THE
RADIO CONSTRUCTOR

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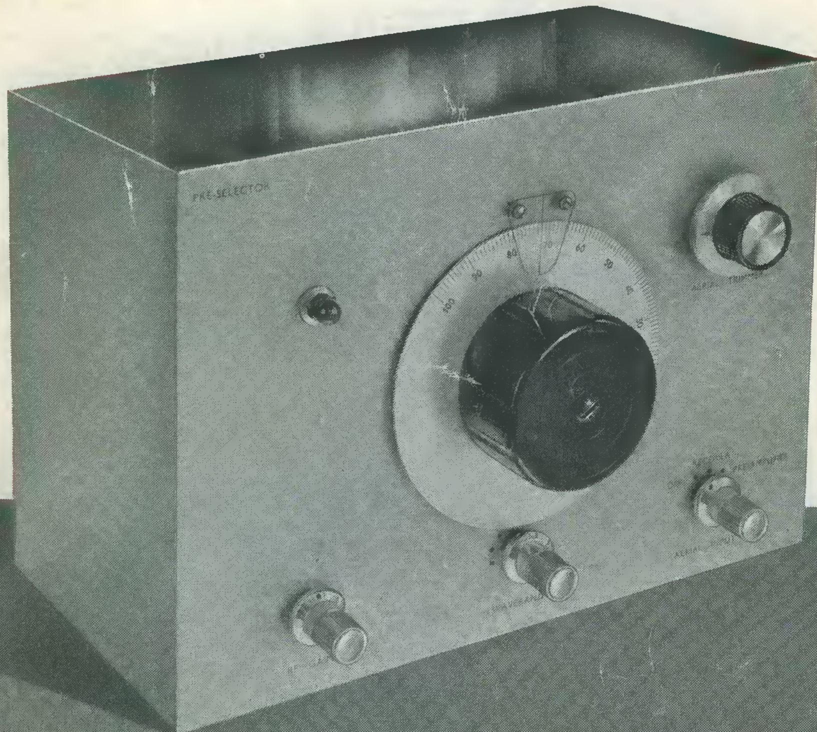
2/6

A DATA PUBLICATION

RADIO . TELEVISION
ELECTRONICS . AUDIO

3-STAGE PRESELECTOR



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500	4/–	6/6	9/6	30/–
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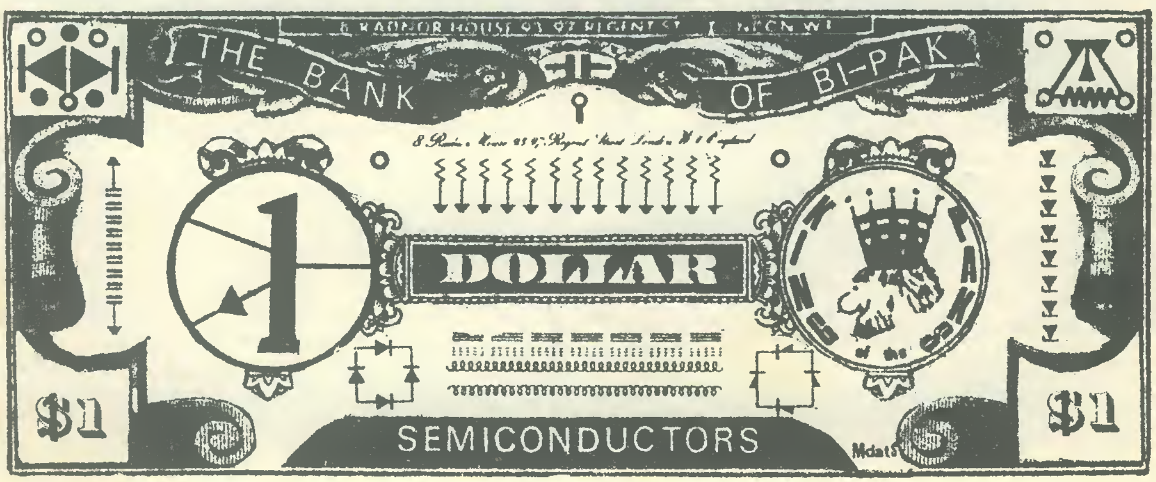

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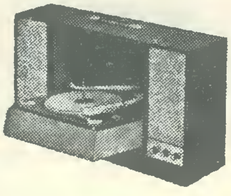

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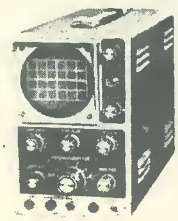

OS-2

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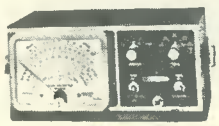

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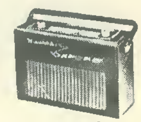

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FM Tuner

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12 × 12 watts output.

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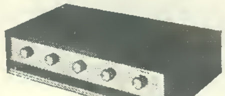

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FOR THIS SPECIFICATION

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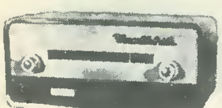
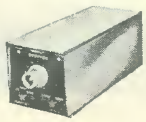


FM TUNER FM-4U



STEREO DECODER SD-1

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit **£16.8.0**
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SPEAKER SYSTEMS

SSU-1

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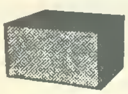
Ducted-port bass reflex cabinet in the white: Two speakers, vertical or horizontal models with legs. **KIT £12.12.0,** without legs, **KIT £11.17.6** incl. PT.



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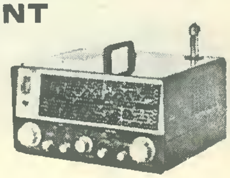
"AMATEUR" EQUIPMENT



GC-1U

THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transfilters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial. Kit **£37.17.6** Assembled **£45.17.6**

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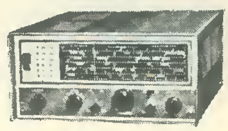

RG-1

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained. Kit **£81.10.0** Assembled **£106.15.0**

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Kit (with handsome finished cabinet) **£18.19.0**

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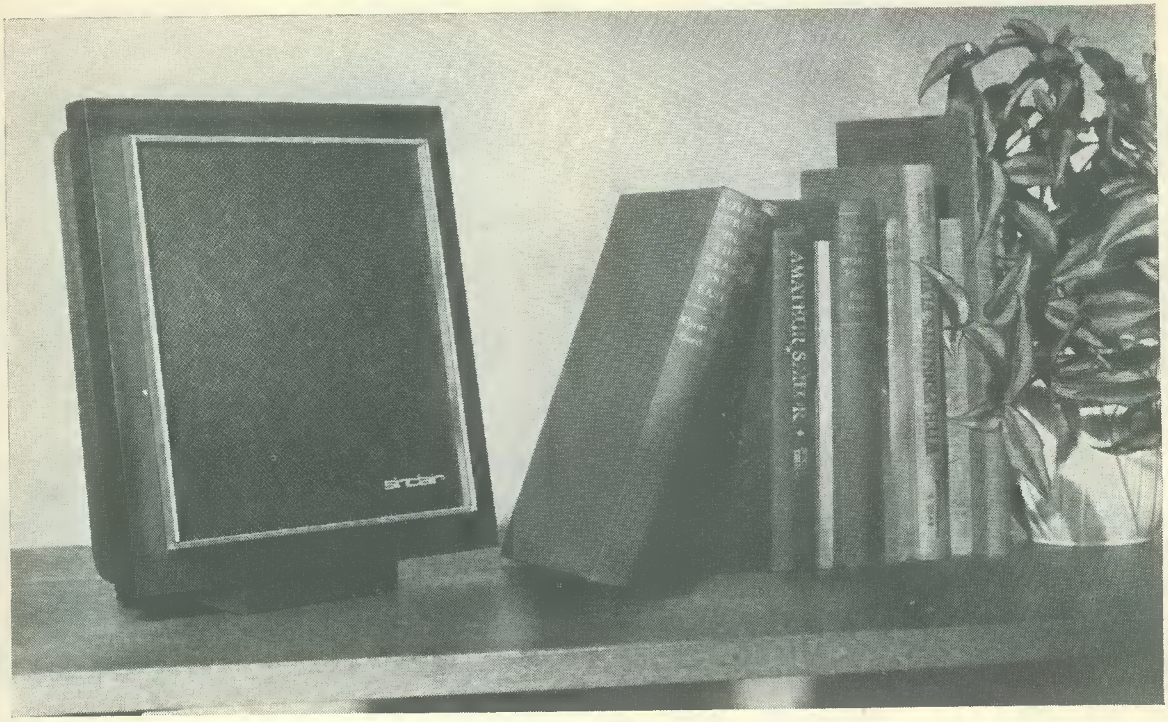

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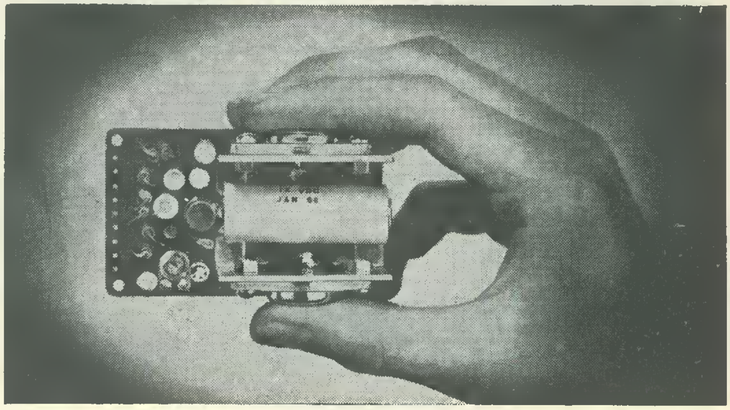

