currents, marine life, composition of the sea-bed and things of that kind).
(d) Marine engineering directed towards the commercial development of the sea-bed.
(e) Location of wrecks.

The underwater television unit of Group 70 Limited comprises camera, housing pressure tested to any depth, together with individually designed lighting system which can be boosted up to 800 watts, camera control unit, picture monitor, together with high quality 1 inch helical scan videotape recorder.

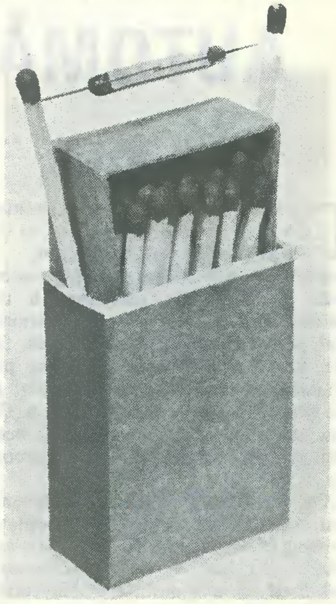
One example of recent work done by Group 70 was in the Solent. The camera was left working underwater continuously for 24 hours and as a result the tidal race in the bed of the Solent was seen and plotted for the first time.

. . . COMMENT

THE END OF WIRES AND PLUGS

How would you like a full-size electric vacuum cleaner—but without a cord and plug to fall over? What about a cordless electric drill which runs not just for an hour on its internal battery, but for a whole day? And a truly silent outboard motor for your boat, so that powered progress up-river is as effortless and quiet as the idle drift downstream? As Richard Oliver reported in a BBC broadcast, all these things are on the way—indeed the out-board motor and the drill have already been demonstrated in London. The secret is a new kind of electric battery, called the zinc-air cell, which can pack away four times more power than a car battery into less than a quarter of the space, and about a seventh of the weight. These demonstrations were arranged by Britain's Energy Conversion Ltd., who claim that their zinc-cells have greater capacity and endurance than any announced elsewhere in the world.

How long do we have to wait for this new age of cordless electrical appliances and silent motive power? It is likely to be a little later than tomorrow, because none of these is a necessity. Essentials come first. Energy Conversion are about to go into production with a zinc-air battery specially designed for portable communications equipment—radio-telephones and so on—and are fully committed to supplying them to bodies like Britain's Royal Aircraft Establishment for evaluation, and to authorities in Australia, where communications in the "outback" at the moment can mean carrying an engine and fuel for recharging batteries, or pedalling a dynamo with your feet each time you want to use the radio-telephone. The zinc-air battery is recharged simply by replacing its zinc plates, which weigh just over 1lb a set. The cost in initial production is expected to be about £25 for a battery equivalent to the much heavier and bulkier accumulator. But this will come down, and there is no basic reason why eventually the zinc-air cell should not be as cheap a source of electricity as torch batteries, and a lot more powerful and convenient.



The M-O Valve Co. Ltd. Dry Reed Switch Type RCX

The M-O Valve Co. Ltd., has introduced a new low-cost dry reed switch, type RCX, suitable for fast low level switching applications where reliability and long life are required.

Priced at 6d. each in bulk quantities, the RCX is rated to switch 5 watts resistive loading and has a contact resistance of not greater than 150MΩ.

This reed is suitable for general industrial applications and is being produced by the same automated production techniques as used for the company's telephone exchange reeds.

"BOOKED TO THE HILT"

The 21st London Electronic Component Show celebrates its majority in 1969 by going fully international. Space for the exhibition at Olympia, London, in May, is now completely booked up.

The Organisers, Industrial Exhibitions Limited, report that a substantial influx of foreign exhibitors, added to the fact that many of the UK firms taking part have increased their stand space, means that the show is 25% bigger than before.

There are 400 exhibitors, 70 of which are from overseas.

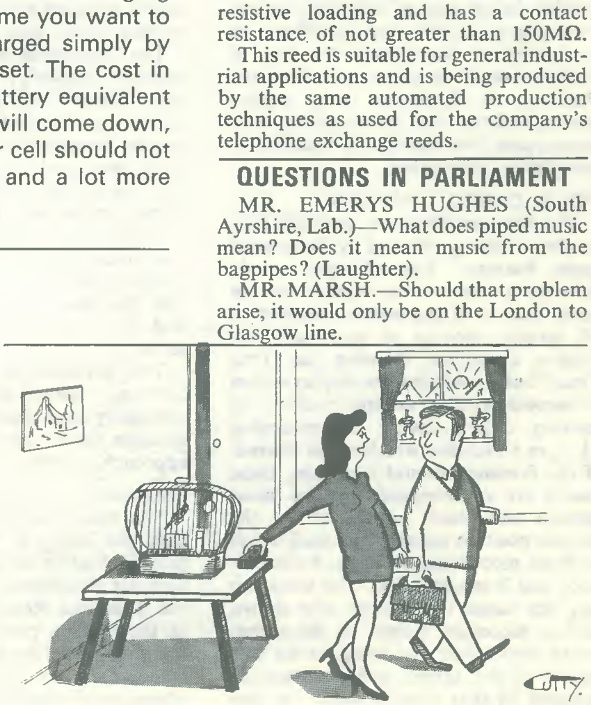
"Olympia is booked to the hilt," said an Industrial Exhibitions spokesman.

The ballot for stand space at the International London Electronic Component Show took place at Grosvenor House, London, on December 12th.

QUESTIONS IN PARLIAMENT

MR. EMERYS HUGHES (South Ayrshire, Lab.)—What does piped music mean? Does it mean music from the bagpipes? (Laughter).

MR. MARSH.—Should that problem arise, it would only be on the London to Glasgow line.



"Yes, I am leaving the radio on all day—he might get lonely!"

AUTOMATIC RADAR PLOTTING

THE MARCONI INTERNATIONAL MARINE Co., Ltd., recently displayed, at the Ships' Gear Exhibition, a completely new departure in marine radar which, while retaining all the normal functions of a conventional high-performance set, also affords, for the first time, unique facilities not available in any other marine radar in the world. The Marconi Predictor, as the new radar has been named, has been designed and developed by the Marconi Co., Ltd.

The new Marconi Predictor is the only marine radar to provide fully automatic plotting of *all* targets visible on the radar screen. It has a bright, compass-stabilised relative motion display upon which can be superimposed—merely by pressing a switch, and without the need for any prior action or calculation—the tracks of all fixed and moving targets, in either true or relative motion, covering a specific immediate past period. True motion presentation of fixed targets appropriately produces a track having no length for each such target. The basic display being one of relative motion, own ship's position remains always at the centre of the screen. No loss of 'radar vision' occurs even when the Predictor is displaying true motion tracks, and the need for re-setting, with consequent interruptions to tracking, is completely eliminated.

FOUR DISPLAY MODES

The Marconi Predictor provides four modes of display, selected by illuminated push buttons. The 'Targets' mode presents a conventional relative motion radar picture of the present position of all targets, moving or stationary, including coastlines. Pressing the 'True Track' button switches the display within 10 seconds to show the true tracks of all moving targets during the preceding $1\frac{1}{2}$, 3, or 6 minutes, whichever is desired. If the 6-minute period is chosen, these tracks are superimposed on the 'now' picture and show on the screen the precise position occupied by each target in three plots 6 minutes ago, 4 minutes ago, and 2 minutes ago. The track for any one target is therefore now shown as four successive 'paints' on the screen, up to 'now', their line being on the true course of that target, and their spacing dictated by that target's speed, i.e., the greater the speed the greater the distance between 'paints' and the greater the overall length of the displayed track. With stationary targets the four 'paints', of course, appear successively in the same position.

The 'four-paints' picture applies to *every* target, moving or stationary, within the radar range in use, and the information on all targets is automatically updated every 10 seconds. Moreover, whatever mode of display is in use, this track information is continuously stored within the installation and is produced on the screen within 10 seconds of pressing the appropriate button. The observer switching from 'Targets' to 'True Tracks' does not, therefore, have to wait for a 6-minute picture to build up from 'now'. When he presses the button to change mode the stored past information, up to 'now', is traced out on the screen within 10 seconds, and is continually updated from then on.

This is truly automatic plotting, with the course and speed of every moving target clearly indicated, and changes of course or speed plainly apparent almost as soon as they take place.

The third mode of display available is 'Relative Tracks', providing all the past and current information described above, but in relative instead of true motion presentation. Again, switching from one mode to another means a time-lag of no more than 10 seconds beforethe new presentation, covering the previous $1\frac{1}{2}$, 3 or 6 minutes, is shown. The tracks are built up as before but this time they are relative motion tracks. The triangles of velocities are worked out and the answers presented within 10 seconds.

This presentation of relative tracks covering a specific time provides a clear and easily appreciated indication of the distance and imminence of closest approach of every target.

Prediction

The fourth mode of display, which gave the Marconi Predictor its name, actually enables the observer to make an accurate prediction, merely by pressing the 'Predicted Relative Tracks' button, of the effect a *contemplated* action by own ship would have on the entire radar scene—*before* he in fact orders any alteration of course or speed.

In this mode the user, observing a danger situation developing, and considering that, for example, an alteration of 30 degrees to starboard, accompanied by change of speed, would clear it, feeds this information into the Marconi Predictor by setting the Proposed Turn and Proposed Speed control knobs. On four successive sweeps of the PPI trace (10 seconds in time) the relative motion tracks of all targets are then built up as if own ship were already on the proposed new course and speed. The effectiveness of the proposed manoeuvre is then immediately evident. Only a quick inspection is needed to see whether (a) the proposed manoeuvre would clear the danger target previously observed and (b) would not introduce a new danger situation in relation to other targets previously safe. If, in clearing one danger, the proposed manoeuvre is seen to introduce another, the contemplated alteration can be adjusted on the screen, and the new effect on the collision situation shown in 10 seconds. Then, and only then, would the appropriate orders be given to wheel and engines in the confident knowledge that the course and speed decided upon will bring the ship safely through the situation.

It is worth noticing that, to cater for the fact that a ship does not turn smartly on its heel immediately an alteration of course is ordered, a ring is displayed round own ship in the 'Predicted Relative Tracks' mode. The radius of this ring indicates the amount of overshoot corresponding to the rate of turn of the vessel in which the Marconi Predictor is installed.

Another point worthy of note is that in this mode the prediction, like all other information on the screen, is kept up-to-date both before and during any manoeuvres of own ship. Thus, when a manoeuvre is initiated and completed, and the vessel is on her new course, the predicted heading becomes the actual heading unless and until another prediction becomes necessary. Meantime, the effectiveness of the manoeuvre has been monitored throughout.

With facilities never before available in marine radar, the Marconi Predictor out the work-load—and the dangerous time-lapse—imposed by manual plotting; it copes equally well with a multi-ship situation as with a few

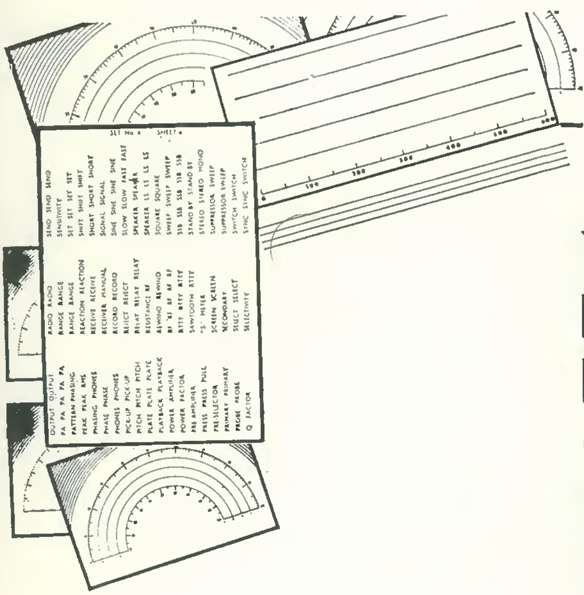
(continued on page 367)

RADIO CONSTRUCTORS DATA SHEET 19

IR DISSIPATION CURRENTS BELOW 50mA

The Table gives dissipation in watts, from $W = I^2R$, for resistance at commonly encountered current values below 50mA. For intermediate resistances multiply up from the most convenient lower value. Thus, the dissipation in 68kΩ at 6mA is about 3 times that in 22kΩ at this current and equals 3 × 0·79 approximately, or 2·4 watts. (See Data Sheet No. 20 for further details.)

Resistance	1mA	2mA	3mA	4mA	6mA	8mA	10mA	15mA	20mA	30mA	40mA
47Ω								0·011	0·019	0·042	0·075
100Ω							0·01	0·022	0·04	0·09	0·16
220Ω						0·014	0·022	0·05	0·088	0·2	0·35
470Ω					0·017	0·03	0·047	0·11	0·19	0·42	0·75
1kΩ				0·016	0·036	0·064	0·1	0·22	0·4	0·9	1·6
2·2kΩ			0·02	0·035	0·079	0·14	0·22	0·5	0·88	2·0	3·5
4·7kΩ		0·019	0·042	0·075	0·17	0·3	0·47	1·1	1·9	4·2	7·5
10kΩ	0·01	0·04	0·09	0·16	0·36	0·64	1·0	2·2	4·0	9·0	16
22kΩ	0·022	0·088	0·20	0·35	0·79	1·4	2·2	5·0	8·8	20	
47kΩ	0·47	0·19	0·42	0·75	1·7	3·0	4·7	11	19		
100kΩ	0·1	0·4	0·9	1·6	3·6	6·4	10	22			
220kΩ	0·22	0·88	2·0	3·5	7·9	14	22				
470kΩ	0·47	1·9	4·2	7·5	17						
1MΩ	1·0	4·0	9·0	16							
2·2MΩ	2·2	8·8	20								



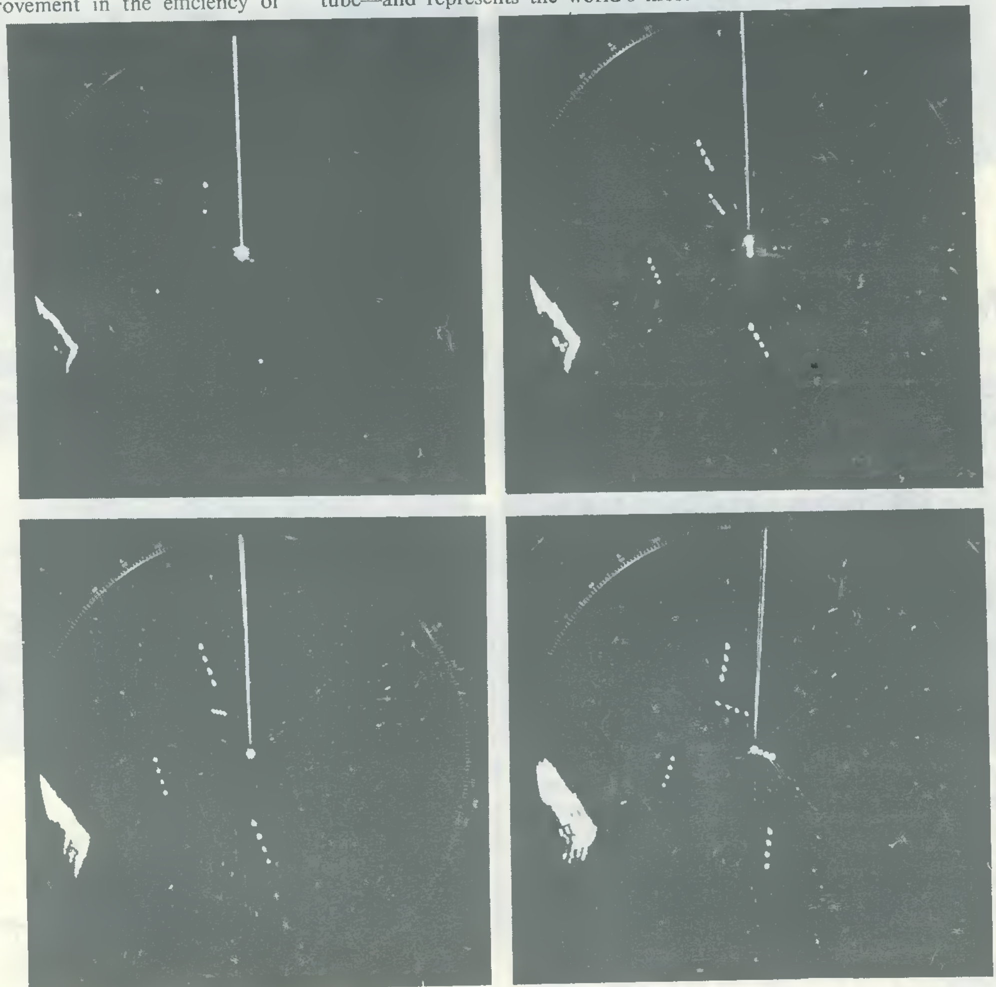
AUTOMATIC RADAR PLOTTING

(Continued from page 364)

targets, and eliminates the need for arbitrary preselection of those which *seem* to present danger; it provides a vast improvement in the efficiency of anti-collision radar; and yet carries out all the normal functions of a conventional high-performance set.

No chemicals are employed—all functions are performed electronically. No manual operation is necessary beyond the pressing of buttons and the turning of knobs. The entire equipment incorporates only two thermionic valves—the magnetron and the cathode ray tube—and represents the world's most complete application of solid state techniques to marine radar. What are generally known as transistorised radars still employ ordinary klystrons and valve modulators, both of which are expensive items with a relatively short working life of approximately 1,000 hours.

The whole display, on an extra-bright 16in screen, can be presented either ship's head up or north up by push button selection. The display unit is



The four modes of the Marconi Predictor, set to 12 miles range with ship's head up. Own ship (at centre of screen) is on 125 degrees approximately at 9 knots.

Targets (top left) shows a conventional radar picture of the now positions of four other ships and land on the port quarter. Switching to True Tracks of 6 minutes length (top right) portrays own ship stepping forward whilst those astern are seen to be steaming away. The nearer ship on our port bow is also steaming away but the further ship is closing rapidly on an approaching course and could present danger. (In practice, the direction of progress is clearly seen from the stepping forward action of successive paints, which unfortunately cannot be reproduced in a static photograph.)

Changing to Relative Tracks (lower left) immediately shows that the closest approach of the possible danger ship is about $\frac{1}{3}$ mile on the port hand and that, since the display is set to 6 minute tracks, this point will be reached in about 10 minutes unless avoiding action is taken

We now propose a starboard alteration to 171 degrees and feed this proposal into the radar display while switching to Predicted Relative Tracks (lower right). Within 10 seconds, although no actual helm order has yet been given, the dashed radial line now indicates our proposed new course and the relative tracks of all targets are presented as they will be if the contemplated alteration is carried out. On our proposed course, the closest approach of the danger target will be about two miles away on our port quarter; and it is clearly seen that the contemplated alteration can now be made without introducing a new hazard situation. (In practice the apparent track of own ship, seen in the last photograph, is not displayed on the screen.)—Courtsey The Marconi International Marine Co., Ltd.

smaller than that of most conventional 16in radars, with a total height of 40 inches, width of 30 inches, and a depth of 21 inches. The complete system comprises the display unit, an 8ft slotted waveguide scanner; the transceiver unit; a servo unit; and the track information storage unit. Operation is normally direct from ship's a.c. mains, and no inverter is required. For ships with d.c. mains an inverter or rotary converter is necessary.

Display unit ranges, operating in the 'Targets' mode (i.e., as a conventional radar) are eight in number covering $\frac{3}{8}$, $\frac{3}{4}$, $1\frac{1}{2}$, 3, 6, 12, 24, and 48 miles. In the 'Tracks' modes push-button superimposition of $1\frac{1}{2}$, 3 or 6 minute tracks is available on the $1\frac{1}{2}$, 3, 6, 12, and 24 mile ranges.

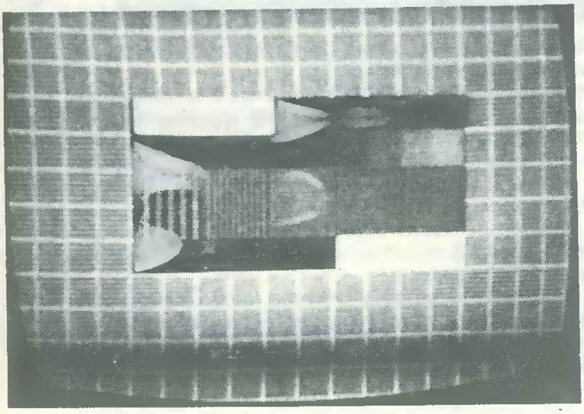
LOOKING INTO EUROPE

by M. N. CORBETT

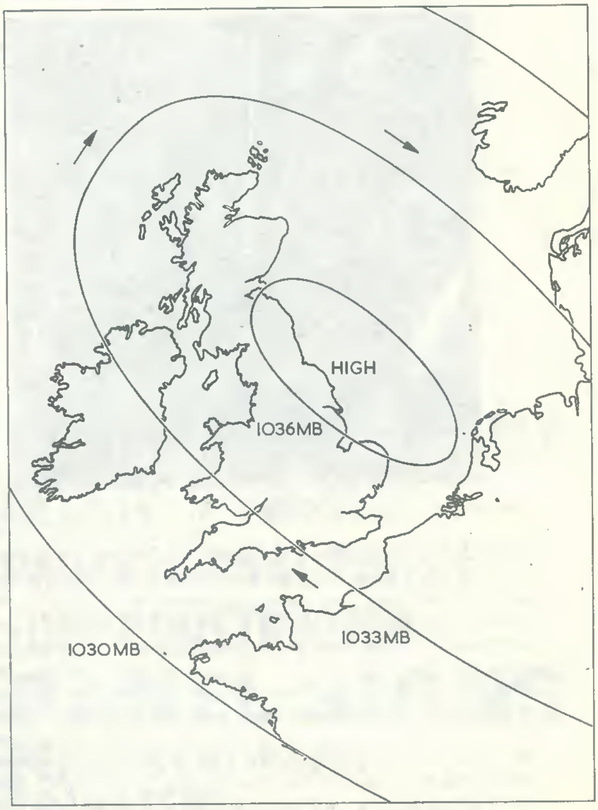
French colour test transmission

Are you interested in obtaining some really outstanding Dx? Then try searching for Continental TV and Bands IV and V! Our contributor describes the results he obtained in 1968 using a standard 625 line receiver with modifications, together with a sensitive aerial system. Some knowledge and experience with TV receivers is required if the suggested modifications are to be carried out

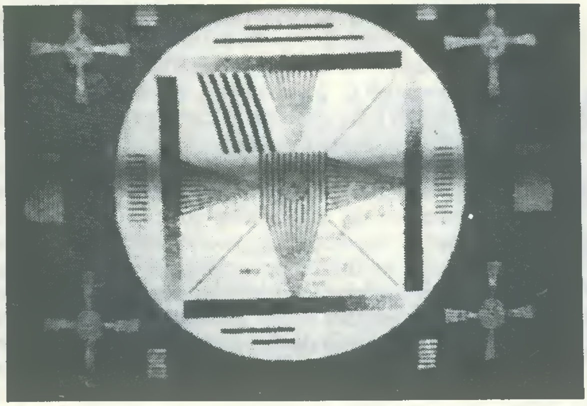
AS THE FREQUENCIES USED FOR TV HAVE INCREASED OVER the years so the effective service area of the stations has been reduced to the more stringent line-of-sight effect at the higher frequencies. Therefore many will be surprised to know that quite spectacular Dx can occur on the new u.h.f. Bands IV and V used for B.B.C. 2, and can include reception of European stations in colour. There are, however, a number of things to be taken into account and the main one is the weather.