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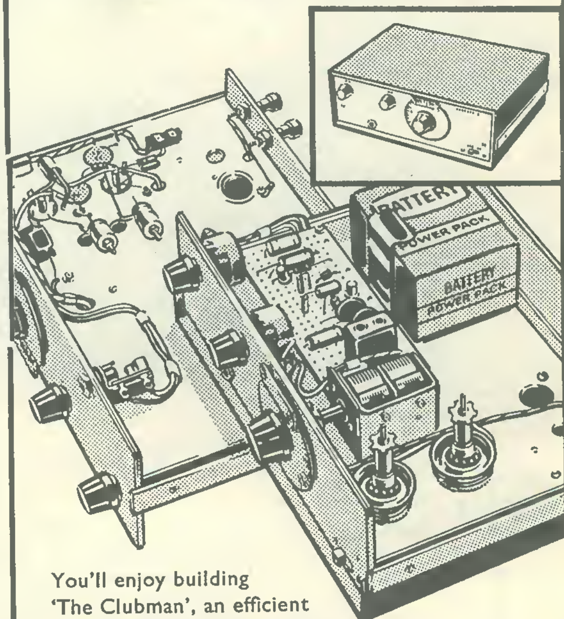

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ELECTRONIC

This article describes an ingenious warning device which immediately catches the attention of the continually varying output frequency that it generates. Particularly noteworthy features of the circuit are the use of a complementary 2-transistor multivibrator and the fact that all components remain connected across the battery when the oscillator is not actuated. To obtain the exceptionally low standby current given with the prototype, it may be necessary to select transistors and electrolytic capacitors for low leakage current

THIS USEFUL LITTLE CIRCUIT, WHICH COSTS ABOUT fifty shillings to build, incorporates a number of unique design features and gives a performance that is unlike that of any commercially available electronic siren. The circuit is permanently connected to a 9 volt battery supply, but generates no sound until a Start switch is operated. The circuit consumes a total current of less than 1μA when in the standby condition, so that the life of the battery is virtually equal to its shelf life under this condition.

When the Start switch is closed the siren generates a rich "gliding" tone which starts at a low frequency and builds up to a frequency of a few kilocycles per second over a period of 15 to 20 seconds, after which time the tone frequency stabilises. When the Start switch is opened the tone falls slowly in frequency, dying away completely after 20 to 30 seconds. Thus, the sound of the electronic siren is very similar to that of the air-raid sirens used during the last war.

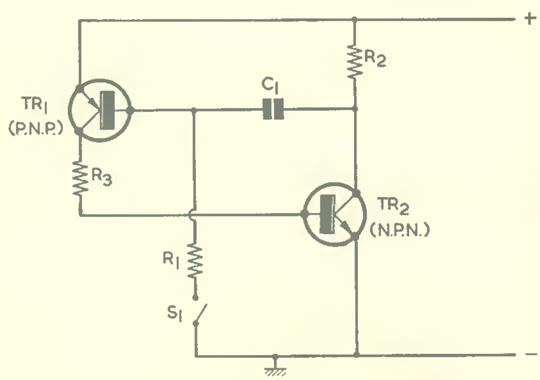


Fig. 1. The basic astable complementary multivibrator circuit which is used in the siren

The circuit incorporates a pre-set volume control, and the maximum output power is equal to about 250mW r.m.s. Although this output level is not sufficient to attract the attention of the police, etc., it is sufficient to frighten away an intruder, and the device can thus be used as a burglar alarm. The unit is, however, primarily intended for normal domestic use to replace a bell or buzzer, and it has a distinct advantage over these alternative types of warning device since its varying tone is far more effective in attracting attention.

The electronic siren is ideally suited to operation by devices such as fire or smoke detectors, rain operated switches and proximity detectors.

Circuit Operation

The circuit is developed from the basic astable complementary multivibrator shown in Fig. 1, in which either both transistors are *on* or both transistors are *off*. The circuit operates in the following manner.

Base current to TR_1 is derived from the negative supply line via R_1, and base current to TR_2 is derived from the positive supply line via R_3 and TR_1. Thus, if S_1 is open-circuit no base current will flow to TR_1 and this transistor will be cut off and, since TR_1 is cut off, no base current can flow in TR_2 and that transistor will be cut off also. If S_1 is now closed TR_1 will begin to conduct, thereby supplying base current to TR_2 and driving that transistor hard on; as TR_2 is driven hard on a large part of the supply voltage will be dropped across R_2, causing TR_2 collector to move towards zero volts with respect to the negative supply line. This excursion will be communicated to TR_1 base via C_1, thereby driving TR_1 hard on, until both transistors become saturated. C_1 then charges up rapidly via the two transistors until a point is reached at which the base current of TR_1 starts

SIREN

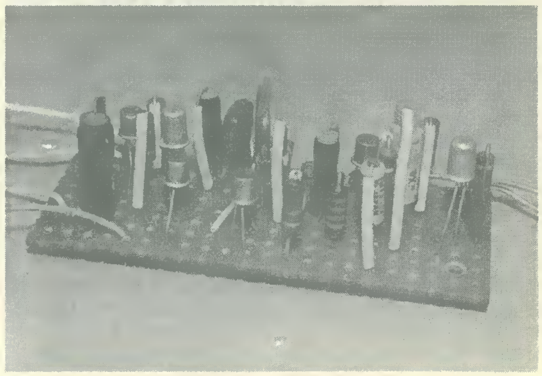
by W. Kemp

to decrease. This decrease in current is then transmitted, in amplified form by way of TR_2, R_2 and C_1, back to TR_1 base, so that a regenerative action takes place and both transistors cut off. C_1 then discharges, with a fairly long time constant, via R_1, until TR_1 just begins to conduct again, and the cycle then repeats itself *ad infinitum*. A rectangular waveform, with a wide mark-space ratio, is generated by the circuit.

The frequency of operation of the circuit can be altered by varying the basic base current of TR_1, this being achieved by either varying the value of R_1 or the voltage that is fed to the low end of R_1. In either case the frequency of operation will rise as the base current is increased, i.e. as R_1 is reduced, or as the low end of R_1 is made more negative.

The circuit can be switched off either by disconnecting the battery supply, or by opening S_1. In the latter case both transistors will switch off, and the only current consumed will be the leakage currents of TR_1 and TR_2 which, assuming that silicon transistors are used, will normally be less than $1\mu A$.

The full circuit diagram of the electronic siren is shown in Fig. 2. Here, TR_1, TR_2, R_2, R_3 and C_1 correspond to the similarly marked components of Fig. 1, but the main timing resistor is split into two parts given by R_1 and R_5. The junction of these two resistors is connected to the positive supply



The neat and compact appearance of the completed unit may be readily judged from this view of the prototype

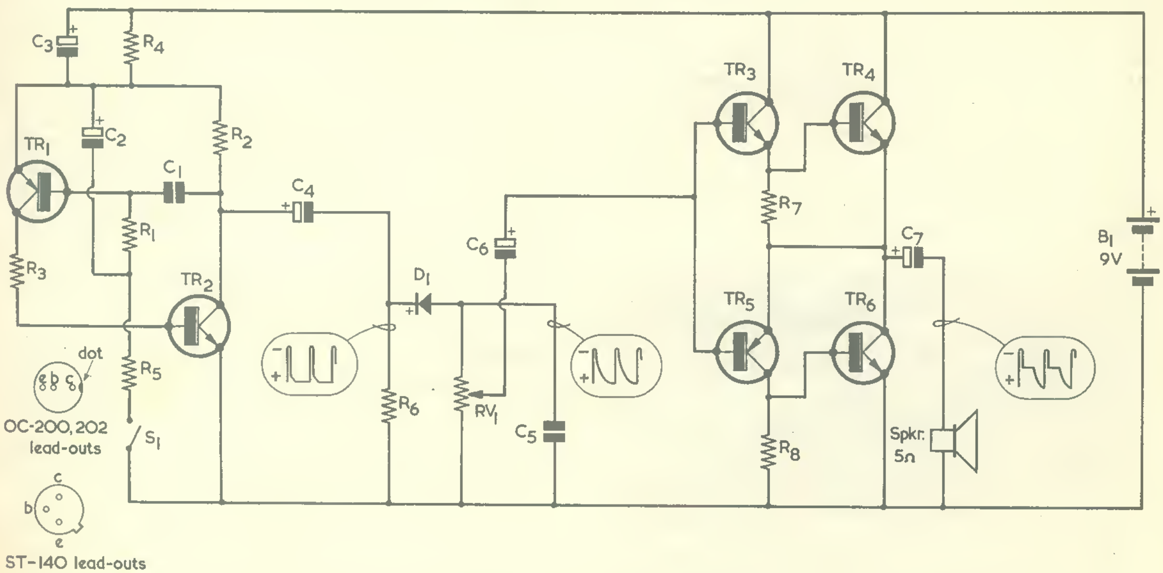


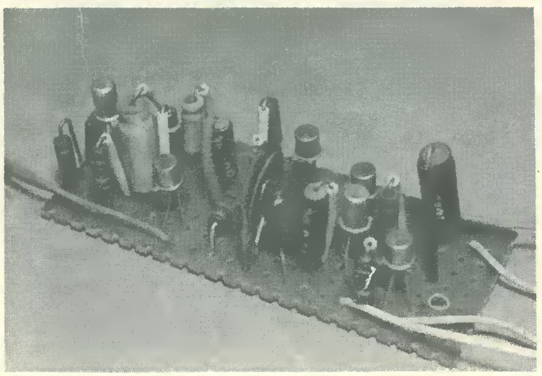
Fig. 2. Complete circuit diagram for the electronic siren. Note that there is no on-off switch with the battery

line via C_2 and C_3, R_4. Thus, at the moment that S_1 is closed, C_2 will be discharged and the potential at the junction of R_1 and R_5 will be close to that of the positive supply line, with the result that the circuit will oscillate at a fairly low frequency. C_2 will then charge up via R_5 so that the potential at the junction of R_1 and R_5 will move negative in an exponential fashion, causing the operating frequency to rise in a similar manner, until finally C_2 will be fully charged and the operating frequency becomes stabilised. When S_1 is reopened, C_2 will discharge itself via R_1 and the emitter-base junction of TR_1, causing the frequency of operation to decay in an exponential manner until C_2 is fully discharged, whereupon the circuit ceases to operate.