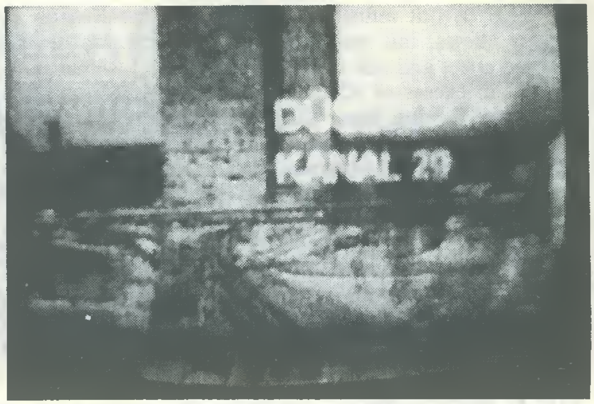
German cross-hatch and bars



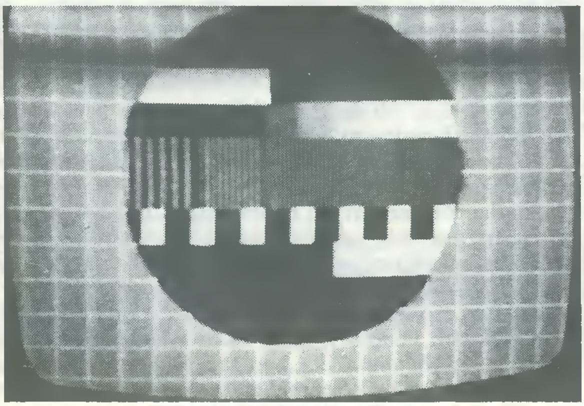
Typical weather chart for extended v.h.f. reception. Winter anticyclones often produce longer range reception, but those in the Summer can give extra-strong Dutch reception



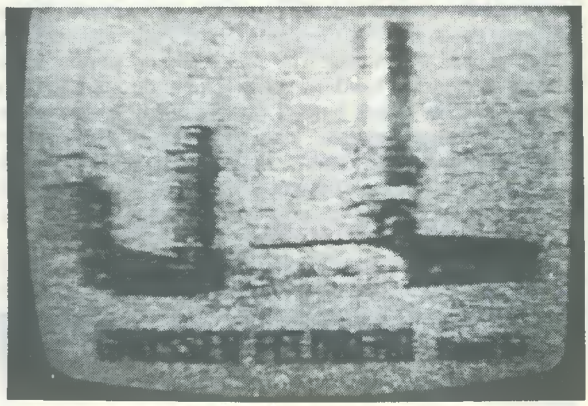
German test card



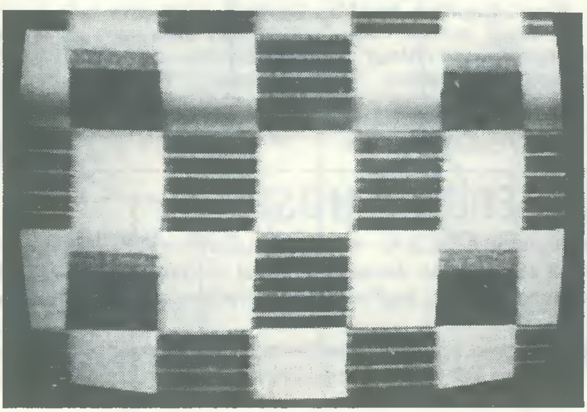
Dusseldorf transmission on Channel 29



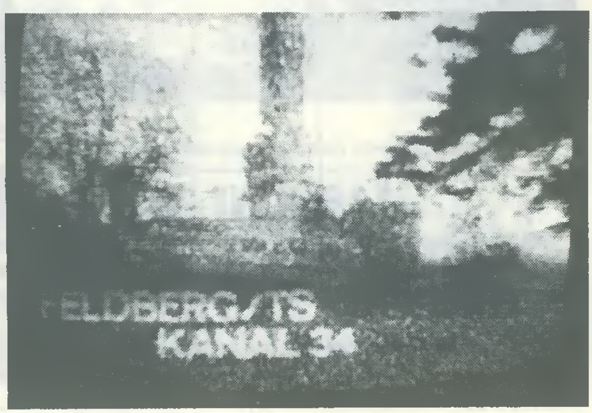
Dutch test card



German station identification



Dutch chequer board



Channel 34 transmission

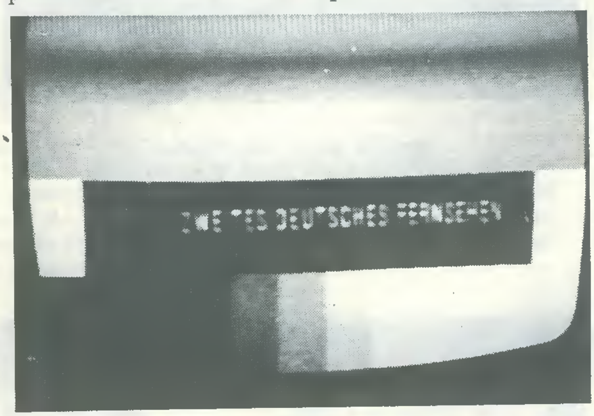
U.H.F. is not influenced by sporadic-E reflection or similar effects, but major weather patterns can have a marked effect and can at times cause a u.h.f. signal to be pushed in excess of 450 miles. Many TV pioneers will remember the fog being their best ally when struggling in the outer fringe. To a certain extent fog will extend u.h.f. reception, but observation has shown that it is high pressure belts which "open up the bands". A large anticyclone of 1034 millibars extending from the Midlands through Holland and into Germany has in the writer's area of Ipswich resulted in the reception of a host of stations, some of which have remained steady throughout the day. It must be emphasised that this reception cannot be relied on. Nevertheless, for those who are interested in u.h.f. propogation, chasing Dx can be very interesting.

FIELD STRENGTH

In order to achieve the same field strength per metre as is given by Band I and III transmitters, u.h.f. stations require a much greater e.r.p. This can be in excess of 1,000kW so it is easy to see that, with this and a high gain receiver aerial, once a reception path is formed the station will break through. A rotating mast is essential for Continental reception as there may be two signals from different parts on the same channel and a few degrees turn will tune one or the other. The aerials should be double 18 element with mast-head boosters. The main activity is in group "A", the lower part of the band, but to complete the coverage groups "B" and "C" can be added. The South and East of the country will have the best chance of seeing some of this reception, but as the writer has logged stations as far into Germany as Bonn, who knows what might turn up? Records are always there to be broken!

Any 625 line set can be used for the receiver and will produce German and Dutch pictures without further alteration. The sound is intercarrier at 5·5 Mc/s so some adjustment will be required to the 6 Mc/s i.f. amplifier and f.m. discriminator. To avoid leaving the family with a receiver silent on B.B.C. 2 a small switch could be mounted near the sound i.f. circuits to cut in the required trimmers for Continental reception.

French transmissions on Channel 21 are very strong at times in the South-East, but a video diode reversing switch has to be fitted as they are running positive modulation. If the TV set is transistorised some difficulty may be experienced due to the diode cutting off the following stage when reversed but it might be possible to reverse phase by adding another stage. The easiest way to switch the detector is to use two diodes and a simple changeover switch. The French sound, unfortunately, is adjacent channel a.m. Possibly, an old i.f. strip could be pressed into service and switched in to provide sound for these transmissions.



Second German programme

COLOUR RECEPTION

Colour pictures from Holland and Germany will be received with no alteration to the receiver as the PAL system is used by these countries. The signal will have to be at reasonable strength before the colour-killer will operate, but the ruggedness of the PAL system will be demonstrated by the faithful colour rendering. At the time of writing, Holland broadcasts colour bars in the afternoons Tuesday to Saturday, and both Nederland 1 and 2 have some evening programmes in colour, some with English sound and subtitles. Germany has a colour test in the mornings at 9 a.m. and again in the afternoon with bars and cartoon films. The French appear to be broadcasting a lot of colour on Channel 21 but the system is SECAM so a special decoder would be needed.

The best reception the writer has had to date was on 27th and 28th February, 1968, when a large anticyclone settled over Holland. This had taken about a week to come down the North Sea and on the morning of the 28th was filling the u.h.f. band with German transmissions. An interesting feature was the sharing of Channel 55 between Tacolneston B.B.C. 2 and Dusseldorf and the ability to switch from one to the other just by turning the aerial.

EDITOR'S NOTE

The accompanying illustrations show pictures photographed by Mr. Corbett from the television receiver screen. Mr. Corbett has also sent us some impressive colour transparencies of Dutch and German colour transmissions, these showing extremely good resolution and colour rendering. Unfortunately we cannot, of course, reproduce these colour pictures.

MARCONI TV FOR UNIVERSITY HOSPITAL

The Marconi Company recently installed and commissioned a £4,000 closed-circuit television system for the University Department of Obstetrics and Gynaecology and for the Jessop Hospital for Women, Sheffield. The system is used to facilitate undergraduate, postgraduate, nursing and midwifery training, and to improve the quality of care offered to patients.

The television camera, with a video tape recorder and its own monitor, has been so housed as to be fully mobile. The five labour wards, two operating theatres and lecture theatre projection room are all linked by a vision, sound and talk-back system so that recorded or live programmes can be shown in the lecture theatre.

The camera used in the system, the Marconi V322B, has been designed specifically to meet the needs of educational closed circuit television. For the Jessop Hospital application the camera is fitted with a tripod and a 4–1 zoom lens.

150 WATT AMATEUR BANDS TRANSMITTER

Part 3

by

F. G. RAYER, G3OGR

This concluding article in our short series describes modulation amplifiers and output stages suitable for modulating an 813 power amplifier

METHODS WHICH HAVE BEEN USED TO MODULATE THE 150 watt power amplifier described in the first article of this series are dealt with here, and similar considerations apply to other transmitters, including those of lower power. Two systems were found the most straightforward and satisfactory:

Screen grid "efficiency" modulation;

High-level modulation of anode and screen grid.

S.G. MODULATION

This requires only a small modulator, such as a speech amplifier by a 6V6, 6BW6, or similar valve giving about 3 to 5W output. As the unmodulated screen grid has to be lowered, anode efficiency is less than with c.w. or high-level modulation. As a result, appreciable power is dissipated at the p.a. anode. The 813, with its very large anode dissipation, proves to be very satisfactory for this system.

Efficiency should generally be over 30%, but assume this figure and 150W input. R.F. output without modulation is 45W. At 100% negative modulation peak, input current is zero, input in watts zero, and output zero. At 100% positive modulation peak anode current is doubled, and instantaneous input is 300W. Average input with 100% modulation is 0+300 divided by 2=150W (as with no modulation). At maximum positive peaks c.w. efficiency should be obtained (say 60%). Sideband power is obtained from increased efficiency, the d.c. input

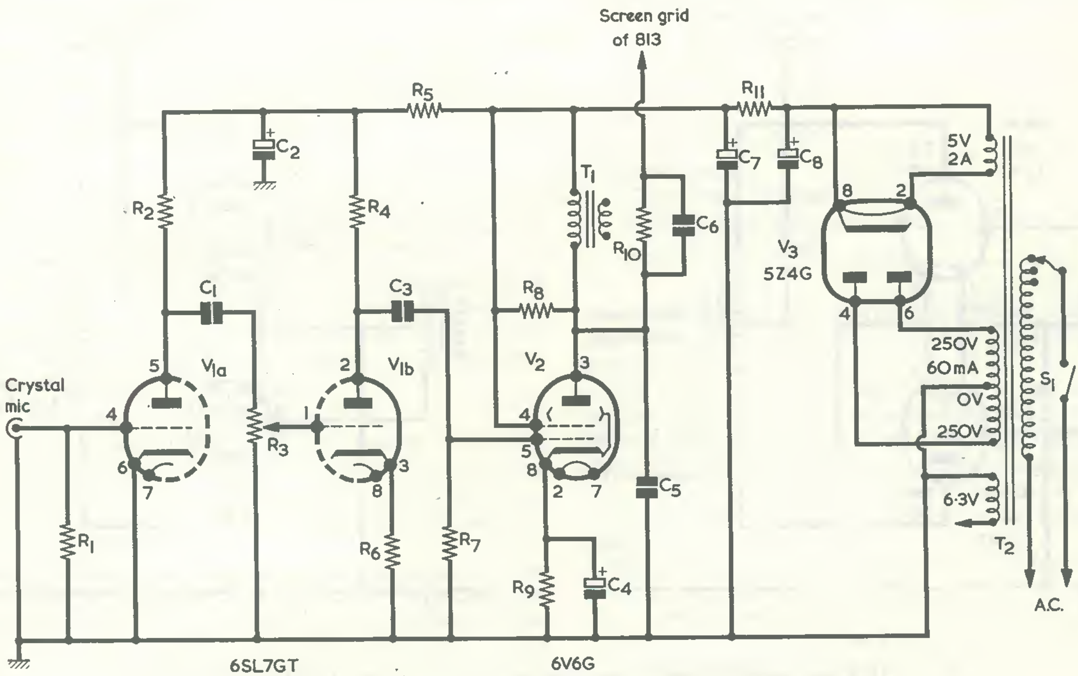


Fig. 1. Circuit of a modulation amplifier suitable for screen grid modulation of an 813 p.a.

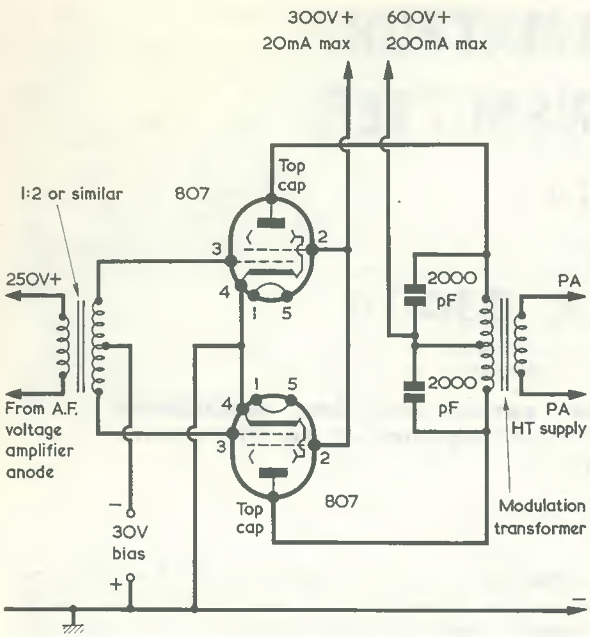


Fig. 2. Using two 807's in an 80W modulator stage

remaining unchanged. With full sine-wave modulation, the sidebands contain one-half the r.f. power, or 22·5W. Total r.f. output is now 45+22·5W=67·5W. Efficiency with 150W input is thus 67·5×100/150=45%.

The circuit in Fig. 1 has been found to modulate the 813 well. As with all screen grid modulators, the p.a. should be loaded heavily by the aerial. P.A. anode voltage remains at that of the supply (say 1,000V) and anode current (as shown by a meter) is unchanged by modulation.

Speech quality of the radiated signal was checked by using a semiconductor diode and tape recorder during transmission. Later, high-level modulation signals were taken on the same tape. When playing both back, the loss of speech quality from the screen grid modulation system was only *just* apparent. It is necessary that some excess audio power is available, here dissipated in the 4·7kΩ resistor R_8, which helps to equalise the load.

In the circuit of Fig. 1, T_1 is a standard speaker transformer whose primary is capable of carrying 50mA. No connection is made to its secondary. Resistor R_{11} may, if desired, be replaced by a smoothing choke.

(The circuit of Fig. 1 is not compatible with the 6L6 clamp circuit for the driver/p.a. unit published in the first article in this series. If it is used, drive to the 813 should always be maintained when anode voltage is present.—EDITOR).

HIGH-LEVEL MODULATOR

With the high-level modulation system, efficiency in the p.a. should exceed 60%, as optimum screen grid voltage can be used. A large modulator is required. At 100% positive modulation peaks the p.a. supply (to anode and screen grid) is swung to twice its non-modulated or resting value—e.g. 2,000V with a 1,000V h.t. line. At 100% negative peaks, the p.a. supply is zero. Average d.c. input, as shown by a meter, thus remains unchanged.

Assuming an input of 150W with 60% efficiency, r.f. output is 90W. At full modulation 45W appear in the sidebands, r.f. output being 135W, and this extra power comes from the audio section or high-level modulator. Since the d.c. input to the p.a. is modulated, it is usually considered that the high-level modulator should be capable of supplying one-half this figure. That is 75 watts. The peaky nature of speech allows some extra power to be obtained from the modulator but losses; and the need to supply power to the screen grid also, make it unwise to rely on too small a modulator.

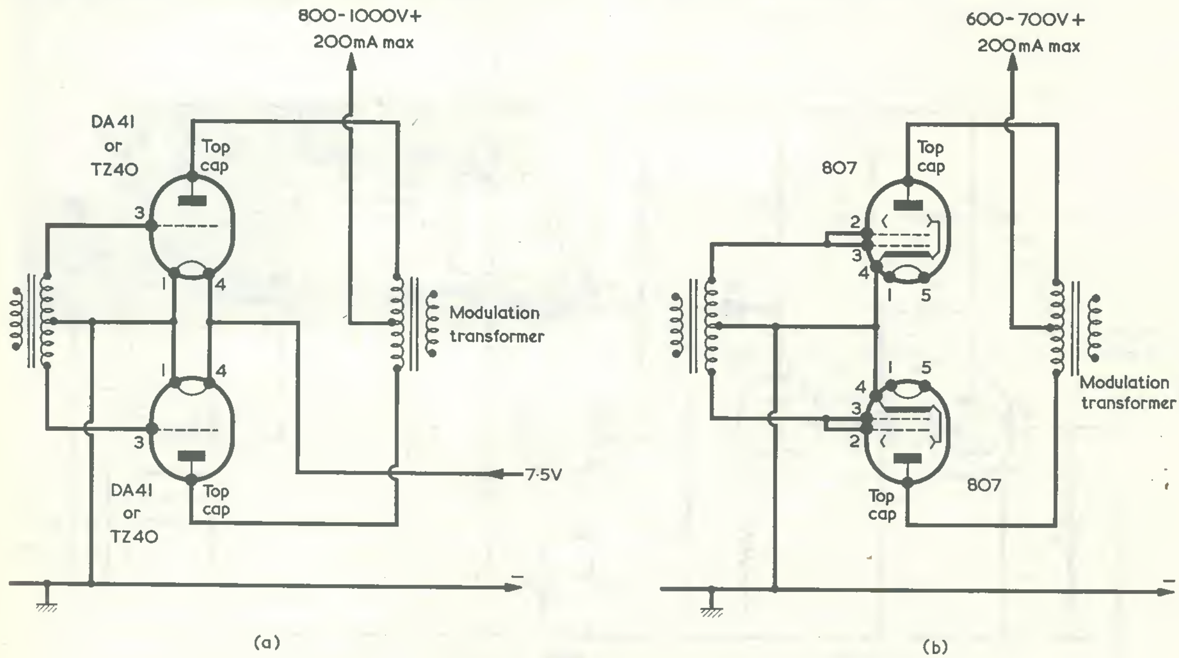


Fig. 3 (a). A zero-bias modulator power output stage using two DA41 or TZ40 triodes (b). Two 807's may be similarly incorporated in a zero-bias stage

In addition to the extra power given by high-level modulation, the speech quality will not degenerate badly with incorrect aerial loading.

The 813 p.a. in the writer's transmitter has been fully and continuously modulated at high level for long periods by employing a small 6 to 8W amplifier to drive two modulator valves operating in the zero-bias condition. Advantages of this system are that no bias or screen grid supplies are needed. A disadvantage, compared with a pair of pentodes or tetrodes operated in the usual manner, is that several watts drive must be available.

The load or modulating impedance of the p.a. is V/I. If this valve draws 150mA at 1,000V, 1,000/0·15 then equals 6,600Ω. Optimum load for the modulator valves can be found from the valve maker's data. The modulation transformer ratio can then be found from

$$\sqrt{\frac{\text{Optimum Load}}{\text{Modulating Impedance}}}$$

following the same principle as with a speaker output transformer.

USING 807's

Among the cheapest valves capable of sufficient power is the 807. With 600V at anodes, 300V for screen grids and 30V negative fixed bias, a pair will supply 80W of audio, anode-to-anode optimum load being 6,400Ω. This is sufficiently near to 6,600Ω for the modulation transformer to have a 1:1 ratio. Woden modulation transformers of sufficient size with multi-ratio tappings are readily obtained, and the Woden type UM3, with an audio power rating of 120W would be suitable for the present application. Fig. 2 shows a pair of 807's operating under the conditions just described.

ZERO-BIAS WORKING

Fig. 3 (*a*) gives the circuit for zero-bias DA41 (or TZ40) triodes, which easily supply enough audio output, and have been used for a long time without snags. Fig. 3 (*b*) has 807's connected for zero-bias working, and giving similar power to Fig. 2, but needing more drive. A 5–10W amplifier will drive the zero-bias stage, and a 5–10W Woden or similar transformer is suitable for input, with a ratio of about 1:1. Sundry surplus, ex-service and other transformers have been used in these and similar circuits with satisfactory results.

(It is a common practice to insert fixed resistors of around 20kΩ in series with the control grids for zero-bias operation, and such resistors may be added to the circuits of Figs. 3 (*a*) and (*b*) if it is desired to reduce grid dissipation.—EDITOR).

POWER SUPPLIES

Suitable power supplies were described by the author in *The Radio Constructor* for June, 1967. Supplies in the 350 to 500V range for early audio and r.f. stages present no difficulty, since they are similar to those used for receivers and audio amplifiers.

For rather higher voltages, such as will be required by the modulator output stage, 5R4GY rectifiers are convenient. A pair of these rectifiers employed with capacitor input have a maximum rating of 500mA rectified current output, with 750V r.m.s. input each anode. With choke input, maximum ratings for a pair are 350mA output at 870V when receiving 1,000V r.m.s. each anode. With these characteristics a 700V or 750V r.m.s. supply to each anode will give a well regulated output around 600V.

For the very high voltage supply, a pair of 866A rectifiers has been found trouble-free, giving 1000V at 450mA, with 1,250V r.m.s. to each anode and using choke input. (See the June, 1967 issue). High voltage and other supplies should have safety bleeders, a suitable h.t. fuse in the h.t. positive line, and *must* be constructed for adequate safety.

The modulator stage shown in Fig. 3 (*a*) has been run from its own separate 1,000V supply, and also from the same 1,000V supply as used for the 813. With an adequate 1,000V pack (such as was described in the June, 1967 issue) the single supply is perfectly satisfactory for both modulator and power amplifier.

(*Concluded*)

COMPONENTS

Resistors
(All fixed values $\frac{1}{2}$ watt 10% unless otherwise stated)

R_1	1MΩ
R_2	270kΩ
R_3	1MΩ potentiometer, log track
R_4	220kΩ
R_5	22kΩ
R_6	2·2kΩ
R_7	470kΩ
R_8	4·7kΩ 2 watt
R_9	270Ω 1 watt
R_{10}	2kΩ 1 watt
R_{11}	100Ω 1 watt (see text)

Capacitors
(All 350V wkg. unless otherwise stated)

C_1	5,000pF paper or plastic foil
C_2	8μF electrolytic
C_3	5,000pF paper or plastic foil
C_4	50μF electrolytic, 25V wkg.
C_5	2,000pF paper or plastic foil, 500V wkg.
C_6	2μF paper
C_7	32μF electrolytic
C_8	16μF electrolytic

Inductors

T_1	speaker transformer (see text)
T_2	Mains transformer. Secondaries: 250-0-250V at 60mA; 5V at 2A; 6·3V at 0·75A (minimum)

Valves

V_1	6SL7GT
V_2	6V6G or 6V6GT
V_3	5Z4G

Switch

S_1	s.p.s.t. toggle

Miscellaneous
Crystal microphone
Coaxial input plug and socket
3 octal valveholders

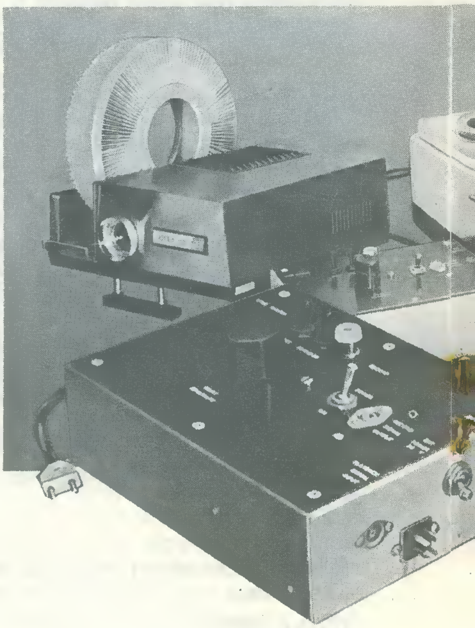
Cover Feature

SLIDE PROJECTOR SYNCHRONISER

for HOME ENTERTAINMENT

by

D. A. RHYS-JAMES



How to synchronise your projector slides with a pre-recorded commentary from your tape recorder. The synchroniser unit may be coupled to most 4-track recorders and it controls a projector having a remote slide changing circuit

INTRODUCTORY NOTES

The projector synchroniser described in this article functions with synchronising signals recorded via the unused (i.e., unselected) record/playback head of a 4-track recorder when making the commentary. The projector requires a remote slide changing circuit and this is actuated on playback by the synchronising signals from the unused record/playback head. The tape recorder employed by the writer is fitted with an accessory socket allowing direct connection to the unused record/playback head (together with a 32 volt supply for auxiliary equipment) but many 4-track machines do not provide this facility. It then becomes necessary for the constructor to add the requisite internal connections himself if he wishes to use the synchroniser unit.

This project is intended for the more experienced constructor who is conversant with tape recorder functioning and who fully understands the principles involved. It should not be embarked on without a circuit diagram of the tape recorder to be used in order that the connections to the unused head may be reliably located. In this respect we cannot advise on the connections which need to be made to any specific recorder: this information must be obtained from its circuit diagram. It should be remembered that the projector switching circuit may be at mains potential.—Editor.

THE DEVICE TO BE DESCRIBED ENABLES A 4-TRACK TAPE recorder to control an automatic slide projector and also reproduce a synchronised recorded commentary, with or without background music as preferred.

APPLICATION

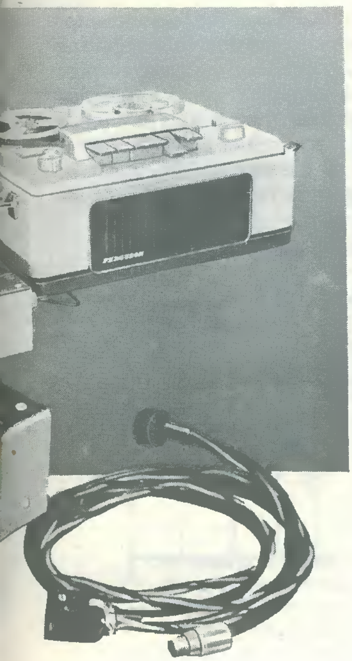
The prototype gives a completely reliable performance when used with a Hanimex "La Ronde" Auto Slide Projector and a Ferguson (Model 3202) tape recorder. There is no apparent reason why any other projector having a remote switch for slide changing could not be used, providing a connection to the switch can be made without upsetting any remote focusing arrangements that may also be incorporated. The tape recorder employed, in common with other British Radio Corporation 4-track models, has an accessory socket (B9A valveholder) at the rear of the chassis which provides a connection to the unselected record/playback head and this is required for the signals used for slide changing. Also a 32 volt d.c. supply is available at the socket and this has been made use of, although provision is made for the synchroniser to be alternatively supplied by a type PP6 9 volt battery.

It is possible that a 2-track tape recorder could be employed, but it would require an extra head fitting so that both tracks can be used simultaneously, or the type of head used in a 4-track tape recorder could be substituted for the original. Stereo tape recorders and those having separate record and playback heads and amplifiers would require different treatment in that the synchroniser could be more simple.

THE SYSTEM

Fig. 1 gives a block diagram for the system, illustrating the various stages in the synchroniser unit.

Returning to 4-track tape recorders, the selected track is used for sound in the usual way, but the unselected track is used exclusively to record and playback the slide



changing signals. These signals are not exacting so far as waveform and frequency are concerned (a near square wave of about 300 c/s is used), but they must be of short duration to avoid several slides being changed in quick succession. Also the amplitude of the signals should decay to reduce the risk of leaving the record head magnetised, as would happen if the signals were terminated at peak voltage. In this system the last two points are controlled automatically by the method shown in Fig. 2.

In Fig. 2 (*a*) the switch which controls the oscillator providing the slide changing signal is shown in its normal condition, whereupon it allows the electrolytic capacitor to become charged via the 10kΩ resistor. When it is desired to generate a slide changing signal the switch is moved to the position illustrated in Fig. 2 (*b*), with the result that the capacitor provides a supply for the oscillator until it becomes discharged. The signal from the oscillator than decays in the required manner, as shown in simplified form in Fig. 2 (*c*).

When a programme is to be recorded, the oscillator (an astable multivibrator) gives a signal when the Record button is depressed and this is amplified to a suitable level for the record head. At the same time the signal is passed to an amplifier which operates a relay, via a rectifier and a switching transistor in the manner of the sound operated switch described in *The Radio Constructor* for April 1967.* The contacts on the relay close for about 0·5 second and the slide is changed. The commentary is recorded, or superimposed, on the selected track at the same time. Background music can be pre-recorded, mixed, or superimposed.

On playback, the signal from the playback head operates the relay in the same way, but the signal is weaker than before and therefore a pre-amplifier is used to bring it to a suitable level. Switches are included to advance, or arrest the slide changing to restore synchronisation, if this becomes necessary.

During development some difficulty was experienced when the tape recorder was recording the commentary. The signal due to the tape recorder's bias oscillator (55 kc/s) found its way into the synchroniser and operated the relay. To prevent this, the higher frequencies had to be attenuated in the pre-amplifier and amplifier that operate

*J. Roberts, "Sound Operated Switch", *The Radio Constructor*, April, 1967.

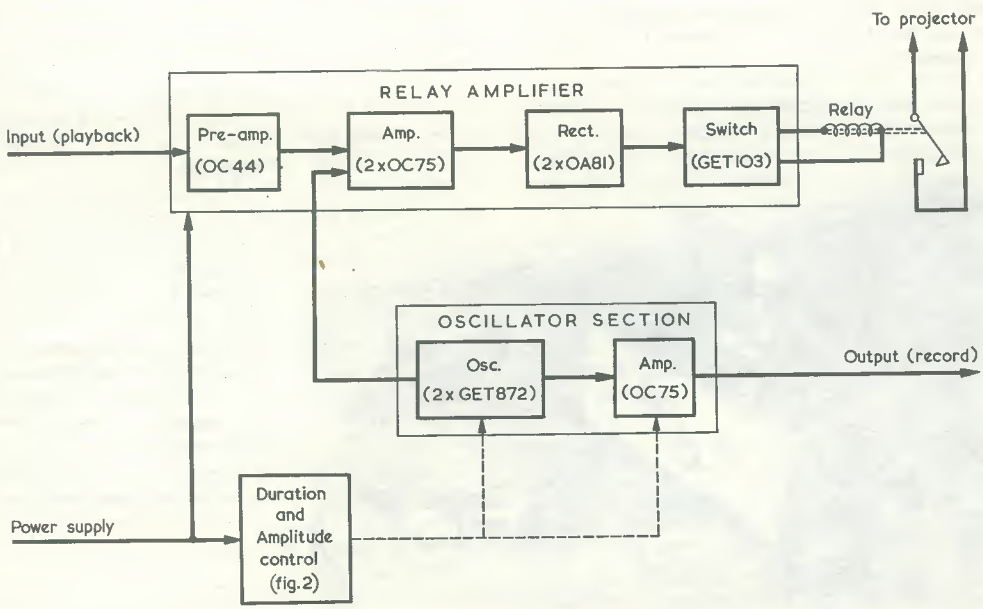
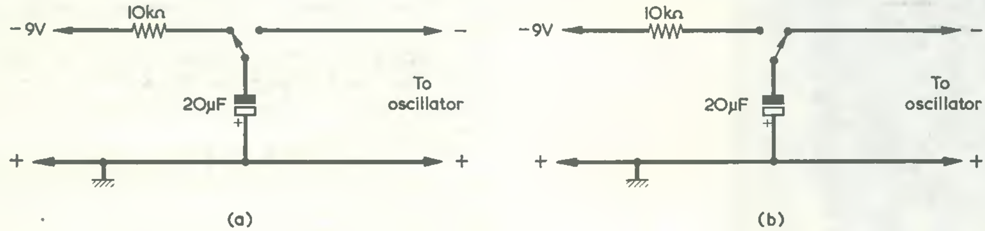


Fig. 1. Block diagram illustrating the individual stages in the slide synchroniser unit

the relay. Interferences from the relay contacts also gave this trouble until suppression was provided.

Provision is made for both 9 volt battery and external (32 volt) power supplies, but a requirement for one only would simplify the switching. If a tape recorder provides an external supply at some other voltage, it would not be difficult to adjust the synchroniser to suit it. Equally, a mains unit could easily be devised.

C_3 has a low reactance (about 30Ω) at the bias oscillator frequency of 55 kc/s and helps to prevent this operating the relay when recording. C_7 is fitted for the same purpose between TR_2 and TR_3. The amplified signal is rectified by D_1 and D_2 and the resulting d.c. potential is developed across C_{11}. This causes TR_4 to conduct and the relay is energised for the duration of the signal. VR_2 must be adjusted so that the relay opens at the termination of the signal, although there will still be a slight delay while C_{11} discharges. D_3 prevents a high reverse voltage developing in the relay coil when the current falls. The relay used has a resistance of 600Ω and a P.O. type is suitable. All unused contacts were removed from the relay used by the writer, giving some improvement in sensitivity. The contacts on the relay, which make when it is energised, replace, or are connected in parallel with, the slide changing switch on the projector. C_{13} and R_{15} are interference suppressors which were found to be necessary. (The relay contact insulation should be suitable for mains voltage and increased insulation between the contacts and the metal case of the synchroniser unit may be provided by mounting the relay metalwork on a Paxolin panel. For complete safety, the synchroniser case should be carried via the appropriate contact of a 3-way mains socket.—EDITOR).



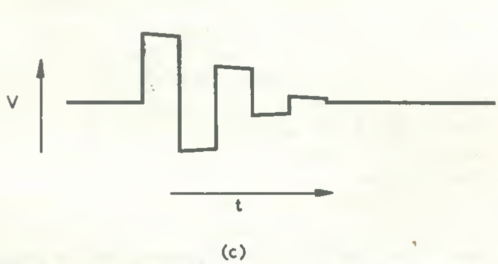


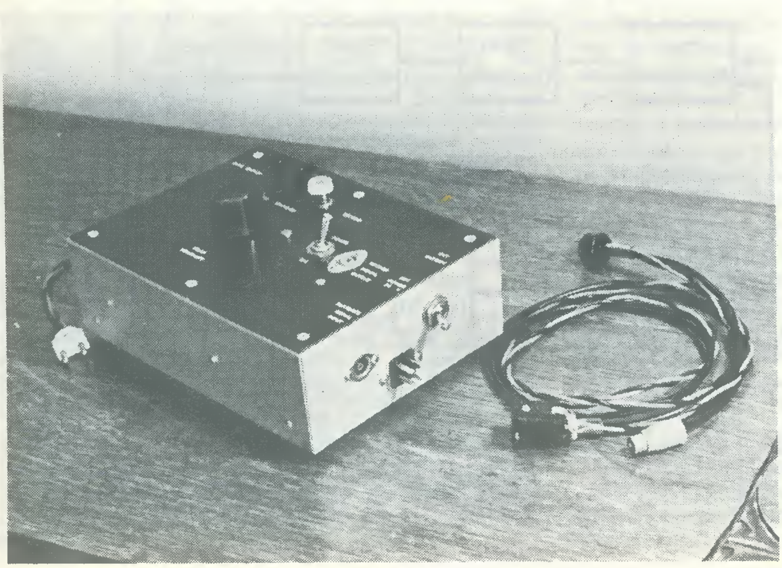
Fig. 2. How the slide changing signal is produced. In (a) the control switch causes the capacitor to charge, whilst in (b) the capacitor provides power for the oscillator until it becomes discharged. The resultant decaying oscillator waveform is shown, in amplified form, in (c)

RELAY AMPLIFIER

The full circuit diagram of the unit is given in Fig. 3, the relay amplifier being provided by TR_1 to TR_4.

During playback, the unselected playback head is connected to Skt_1 and the signals are fed to the base of the pre-amplifier (TR_1) via C_1 and C_2. The operating conditions of this stage are adjusted by VR_1, which could be replaced by a fixed component later. (VR_1 and R_5, in series, amount to about 1·2kΩ.) C_1 isolates the head from any leakage current through C_2, reduces low frequency interference, and provides a not too unreasonable match to the head which has an impedance of about 8kΩ at 300 c/s. This last point is not exacting since Hi-Fi standards are not required!

If synchronisation is lost, opening S_3 will stop the slides advancing, while a brief closure of the biased switch S_4 will cause an extra slide change. S_5 (which operates the oscillator in the manner illustrated in Fig. 2) could alternatively be used for this latter function, in which case S_4 would not be really necessary. S_5 must not be used for this purpose if separate heads for record and playback are permanently connected because the signal would be recorded.



The completed synchroniser, with external connecting leads

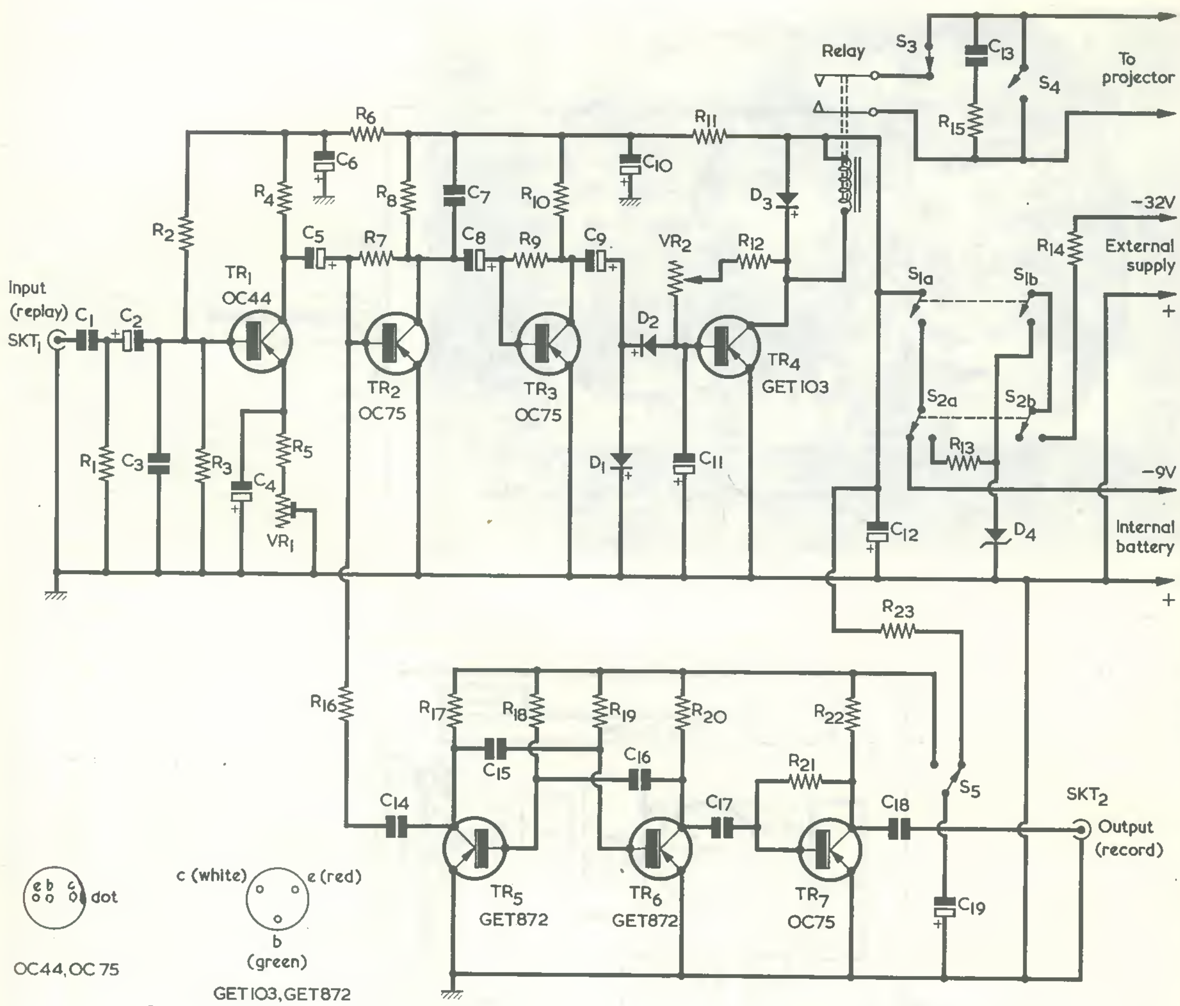


Fig. 3. The complete circuit of the synchroniser unit

OSCILLATOR

The slide changing signal for recording is provided by the astable multivibrator (TR_5 and TR_6) which gives a near square wave output in the region of 300 c/s. An output is taken from the collector of TR_6 and this is coupled by C_{17} to the amplifier TR_7. The amplified signal is then passed by C_{18} to the record head of the tape recorder via Skt_2. A coaxial lead should be used for this purpose and it is transferred to Skt_1 during playback (except when separate heads are used, requiring separate leads).

Another output is taken from the collector of TR_5 and this is fed via C_{14} and R_{16} to the base of TR_2. This signal causes the relay to operate, as previously described, causing the slide to be changed. R_{16} in conjunction with the total base/emitter impedance of TR_2 forms a potentiometer to attenuate the oscillator signal to a suitable level. If separate record and playback heads are used, the signal path through C_{14} and R_{16} should be omitted because the signal would be picked up by the replay head and passed to Skt_1 after a small delay dependent on the tape velocity and the distance between the heads.

C_{19} controls the duration of the signal as well as causing its amplitude to decay, as was shown in Fig. 2. Its capacitance should be increased if the duration of the signal is too short and vice versa. The final value is chosen to suit the projector's slide changing mechanism and steps of 10μF are suggested for valve adjustment purposes. R_{23} limits the charging current of C_{19} to a level that can safely be ignored.

POWER SUPPLIES

S_1 is the main on/off switch and S_2 selects either the internal battery or the external supply from the tape recorder. If battery power only is required, $S_{1(a)}$ is the only switch necessary. The external supply is stabilised by the Zener diode D_4 in conjunction with R_{14}, whilst R_{13} ensures that just over 9 volts is applied to the main bypass capacitor, C_{12}. The rather complex switching ensures that the zener diode is not connected when it is not in use. It is possible for sound signals to reach the synchroniser via the external supply leads. The cause may be due to earth loops being formed and in the case of the prototype it was necessary to join the signal earth to the supply positive at the tape recorder accessory plug. (See Fig. 5).

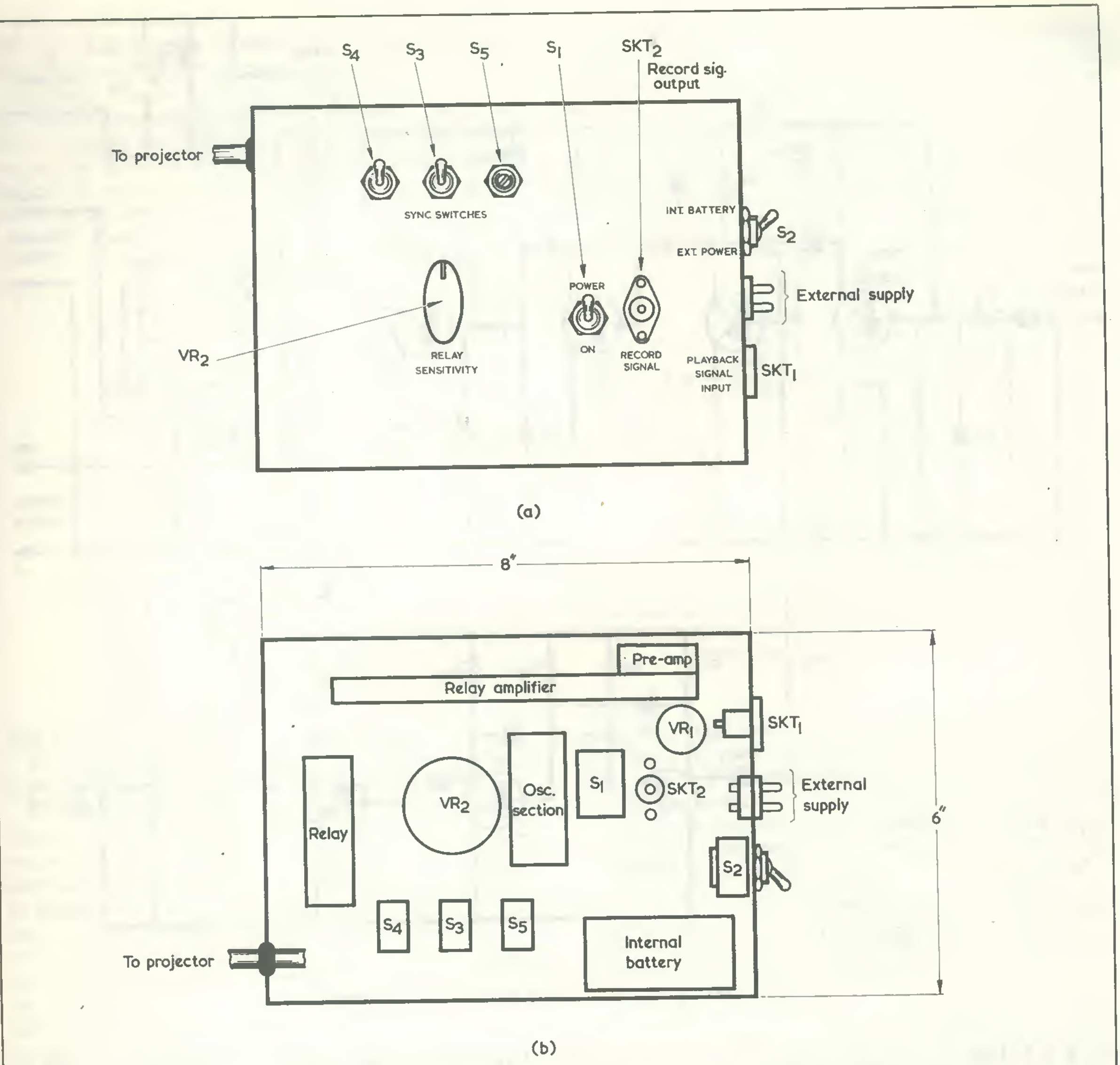


Fig. 4 (a). Top view showing the front panel layout adopted for the prototype (b). Underneath the chassis. Layout is not critical and need not follow that shown here

CONSTRUCTION

A blank chassis measuring 8in × 6in × 2½in was used as a case for the prototype (see Fig. 4) and this was given a "satin" finish by wire brushing with an electric drill. A Paxolin panel was then fitted with pop rivets for the controls. An aluminium base plate, fitted with plastic feet, was secured underneath with self-tapping screws and the controls were marked with "Panel Sign" transfers.