C_3 and R_4 supply a degree of d.c. negative feedback to the oscillator, enabling the circuit to operate correctly over a wide range of transistor gain spreads. The final stabilised oscillation frequency is controlled by C_1, while the period of the rising siren effect is controlled by C_2 and R_5, and that of the falling siren effect by C_2 and R_1.

The waveform generated by the oscillator is of rectangular form, as shown, but has a wide mark-space ratio so that although the peak amplitude of the signal is quite large the mean value is fairly small. This snag is to some degree overcome by feeding the signal from TR_2 collector to R_6 via C_4, and then on to the shaping circuit given by D_1, RV_1 and C_5. This circuit modifies the waveform as shown and increases its mean value. A portion of this modified waveform is taken from the slider of RV_1, which acts as a volume control, and fed to the power amplifier stage via C_6.

The power amplifier stage comprises TR_3, TR_4, TR_5, TR_6, TR_7 and R_8, these being wired in the well-known complementary emitter follower mode. The amplifier stage gives near-unity voltage gain with a very low output impedance, whereupon this output is used to drive the 5Ω speaker via C_7. The present circuit is unusual, however, in that no base-biasing is applied to the transistors, so that, in the absence of an input signal, all transistors are cut off and consume negligible current from the supply. The absence of base-biasing on the transistors results in considerable crossover distortion, which proves to be an advantage in this particular application since it modifies the output waveform as illustrated and thereby increases the mean power of the signal. Also, the crossover distortion increases the harmonics in the output and thereby harshens the quality of the siren.



From the output waveform shown in Fig. 2 it can be seen that a very large pulse or spike of current is fed into the speaker, and it is the magnitude of this spike that limits the available mean output power to 250mW. It is important to note that the speaker used must have an impedance of 5Ω or greater, and that a 9 volt supply must be used. *Do not use a speaker impedance less than* 5Ω, *nor a supply voltage in excess of* 9 *volts.**

The standby current of the circuit (with S_1 open) is of the order of 1μA, the actual current measured on the prototype being 0.6μA at normal room temperature.

Construction

Before starting construction of the unit, a check should be carried out on all transistors to ensure that they have leakage currents, with base open-circuit, of less than 1μA when connected across a 6 volt supply. In practice, it will usually be found that leakage currents are so small that no reading can be obtained on a standard meter. It should be noted that the completed circuit will still work perfectly well even if all transistors have leakage currents of several μA, but that the standby current of the unit will then be correspondingly higher.

The unit is wired up on a small piece of Veroboard, which measures 1⅞ x 3⅜in and has 0.15in hole spacing, and construction should be started by cutting this panel to size and drilling the two small mounting holes, to clear 6BA screws, as shown in Fig. 3. The copper strips should then be broken, with the aid of a small drill or the special cutting tool that is available, in the positions indicated.

The components and leads, etc., should be soldered in place on the blank side of the panel in the positions indicated in the lower part of Fig. 3 and here it should be noted that all components other than R_6 are mounted vertically and that insulated sleeving should be used where there is any danger of components short-circuiting against one another. Also, the mounting legs of RV_1 should be reduced in width with the aid of a small file, so that they fit in the holes in the panel, before attempting to solder this component in place.

It is recommended that the wiring up be carried out in a number of stages, so that each section of the circuit can be checked and tested for faults before proceeding with the next stage. The following procedure may then be carried out.

Wire TR_1, TR_2, R_1, R_2, R_3, R_4, R_5, C_1, C_3, C_4, S_1 (complete with leads), and the positive and negative battery supply leads in place on the panel. Do *not* solder C_2 in place at this stage. Now

*If desired, transistors TR_4 and TR_6 could be fitted with small cooling fins to increase dissipation. Since the metal cases of the transistors specified are common to their collectors, these fins must not touch each other or any other connections or wiring in the circuit. —Editor.

COMPONENTS

Resistors
(All fixed values ½ watt 10%)

R_1 120kΩ
R_2 270Ω
R_3 180Ω
R_4 1kΩ
R_5 82kΩ
R_6 1kΩ
R_7 820Ω
R_8 820Ω
RV_1 5kΩ, skeleton pre-set potentiometer

Capacitors
(All electrolytic capacitors should be good-quality low-leakage types)

C_1 0.01μF
C_2 100μF electrolytic, 12V wkg.
C_3 1μF electrolytic, 12V wkg.
C_4 16μF electrolytic, 12V wkg.
C_5 0.1μF
C_6 16μF electrolytic, 12V wkg.
C_7 100 to 250μF electrolytic, 12V wkg.

Semiconductors

TR_1 OC200 or OC202 (Mullard)
TR_2 ST140 (Sinclair)
TR_3 ST140 (Sinclair)
TR_4 ST140 (Sinclair)
TR_5 OC200 or OC202 (Mullard)
TR_6 ST140 (Sinclair)
D_1 OA200 or OA202 (Mullard)

Switch

S_1 s.p.s.t. switch (see text)

Battery

B_1 9-volt battery

Miscellaneous

Loudspeaker, 5Ω impedance or greater
Veroboard, 0.15in matrix, dimensions as in Fig. 3
Connecting wire, sleeving, etc.

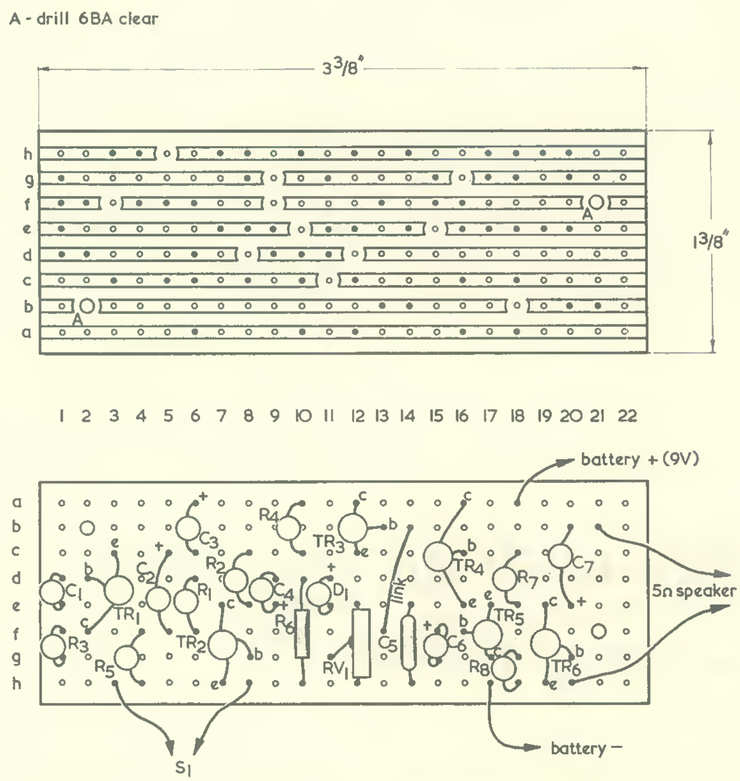


Fig. 3. The upper section of this diagram illustrates the manner in which the copper strips are cut, whilst the lower section shows the components mounted in position on the Veroboard

temporarily connect a crystal earpiece between the negative supply line and the negative side of C_4 and, with S_1 open, connect the 9 volt battery in place and check that the circuit draws a current of less than 2μA. Next, close S_1 and check that a powerful and steady tone is heard in the earpiece, and that the circuit draws a current of approximately 1 to 2mA. If the circuit does not pass these tests, a fault is indicated and this should be cleared up before proceeding with the next stage of construction.

When the above checks have been completed satisfactorily, S_1 should be opened and C_2 should be soldered in place. When S_1 is closed again, the tone should, after a fraction of a second, start to operate at a fairly low frequency and then begin to rise until, after a period of approximately 15 to 20 seconds, it stabilises at a fairly high frequency. When S_1 is opened again the tone should decay in frequency, dying away after about 20 to 30 seconds. The supply current should then decay slowly to less than 2μA.