The relay amplifier is built on a large tagboard and the oscillator with its amplifier is on a smaller one. The layout is not very critical except that precautions should be taken to ensure that unwanted signals do not reach the pre-amplifier (TR_1). This stage should therefore be kept away from stages operating at a high signal level. Screening may be required and leads should be as short as possible.

A neater appearance and layout than is apparent in the "much modified" prototype should be obtainable and printed circuitry could be used with advantage. There appears, however, to be no merit in excessive miniaturisation.

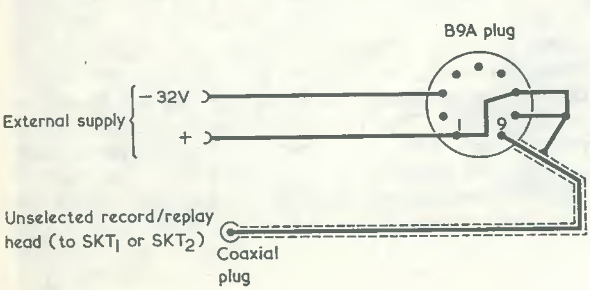
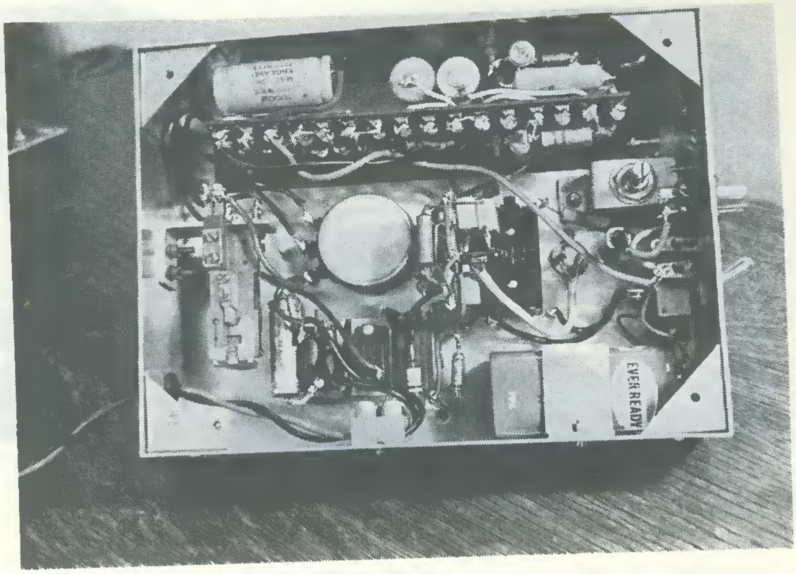


Fig. 5. Connections to the accessory socket of the Ferguson tape recorder used by the writer

Internal view of the synchroniser



OPERATING

The notes which follow apply for tape recorders having combined record/playback heads.

Recording. It is perhaps preferable to pre-record any background music at a suitable level on the selected track unless a mixer unit is in use. The commentary is then superimposed while the slides are changed.

a. Connect the unselected record/playback head to Skt_2.

b. Connect the relay contacts to the projector, which should have a magazine in position.

COMPONENTS

Resistors

(All fixed values ¼ watt 10% unless otherwise stated)

R_1 47kΩ
R_2 47kΩ
R_3 4·7kΩ
R_4 18kΩ
R_5 470Ω
R_6 4·7kΩ
R_7 220kΩ
R_8 4·7kΩ
R_9 220kΩ
R_{10} 2·2kΩ
R_{11} 470Ω
R_{12} 56kΩ
R_{13} 68Ω
R_{14} 1kΩ 2 watt
R_{15} 100Ω
R_{16} 47kΩ
R_{17} 1·2kΩ
R_{18} 22kΩ
R_{19} 22kΩ
R_{20} 1·2kΩ
R_{21} 220kΩ
R_{22} 2·2kΩ
R_{23} 10kΩ
VR_1 2·5kΩ variable preset, linear
VR_2 250kΩ variable, linear

Capacitors

C_1 0·25μF
C_2 10μF electrolytic, 15V wkg.
C_3 0·1μF
C_4 100μF electrolytic, 6V wkg.
C_5 10μF electrolytic, 15V wkg.
C_6 100μF electrolytic, 15V wkg.
C_7 0·1μF
C_8 10μF electrolytic, 15V wkg.
C_9 10μF electrolytic, 15V wkg.
C_{10} 100μF electrolytic, 15V wkg.
C_{11} 100μF electrolytic, 6V wkg.
C_{12} 1,000μF electrolytic, 15V wkg.
C_{13} 0·01μF, paper, 1,000V wkg.
C_{14} 0·005μF
C_{15} 0·1μF
C_{16} 0·1μF
C_{17} 0·005μF
C_{18} 0·1μF
C_{19} 20μF (2 × 10μF—see text) electrolytic, 15V wkg.

Semiconductors

TR_1 OC44
TR_2 OC75
TR_3 OC75
TR_4 GET 103
TR_5 GET 872
TR_6 GET 872
TR_7 OC75
D_1, D_2, D_3 OA81
D_4 9·1V, 5%, 250mW zener diode, Radiospares or similar

Switches

$S_{1(a)(b)}$ d.p.s.t., toggle
$S_{2(a)(b)}$ d.p.d.t., toggle
S_3 s.p.s.t., toggle
S_4 s.p.s.t., toggle, biased to open (or push button)
S_5 s.p.d.t., toggle, biased (or push button)

Relay

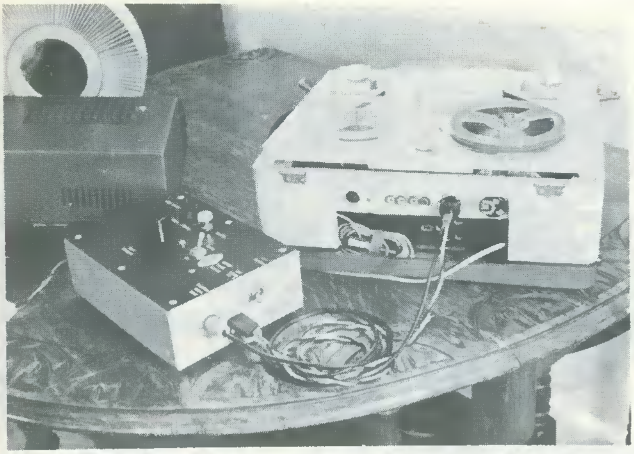
P.O. type, 600Ω coil, with s.p.s.t. contacts normally open

Plugs and Sockets

Skt_1, Skt_2 Coaxial sockets, TV or phono types, with plugs
Connectors for external power supply and projector slide change switch
Connections for battery and tape recorder

Miscellaneous

Chassis (see text)
Knob (for VR_2)
Tagboards, etc.
Battery 9V, type PP6 (Ever Ready)



Another view of the synchroniser whilst in operation, and illustrating the connections to the tape recorder

Note.—The relay may operate once, or twice, when the synchroniser is first switched on. To prevent the unwanted slide changing that this would cause either:

(i) Always switch on the synchroniser *before* the projector, or

(ii) Open S_3 until everything is switched on, S_3 must, however, be closed before commencing to operate the equipment.

CONCLUSION

The construction of the synchroniser should not be difficult for the fairly experienced and this is why no detailed layout, or point-to-point wiring information is included.

c. Connect the external power supply and/or battery. Switch on the synchroniser and adjust VR_2 to leave the delay de-energised, if necessary. (Normally, the setting of VR_2 should not need to be varied for successive periods of use).

d. Switch on the projector and switch the tape recorder to record, or superimpose, as required.

e. Operate S_5 to bring on the slides, one at a time, and use the microphone to record the commentary on the selected track.

Playback. After rewinding the tape and repositioning the slide magazine, proceed in the following manner.

a. Connect the record/playback head to Skt_1.

b. Switch on the tape recorder (with external power lead connected, if fitted), and the synchroniser. (See note at the end of this section).

d. Switch the tape recorder to playback, whereupon the slides should change automatically in synchronisation with the commentary.

There is plenty of scope for further development in this project. In particular, the amplifier section (TR_1 TR_2 and TR_3) might be made frequency selective so that only the oscillator frequency is accepted. A negative feedback loop incorporating a parallel-"T" network might be tried for this purpose. Lastly, those who like a problem worthy of their talents might try to use one track for both sound and slide changing.

As a final point, Fig. 5 gives details of the connections to the necessary plug for the Ferguson 3202 recorder employed by the writer. Pins 8 and 9 connect, inside the recorder, to the unselected record/playback head. It is important to note that the pin numbers in the diagram only apply to this recorder and to other similar models in the British Radio Corporation range.

MARCONI TV FOR EUROPEAN GAMES

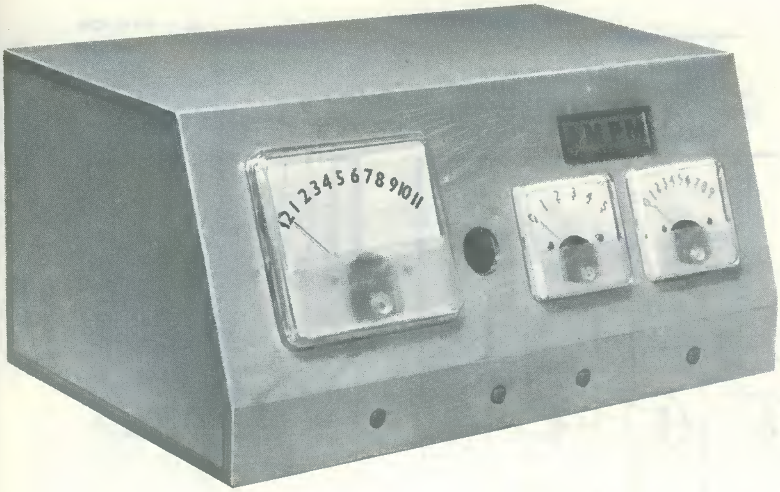
The Greek Amateur Athletic Association (SEGAS) has placed an order worth some £700,000 with English Electric's Marconi Company, for three outside broadcast television units, and a range of cameras and studio equipment to provide full television coverage of the European Games in Athens for the Eurovision network.

A total of 14 of the very advanced Marconi Mark V black-and-white cameras are to be supplied. This camera is fully transistorised, and provides a remarkable degree of stability and reliability in the operation. Both of these features will be particularly important as one of the cameras will be installed in a small car, to provide coverage of the marathon event. A microwave link will also be supplied by Marconi to bring the picture via a helicopter to one of the outside broadcast units.

A total of thirty separate sound and thirty television commentary positions will be installed to cater for all the nations competing in the European Games. Two of the outside broadcast units will be equipped with four Mark V cameras, in addition to full production facilities—the third will have 5 cameras and will provide the basis of the studio facilities at the new stadium.

In addition to the cameras, a range of studio control and switching equipment will be supplied, together with three Ampex Videotape recorders. One of these will be a special effects recorder, capable of providing slow motion playback facilities.

The Marconi equipment has to be delivered to Athens by March, and then installed by Marconi engineers in time for acceptance trials in April. SEGAS personnel will then be trained by Marconi in the operation and maintenance of the equipment, to ensure that they are completely familiar with it by September, when the Games are due to start.



SOLID STATE DIGITAL CLOCK

Part 2

by
A. J. EWINS

In last month's issue the functions provided by the digital clock were described, as also was the basic operation of its time-keeping circuit and the chime circuit. The next sections of the clock to be dealt with, and which are discussed this month, are the read-out circuit, power supply, 50 c/s Schmitt trigger, bistables, reset monostables, comparators and gates

IN LAST MONTH'S ISSUE THE FUNCTIONS PROVIDED BY THE digital clock were discussed, as also was the operation of the basic circuit and the chime circuit. The next section of the clock to be dealt with is the circuit controlling the read-out meters.

DIGITAL TO ANALOGUE READ-OUT CIRCUIT

The read-out circuit is shown in Fig. 4. Only the 0–59 seconds read-out is shown in detail, the design of the other read-outs being identical in principle.

The outputs from binaries B7 to B13 feed into the bases of transistors TR_1 and TR_7 of the read-out circuit via 100kΩ resistors. When the output of a binary is a one its output is up at nearly the full positive rail potential with the result that the associated read-out transistor is switched hard on, i.e., fully conducting. Let us consider that the output of B7 is a one, in which case TR_1 of the read-out circuit is fully conducting. This means that the collector voltage of TR_1 will be about 0·2 volts, thus the collector current, Ic1, will be equal to $(Vs-0{\cdot}2)/RC_1$, which to all intents and purposes, equals Vs/RC_1. Similarly, the collector currents of transistors TR_2 to TR_7, when they are fully conducting, will be Vs/RC_2, Vs/RC_3, Vs/RC_4, Vs/RC_5, Vs/RC_6 and Vs/RC_7 respectively. Now the outputs from binaries B7 to B13 represent 1, 2, 4, 8, 10, 20, and 40 counts respectively, since it takes 1, 2, 4, 8, 10, 20, and 40 pulses before the appropriate binary is switched on. Thus if we choose RC_1 such that $Ic1 = \frac{1}{59}$ of a milliampere, then full scale deflection on the 1mA meter will be 59 seconds (0 and 60 are the same). As Ic2 represents two counts or two seconds, Vs/RC_2 must be equal to $\frac{2}{59}$ of 1mA, i.e., $RC_2 = RC_1/2$. Similarly, $RC_3 = RC_1/4$, $RC_4 = RC_1/8$, $RC_5 = RC_1/10$, $RC_6 = RC_1/20$ and $RC_7 = RC_1/40$. 59 seconds will have been counted by binaries B7 to B13 when there is a one output from binaries B13 (=40), B11 (=10), B10 (=8) and B7 (=1). Thus transistors TR_1, TR_4, TR_5 and TR_7 of the read-out circuit will be fully conducting. The current flowing through the 1mA meter will be:

$$Vs/RC_1 + Vs/RC_4 + Vs/RC_5 + Vs/RC_7 = I$$

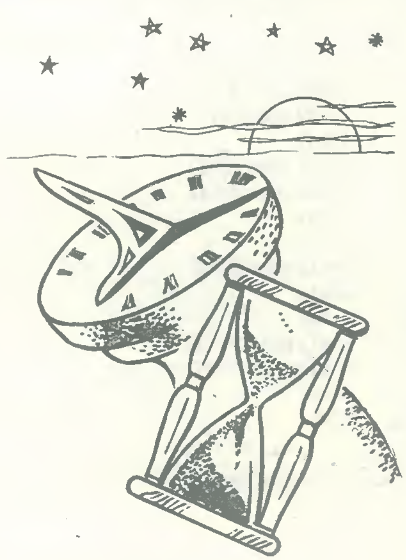
Substituting RC_1 for RC_4, RC_5, and RC_7 we have:

$$I = Vs/RC_1 + 8Vs/RC_1 + 10Vs/RC_1 + 40Vs/RC_1 = 59Vs/RC_1.$$

But we already know that $Vs/RC_1 = \frac{1}{59}$mA, therefore I = 1mA.

The read-out circuits for the minutes, tens-of-minutes and the hours all operate in a similar way to that described above.

The 820kΩ resistors connected between the bases of transistors TR_1 to TR_{18} and the negative rail ensure that



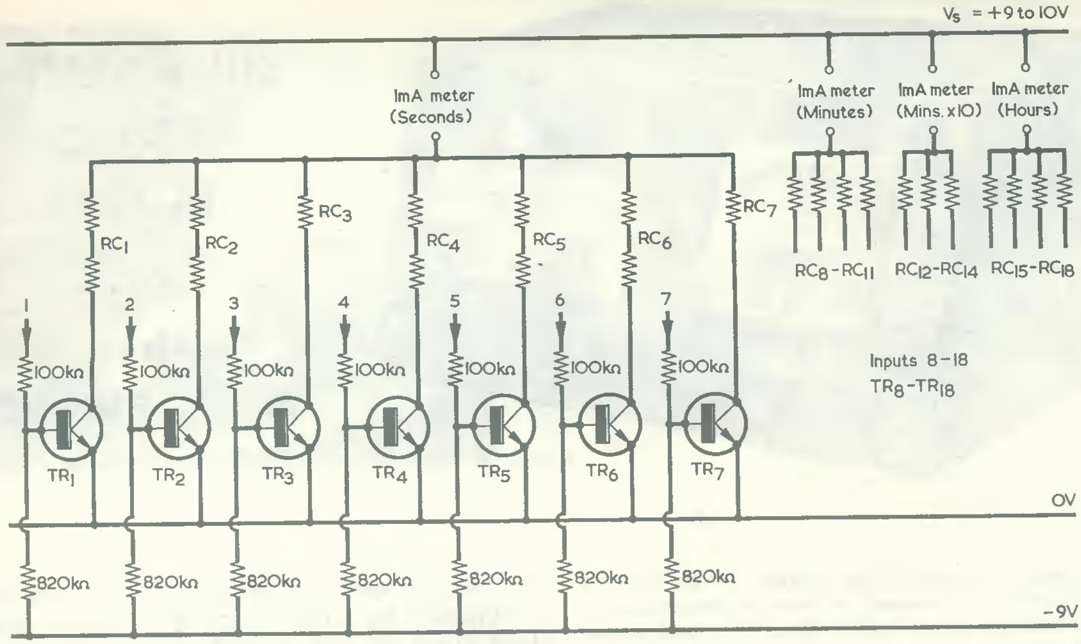


Fig. 4. The read-out section of the clock circuit

a negative voltage of about 1 volt is applied to the transistor bases, thus holding them non-conducting when the outputs from the appropriate binaries are zero's. As the transistors are silicon planar their leakage currents will be negligibly small. High stability 5% resistors were used for all the collector resistors, additional ones being connected in series or parallel to correct the output readings where necessary. With a positive rail voltage of between 9 and 10 volts and the values of RC_1 to RC_{18} as given, the outputs of all four read-out meters will be more than 1mA when reading f.s.d. A suitable resistor should, therefore, be shunted across each meter to bring the f.s.d. to 1mA.

N.B. A few additional resistors may be required for trimming. In some cases a single identifying number is given to two resistors in series.

Resistors

18	100kΩ resistors
18	820kΩ resistors
RC_1	510kΩ plus 10kΩ
RC_2	240kΩ plus 20kΩ
RC_3	130kΩ
RC_4	62kΩ plus 3kΩ
RC_5	47kΩ plus 5·1kΩ
RC_6	24kΩ plus 2kΩ
RC_7	13kΩ
RC_8	47kΩ plus 33kΩ
RC_9	20kΩ plus 20kΩ
RC_{10}	20kΩ
RC_{11}	10kΩ
RC_{12}	24kΩ plus 20kΩ
RC_{13}	22kΩ
RC_{14}	11kΩ
RC_{15}	91kΩ plus 5·1kΩ
RC_{16}	43kΩ plus 5·1kΩ
RC_{17}	24kΩ
RC_{18}	12kΩ

Transistors

18 silicon planar transistors

Meters

4 1mA meters

POWER SUPPLY AND SCHMITT TRIGGER

Details of the power supply and the Schmitt trigger are shown clearly in Fig. 5. Both circuits are variants of well known designs.

The Schmitt trigger will operate with a peak-to-peak input voltage of just over 600mV. The input is provided from a 3 volt tapping of the mains transformer, T_1, via a potential divider network, R_5 and R_{13}. RV_1 sets the d.c. bias to TR_5 and it is adjusted to provide a 1:1 mark-space ratio of the square wave output from the Schmitt trigger. C_6, C_7 and R_{14} help to reduce any unwanted interference from unsuppressed electrical equipment. (They were, unfortunately, ineffective against the author's refrigerator switch contacts, which are so bad that great "plops" are transmitted over the Hi-Fi system. The solution here must be to suppress the refrigerator contacts). The output from the Schmitt trigger is a square wave of approximately 2·7 volts peak-to-peak.

The voltage output from the power supply is adjusted by varying the values of R_3 and/or R_4 to be within the range 9 to 10 volts. The author's was 9·6 volts. The negative supply rail is adjusted to —9 volts approximately by alteration of the value of R_6. A drain of about 1mA is all that is taken from the negative supply rail.

The power requirement of the AM/PM light circuit is over 40mA at 12 volts. This is provided as a separate, unsmoothed, full-wave rectified supply by diodes D_1 and D_6. This is perfectly satisfactory for the circuit. (As will be explained in Part 3, one of the diodes for the 12 volt unsmoothed supply in the prototype clock is mounted on

(Continued on page 385)

RC/DS/20

RADIO CONSTRUCTORS DATA SHEET 20

IR DISSIPATION 50mA AND ABOVE

The Table gives dissipation in watts, from $W = I^2R$, for resistance at commonly encountered current values from 50mA to 1A. Dissipation for intermediate resistances can be found by multiplying up, as described in Data Sheet No. 19. For reliable working, use carbon resistors with ratings at least 1·5 times the wattage figure given here or in Data Sheet No. 19.

Resistance	50mA	60mA	80mA	100mA	120mA	140mA	160mA	200mA	300mA	500mA	1A
1Ω				0·01	0·014	0·02	0·026	0·04	0·09	0·25	1·0
2·2Ω			0·014	0·022	0·032	0·043	0·056	0·088	0·2	0·55	2·2
4·7Ω	0·012	0·017	0·03	0·047	0·068	0·092	0·12	0·19	0·42	1·2	4·7
6·8Ω	0·017	0·024	0·044	0·068	0·098	0·13	0·17	0·27	0·61	1·7	6·8
10Ω	0·025	0·036	0·064	0·1	0·14	0·2	0·26	0·4	0·9	2·5	10
22Ω	0·055	0·079	0·14	0·22	0·32	0·43	0·56	0·88	2·0	5·5	22
47Ω	0·12	0·17	0·3	0·47	0·68	0·92	1·2	1·9	4·2	12	
68Ω	0·17	0·24	0·44	0·68	0·98	1·3	1·7	2·7	6·1	17	
100Ω	0·25	0·36	0·64	1·0	1·4	2·0	2·6	4·0	9·0		
220Ω	0·55	0·79	1·4	2·2	3·2	4·3	5·6	8·8	20		
470Ω	1·2	1·7	3·0	4·7	6·8	9·2	12	19			
680Ω	1·7	2·4	4·4	6·8	9·8	13	17				
1kΩ	2·5	3·6	6·4	10	14	20					
2·2kΩ	5·5	7·9	14	22							
4·7kΩ	12										

ELECTRONIC NEWS

OMEGA SYSTEM EXTENSION

The United States Secretary of Defence, as announced by a Defence Department statement, has approved a request to establish four more transmitting stations for the Omega navigation system which, with four transmitters operating at present, provides coverage of all of the North Atlantic and the Eastern North Pacific to give ships position fixes accurate to within one mile. When the other four transmitters are on the air the total of eight stations will provide complete global coverage. It is hoped that this will be achieved before the end of 1972.

The additional four stations will be sited in the areas of the Western Pacific, the Tasman Sea, the Indian Ocean, and Southern South America. Rather than seek permission to erect and operate U.S. stations on the territory of other countries, the intention is to enlist those countries in joint operation of the world-wide system to the advantages of navigators of all nations.

During the past year United States representatives have been engaged in informal discussions with officials in countries in which the new Omega stations might be located. These discussions have revealed a general enthusiasm for Omega and a consequent prospect that a truly international partnership of six contributing nations can be formed to establish the system on a world-wide basis. The United States Secretaries of State and of Defence have now authorised the progress of formal negotiations with prospective partner nations in this enterprise.

In the United Kingdom and the Republic of Ireland Marconi Marine market the Omega 1 position-fixing receiver manufactured by the Northrop Corporation of California, who also produced the military version of this equipment for the U.S. Navy Department. The first merchant ship installations are in the new *Manchester Challenge* and the new Cunard liner, *Queen Elizabeth 2*.

MULLARD MEMORY SYSTEM

Mullard Ltd. are to supply a special memory system for a unique aircraft project devised by the Slingsby Aircraft Co. Ltd., of Kirby Moorside, Yorks.

Under contract to the Central Aircraft Manufacturing Company, Washington D.C., Slingsby have developed a 378 ft. long aircraft carrying on its sides illuminated panels, consisting of a matrix of special tungsten lamps, which will reproduce advertising or other messages while the plane is airborne.

The memory system has been designed and built by the Industrial Assemblies Division of the company's Mitcham plant. This division specialises in the design and manufacture of magnetic memory systems, core matrix stacks and custom built modules, particularly those employing thyristors or concerned with thyristor control.

The memory system for the Slingsby Aircraft accepts alpha/numeric characters from an electric typewriter, storing these in such a way that messages nominally 50 words in length can be reproduced at will.

Logic circuitry converts the memory output into a form where it can drive the thyristors which provide the lamp current required.

To minimise power consumption messages are flashed on alternate sides of the aircraft. The means of switching the power from port to starboard is provided by standard Mullard thyristor trigger modules and special thyristor control circuitry.

SOLID - STATE DIGITAL CLOCK

(Continued from page 382)

the Veroboard which carries the AM/PM light circuit. It is suggested that both the diodes in this circuit—D_1 and D_6—could be mounted on the board carrying the AM/PM light circuit rather than on the power supply Veroboard.).

A suitable mains transformer for T_1 is the Douglas MT112AT (available from G. W. Smith & Co. (Radio) Ltd., 3 Lisle Street, London, W.C.2). This has a 500mA secondary with tappings at 0–12–15–20–24–30 volts. For the present circuit, connections are made to the 0, 12, 15 and 24 volt taps.

THE BISTABLE DIVIDER

The bistable divider of Fig. 6 is a conventional bistable of the multivibrator family suitably connected for binary division. Consider that initially TR_1 is conducting and TR_2 is non-conducting. The collector of TR_1 will be effectively down at ground potential whilst that of TR_2 will be up at almost the full rail potential. This means that the base of TR_1 will be sufficiently positive to keep TR_1 conducting and the base of TR_2 will be negative, keeping TR_2 non-conducting. D_2 will be reversed biased via R_6

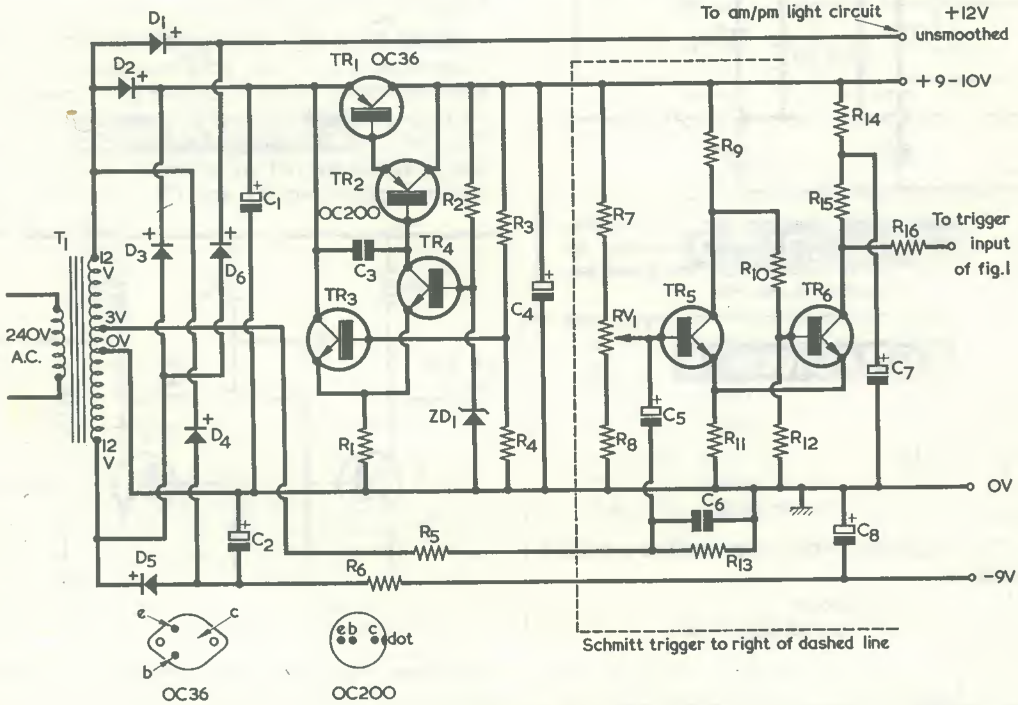


Fig. 5. The power supply and Schmitt trigger. The latter passes pulses at 50 c/s to the binary dividers of Fig. 1 (published last month)

COMPONENTS

Resistors
(R_3, R_4 or R_6 may require adjustment)

- R_1 3·3kΩ
- R_2 680Ω
- R_3 820Ω
- R_4 1·5kΩ
- R_5 10kΩ
- R_6 8·2kΩ
- R_7 10kΩ
- R_8 10kΩ
- R_9 3·3kΩ
- R_{10} 10kΩ
- R_{11} 4·7kΩ
- R_{12} 15kΩ
- R_{13} 2·2kΩ
- R_{14} 2·7kΩ
- R_{15} 2·7kΩ
- R_{16} 10kΩ
- RV_1 2kΩ potentiometer, linear

Capacitors

- C_1 500μF electrolytic, 20V wkg.
- C_2 10μF electrolytic, 12V wkg.
- C_3 0·01μF disc ceramic
- C_4 25μF electrolytic, 12V wkg.
- C_5 10μF electrolytic, 12V wkg.
- C_6 0·47μF
- C_7 25μF electrolytic, 12V wkg.
- C_8 10μF electrolytic, 12V wkg.

Transformer

- T_1 Mains transformer. Douglas type MT112AT

Semiconductors

- D_1–D_6 Silicon rectifiers, 250mA, p.i.v. greater than 40V (e.g. Lucas DD000)
- ZD_1 Zener diode, 6·2 volts, 250mW
- TR_1 OC36
- TR_2 OC200
- TR_3–TR_6 silicon planar transistors

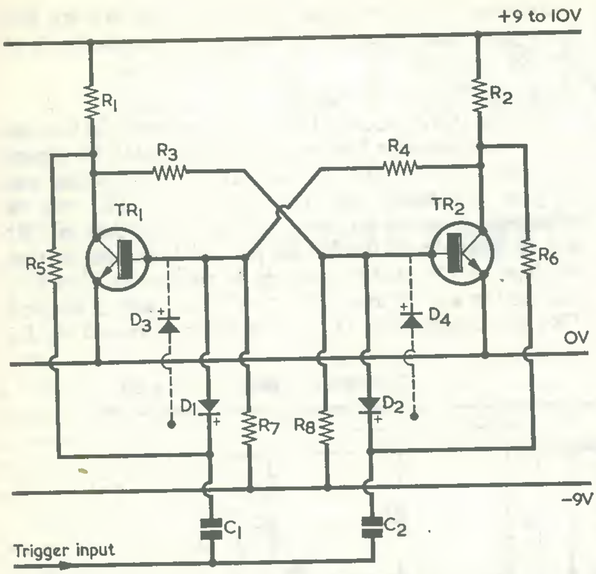


Fig. 6. Basic circuit diagram for the bistable dividers. There are slight changes according to position in the overall clock circuit, and these are described in the text

COMPONENTS

Resistors
R_1, R_2 10kΩ
R_3–R_6 100kΩ
R_7, R_8 820kΩ

Capacitors
C_1, C_2 0·01µF disc ceramic (as small as possible)

Semiconductors
D_1, D_2 silicon diodes
TR_1, TR_2 silicon planar transistors

by almost the full rail potential and D_2, via R_5, will be just conducting.

When a negative going pulse arrives at the trigger input, it is directed by D_1 to the base of TR_1; it is held off from the base of TR_2 by the reverse biased diode D_2. The negative voltage pulse draws current from the base of TR_1, turning it "off" (i.e., making it non-conductive). As it becomes non-conducting TR_1 collector rises to almost the full rail potential, raising the base of TR_2 sufficiently positive for it to be turned "on" (i.e., become conducting). The collector of TR_2 drops to near zero potential, with the result that the base of TR_1 goes negative holding TR_1 "off". On receipt of a second negative pulse at the trigger input to TR_1 and TR_2, these revert to their original states. Thus an output pulse is obtained from the collectors of either TR_1 or TR_2 for every two pulses that are received at the trigger input. The length of time that a negative pulse is present at the bases of TR_1 or TR_2 is determined by the time constants R_5, C_1 and R_6, C_2. The diodes, D_3 and D_4 (shown in dashed line), pass the d.c. set and reset connections to the binary dividers. For binaries, such as B_{10} and B_{13}, which require separate input connections to the two transistor bases, the connection between C_1 and C_2 is broken, providing the two inputs. Theoretically, in such circumstances, the diodes D_1 and D_2 and the resistors R_5 and R_6 become redundant. However, for some unknown reason the binaries refused to operate satisfactorily without them so that the diodes and resistors were retained in the circuits of binaries of B_{10} and B_{13} and all other such binaries.

In Figs. 1 and 2, inputs were shown passing inside the block representing each bistable. It may now be seen that these correspond, in position, to the input to C_1 and C_2 and the transistor bases (via D_3 and D_4) as applicable. Outputs are taken from the collectors of TR_1 and TR_2. (D_3 and D_4 are included in Fig. 6 to indicate the circuit position of the external set and reset diodes).

RESET MONOSTABLE

The reset monostable (Fig. 7) is a conventional monostable of the multivibrator family. Its normally stable state is with TR_2 fully conducting and with TR_1 non-conducting. Upon a negative going pulse arriving at the trigger input the base of TR_2 goes negative, switching TR_2 "off." As TR_2 becomes non-conducting, its collector rises to almost the full rail potential, thus the base of TR_1 is taken positive, via R_4, and TR_1 is switched "on." The

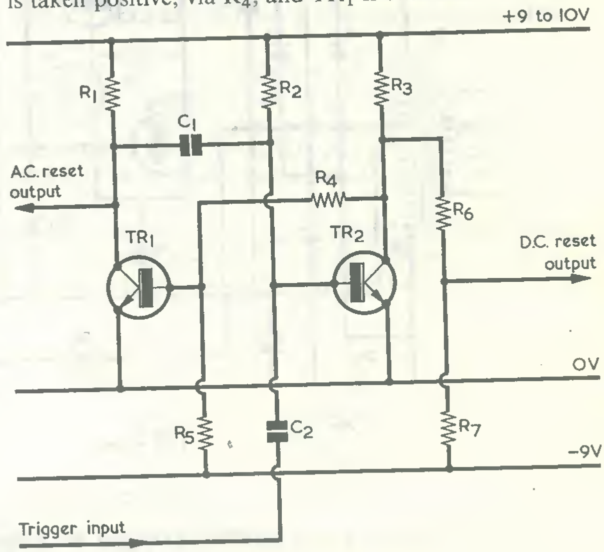


Fig. 7. The monostable reset stage, as used in Figs. 1 and 2

COMPONENTS

Resistors
R_1 10kΩ
R_2 100kΩ
R_3 10kΩ
R_4 100kΩ
R_5 820kΩ
R_6 10kΩ
R_7 100kΩ

Capacitors
C_1 0·1µF (as small as possible)
C_2 0·01µF disc ceramic (as small as possible)

Transistors
TR_1, TR_2 silicon planar transistors

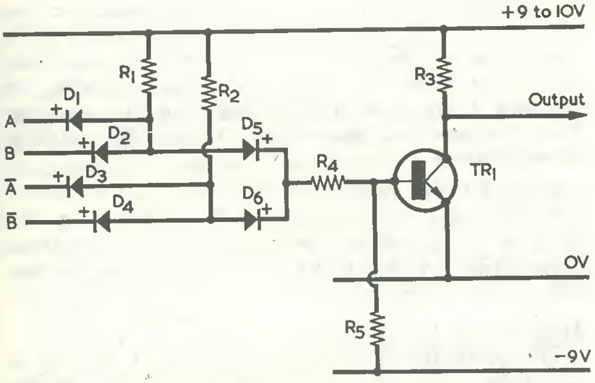


Fig. 8. Circuit diagram for the comparator stages of Fig. 2

COMPONENTS

Resistors
R_1, R_2 47kΩ
R_3 10kΩ
R_4 47kΩ
R_5 330kΩ

Semiconductors
D_1–D_6 silicon diodes
TR_1 silicon planar transistor

collective side of C_1 is now at zero volts and the R_2 side of C_1 is at a negative voltage of about 8 volts. C_1 now charges up through R_2 and when the junction of C_1, R_2 and the base of TR_2 reaches approximately 0·6 volts TR_2 will again become fully conducting and TR_1 will be switched "off." The time that the monostable is out of its normally stable state is approximately determined by the time constant, $R_2.C_1$.

The output from the collector of TR_1 is normally up at nearly the full rail potential. When the monostable is triggered, TR_1 collector goes down to nearly zero volts producing a negative going pulse of approximately $R_2.C_1$ seconds duration.

The output from the collector of TR_2 is normally at about 0·2 volts hence the output at the junction of R_6 and R_7 will be about 1 volt negative. When the monostable is triggered, the collector of TR_2 will rise to almost the full rail potential and the junction of R_6 and R_7 will also rise to some positive potential, the precise value of which will depend upon the amount of current passed through R_6.

The negative going output pulse from the collector of TR_1 is used as an a.c. reset signal to binaries BC1 and BC2 in the chime circuit of Fig. 2. The positive going output pulse from the junction of R_6 and R_7 is used to reset binaries B1 to B4 of the clock's basic circuit (Fig. 1), and the binaries BS1 to BS4 of the chime circuit of Fig. 2.

It is important that the d.c. set and reset diodes for the binaries B1 to B4 and BS1 to BS4 should be normally reverse biased. This is why the output from the monostables is taken from the junction of R_6 and R_7 instead of the collector of TR_2.

THE COMPARATORS

The comparators are used to determine when the

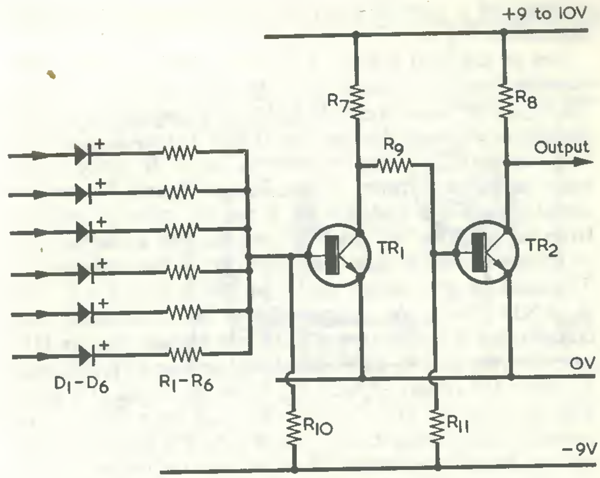


Fig. 9. The six-input OR gate is connected up as shown here

COMPONENTS

Resistors
R_1–R_6 100kΩ
R_7, R_8 10kΩ
R_9 100kΩ
R_{10}, R_{11} 820kΩ

Semiconductors
D_1–D_6 silicon diodes
TR_1, TR_2 silicon planar transistors

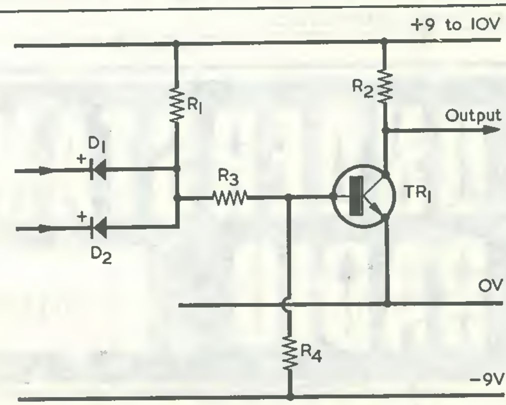


Fig. 10. The simple circuit employed for the NAND gate

COMPONENTS

Resistors
R_1 47kΩ
R_2 10kΩ
R_3 47kΩ
R_4 330kΩ

Semiconductors
D_1, D_2 silicon diodes
TR_1 silicon planar transistor

outputs of a pair of binaries are the same. The circuit appears in Fig. 8.

Let us consider a pair of binaries, "A" and "B." The outputs from the collectors of the transistors of binaries "A" and "B" we will call A, A, B and B respectively. It is a feature of a binary divider that if A = 1 then A *must* = 0, and vice-versa. For the binaries "A" and "B" to be in the same state the outputs A and B, and $\bar{A}$ and $\bar{B}$ must be equal (i.e., A = B and $\bar{A} = \bar{B}$). If the two pairs of outputs from the binaries "A" and "B" are fed into a comparator as shown in Fig. 8 then the output from the collector of TR_1 will be zero when the inputs A AND B = 1, OR $\bar{A}$ AND $\bar{B}$ = 1. As suggested by the conditions, the comparator is in fact two AND gates feeding into an OR gate. D_1, D_2 and R_1 form one AND gate and D_3, D_4 and R_2 form the other. D_5 and D_6 form the diode OR gate. The junction of D_1, D_2 and R_1 will be at a positive potential only when the inputs A AND B are ones, i.e., up at a positive potential. If either input is down at zero volts then the junction must also be down at zero volts. The same is true about the junction of D_3, D_4 and R_2, except in this case the inputs are $\bar{A}$ AND $\bar{B}$. However, if either the junction of D_1, D_2 and R_1 OR D_3, D_4 and R_2 is up at a positive potential then the junction of D_5, D_6 and R_4 must also be at a positive potential, and hence the base of TR_1 is sufficiently positive for TR_1 to be fully conducting and the collector to be at zero potential. Thus the output from the comparator is zero if either the inputs A AND B OR A AND $\bar{B}$ are ones, i.e., positive. For either condition the binaries "A" and "B" will be in identical states.

SIX-INPUT OR GATE

The circuit of the OR gate is given in Fig. 9. As the name of the gate implies, an output is "up" at a positive potential at the collector of TR_2 if an input is "up" at one OR more of the inputs.

THE NAND GATE

The operation of this circuit (shown in Fig. 10) is self-explanatory; an output from the collector of the transistor being NOT "up" when inputs 1 AND 2 are "up".

NEXT MONTH

The only circuits not so far described in detail are the AM/PM light switching circuit and the chime oscillator. These will be dealt with in Part 3, after which constructional details will commence.

(*To be continued*)

UNDERSTANDING RADIO

DELAYED A.G.C. CIRCUITS

$f = \frac{1}{2\pi\sqrt{LC}}$

by W. G. Morley

DELAYED A.G.C. CIRCUITS

IN LAST MONTH'S ARTICLE IN THIS SERIES WE INTRODUCED the subject of automatic gain control in a.m. radio receivers, and saw that an a.g.c. voltage is obtained by rectifying the output signal from the i.f. amplifier. The resultant direct voltage is then fed back to the preceding valves as a negative bias voltage. These valves are the r.f. amplifier (if fitted), the frequency changer, and the valve or valves in the i.f. amplifier, and they are all types having a variable-mu characteristic.

We also examined a simple a.g.c. diode circuit in which a single diode carries out the functions of both signal detector and a.g.c. diode.

SEPARATE A.G.C. DIODE

For purposes of comparison with other a.g.c. circuits, the single diode circuit given last month is reproduced here in Fig. 1 (*a*). R_1, R_2, C_1 and C_2 appear in a standard signal detector circuit, whilst C_3, which has a low reactance at a.f., passes the detected signal to the triode a.f. amplifier. R_3 has a high value, allowing the triode to operate with grid current bias. When an i.f. signal is passed to the diode its rectifying action causes the upper end of the diode load (R_2, plus the relatively low-value resistor R_1) to take up a negative potential with respect to chassis, the amplitude of this negative potential being proportional to the amplitude of the i.f. signal. A direct a.g.c. voltage is then available after the filter given by R_4 and C_4. In the circuit of Fig. 1 (*a*) R_4 and C_4 prevent both i.f. and detected a.f. signals from appearing on the a.g.c. voltage. A common variant on this circuit consists of taking the a.g.c. voltage from the upper end of R_2, whereupon R_4 and C_4 have to prevent a.f. signals only from appearing on the a.g.c. voltage. The double diode triode in Fig. 1 (*a*) has its cathode (common to both diodes and the triode) connected to chassis.

An important feature of the circuit of Fig. 1 (*a*) is that, so far as a.c. is concerned, R_4 is in parallel with the diode lead, whereupon it provides additional a.c. loading. This point was dealt with in detail last month.

An alternative type of a.g.c. circuit is shown in Fig. 1 (*b*). Here, the left hand diode of the double triode functions as the signal detector and provides a detected a.f. signal in conventional manner. The i.f. signal is also applied, via capacitor C_5, to the right hand diode. This functions as the a.g.c. diode. A negative rectified voltage proportional to the amplitude of the i.f. signal appears at the upper end of the a.g.c. diode load R_5, and this is then applied to the filter given by R_4 and C_4, which removes the i.f. component of the rectified voltage.

(Newcomers who are puzzled by the fact that a negative rectified voltage appears at the right hand diode anode should assume that an "a.c. generator" connected between the left hand plate of C_5 and chassis provides the i.f. signal. Capacitor C_5 then becomes charged via the diode to nearly the peak alternating voltage potential, with its right hand plate negative. The capacitor thus provides the negative voltage—actually, negative half-cycles of the alternating voltage—at the diode anode. Filter components R_4 and C_4 ensure that a steady direct voltage, equal to the average direct voltage of the half cycles, becomes available on the lower plate of C_4. In practice the "a.c. generator" is the secondary of the i.f. transformer, its lower end being coupled to chassis via C_1, which has a low reactance at i.f.).

The arrangement of Fig. 1 (*b*) has the advantage that the a.g.c. diode circuit is separate from the detector circuit and that none of the a.g.c. components cause a.c. loading across the detector load. The value of the coupling capacitor, C_5, is normally around 20 to 50pF.