Remove the crystal earpiece from the circuit and solder R_6, D_1, RV_1, C_5, and C_6 in place, and then, reconnect the earpiece between the negative supply line and the positive side of C_6. Check that the siren operates in the manner already described by closing and opening S_1, and that the volume of the signal can be varied by means of RV_1. If results are satisfactory, remove the earpiece from the circuit.

Now wire TR_3, TR_4, TR_5, TR_6, R_7, R_8, C_7 and the link in place and, with S_1 open, check that the total current consumed by the unit is less than 4μA. It should be noted that, initially, the capacitors in the circuit may be only partially formed so that a fairly high current reading is obtained, but that the current should slowly decay to the above figure within a few minutes. In practice, an eventual total reading of less than 1μA can be expected if good quality capacitors are used.

If this test is satisfactory, connect the 5Ω speaker in place and check that there is no significant increase in current, apart from a momentary surge as the connection is made. If there is a significant and sustained increase in current, a high-leakage capacitor in the C_7 position is indicated, and this component should be replaced.

Finally, a check should be made that the siren operates in the manner already described by closing and opening S_1, and ensuring that a reasonably high volume (about 250mW) of output is available. Also confirm that the volume can be varied by means of RV_1, which can be pre-set to give the required level of output volume. The circuit is then complete and ready for use.

Using The Unit

The unit can, if required, be mounted in a case or to a small chassis by passing 6BA screws through the two small mounting holes that are provided and securing these to the chassis. Fit two small rubber grommets to act as spacer-insulators between the copper side of the Veroboard and the surface to which it is secured. If the Veroboard is mounted in this fashion, clear the copper away from the 6BA holes (at points adjacent to 20f and 3b in Fig. 3) so that there is no risk of short-circuits to the mounting screws.

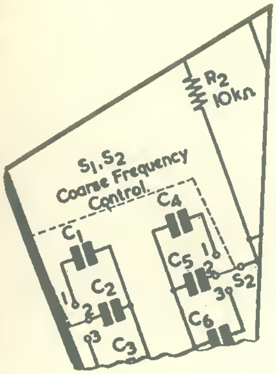
In practice, S_1 may be replaced by a microswitch or the contacts of a relay, so that the unit can be operated (using the microswitch) by the opening of doors or windows, etc. or (using the relay) by electronic devices such as rain detectors, smoke or flame detectors, proximity switches, etc. Several microswitches or sets of relay contacts can, if preferred, be wired in parallel across the S_1 position, thereby enabling the siren to be activated by any one of a number of "detector" devices.

The unit should be permanently connected to its 9V battery. The standby current is so small that, when using a small PP3 battery, a theoretical battery "life" of approximately 10 years is available! In practice, of course, the shelf life of a normal battery is considerably less than this, so that the "ideal" 10 years of life cannot be obtained.

We wish all our readers

a very Happy Christmas

and a Prosperous New Year—Editor



S.C./O.C. Tester Using an I.C.

SUGGESTED CIRCUIT No. 205

by G. A. FRENCH

Now that integrated circuits (I.C.'s) are becoming available through home-constructor retail channels at prices comparable with the discrete transistors, diodes and resistors which they replace, it becomes an interesting challenge to find simple applications for them which take utmost advantage of their unique characteristics.

The low cost I.C.'s available at the time of writing are primarily intended for digital computer and control functions, and the writer felt it would be worthwhile devoting this month's article to a device which employed an I.C. in a circuit application fairly similar to that for which it was originally designed. The main intention was to use as much of the internal circuitry of the I.C. as was possible, reducing external components to a minimum. The resultant device would then be roughly comparable in cost with a similar circuit using separate silicon transistors, as well as being smaller and involving much less work in wiring and connecting up. Perhaps most important of all, however, the device would enable practical experience to be obtained with a fascinating new development which may well, in the future, completely alter the world of electronics as we see it today.

The Integrated Circuit

The integrated circuit chosen by the writer was the Fairchild μL914 Dual Gate, this incorporating 4 n.p.n. transistors and 6 resistors in two separate gate functions. This I.C. is available from advertisers in this journal. The μL914 has an epoxy resin encapsulation which provides a circular housing with a diameter of about 0.3in and a height of about 0.15in. Connections are made by way of 8 lead-outs projecting from the lower surface of the housing.

The internal circuitry of the μL914 is shown in Fig. 1 (in which the designations TR_1 to TR_4 have been added for convenience of explanation here). In normal use, terminal 8 connects to a positive source of supply and terminal 4 to a negative source of supply. The appropriate transistor inside the I.C. then becomes conductive when any of the terminals 1, 2, 3 or 5 are made positive. As may be seen, TR_1 and TR_2 can function, for instance, as a NAND gate. The output, at terminal 7, will only go positive when both terminals 1 *and* 2 are negative. Other gate functions offered by two transistors with their collectors connected to a common output are also readily obtained. Transistors TR_3 and TR_4 offer similar gate facilities, and since they operate independently of TR_1 and TR_2 the I.C. is described as a "dual gate."

The application which forms the subject for this month's "Suggested Circuit" appears in Fig. 2. The device shown in this diagram is a tester for intermittent short-circuits or open-circuits and will give an indication even if the short-circuit or open-circuit exists for less than

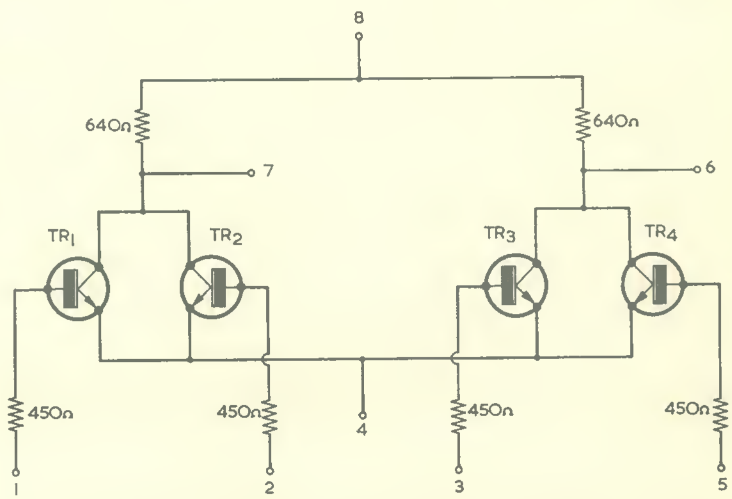


Fig. 1. The internal circuitry of the integrated circuit used in the tester

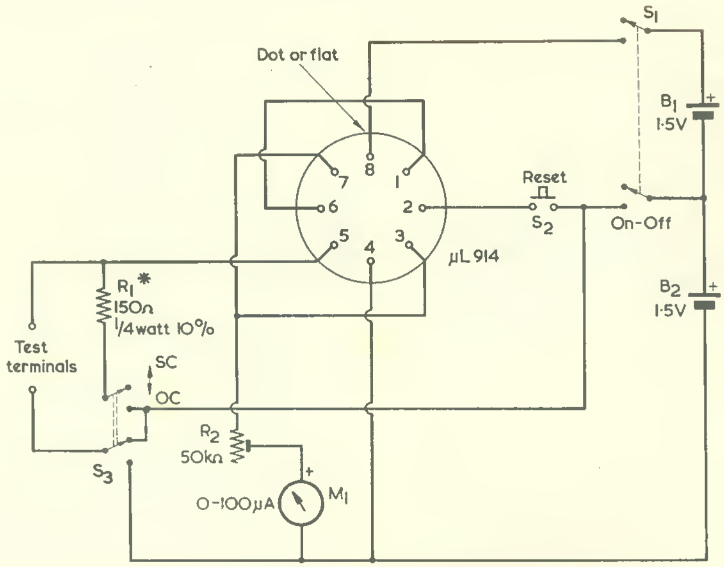


Fig. 2. The circuit of the tester. Note the small quantity of components external to the integrated circuit

a microsecond. The μL914 integrated circuit is represented by the circle which encloses its terminals (1 to 8) and it will be seen that, apart from the supply, the only external components are the on-off switch, a Reset button, a function switch, a voltmeter (M_1 and R_2) and a resistor.

To understand how the circuit of Fig. 2 operates, it is necessary to refer back to Fig. 1. It is helpful, also, to look upon all supply voltages as being with reference to the negative supply line given by the negative terminal of cell B_2. Terminal 4 of the I.C. connects to this negative supply line whilst terminal 8 connects, via one pole of on-off switch S_1, to the 3 volts positive given by the two 1.5 volt cells in series. Thus, the emitters of all four transistors in Fig. 1 are connected to the negative supply line and the upper ends of the two 640Ω resistors are connected to 3 volts positive.

In Fig. 2, terminal 1 is connected to terminal 6. This connection results in the base of TR_1 (Fig. 1) being connected, via its series 450Ω resistor, to the collector of TR_3. Similarly, terminal 3 of the I.C. is connected to terminal 7, which means that the base of TR_3 is connected, via its series 450Ω resistor, to the collector of TR_1.

We thus have transistors TR_1 and TR_3 coupled together in the following fashion: TR_1 base is d.c. coupled to TR_3 collector, and TR_3 base is d.c. coupled to TR_1 collector. As a result, TR_1 and TR_3 form a flip-flop which can exist in one of two stable states. One of these is TR_1 conductive and TR_3 non-conductive, and the other is TR_3 conductive and TR_1 non-conductive.