Another a.g.c. diode circuit is illustrated in Fig. 1 (*c*). Here the detector circuit remains unaltered and the right hand diode now receives an i.f. signal from the anode of the i.f. amplifier valve preceding the last i.f. transformer. Again, the a.g.c. diode circuit is separate from the signal detector circuit and it similarly adds no a.c. loading across the signal detector load. The circuit of Fig. 1 (*c*) has a particular advantage when used in domestic a.m. receivers, this arising from the fact that the overall receiver selectivity at the i.f. amplifier anode is less than it is—one i.f. tuned circuit later—at the signal detector. With the circuits of Figs. 1 (*a*) and (*b*) a.g.c. voltage rises relatively sharply when the receiver tuning approaches its correct setting, as is indicated by the sharp curve of Fig. 2. When the circuit of Fig. 1 (*c*) is used a high a.g.c. voltage is provided even when the receiver tuning is some way removed from its correct setting, this state of affairs being illustrated by the broader curve in Fig. 2. The result is that tuning, close to the correct tuning position, becomes somewhat easier for a non-technical person to carry out, since the correct tuning position corresponds to a small increase in a.f. output. Also, since the receiver gain is kept at a reduced level on either side of the correct tuning position, there is less tendency for the receiver to offer a shrill distorted output when slightly off-tune, as can occur when the a.g.c. circuits of Figs. 1 (*a*) and (*b*) are used. Care has to be taken, when designing a receiver using the a.g.c. circuit of Fig. 1 (*c*) to ensure that the a.g.c. voltage/frequency response (as illustrated by the broad curve of Fig. 2) is not so broad that the a.g.c. voltage generated by a powerful signal can reduce sensitivity for a weak adjacent signal. However, this requirement is normally met quite satisfactorily in standard a.m. receivers employ-

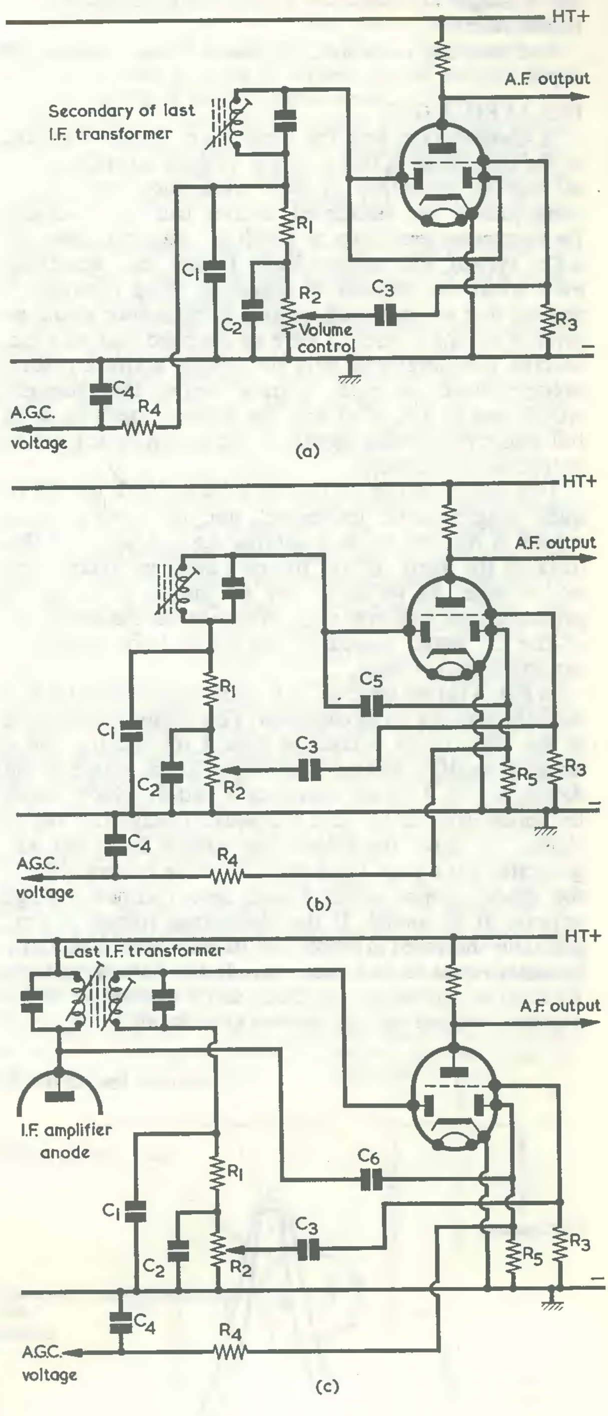


Fig. 1 (a). A circuit in which an a.g.c. voltage is taken from the upper end of the signal detector load
(b). Here, a separate diode functions as a.g.c. diode
(c). Supplying a separate a.g.c. diode from the anode of the last i.f. amplifier valve

ing a single i.f. amplifier valve and good quality i.f. transformers.

The coupling capacitor, C_6, has a value, typically of 50pF.

DELAYED A.G.C.

A disadvantage with the three a.g.c. circuits we have so far considered is that an a.g.c. voltage is produced for *all* signals, regardless of how weak they may be. In consequence, the associated receiver can never achieve the maximum sensitivity of which it is capable, since the a.g.c. system will automatically reduce that sensitivity even when the weakest of signals is being received. It follows that an improved receiver performance would be given if the a.g.c. circuits were so designed that an a.g.c. voltage was developed only for signals above a certain predetermined strength. Signals below this strength would then be amplified with the receiver operating at its full sensitivity, whilst signals above would be subject to automatic gain control.

This condition can be readily achieved with the aid of quite simple circuit techniques, and the system which results is referred to as a *delayed a.g.c.* system. In this instance the word "delay" means a delay in voltage, and not in time. As we shall now see, no a.g.c. voltage is produced with a delayed a.g.c. system unless the amplitude of the i.f. signal passed to the a.g.c. diode exceeds a predetermined voltage.

In Fig. 3 (*a*) we have an "a.c. generator" which feeds a diode by way of a series capacitor. This circuit is equivalent to the a.g.c. diode circuits of Figs. 1 (*b*) and (*c*), and a negative rectified voltage is produced at the anode of the diode. In Fig. 3 (*b*) we introduce a battery which causes the diode cathode to have a positive voltage relative to chassis. If, now, the alternating voltage from the a.c. generator has a peak value lower than the battery voltage the diode cannot conduct and zero rectified voltage appears at its anode. If the alternating voltage is next gradually increased in amplitude, its peak value eventually becomes equal to and then exceeds the battery voltage. As soon as this occurs the diode starts to conduct and a negative rectified voltage appears at its anode.

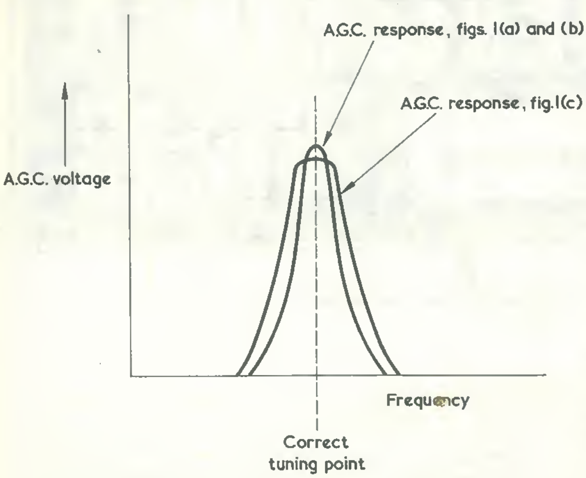


Fig. 2. The circuit of Fig. 1 (c) allows a high a.g.c. voltage to be provided for a wider range of tuning control settings than do the circuits of Figs. 1 (a) and (b)

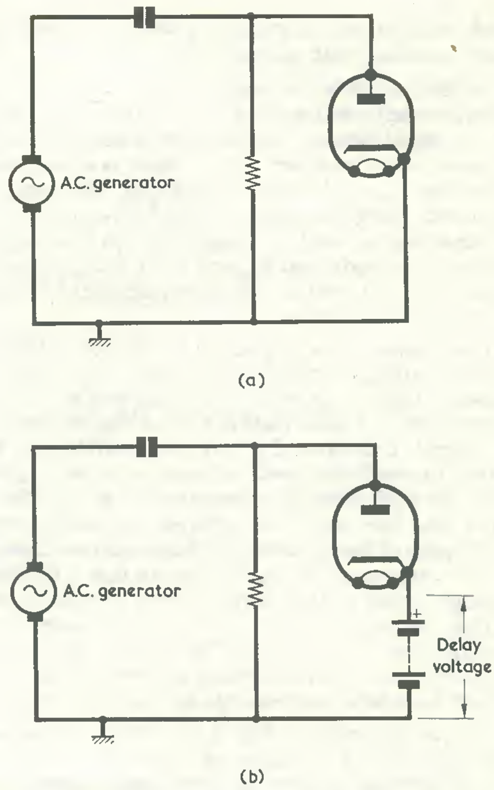


Fig. 3 (a). A basic diode circuit, as is employed in a.g.c. circuits
(b). Adding a battery as shown here, introduces a delay voltage

Thus, the circuit of Fig. 3 (*b*) offers no rectified output when the peak value of the alternating voltage is less than the battery voltage. If, on the other hand, the peak value of the alternating voltage is greater than the battery voltage a rectified output is given, this increasing as the alternating voltage increases. A diode circuit of this nature is described as being "delayed", the voltage provided by the battery being the *delay voltage*. It will be seen that the rectified voltage obtained in Fig. 3 (*b*) for alternating voltages which "overcome the delay" is less (by the battery voltage) than would be given for the same voltages by the circuit of Fig. 3 (*a*). This effect is relatively unimportant so far as an a.g.c. diode circuit is concerned because most of the alternating voltages (that is, i.f. signal voltages) fed to it are considerably greater than the delay voltage. The rectified voltage obtained is, in consequence, only slightly less, proportionally, than if a diode without a delay were used.

Since the a.g.c. diodes in Figs. 1 (*b*) and (*c*) are separate from the signal detector diodes, either of these two circuits may be modified so that the a.g.c. diode becomes delayed in the same manner as occurs in Fig. 3 (*b*). For an a.m. broadcast receiver the delay required for the a.g.c. diode is of the order of several volts only, whereupon it becomes very convenient to obtain this delay voltage by using cathode bias for the triode section of a double diode triode. This bias voltage also provides the delay voltage.

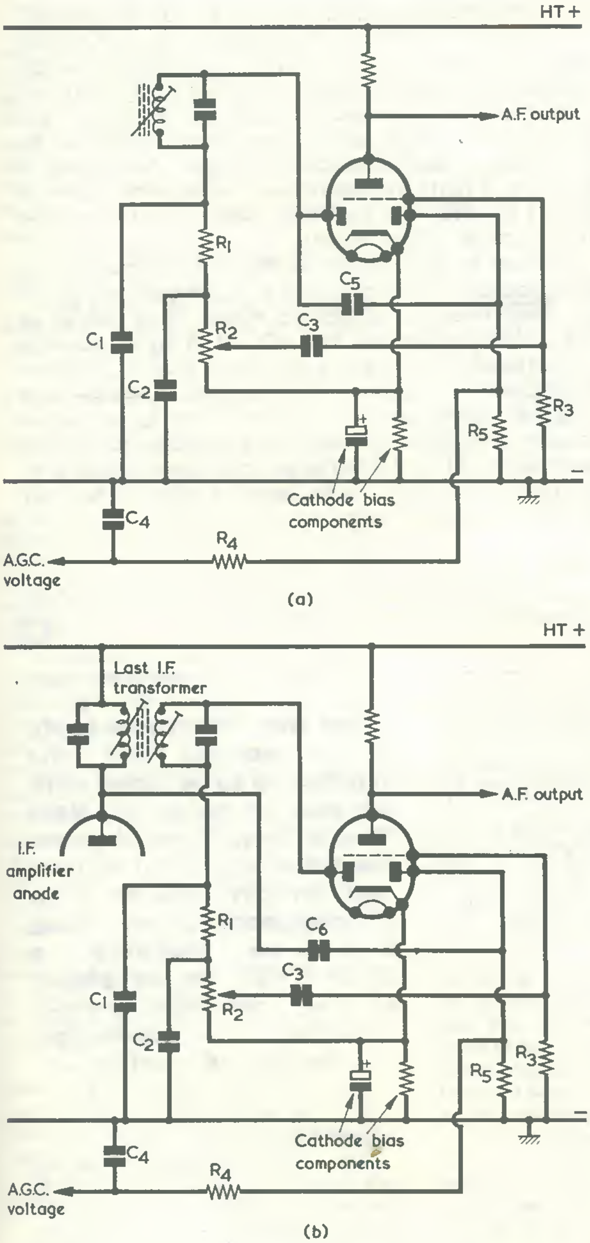


Fig. 4 (a). The circuit of Fig. 1 (b) modified for delayed a.g.c. operation
(b). The circuit of Fig. 1 (c) similarly modified

Fig. 4 (*a*) shows Fig. 1 (*b*) modified to provide a delayed a.g.c. voltage. Conventional cathode bias components appear between chassis and the cathode of the valve, a cathode bias voltage being produced across them in the usual manner due to the current passed by the triode. The signal detector load, R_2, now has its lower end returned to cathode instead of to chassis. In consequence, the signal detector circuit functions in the same manner as it did previously, with the exception that the lower end of the load now happens to be a few volts positive of chassis. (This is the same signal detector circuit as was illustrated in Fig. 1 (*d*) of last month's article). The a.g.c. diode is once more on the right and its load resistor, R_5, connects to chassis, whereupon this diode enters into the same circuit configuration as did that of Fig. 3 (*b*), the cathode being maintained positive of chassis by the cathode bias potential. In Fig. 4 (*a*) the signal detector functions with *all* signals, regardless of their strength. On the other hand, the a.g.c. diode provides an a.g.c. voltage only when the peak amplitude of the i.f. signal from the i.f. transformer secondary exceeds the delay voltage at the cathode of the valve.

Incidentally, since the triode in Fig. 4 (*a*) is biased by cathode bias, R_3 does not now require the very high value needed with grid current bias.

The circuit of Fig. 1 (*c*) may be modified in a similar manner, giving us the delayed a.g.c. circuit shown in Fig. 4 (*b*). Again, the same conditions prevail, an a.g.c. voltage being produced only when the i.f. voltage amplitude at the i.f. amplifier anode is sufficiently high to overcome the delay voltage at the cathode of the valve.

A disadvantage with both the circuits of Figs. 4 (*a*) and (*b*) is that distortion can occur with signals whose average amplitude is very close to the delay level. The modulation of such signals causes their amplitude to vary, with the result that the a.g.c. diode may be conducting over part of the modulating cycle and non-conducting over the remainder. The i.f. transformer tuned circuit feeding the a.g.c. diode is slightly damped when the diode conducts.[1] Since this damping occurs only over *part* of the modulating cycle, the modulated signal passed to the signal detector carries a distorted version of the true modulation. This effect is much more in evidence with the circuit of Fig. 4 (*a*) than it is with that of Fig. 4 (*b*),[2] and the circuit of Fig. 4 (*b*) is on this score preferable. In practice, the distortion offered by the circuit of Fig. 4 (*b*) is not excessively high and it is only in evidence with a relatively narrow range of signals whose amplitudes bring them close to the a.g.c. delay level. Signals which will normally be relied on to provide a detected signal of good quality should have an

[1] Damping of a parallel tuned circuit occurs when an external resistive load is connected across it, causing its effective Q factor to become reduced.

[2] This is largely because, when the a.g.c. diode of Fig. 4 (*a*) conducts, a capacitive potentiometer is set up with C_5 and C_1 in series. C_1 has a value which would normally only be about 5 to 10 times higher than C_5, whereupon an appreciable voltage can appear across it, reducing the voltage fed to the signal detector diode.

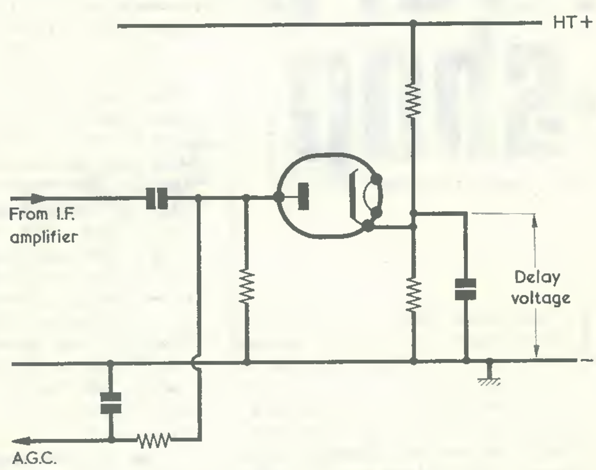


Fig. 5. A common method of providing the a.g.c. diode delay voltage in more complex receivers

amplitude well above the delay level, and are not subject to the distortion. Before concluding on this point it should be mentioned that distortion due to a delayed a.g.c. diode being non-conductive over part of the modulating cycle is inevitable if the signal is modulated 100%, because the carrier then drops to zero once for each modulating cycle. Broadcast transmissions have a much lower modulation depth and are not liable to give rise to this effect. Nevertheless, it is still advisable to keep the delay voltage on the a.g.c. diode sufficiently low to prevent distortion with the more heavily modulated transmissions of reasonable strength; and it may be stated that the circuit of Fig. 4 (*b*) offers acceptable results for domestic listening provided that the delay voltage at the cathode is kept at around 2 to 3 volts.

The distortion just discussed is not evident in the non-delayed a.g.c. circuits of Figs. 1 (*b*) and (*c*). Also, the circuit of Fig. 4 (*b*) has the same advantage with respect to ease of tuning as has that of Fig. 1 (*c*).

The delayed a.g.c. diode circuit of Fig. 4 (*b*) has been widely used in commercially manufactured a.m. valve receivers and, since the cathode bias components carry out the secondary function of producing an a.g.c. delay voltage, it presents a useful economy in valves and components. This circuit could also be used with a double diode pentode if the pentode were an a.f. voltage amplifier.

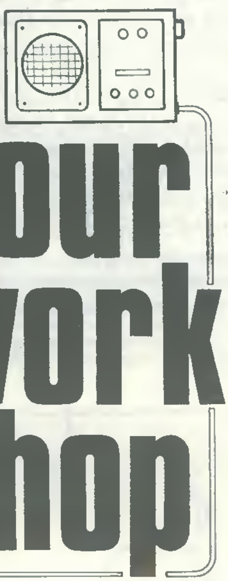
Despite the fact that it provides no delay and that care has to be taken to prevent excessive a.c. loading of the detector, the basic circuit shown in Fig. 1 (*a*) has also been widely used in commercially made receivers, the a.g.c. voltage being taken from the upper end of R_1 or R_2 according to individual circuit design. The circuit of Fig. 1 (*c*) is fairly frequently encountered, whilst those of Figs. 1 (*b*) and 4 (*a*) are less popular (the latter because of distortion, as just stated).

In more specialised a.m. receivers, where economy in components is not so important as in competitively priced domestic receivers, alternative means of providing an a.g.c. delay voltage may be employed. A typical instance is illustrated in Fig. 5, where a single a.g.c. diode is shown, its cathode being taken to the junction of two resistors connected across the h.t. supply lines. The junction of the resistors is bypassed to chassis via a capacitor having low reactance at i.f. and a.f. The standing current drawn by the two resistors from the h.t. supply need be of the order of several milliamps only.

NEXT MONTH

In next month's issue we shall see how the a.g.c. voltage is applied to the controlled valves. ✱

In your work-shop



After the Christmas rush, it is normal for the Workshop to be faced with no sets to repair on New Year's Day. Nevertheless, the time is still put to use, and Smithy spends it in demonstrating to Dick how to modify a UL84-UY85 record-player so that it produces greater output at considerably enhanced quality

"I," announced Dick, as he carried a record player in a battered wooden cabinet into the Workshop, "am in dead trouble, mate!"

Sipping tea from his disgraceful tin mug, Smithy looked up at his assistant.

"Well," he remarked heavily after a moment, "I won't blame you for coming in late this morning because this *is* New Year's Day and there's no work for us to do in any case. So, what's your trouble?"

"We've got a New Year's Day party on tonight," wailed Dick, "and I've been detailed to provide the music. But all I can dig out is this record-player I've got here."

"I recognise the model," said Smithy. "It's one of those low-cost jobs with just a UL84 output pentode and a UY85 rectifier in them. All the a.f. gain is provided by the UL84 on its own."

RECORD-PLAYER

"Exactly," returned Dick in disgust. "And that's my problem. The output from this record-player just isn't loud enough, particularly for the sort of party we'll be having tonight. I've checked all the voltages in it at home, and I've tried a new UL84 which I happened to have on hand, but everything is all right."

"Put it on," said Smithy.

Dick removed his mackintosh then carried the record-player over to his bench, plugged it into the mains and switched it on. He next set one of his 45 r.p.m. test records on the changer spindle and started the turntable running. Smithy listened attentively to the output. The volume level was adequate enough for domestic listening.

"It seems about normal for this class of record-player," he commented. "You *could* try another pick-up cartridge. One hears tales of these crystal cartridges losing their output over the years and there's a new one of the type employed in that record-player in the spares cupboard."

Eagerly, Dick searched through the spares cupboard and located the new cartridge. He fitted it to the record-player tone arm and played the test record once more. There was no discernable difference in volume.

"Oh well," remarked Smithy, shrugging his shoulders. "You've got to face up to it, Dick. That record-player is operating just about as well as you can expect it to!"

"Is it possible," asked Dick, "to add another a.f. stage and get a bit more gain out of it?"

"Oh yes," said Smithy. "Provided, that is, that there's enough room for the extra parts that will be required. Seeing that we've got nothing else in hand today, we'll have a stab at doing just that if you like."

"Good old Smithy," returned Dick warmly. "I knew you'd come up with something. Will there be any snags?"

"Not really," replied Smithy. "Provided, as I say, that there's sufficient room for the extra components needed it's not at all difficult to add another stage of amplification to a single-pentode record-player of the type you have here.

Even so, however, you won't have *considerably* greater output because this will be limited by the power-handling capability of the speaker that's already fitted. Again, you may run into acoustic feedback to the pick-up, which will also limit the gain. Nevertheless, it should still be possible to obtain a very useful increase in volume as well, incidentally, as quite a reasonable improvement in quality."

"What," asked Dick, "is the first thing to do?"

"Open up the cabinet," replied Smithy promptly, "and have a look to see what space is available."

"That's not too difficult here," said Dick. "With this record-player there's a hatch underneath the whole box, as well as an inspection cover above."

"Fine," said Smithy. "Whip them off."

Dick switched off the record-player, secured the pick-up arm on its rest then, after removing its main plug from the mains socket, proceeded to remove the covers. Smithy looked inside at the underneath of the deck and the amplifier chassis.

"Excellent," he said. "There's stacks of spare room here. Now, I think I'd better explain the line of action I propose carrying out. At the moment you have a single pentode doing all the amplification inside this record-player. What I intend to do is to stick a triode in front of it so that the gain available is that given by a triode and pentode in cascade. The gain given by this combination will, initially, be far too great so I'll then proceed to reduce it by adding negative feedback so that the output, at full volume level, doesn't overload the speaker or cause acoustic feedback to the pick-up."

Smithy peered inside the cabinet and scowled at the small elliptical speaker it contained.

"It's a pity," he complained, "that we haven't got a bigger speaker to play with. However, we should still get a fair bit of volume out of the one that's already here."

Smithy walked over to the filing cabinet and searched inside.

"We're in luck," he announced. "We've got the service sheet for this record-player on file."

The serviceman returned and placed the service sheet on his bench. He and Dick gazed at its circuit. (Fig. 1).