For the present application it is necessary to know in which of the two states the flip-flop exists at any moment, and the simplest way of obtaining this information is to connect a voltmeter between either of the two collectors and the negative supply line. In Fig. 2 the voltmeter is given by R_2 and the 0—100μA meter M_1, and is connected to terminal 7 of the I.C. In consequence, the voltmeter indicates the voltage on the collector of TR_1. R_2 is adjusted so that the meter gives its full-scale deflection of 100μA when TR_1 is non-conductive; and it was found with the prototype circuit that the reading given when TR_1 became conductive was then approximately 8μA. The current drawn by M_1 does not affect the functioning of the flip-flop.

It is possible to change the flip-flop from one state to the other by applying 1.5 volts positive to the 450Ω resistor in series with the base of TR_2 or TR_4 as applicable. If TR_1 is non-conductive and 1.5 volts positive is applied to terminal 2, TR_2 becomes conductive, reduces the voltage on TR_1 collector and causes the flip-flop to change over. On removal of the 1.5 volts positive from terminal 2, TR_1 remains conductive and TR_3 remains non-conductive. To bring the flip-flop back to its previous state, 1.5 volts positive is applied to terminal 5. Transistor TR_4 then becomes conductive, reduces the voltage on TR_3 collector and the flip-flop changes over again, remaining in its first state after the 1.5 volts positive has been removed.

To summarise overall operation it may now seen be that, if 1.5 volts positive is applied to terminal 2, TR_1 becomes conductive and a reading lower than 10μA is given in meter M_1. If, then, 1.5 volts positive is applied to terminal 5, TR_1 becomes non-conductive and meter M_1 gives full-scale deflection.

In the tester being described, full-scale deflection in M_1 indicates the fault condition.

Short-Circuit Testing

The function of push-button S_2 is to reset the flip-flop to the condition which corresponds to a low reading in the meter, and it does this by applying 1.5 volts positive from cell B_2 to terminal 2 of the I.C. After the flip-flop has been reset by S_2, further pressing of this switch has no effect.

When function switch S_3 is in the upper position ("S.C.") a short-circuit applied to the test terminals causes 1.5 volts positive to be applied to terminal 5. Even if the short-circuit exists for only a microsecond the flip-flop will change over and cause the meter to give full-scale deflection. This reading will be maintained until the Reset button is pressed. If, however, there is a continual short-circuit across the test terminals the meter will revert to f.s.d. as soon as the Reset button is released.

To check for open-circuits S_3 is set to the lower position ("O.C."), whereupon the lower test terminal connects to the negative supply line and R_1 connects to the 1.5 volt positive line. If a connection exists across the test terminals, a current of 10mA will then flow through R_1 and the circuit across the test terminals. Under this condition terminal 5 of the I.C. is at the same potential as the negative supply line, whereupon the flip-flop is in the state which causes a low reading to be given in the meter. Should the connection between the test terminals become open-circuit, terminal 5 will be at once connected to 1.5 volts positive via R_1, the flip-flop will change over and the meter will give an f.s.d. reading. This reading will be maintained even if the open-circuit existed for only a microsecond.

Because of the risk of damage if high voltages were applied to terminal 5 of the I.C. it would be advisable to avoid carrying out the open-circuit test on high value iron-cored inductors. If capacitors are connected to the test terminals, they *must* be fully discharged first. Capacitors of the order of $0.05\mu F$ and higher will probably cause the flip-flop to trip when initially applied to the test terminals for a short-circuit test, but it should be found that, after pressing the Reset button, they will have acquired sufficient charge to enable the flip-flop to subsequently remain in the correct state for testing.

The open-circuit test will be particularly useful for checking plugs and sockets. One test terminal is connected to the plug and one to the socket. Any intermittent open-circuit which occurs if the plug is moved around inside its socket will then be at once indicated. The open-circuit test will also be helpful for checking r.f. coils and r.f. chokes, since light pressure can be applied to the windings and solder terminations whilst the tester is connected.

Components

The most important component in the circuit is, of course, the I.C. itself, and this should be treated with reasonable care during construction. Its 8 lead-outs will need to be splayed out for wiring up and they should not be bent close to the point where they leave the housing. The lead-out surface enables instant tinning to occur when the soldering iron is applied. A heat shunt is advisable if any but extremely quick solder connections are to be made.

The published information on the μL914 refers to terminal 8 as being identified by a coloured dot. With the I.C. employed by the writer, however, terminal 8 was identified by a flat on the housing. The μL914 leadouts have the positioning shown in Fig. 2, the numbers proceeding clockwise from terminal 8. *It is important to note that, in Fig. 2, the lead-outs are pointing towards the reader.* Published information on this I.C. normally shows lead-out positioning from the top of the device, with leads projecting away from the reader.

The only other components which require special mention in Fig. 2 are S_3 and R_2. S_3 may be a miniature d.p.d.t. slide switch but care should be taken to ensure that it is of a type which allows one contact to break before the other makes. Otherwise, B_2 will be momentarily short-circuited by the lower section of the switch (see Fig. 2) as it is changed from one position to the other. With reference to R_2, this should be set to insert maximum resistance when switching on the tester for the first time. The rather low readings initially given in M_1 should still be adequate to show whether the flip-flop is working correctly. The flip-flop is then put in the state where TR_1 is non-conductive, and R_2 is adjusted for f.s.d. in the meter. If desired, R_2 may be replaced afterwards by a fixed $\frac{1}{4}$ watt resistor of the appropriate value. In the prototype, the final adjusted value in R_2 was $17k\Omega$.

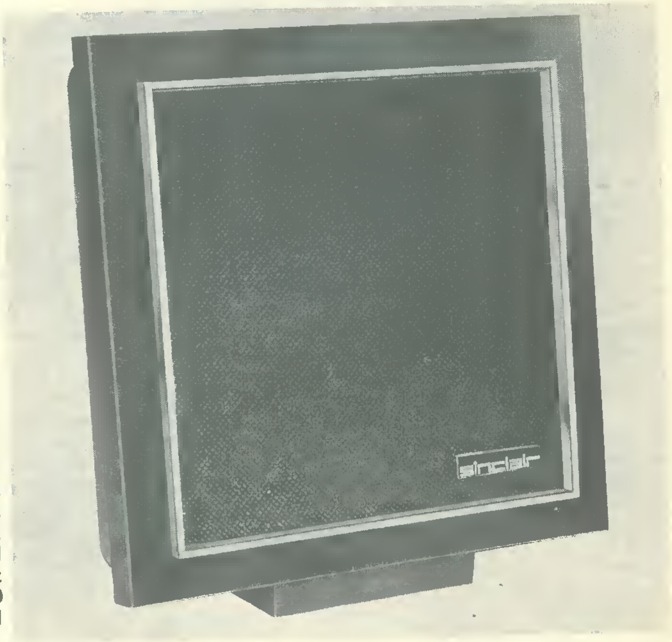
Due to the small quantity of components, the completed unit may be assembled in an extremely small case. With the prototype, the current drawn from the 3 volt supply by the flip-flop in either state was slightly in excess of 5mA. An additional 10mA was drawn from B_2 when the open-circuit test facility was selected. These low currents can be adequately provided by small 1.5 volt cells.

1969 Radio and Electronic Components Show

At a recent meeting of the Council of the Radio and Electronic Component Manufacturers' Federation it was decided unanimously to give international status to the Radio and Electronic Components Show by admitting foreign exhibitors and products. The Regulations for the next Exhibition, which will be held at Olympia in May 1969, sponsored by the Federation and organised by Industrial Exhibitions Limited, will be amended accordingly.

The decision is the outcome of discussions in recent months which have taken account of opinions expressed by exhibitors and visitors during and subsequent to this year's exhibition at Olympia. A referendum conducted by the Federation early in August among R.E.C.M.F. exhibitors and non-member exhibitors produced a decisive vote in favour of relaxing the restrictions on the display of foreign components and materials.

TRADE NEWS



● Sinclair 'Q14' Hi-Fi Speaker

Sinclair Radionics have announced a compact high fidelity loudspeaker to compliment its popular line of micro and sub miniature receivers and amplifiers which have proved so successful for the Cambridge firm.

Called the 'Q.14', the comparatively small ($9\frac{1}{2}$ in x $9\frac{1}{2}$ in square by $4\frac{3}{4}$ in deep) loudspeaker marks a decided departure from conventional loudspeaker design. High density materials are used in the construction of the cabinet which takes maximum advantage of modern bonding techniques to ensure freedom from resonances in the baffling. Additionally, the moulded, permanently sealed sound chamber has been contoured to best suit the characteristics of the driver unit, an 11,000 gauss ultra-high compliance speaker designed specially for this application.

The 'Q.14' maintains a smooth level of response between 60 and 16,000 cycles per second, is inherently free from 'boominess' under speech conditions, and will accept up to 14 watts peaks (r.m.s.) at 1,000 cycles. Full frequency response is 45 to 18,000 c.p.s. The impedance is 15 ohms (8 ohms to special order).

Simplicity of appearance is the dominant theme used, as the black grill cloth is attractively finished with a surround of solid aluminium bars. The 'Q.14's' angled back allows it to be placed conveniently in wall corners when desired, and by omitting the removable base, a cluster formation of the speaker may be arranged to make a full-range p.a. assembly.