"It's the usual stock UL84–UY85 arrangement," pronounced Smithy. "The two valves get their heater supply from a tap in the gram motor windings. The a.f. circuits to the pick-up are isolated by 0·002µF capacitors, and there's a 0·002µF capacitor between the amplifier chassis, which connects to the neutral side of the mains, and the gram deck, which connects to the mains earth. Whatever modifications we make, Dick, we must *always*, for safety reasons, ensure that we don't upset these isolating arrangements in any way."

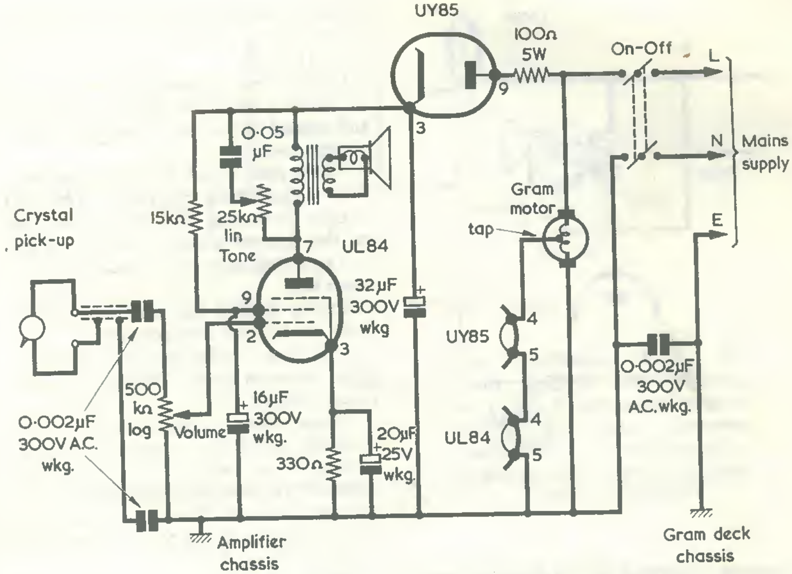


Fig. 1. The circuit of Dick's record-player. This is typical of all players employing the UL84-UY85 combination. The on-off switch is ganged with the volume control

"Good point," said Dick. "There doesn't seem to be very much else in the circuit so far as a.f. is concerned."

"The only other thing of any importance," replied Smithy, "is that rather horrible bit consisting of a 25kΩ pot and a 0·05µF capacitor across the speaker transformer primary which is supposed to act as a tone control. *That* will have to come out!"

"Is that," asked Dick, "because you aren't too keen on it from the quality point of view?"

"Partly," said Smithy. "But the main reason is that it will come inside the feedback loop of the modified amplifier. Fortunately, we'll be able to use the 25kΩ pot in the new tone control circuit, so you won't have to fit a new control. Now, the next thing is to decide how we're going to change the amplifier to one having a triode and pentode in cascade. There are two approaches here, one consisting of replacing the UL84 with a triode-pentode and completely rewiring the amplifier chassis. The other

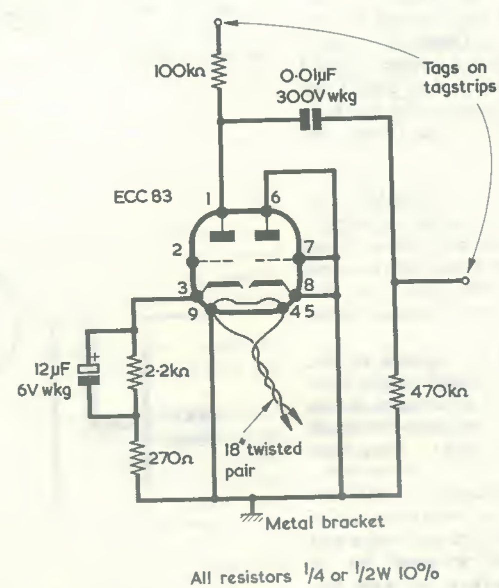


Fig. 2. The components initially fitted by Dick to the added metal bracket. The 18in twisted pair is later connected, shortened as necessary, to a heater transformer secondary

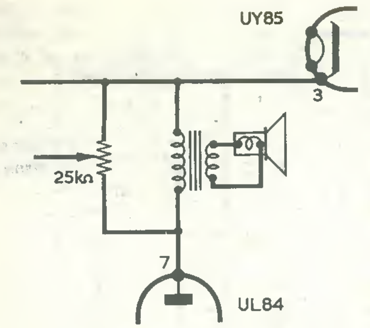


Fig. 3. In modifying the amplifier, the 0·05μF tone control capacitor of Fig. 1 is removed and the 25kΩ potentiomater connected directly across the speaker transformer primary

consists of leaving the UL84 pretty well the same as it is now and adding an external triode mounted on a little metal bracket and with its filament run from a heater transformer. The second approach is usually the easier, even if it *does* incur some extra metal-bashing in making up the bracket and any other incidentals that are required. This is because most of these UL84 amplifier chassis are too small to take the extra components needed for a triode-pentode."

"We'll add the extra triode on a bracket," said Dick decisively. "There's plenty of room inside the cabinet for it, *and* for a small heater transformer."

MODIFICATION BEGINS

"Fair enough," said Smithy. "Well, you can start on the bracket for the triode straight away. Design it to take a B9A valveholder and a couple of small 4 or 5-way tagstrips, and so that it can be secured with at least one nut and bolt, at some convenient point, to the existing chassis."

"Why's that?"

"Because," explained Smithy, "the wooden sides of this cabinet are sure to be pretty thin and you can't rely on being able to mount extra assemblies on them securely with woodscrews. All the existing metalwork will be reliably bolted down."

Smithy returned to his mug of tea, and scribbled out a circuit whilst Dick picked up a sheet of aluminium. It was not long before he produced a small bracket which met Smithy's requirements.

"Excellent," said Smithy. "I think the best triode we can use here is one half of an ECC83. This is a high-gain valve and will give us quite a good bit of amplification before we add the feedback. Now, whilst you were making that bracket I was working out a circuit for the triode. Before you fit the bracket in place, mount the tagstrips and valveholder on it, and then wire it up like this." (Fig. 2).

Dick soon mounted the components in Smithy's circuit to the metal bracket, and passed it over to the Serviceman for his approval.

"Very nice," said Smithy, examining Dick's handiwork carefully. "The next thing is to fix that bracket into position in the record-player cabinet. Whilst you're doing that I'll get myself a spot more tea."

Smithy refilled his mug whilst Dick fitted the bracket into position.

"All done," called out Dick cheerfully some minutes later. "What's the next thing to do?"

"Some minor circuit mods to the existing amplifier," replied Smithy. "First of all whip out that 0·05μF capacitor in the tone control circuit, and connect the track of the tone control pot directly across the speaker transformer primary." (Fig. 3).

"What about the slider of the tone control pot?"

"Just leave that disconnected for the moment."

Smithy sipped contentedly at his replenished mug of tea whilst Dick set to work with his soldering iron. Lucky are those, it may be said in passing, who due to their greater intellect are capable of taking life easy whilst the rest of us mugs labour away at their bidding.

"That's done," announced Dick. "Next?"

"Disconnect," pronounced he of the superior intellect, "the existing lead between the volume control slider and the control grid of the UL84. Then run a screened lead from that grid to the coupling capacitor from the ECC83 anode, earthing the screening at the ECC83 end. Next, run a screened lead from the slider of the volume control to the grid of the ECC83, earthing *that* at the ECC83 end, too." (Fig. 4).

Again, there was silence in the Workshop, broken only by the clatter of Dick's tools as he prepared the lengths of screened cable and the smacking of Smithy's lips after what were patently very gratifying intakes of tea.

"I've done all that," announced Dick. "But I've just spotted something that's got me worried."

"What's that?"

"Both the grid leads I've fitted are screened," said Dick. "But there's no screening on the lead-outs of the existing 0·002μF isolating capacitor between the pick-up and the top end of the volume control track. Isn't there liable to be some hum pick-up on those lead-outs?"

"We'll have to see what happens there when we start testing," replied Smithy. "As a matter of fact, the only reason I recommended screening those two grid leaks you've just now fitted is because they travel over fairly long distances. The screening is purely a precaution and wouldn't be necessary if we had a proper layout instead of the rather haphazard layout imposed on us here. If after completing the mod we find that, because of the increased amplification, hum picked up by that 0·002μF capacitor is troublesome, we'll either have to re-position it or, preferably, move any mains or heater wiring that's near it further away. Whatever we do here, though, we *must* take great care not to reduce its efficiency as a mains isolating capacitor."

"Righty-ho," said Dick. "Well, we'll cross that bridge when we come to it! What do I do next?"

"Pick up an h.t. positive supply for the ECC83," replied Smithy. "You can get this direct from the screen-grid of the UL84. Just run a lead from the

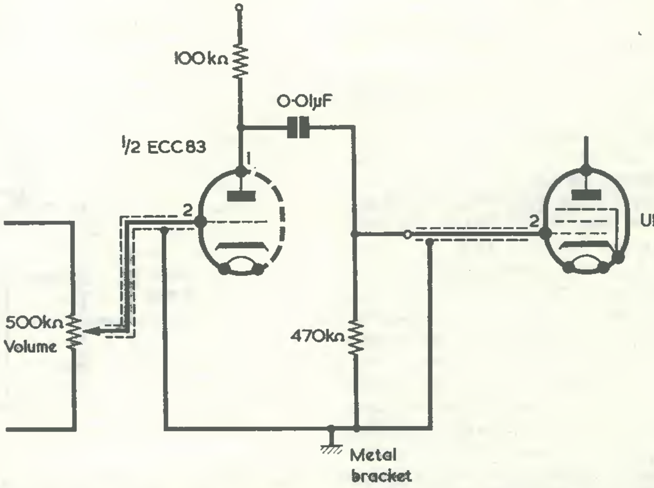


Fig. 4. The volume control slider is transferred from the grid of the UL84 to the grid of the ECC83; and the grid of the UL84 now connects to the anode coupling capacitor from the ECC83

screen-grid to the top of the ECC83 anode load resistor. (Fig. 5). Since the chassis and the bracket are bolted together, we don't need to worry about the h.t. negative connection. If they weren't bolted together they'd need, of course, to be bonded together with a length of wire."

Again, silence fell on the Workshop.

"Job done!" announced Dick after a few moments. "Anything else?"

Smithy rose and looked inside the spares cupboard. He returned and handed a small transformer to his assistant.

"Seeing that it's New Year's Day," he remarked, "you can have this as a present! It's a nice wee little 6·3 volt heater transformer for the ECC83. Mount it at any convenient point inside the cabinet remembering, once again, not to rely on woodscrews for a secure fitting. Then wire it up to provide a heater supply for the ECC83." (Fig. 6).

Dick took the transformer from Smithy, and tried it out in different positions in the record-player cabinet.

"This will be easy enough to fit in," he called out. "One end can share the same bolt that's used for the existing speaker transformer."

"Good show," said Smithy. "Make up another small bracket, so that the transformer can be secured to the cabinet by the same bolts as the speaker transformer. Something like this."

Smithy sketched out a bracket suitable for this application. (Fig. 7).

"No sooner asked for," remarked Dick keenly, "than done! Gosh, Smithy, we should be getting near the end of this job."

"We're approaching the interesting part now," Smithy told him. "As soon as you've got that heater transformer in place and wired up, we'll start checking performance."

CIRCUIT TESTING

Smithy had nearly finished his second mug of tea when a perspiring Dick announced that all was now completed.

"Excellent," said Smithy, placing his mug on his bench and rising. "Let's now see how things work out in practice. First of all, put the cabinet in a position that enables the gram deck to be horizontal and capable of playing a record."

Dick did as he was bid. Smithy then took the record-player mains lead and plugged it into the mains socket at the rear of Dick's bench. He switched on, taking care to keep the volume control at a low setting.

Obligingly, the valve heaters commenced to glow. After a while, a low hum became audible from the speaker.

"Hmm," commented Smithy. "Not *too* bad."

He turned the volume control up and the hum level increased, accompanied by a slight background hiss. With the volume control near its maximum setting a shrill metallic howl became evident.

"Acoustic feedback from the speaker to the pick-up," commented Smithy laconically, as he turned the volume control back sufficiently far for the howl to cease. "Just listen to this."

The Serviceman picked up a small screwdriver and lightly tapped the pick-up head with its blade. The familiar jangle given by a microphonic component became audible from the speaker.

"Gosh," said Dick. "We've certainly got stacks of gain now. Let's try the amplifier with a record."

"Okey-doke," said Smithy, "but don't turn the volume up too high."

Dick placed the test record on the changer and set it in motion. At low settings of the volume control reproduction had about the same quality level as existed before the triode had been added, but the available audible output was obviously greater. Impulsively, Dick set the volume control to its full setting. The result was an ear-splitting cacophony of noise consisting of the music reproduced by a grossly overloaded speaker accompanied by the feedback howl. Angrily, Smithy jerked forward and turned the volume down again.

"But I just wanted to hear," protested Dick, "what it sounded like when it was going full blast."

"If the output of that amplifier," returned Smithy censoriously, "had been coupled to a decent-sized speaker capable of handling a high level of audio power, then your action would have been forgiveable. But it isn't. The amplifier is coupled instead to a small speaker which could quite possibly be damaged by an input as high as the one you just fed to it. Fortunately, no harm seems to have been done this time, so let's press on to the next step. Which is to slightly attenuate the output from the pick-up."

"How," asked a contrite Dick, "do we set about that?"

"With the input circuit in its unmodified state," said Smithy in reply, as he pulled Dick's note-pad towards him, "the output of that pick-up goes straight into the 500kΩ volume control. (Fig. 8 (*a*)). But, for good bass reproduction a crystal pick-up needs to work into a load of 2MΩ or more. So, what we do next is to insert a 1·5MΩ resistor in series with the volume control. Like this, for instance. (Fig. 8 (*b*)). We'll also add a 75pF capacitor across the 1·5MΩ resistor to ensure that there isn't excessive loss of the higher frequencies. An alternative position for the 1·5MΩ series resistor is at the pick-up end of the screened lead and isolating capacitors (Fig. 8 (*c*)), in which case the parallel capacitor should be a bit higher, say 100pF, to take up the self-capacitance in the screened cable. This second position will be the easier to wire up if, like many gram decks, this one has a convenient tagstrip on the underside near the pick-up arm pivot, the tagstrip

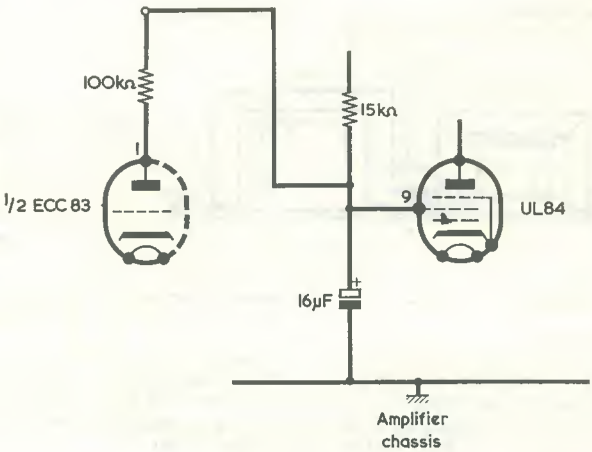


Fig. 5. The h.t. supply for the ECC83 is taken direct from the screen-grid of the UL84

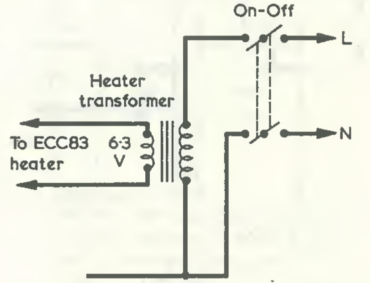


Fig. 6. Connecting up the heater transformer for the ECC83

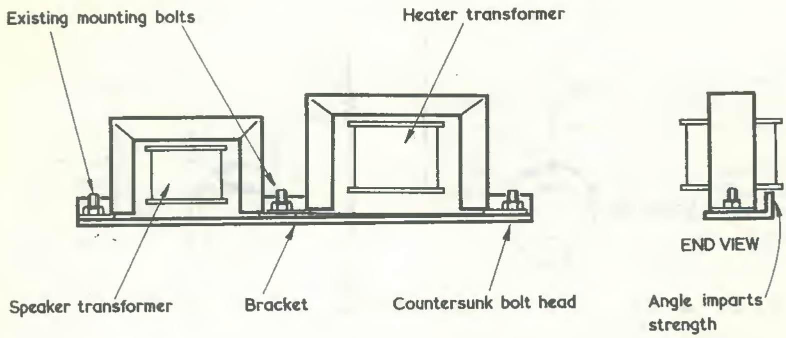


Fig. 7. A mounting bracket such as the example shown here may be necessary for mounting the heater transformer. This enables the heater transformer to be secured to the record-player cabinet by the existing bolts for the speaker transformer

taking the thin flexible wires from the pick-up itself."

Whilst Smithy was speaking, Dick

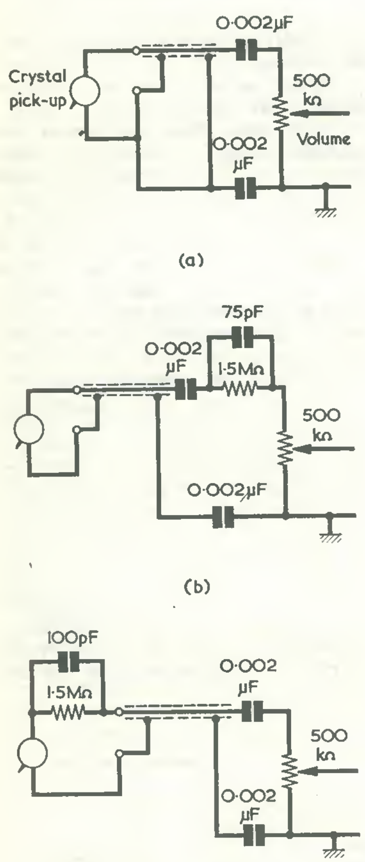


Fig. 8 (a). In the unmodified circuit the pick-up fed directly into a 500kΩ volume control (b). Reponse is improved if an additional resistor and capacitor are wired in, as here (c). An alternative circuit position for the added resistor and capacitor

had already returned the pick-up arm to its rest and switched off the record-player. He next turned its cabinet on its side to examine the underside of the gram deck.

"There's just such a tagstrip here," he announced excitedly. "*And* it's got a couple of spare tags."

"Fine," said Smithy. "Those would have been used if the deck were fitted with a stereo cartridge."

Dick soon soldered the resistor and capacitor into place and the pair listened once more to the output of the record-player.

"Don't forget," Smithy warned Dick, "that we haven't provided a great deal of attenuation, so still keep that volume control at a reasonably low setting."

"The reproduction," remarked Dick, listening critically, "seems to be noticeably smoother."

"There should be *some* improvement," confirmed Smithy. "The response isn't now quite as peaky in the middle of the frequency range as it was before. I should add, by the way, that some record-players will already have volume controls with values around 2MΩ or so. This last mod we've done wouldn't be needed with these."

"What's the next job?"

"Negative feedback!" said Smithy briskly. "And we'll have to do a bit of experimental design work as well for this. So, using temporary connections only, wire up one side of the speaker transformer secondary to chassis, and the other side to the 270Ω resistor in the cathode circuit of the ECC83 via a 100kΩ pot. Keep the leads to the pot just long enough to enable me to adjust it when the gram deck is horizontal and is playing a record." (Fig. 9).

Once more, Dick quickly carried out Smithy's instructions.

"Don't bother to get that gram deck horizontal yet," remarked Smithy, as Dick completed the last of the temporary connections. "I'll check first to see if we're connected right way round to the speaker transformer secondary."

He adjusted the 100kΩ potentiometer to insert full resistance then switched on the record-player, keeping the volume control at a low setting. Carefully, he reduced the resistance inserted by the potentiometer. Almost immediately, the loudspeaker gave voice to a loud squawk. Smithy switched the record-player off hastily.

"Reverse the connections to the speaker transformer secondary," he said. "We were getting *positive* feedback that time!"

Dick quickly transposed the connections, and Smithy switched on

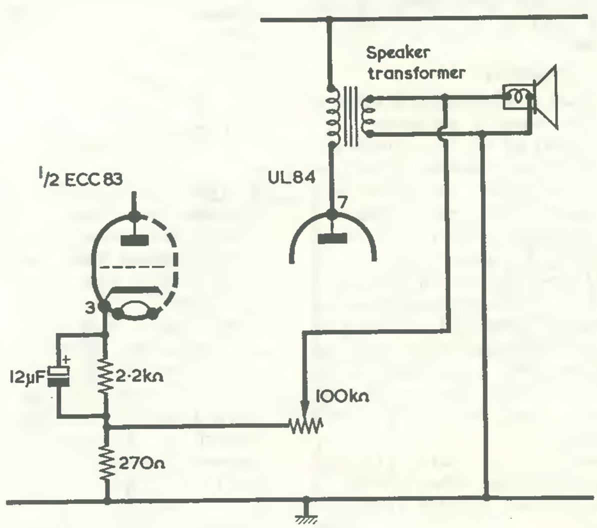


Fig. 9 A temporary circuit employed for finding the degree of feedback required. The chassis symbol here and in subsequent drawings applies to both the amplifier chassis and the metal ECC83 bracket, which are bolted together

once more. This time there was no oscillation as he reduced the resistance offered by the potentiometer. Gradually, the hum level dropped down to an inaudible level. When the potentiometer was inserting almost zero resistance, the amplifier broke into a quiet motor-boating. Smithy returned the potentiometer spindle to the position it had held just before the motor-boating commenced, and switched off again.

"Things are going very nicely, Dick," he announced cheerfully. "What this last check has told me is that the amplifier can stand a really high level of feedback before its phase-shifts make the feedback go positive. Most of these phase-shifts will be in the speaker transformer, of course. Anyway, let's now get the record-player in a position where we can play a record."

When, several minutes later, the test record once more revolved on the turntable, Smithy turned the volume control to full. The output now was very much lower than it had been previously, even with the single valve. Cautiously, Smithy adjusted the 100kΩ potentiometer so that it inserted more resistance. At once the output increased in amplitude. Smithy turned the potentiometer spindle slowly and carefully until the audible output, on peaks from the record, was just at the point where the speaker gave evidence of being overloaded. This was well below the output level which had previously caused the acoustic feedback.

"Is this output loud enough for you?" asked Smithy.

"I'll say it is," replied Dick, his eyes shining. "There's far more volume than there was originally, and the quality is a darned sight better, too. Blimey, Smithy, you've done a smashing job on this record-player!"

"Well, it *should* sound a little better," commented Smithy modestly, "after all we've done to it. Now, the next job for you is to make those temporary connections to the speaker transformer secondary permanent."

"What about the 100kΩ pot?"