The 'Q.14' is supplied strongly boxed in fitted carton, and as with all Sinclair products, is fully guaranteed by the makers, Sinclair Radionics Limited, 22 Newmarket Road, Cambridge, Price is £6 19s. 6d. (inc. P.T.).

● Knight KG-640 Volt/Ohmeter

The Knight KG-640 Volt/Ohmeter assembled, and shown alongside one of the many "Knight-Kit" construction kits now being marketed in the UK exclusively by Electroniques (prop. STC Ltd.). "Knight-Kits" are easy to assemble kits which enable anyone, regardless of their technical knowledge, to construct professional standard electronic equipment. The KG-640 is a multi-range (57 ranges) instrument which features a $50\mu A$ taut-band movement fully protected against mechanical shock and electrical overload.

Solid-State Time Delay Unit

By B. T. Hathaway

A simple but reliable circuit offering a time delay ranging from 2 to 80 seconds. A particular feature of the design is the provision of a sharp relay energising characteristic which ensures that variations in relay operation do not adversely affect the length of timing periods

THIS VERSATILE LITTLE UNIT, WHICH USES ONLY three transistors, operates an external relay and gives an operating time delay which may be varied between 2 seconds and 80 seconds by means of a single built-in variable resistor. The circuit is designed to operate from a 9 volt battery supply, the current drawn depending mainly on the coil resistance of the relay employed.

External circuits can be operated via the unit's relay contacts, and the precise mode of operation

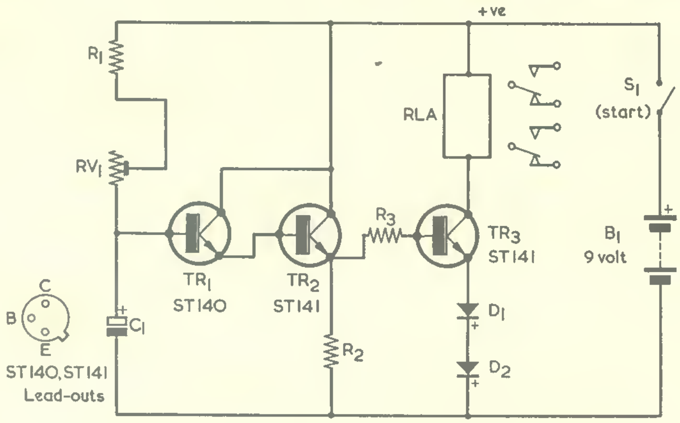


Fig. 1. The circuit of the solid-state time delay unit

COMPONENTS

(Fig. 1)

Resistors
(All fixed values ½ watt, 10%)
- R_1 22kΩ
- R_2 3.3kΩ
- R_3 470Ω
- RV_1 680kΩ, skeleton preset

Capacitor
- C_1 100μF electrolytic, 15V wkg.

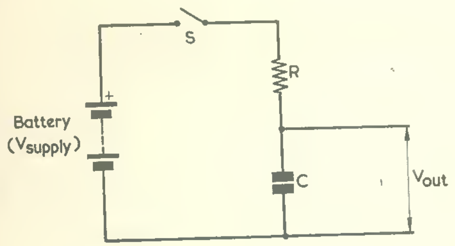
Semiconductors
- TR_1 ST140 (Sinclair)
- TR_2 ST141 (Sinclair)
- TR_3 ST141 (Sinclair)
- D_1 OA200 or OA202
- D_2 OA200 or OA202

Relay
- RLA. Any relay with suitable contacts capable of operating from *less* than 6 volts, with coil resistance in range 50Ω to 1,000Ω. (See text)

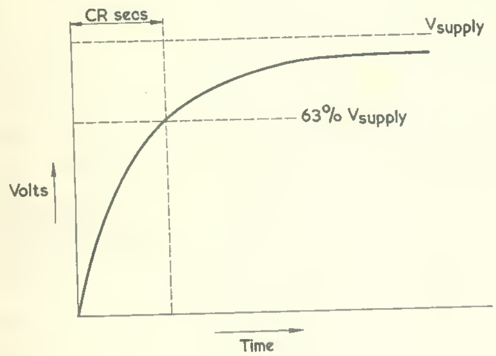
Switch
- S_1 s.p.s.t. on-off switch

Battery
- B_1 9-volt battery

Miscellaneous
- Veroboard panel, 0.15in matrix, dimensions as in Fig. 3
- Wire, sleeving, etc.



(a)



(b)

Fig. 2 (a). A basic CR circuit
(b). After closing S, the voltage across the capacitor follows the exponential curve shown here

can be varied to suit individual applications by wiring these contacts in suitable ways. The unit can, for example, be so arranged that there is an automatic time delay between the moment at which the Start switch is closed and the instant at which the external circuits are actually operated. Alternatively, the mode can be changed so that the external circuits are operated as soon as the Start switch is closed, switching off again automatically after a pre-determined period.

The Circuit

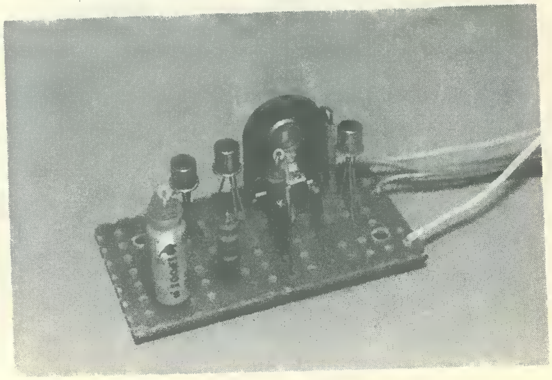
The full circuit diagram of the unit is shown in Fig. 1, and consists basically of a simple 2-stage (TR_1 and TR_2) "rising-voltage" generator which drives a voltage-sensitive transistor "switch" (TR_3) wired in series with the coil of the external relay, RLA. Although the circuit is fairly simple in appearance its operation is in fact moderately complicated, and to fully understand the principles involved we must first turn to some basic theory.

Fig. 2 (*a*) shows a basic CR time-constant circuit. Capacitor C is initially discharged. When S is closed current begins to flow in the circuit and the potential at the upper output terminal, which is initially at zero with respect to the lower terminal, begins to rise in a positive direction as shown in Fig. 2 (*b*). At first the output voltage rises sharply and in a fairly linear fashion with time, but this rate of rise soon slows down and becomes distinctly non-linear. When V_{out} is nearly equal to V_{supply}, there is only a negligible increase in V_{out} with time. The output voltage follows what is referred to as an exponential curve. Note that, after a time equal to C (in Farads) x R (in ohms) seconds, the output voltage has risen to 63% of V_{supply}. This represents the time constant.

The rising voltage that is available from the CR circuit could be used to operate an external device such as a relay, but in practice such a device would take too great a power if connected directly to the CR circuit. It is necessary for the output of the CR circuit to be fed to a high impedance device, which consumes only a negligible amount of power, and which, in turn, operates the relay.

Returning now to Fig. 1, we can see how this requirement is met. In this diagram the actual time constant circuit comprises R_1, RV_1 and C_1, and is variable. The output of this part of the unit is fed to TR_1, TR_2 and R_2. TR_1 and TR_2 comprise a Darlington or "Super-Alpha" pair and can be regarded as an emitter follower stage with a very high input impedance and low output impedance, and having unity voltage gain. Thus, a faithful copy of the exponential time constant curve appears across R_2. This is at a very low impedance level and can be used to drive a following low impedance stage without fear of upsetting the time constant action in R_1, RV_1 and C_1.

If we want the timing periods of the complete unit to be consistent, we must arrange things so that the relay is switched by a voltage that is on a fairly quickly-rising part of the exponential curve, and the present unit is, in fact, designed to "switch" at approximately 2.4 volts across C_1. To achieve this switching potential, we rely on the fact that a silicon diode commences to become conductive at forward voltages between 600 and 800mV. If a variable forward voltage is applied across a silicon diode and the diode current is measured, it will be found that virtually no forward current flows until the voltage reaches about 600 to 800mV. A small increase in forward voltage



Side view of the completed time-delay unit. Component positioning may be compared with Fig. 3

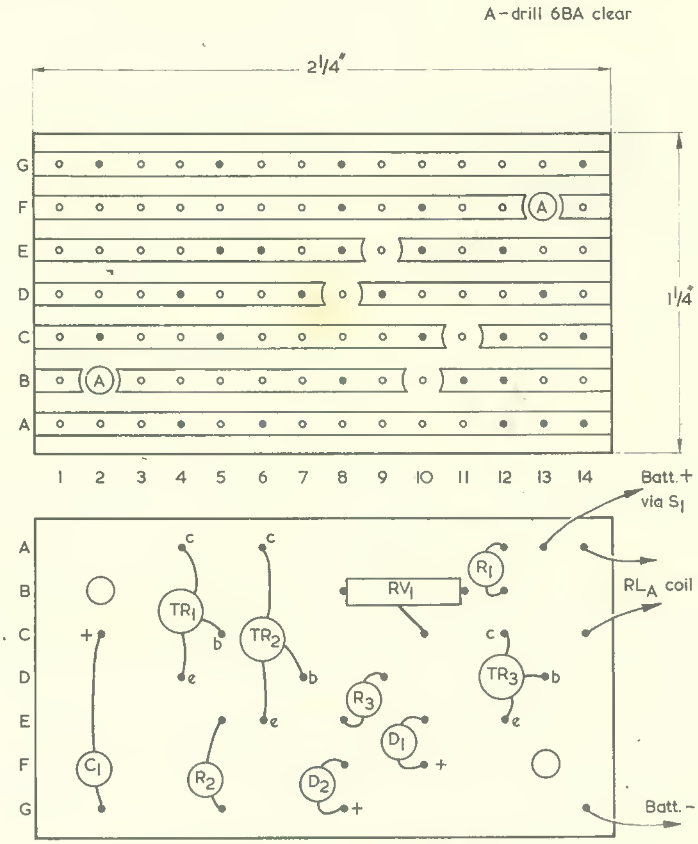


Fig. 3. Showing (above) the copper side of the Veroboard on which the delay unit is assembled and (below) the component side

above this level then results in a large increase in diode current. It should be noted that all silicon transistors have an effective internal "diode" between the base and the emitter, and that this "diode" exhibits the same characteristic.

In Fig. 1, D_1 and D_2 are in series with the TR_3 emitter-base "diode", so that forward current only begins to flow when the voltage at TR_3 base equals the sum of the voltages needed to produce forward current in each of the three diodes. In practice, forward current flows when a voltage of approximately 2.2 appears at TR_3 base. Thus, as the exponential rising voltage across R_2 increases, a similar voltage appears between TR_3 base and the negative supply line, but virtually no current flows in TR_3 until about 2.2 volts is reached. Once this voltage is reached, however, a further increase of only 200mV is needed to drive TR_3 sharply on and operate the relay that is used as its collector load. R_3, in series with TR_3 base, prevents excessive base current from damaging the transistor as the exponential voltage from R_2 rises above the "trigger" level for TR_3.

Using this system of relay operation a sharp switching action is obtained in TR_3 and consistent timing operations are obtained from the complete unit. It is important to note, however, that the specified transistors and diodes *must* be used in this circuit if correct operation is to be obtained.

A general specification for relay RLA is given in the Components List, and this offers a wide range of suitable components. Constructors who do not have a suitable relay to hand may note that a miniature type which would work satisfactorily is available from Henry's Radio Ltd. This has a coil resistance of 185Ω, operates at 4.5 to 9 volts and has 2-pole 2-way contacts rated at up to 2 amps.

Construction

The unit, less relay, is wired up on a small piece

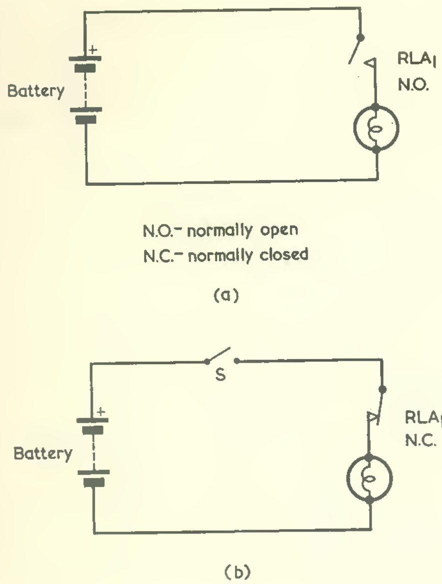


Fig. 4 (a). In this diagram, the relay contacts complete an external circuit on completion of the timing period

(b). A circuit in which the external circuit is completed during the timing period

of Veroboard panel with 0.15in hole spacing, and construction should be started by cutting this panel to size and drilling the two small mounting holes to clear 6BA screws, as shown in Fig. 3. Next, break the copper strips, with the aid of a small drill or the special cutting tool that is available, where indicated.

The components and leads can now be soldered in place on the panel, as shown in the lower view of Fig. 3. Note that all components are mounted vertically, and that insulated sleeving should be used where there is any danger of components short-circuiting against one another. The transistor cans should not touch each other as they are common to the collectors. The mounting legs of RV_1 should be reduced in diameter with the aid of a file, so that they fit in the holes in the panel, before attempting to solder this component in place.

When construction is complete, the unit can be given a functional check by wiring the external relay in place and connecting the 9 volt battery to the appropriate terminals via switch S_1. RV_1 should be adjusted to insert minimum resistance and S_1 should then be closed. If the circuit is functioning correctly, the relay should operate approximately 2 seconds after S_1 is closed. If this check is satisfactory, check that the delay period can be varied between approximately 2 seconds and 80 seconds by adjustment of RV_1, the circuit being re-set between each timing period by opening S_1 for a few seconds. If these tests are satisfactory, the unit can be considered as complete and ready for use.

It should be mentioned that variations in leakage current and capacitance between different components employed in the C_1 position may cause a slight alteration in the range of delay periods available.

Using The Unit

External circuits, employing lamps, etc., can be operated via the contacts of RLA, and alternative modes of operation can be selected by wiring these contacts in suitable ways. If, for example, it is required that there be a delay between the moment at which the Start switch is closed and the moment at which the external circuits are actually operated, the relay contacts should be wired as shown in Fig. 4 (*a*). If, on the other hand, it is required that the external circuit be operated as soon as the Start switch is closed, but switched off again after the pre-set period, the connections of Fig. 4 (*b*) should be used. In Fig. 4 (*b*), switch S may be S_1 of Fig. 1, or it may be a separate switch ganged with S_1 if it is not intended to use the 9-volt battery of Fig. 1 to power the external circuit. In both Figs. 4 (*a*) and (*b*) the external circuit is represented as a lamp. Note that the relay just referred to has two sets of change-over contacts. However, only one set of contacts is needed if the simple circuits of Figs. 4 (*a*) and (*b*) are to be used.

In both of the above cases, the time delay unit continues to consume power from its batteries until the Start switch is re-opened, and this may be undesirable in some applications. It may, for instance, be required that the circuit automatically disconnects itself from the supply once an operation is complete. This mode of operation can be achieved by using an additional relay, RLB, in the circuit shown in Fig. 5.

Here, the original Start switch is replaced by a push-button type. When S_1 of Fig. 5 is closed the supply is connected to RLB via normally closed contacts RLA1. Relay RLB operates, closing contacts RLB1 so that the relay stays on even when S_1 is released, and closing contacts RLB2 to complete the supply to the time delay unit. After the predetermined delay period, RLA will operate and

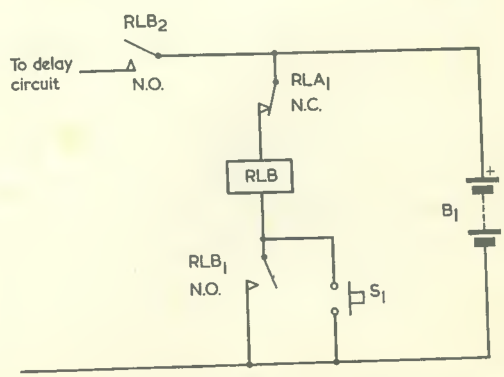


Fig. 5. By adding a second relay, the unit can switch itself off on completion of the timing period

contacts RLA1 will open, thereby breaking the supply to RLB so that RLB will de-energise. Contacts RLB2 will then open, breaking the supply to the time delay unit, while contacts RLB1 also open, ensuring that RLB will not switch on again automatically when contacts RLA1 close as the circuit re-sets itself. By using a third set of contacts (not shown) on relay RLB to control the external circuit, the arrangement of Fig. 5 offers the same facility as that of Fig. 4 (*b*).

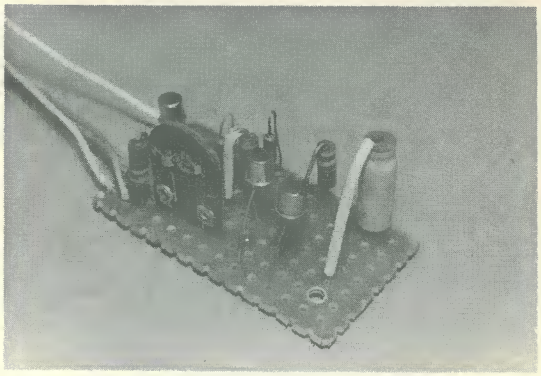
Relay RLB may be any 9 volt relay with three sets of changeover contacts.

Applications Of The Unit

The unit is versatile and offers quite a number of applications. A few are listed here.

(1). Porch light switching. Here, the porch light can be switched on manually but made to switch off automatically after a reasonable period, in which time the owner can find his door keys, etc. The light may also be switched on for a preset period during the arrival of guests, etc. The circuit of Fig. 5 should be used here, but ensure that the relay contact set which switches the porch light has insulation suitable for mains voltages.

(2). Car spot-lamp hold-on unit. In this case, the spot-light of a car can be operated in a manner similar to (1) above, enabling the owner to find his way up a driveway, etc., after parking in a poorly lit area.



Another view of the unit

(3). Photo timer. The circuit shown in Fig. 4 (*b*) can be used to give automatic timing exposures when carrying out photographic development or enlargement work. For best results in this application, the timing capacitor, C_1, should preferably be a tantalum type. Switch and relay contact insulation should, again, be suitable for mains voltages.

CAN ANYONE HELP ?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

Minimitter Receiver MR44 or MR44/11.—J. Walker, 16 Himley Road, Clayton, Manchester, 11—alignment details required.

* * * *

Grundig TK18 Recorder.—K. Bartram, 89 Viney Avenue, Romsey, Hants—loan of service sheet.