"Measure the resistance it's set to,"

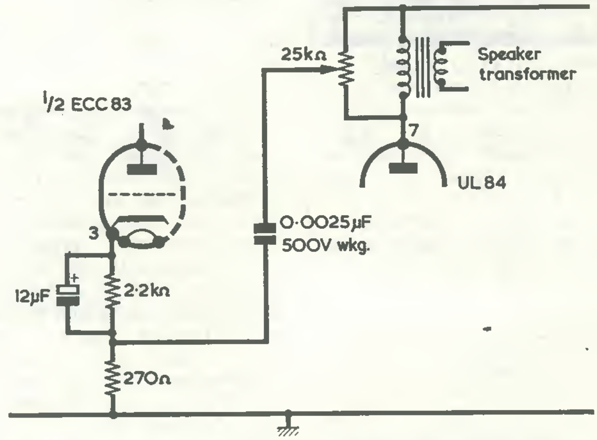


Fig. 10. The simple tone control circuit used by Smithy. This incorporates the original tone control potentiometer

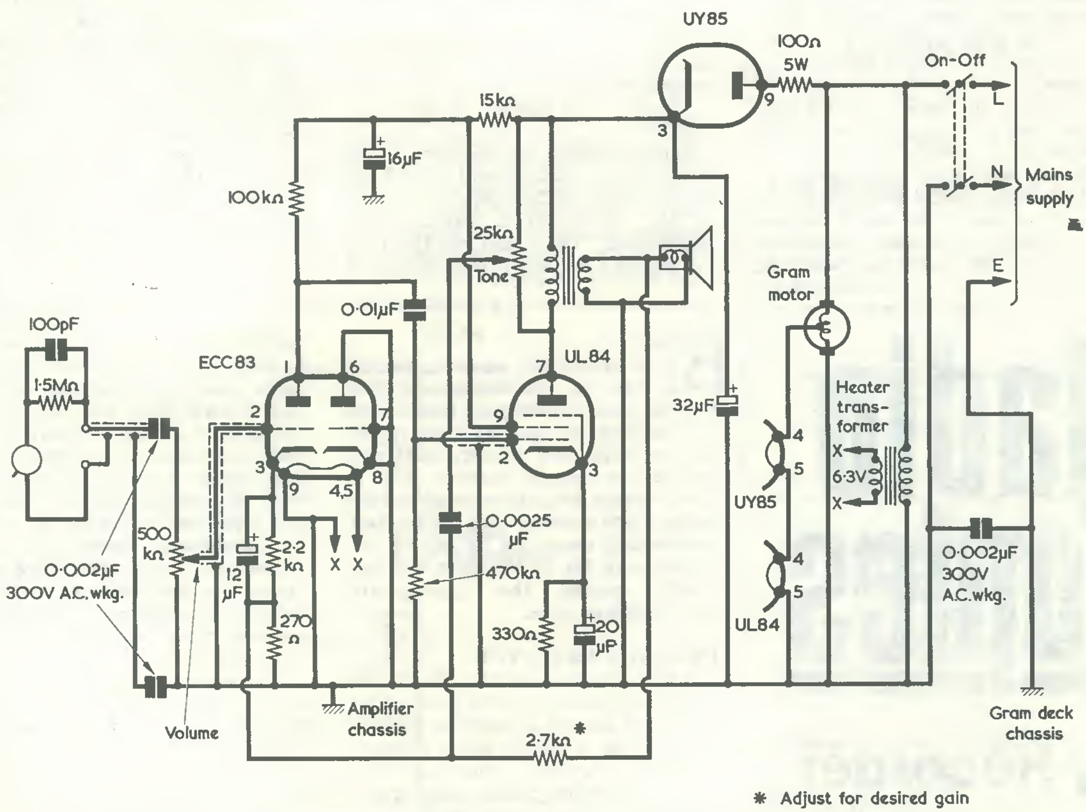


Fig. 11. Complete circuit of the modified amplifier. Screening on the two leads to the control grids is required because of the layout imposed by the modification

said Smithy, "and replace it with a fixed resistor of the same value. And be careful you don't alter its setting when you disconnect it. It's very critical."

Dick quickly unsoldered one of the leads to the potentiometer and applied his test meter prods to it.

"It's measuring just a bit higher," he announced, "than two and a half kilohm."

"Right," said Smithy. "Then pop in a 2·7kΩ fixed resistor. This can be either a quarter or a half-watt component."

TONE CONTROL

Whilst Dick searched for a 2·7kΩ resistor amongst the spares on his bench, a thought occurred to him.

"I've just realised," he remarked, "that that pot was connected into circuit by way of fairly long wires. Is that O.K. when they're carrying a.f., as these ones were?"

"In the present case, yes," replied Smithy. "The circuits on either side of the pot are at quite low impedance and, in any case, I only wanted to find the feedback resistance that would give the desired gain in practice. Incidentally, if you were carrying out this trick with another amplifier you might find that you get best results with a somewhat different value of feedback resistance. The 2·7kΩ value we're using here just happens to suit our own particular circumstances. Have you got those connections done yet?"

"Just finishing," replied Dick.

"Good," said Smithy. "Well, we'll quickly check the results with the fixed resistor, then press on to the last part of the mod."

"What's that?"

"A new tone control circuit."

Dick soon had the test record spinning on the turntable once again. The audible output was the same as with the temporary feedback circuit.

"There's another thing I've just noticed," commented Dick in a pleased tone of voice.

"What's that?"

"The hum level is almost negligible," continued Dick. "It's certainly more than low enough to be completely masked by the music from the record."

"The feedback knocked the hum down so far as the circuitry within the feedback loop is concerned," explained Smithy. "And it looks as though the hum picked up by that 0·002µF isolating capacitor we were worrying about earlier isn't so bad in practice, after all. Right, Dick, let's now get down to the tone control."

"What are you going to do there?"

"Add a bit of frequency-selective n.f.b.," replied Smithy.

"Gosh, that sounds complicated!"

"It won't be in this case," replied Smithy, "because all I'm going to do is to add a capacitor between the slider of the 25kΩ pot across the speaker transformer primary and the top of the 270Ω resistor in the ECC83 cathode circuit (Fig. 10). This capacitor will require a value of 0·002 to 0·003µF, and it should be 500 working volts. Both sides of the capacitor are at fairly low impedance, so that it can be connected into circuit with screened leads. To be on the safe side, though, its body should be closer to the pot than it is to the 270Ω resistor."

"I've got a 0·0025µF capacitor here," said Dick, triumphantly holding up the component.

"Right," said Smithy. "Solder it in, then!"

Smithy checked the operation of the record-player tone control after Dick had fitted the 0·0025µF capacitor.

"Ah," he remarked, with complete satisfaction. "That's just exactly right. I'm getting a beautifully smooth top-cut control which is linearly spread out over all the travel of this tone control pot."

FINAL STEPS

"I think," said Dick, beaming, "it sounds marvellous. I'd never have believed it possible that this record-player could offer as improved a performance as it's giving now."

"I'm glad you're pleased," said Smithy cheerfully. "Well, that's it then! We've now got this record-player completely sorted out so far as the modification for increased output and enhanced quality is concerned."

"Smithy," said Dick enthusiastically, "so far as electronics is concerned you're a genuine Bedouin wizard!"

"On, well," said Smithy. "I suppose it *does* show through at times. Anyway whilst you're putting the covers back on, I'll scribble out the modified circuit diagram for future reference. (Fig. 11). By the way, don't forget to put your old cartridge back into it again! In the meantime, it's worth mentioning, as a form of summing-up, that the improvements we've carried out on this record-player can be made to any other player using a single pentode as a.f. amplifier, provided that there is room for the additional components and that it is remembered that negative feedback *must* be applied to hold the gain down after the added triode has been wired in. And, in all cases, it is *essential* to ensure that the existing mains isolating arrangements to the gram deck and any other exposed metalwork are not in any way altered, and that no additional metalwork at mains potential remains exposed in the modified unit."

With which final words Smithy turned away, to fill his mug yet once more with tea and, momentarily, to look forward with satisfaction to a New Year which had commenced very auspiciously indeed.

Radio Topics

By Recorder

BRRR! Real pawnbroker weather, isn't it? If, like me, you occasionally find that the gales outside your house seem to be finding their way into your rooms via the bricks and plaster, what you require is a draught detector. This is quite a simple device to make up and the design which is now about to be decribed was initially developed by one of our contributors, Mr. G. W. Short, who has kindly passed the appropriate information on to us.

DRAUGHT DETECTOR

Whilst (points out Mr. Short) the back of one's hand is fairly sensitive for the winter task of discovering where a cold draught is coming from, a simple electronic detector is more sensitive. Also, it can be poked into small spaces and saves a lot of crawling about.

The sensing element is the filament of a low consumption bulb such as an 0·04A cycle dynamo lamp. The glass is removed by filing round the neck with a triangular file or crushing the bulb very slowly in a vice. A few loops of wire are soldered to the body to form a protective cage for the fragile exposed filament, and two long flexible wires are soldered to the bulb for connections. See Fig. 1 (*a*). It is then taped to the end of a cane or stick, as shown in Fig. 1 (*b*), this assembly forming the probe. The probe can, of course, be used to explore the space behind the wardrobe or the top of the window frame with minimum trouble to the user.

The electronics are simple, and the circuit is shown in Fig. 2. R_1 in this diagram is used to set the meter pointer to about half-scale deflection. R_2 limits collector current to the f.s.d. of the meter and its value is equal to V_{cc} divided by the meter f.s.d. current. Thus, if the supply is 6 volts and the meter has a 0–1mA movement, R_2 should be 6kΩ

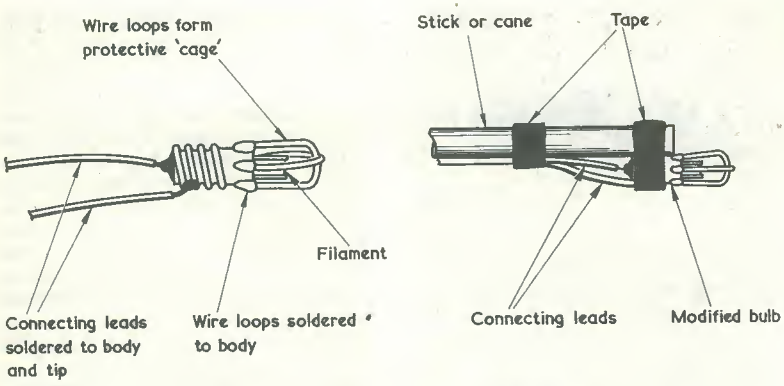


Fig. 1 (a). Adding protective loops of wire to the draught detector probe bulb after the glass has been removed
(b). The bulb and its connecting leads are taped to the end of a stick or cane

(or the nearest preferred value).

The supply voltage depends on the bulb; something approaching the normal rated voltage should be used, so that the bulb runs at black heat. The meter f.s.d. is not at all important, and 1 to 10mA will do with most transistors. Below 1mA, select a transistor with high gain at low currents; above 10mA keep an eye on collector dissipation. R_2 helps here. The detector is extremely sensitive, the slightest air current making the needle flicker.

R_1 will have to be wirewound to take the current. Its track value can be calculated from $2(V_{be}/I)$ where I is about three-quarters of the nominal current rating of the bulb. Thus, for a silicon planar transistor and a 0·04A bulb, R_1 will require a value of about 2(700mV/30mA) — say 50Ω. Make certain that R_1 inserts maximum resistance when the device is switched on for the first time.

Happy draught-hunting!

LUCKY 37

You may recall that, in last month's issue, I remarked on the apparently peculiar behaviour of the number 37. When this number is first multiplied by any figure lower than 10 and the result then multiplied by 3, the final three-figure answer is always made up of the original multiplier. Thus, 37 multiplied by 7 gives 259 which, when multiplied in its turn by 3, gives 777. If the initial multiplier were 4 then the final answer is 444; and so on.

The reason for these somewhat surprising answers becomes apparent, of course, if the multipliers are changed round, so that you initially multiply by 3 and *then* by the number lower than 10. 37 multiplied by 3 is 111, whereupon further multiplication by any number lower than 10 is bound to result in that number appearing three times!

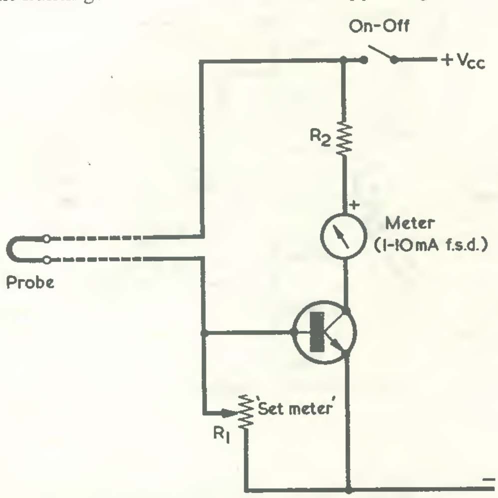


Fig. 2 The circuit of the draught detector. If a p.n.p. transistor is used reverse the supply and meter polarities

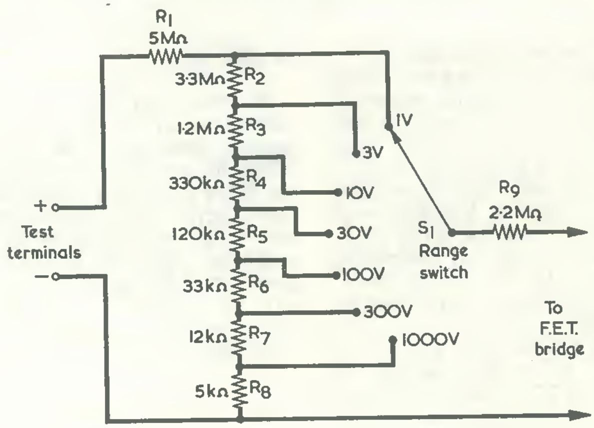
F.E.T. VOLTMETER SWITCHING

G. A. French's "Simple F.E.T. Voltmeter" (Suggested Circuit No. 212—published in the last July issue) has proved to be very popular with readers. The accompanying Fig. 3 (*a*) shows the range switching employed and it will be seen that the test terminals always present an internal resistance of 10MΩ. The range voltages shown at each contact of the range switch correspond to f.s.d. in the bridge meter, this occurring when the voltage at the right of the 2·2MΩ resistor, R_9, goes 0·5 volt positive. It is assumed that the f.e.t. bridge presents infinite input resistance.

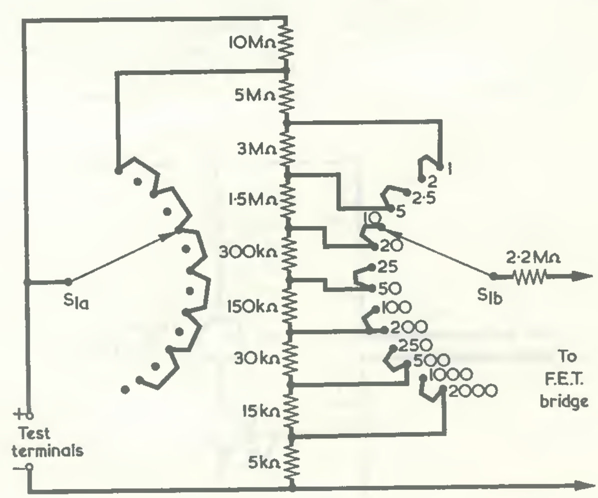
The range voltages selected in the voltmeter follow the 1, 3, 10, 30 progression commonly employed in modern test instruments, and which is catered for by such panel meters as the Radiospares MR22, MR26 and MR31. These meters are calibrated 0–3 and 0–10, and have basic 100μA movements.

A reader, H. S. Bailey of Bolton, Lancs., has sent us an alternative range switching circuit, and this is reproduced in Fig. 3 (*b*). Switches $S_{1(a)}$ and $S_{1(b)}$ are ganged and offer the ranges 1V, 2V, 2·5V, 5V, 10V, 20V, 25V, 50V, 100V, 200V, 250V, 500V, 1000V, 2000V. Mr. Bailey states that readings on these ranges are easier to interpret from a meter having a single scale calibrated 0–1000.

In the 1V position, in Fig. 3 (*b*), the positive test terminal connects via $S_{1(a)}$ to the upper end of the 5MΩ resistor, the 10MΩ resistor above it being short-circuited. In the 2V position the 10MΩ resistor comes into circuit whereupon the internal resistance at the test



(a)



(b)

Fig. 3 (a). The voltage range switching circuit employed in the Suggested Circuit "Simple F.E.T. Voltmeter"
(b). An alternative range switch circuit. In this, $S_{1(a)}$ functions as a "multiplier" switch

terminals becomes 20MΩ and the 1V range is "multiplied" by 2. The same process continues over all the 14 ranges covered.

Difficulty may be experienced in obtaining the 2-pole 14-way switch required in Fig. 3 (*b*), although suitable components may be available in some surplus equipment if you're prepared to search around a bit. Alternatively, by sacrificing two of the ranges, a standard 2-pole 12-way switch could be used instead. Another idea would consist of using a single pole 7-way switch for $S_{1(b)}$ and by replacing $S_{1(a)}$ with an s.p.s.t. switch which acts as a multiplier by short-circuiting the top 10MΩ resistor.

CONVERSION TABLES

Now that we are on the verge of going metric, quite a few of us will be tackling the problem of converting British units to metric units and vice versa. To hand are four "Easy-Way Calculators" which set out to ease this problem, these being published by Easy-Way Publications, Easy-Way Business Methods Limited, 77 New Bond Street, London, W.1. The Calculators provide conversion tables with units running down the centre and the new quantities to be determined on either side. Thus, if one wishes to convert 87 centimetres to inches one finds the 87 in the centre column and notes the inches equivalent under the "inches" heading. Similarly, to change 87 inches to centimetres one finds the 87 in the centre column and notes the centimetres equivalent under the "centimetres" heading.

The Easy-Way Calculators measure $5\frac{1}{2}$ by $8\frac{1}{2}$in and comprise three tables each, with each table having centre value units from 1 to 100. The conversion equivalents are worked out, in some cases, to as much as 8 significant figures. The four Calculators are titled "Volume Measures," "Length Measures," "Weight Measures" and "Area Measures," and are available from Easy-Way Publications at 2s. 6d. each post-free, or 2s. each post-free for five or more copies of any one Calculator.

RADIO LOVE

BY THE TIME THESE NOTES APPEAR, "Radio Love" could well be on the air in London. "Radio Love" is to be run by the younger members of our community whose main outlook is, as I understand it, based on the aphorism "Make love, not war". Programmes to be broadcast will be designed to have a particularly local appeal and usefulness, because the range of a single "Radio Love" transmitter will be of the order of 2 to 3 miles only. "Radio Love", I must hasten to add, will broadcast by way of modulated light, whereupon it falls outside the licensing requirements of the Post Office.

The radiating element at the transmitter will be a gallium arsenide device, which functions as a laser although its radiation is not very coherent. Gallium arsenide devices produce an emission just below the red end of the visible spectrum, and this can be amplitude modulated at frequencies up to hundreds of Mc/s simply by varying the power supply. In the "Radio Love" system the radiating devices will be modulated by subcarrier frequencies in the medium wave band, these in turn being modulated by the a.f. programme material. A single radiating device can be modulated by several subcarrier frequencies simultaneously, whereupon it becomes possible to transmit two or more programmes from one transmitter. This system of operation is to be used by "Radio Love" in order to keep down the capital cost per programme.

The emission of the gallium arsenide device at the transmitter is radiated upwards towards the apex of a reflector shaped like a cone with its axis vertical and the apex "pointing" directly at the gallium arsenide device. The apex angle is 90°, whereupon the reflected radiation becomes unidirectional in the horizontal plane. Some slight rounding at the apex tip causes further reflection downwards, towards nearby receivers. The radiating transmitter will be housed on a tall building with relay receiver-transmitters on other buildings to carry the signal to areas in shadow.

Various designs of receiver are possible and amateur constructors will be free to experiment here. The basic essentials are a parabolic reflector directed at the transmitter, with a photo-electric device having a response time of less than a microsecond at its focus. The subcarrier or subcarriers recovered by way of the photo-electric device are then fed to the aerial socket of a standard medium wave receiver where they are tuned in in normal fashion. In practice, satisfactory modulated light receivers have been built consisting simply of silicon photodiodes in conjunction with reflectors taken from car headlamps. Various additional features may be built into the receiver, such as an r.f. amplifier and filters to select the right frequency.

This, at the time of writing, is the "Radio Love" story to date. As I say, "Radio Love" could well be on the air by the time this report appears. Or it may be delayed. At any event, it is a venture to be followed with great interest.

(As readers may have gathered, these notes were written before the new clauses in the Post Office Bill were made public.—Editor.)

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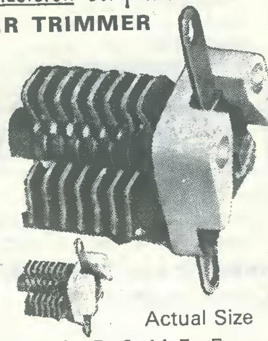

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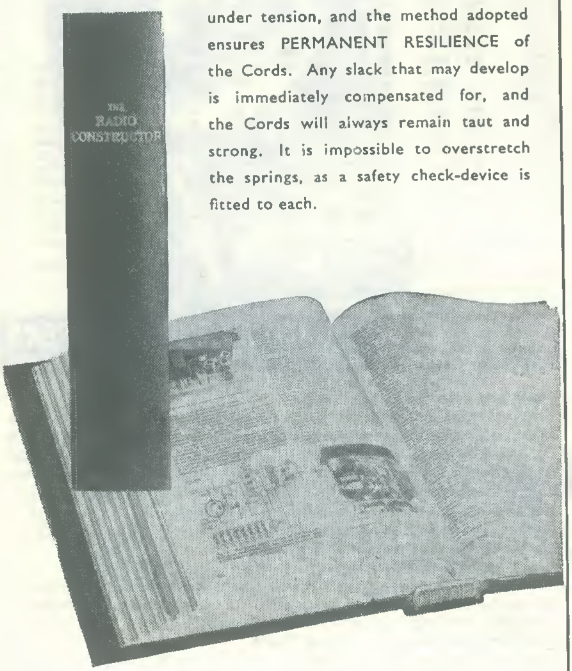

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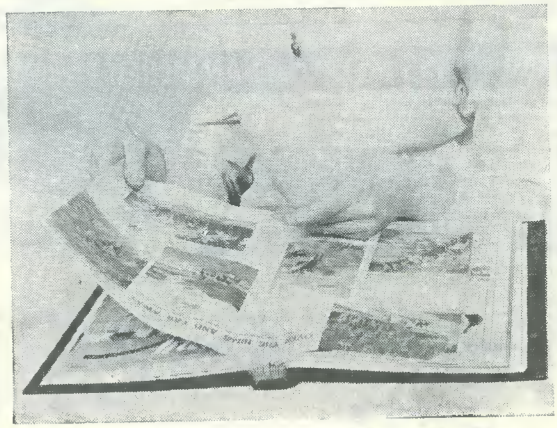

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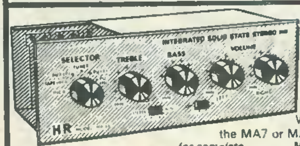

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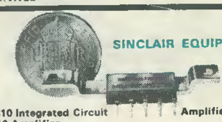

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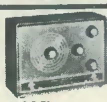

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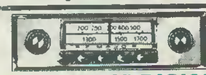

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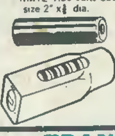

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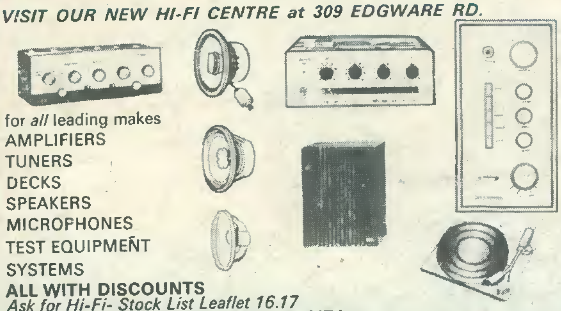

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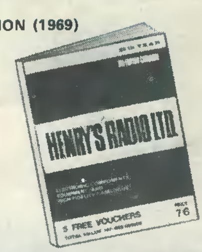

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