* * * *

Pye Receiver Type 47X.—G. Young, 5 Hawthorn Road, Old Leake, Nr. Boston, Lincs—purchase or loan of circuit diagram.

* * * *

HF/G2A Tape Amplifier.—E. Slater, 25 Roker Park Avenue, Audenshaw, Manchester—purchase or loan of circuit diagram or manual.

* * * *

Circuit Diagrams, etc.—W. Van Rensburg, ZD5C, P.O. Box 418, Manzini, Swaziland—circuit diagrams, manuals or any information wanted on the following ex-British Army equipment. Master Oscillator Unit No. 2 Mk 1/1 ZA28895; Ampl. R. F. Unit No. 4 Mk 1/1 ZA28894; Modulator Unit No. 27 Mk 1 ZA22878; Power Supply Unit No. 26 Mk 1/1 ZA28897; Remote Control Unit 'H' No. 1 Mk 1/1 ZA 29539 and Receiver R/TPH 1088.

* * * *

Grundig TK40 Tape Recorder.—D. W. Mannings, 54 Aberthaw Circle, Newport, Mon—circuit or instruction manual, loan or exchange.

* * * *

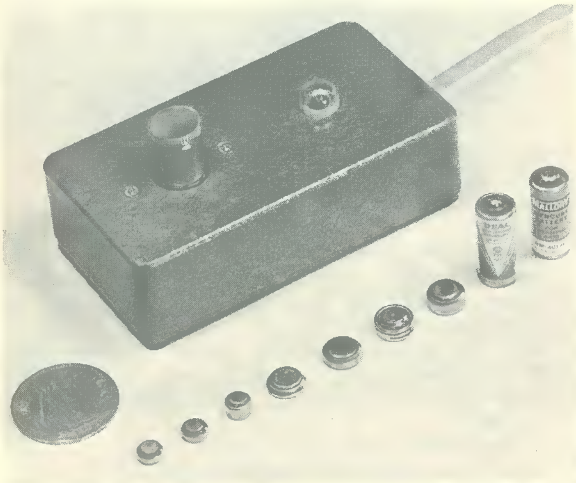
Collins TCS Transmitter.—E. W. Hibbert, 126 West-end Avenue, Harrogate, Yorkshire—circuit or any modification details.

* * * *

Signal Generator.—G. W. Nixon, 243 Kingston Road, Ewell, Epsom, Surrey—circuit, manual or any information about this U.S.A. manufactured generator—made by Espey Manufacturing Co., Ltd., New York City. Type number is I-72 and the range is 100 to 3,200 kc/s.

NEWS . . . AND .

Miniature Battery Charger



A new miniature transistorised battery charger which is operated from the mains, has been introduced by Crowborough Electronics.

It is designed to re-charge the complete range of sub-miniature cells currently used in hearing aids, paging receivers, micro-miniature radios, radio-controlled models, photographic and many other types of equipment.

The charger is intended for nickel-cadmium re-chargeable cells such as the types 10DK, 20DK, and D151, but will also rejuvenate any of the miniature mercury or silver-oxide cells now in universal use, including the popular types 212, 312, 13, 575, 675, 401, and many others.

It is believed to be the only charger specifically designed for these sub-miniature cells, incorporating a double-wound mains transformer for absolute safety.

The transistorised circuit produces a constant charging current which is independent of mains voltage variations, battery voltages or polarity.

The unit is available in either 240 volt or 110 volt models, and includes a neon indicator lamp and 6 feet of mains lead.

Mains consumption is negligible, running costs being about 5/– a year.

Further details are available from Crowborough Electronics, 3 Rotherhill Road, Crowborough, Sussex.

Australis Oscar

The amateur radio satellite being prepared by Melbourne University is likely to be Oscar number 5, although no date has been fixed for its launching. Full details regarding orbit, etc. will be announced by the Sunday RSGB News Bulletin as soon after launching as possible.

This satellite will not be of the translator type, as were the two previous Oscars, but will transmit amplitude modulated signals on both 29.450 Mc/s and 144.050 Mc/s simultaneously. The telemetry channels will consist of tone signals, varying from 500 c/s to 1500 c/s. They can thus be deciphered by feeding the output of the receiver into an oscilloscope and comparing them with the signals from a calibrated audio oscillator. This, and the fact that one of the satellite's frequencies will be in the 28 Mc/s amateur band, will obviate the need for special v.h.f. receiving equipment, and should stimulate more interest in monitoring this satellite than in some of the more complex earlier ones.

Graphs are available correlating various parameters with audio frequency and special report forms will be available for recording observations.

Monitoring these amateur radio satellites is quite fascinating and is a very suitable project for clubs and school radio groups.

Full details can be obtained from W. Browning, G2AOX, Regional Director, Region 1. I.A.R.U. Project Australis, 47 Brampton Grove, Hendon, London, N.W.4.

NEXT MONTH'S ISSUE OF THIS MAGAZINE WILL CONTAIN A *NEW* ADDITIONAL FEATURE.
MAKE SURE OF YOUR COPY.
PLACE AN ORDER WITH YOUR NEWSAGENT.

'Gale force winds imminent in all areas'

. . . COMMENT

The International Short Wave League Comes of Age

We congratulate the International Short Wave League on obtaining its majority. The League was founded in October 1946 and has become, we believe, the largest independent organisation of its kind in the world.

We have an especial affection for the League as, when formed, it was associated with a journal we then published called *Short Wave News*, subsequently renamed *The Radio Amateur* and then finally incorporated into *The Radio Constructor*.

In the December 1951 editorial of *Short Wave News* we said:—"It has always been our hope that we should one day be able to launch the ISWL off on its own course, so that it was quite independent of this journal. It is a bad policy to have any such organisation tied to a commercial project, because the criticism can very justly be made that the organisation is being run to stimulate interest in the commercial concern's products . . . . . . " " . . . . . . A few months ago, the ISWL committee was formed and we now feel that the time is ripe for the ISWL to stand on its own feet as an independent organisation which is not in any way tied to a commercial concern. It can then manage its own affairs and finances and can become a truly independent organisation. . . . . . . "

In the same issue the League's officers expressed appreciation of all the help they had received from our organisation, and from its directors and staff, over the years.

They also expressed thanks " . . . . . for the great amount of stock and equipment which has been handed over as part of the transfer arrangements. . . . . . . "

The League was formed with three main objects:—(a) to bring together the short wave enthusiasts of the world regardless of race, creed or politics, to their mutual benefit; (b) to foster and promote international goodwill through the medium of short wave radio interest; and (c) to provide facilities which will enable enthusiasts to carry out their hobby to the greatest advantage to themselves and their fellow enthusiasts. These objects have always been adhered to.

During the past twenty-one years many small—and some not so small—radio clubs have come and gone and it would be wrong to suggest that the League's history has not been without difficulties at times However, it has a continuous record of progress behind it and can look forward to the future with confidence. There are 1,250 members in 70 countries, including such rare Dx spots as Thailand, Trucial Omen, Turks & Caicos Is, Afghanistan, Cayman Is.

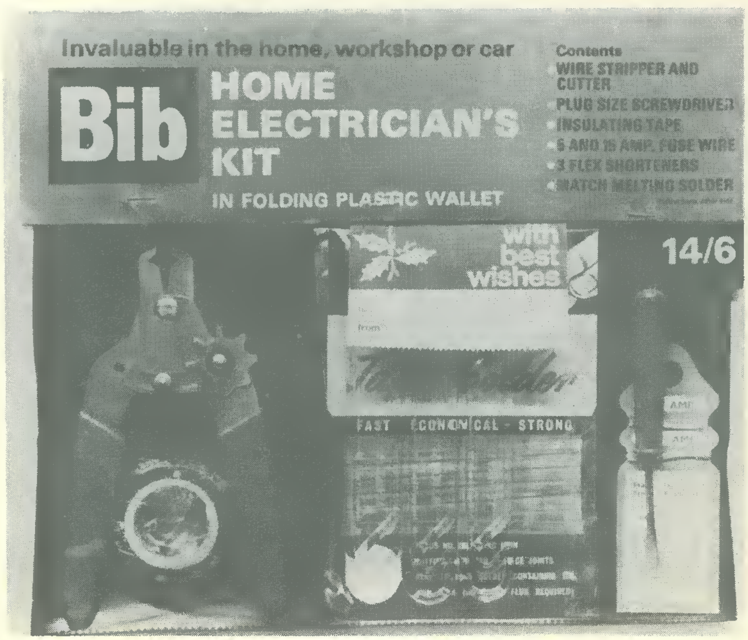
Electrician's Kit for Christmas

The Bib Home Electrician's Kit, introduced recently by Multicore Solders Ltd., is now available as a Christmas gift. The kit can be supplied with a green and white tag, on which is printed a holly symbol with a slogan "With Best Wishes". There is space for the names of the sender and the recipient.

The Bib Home Electrician's Kit is ideal either as a personal or a business gift. It contains, in handy, compact form, virtually every item the handyman (or woman) requires to carry out electrical work in the home, workshop or garage. The kit is contained in an attractive plastics wallet, and has the following items:

Bib Model 8 Wirestripper and Cutter
Three Bib Flex Shorteners
Ersin Multicore Tape Solder
Insulating tape
Screwdriver
Fuse wire

The wallet is accompanied by a card bearing full instructions for use.



HAND HELD 2-WAY RADIOPHONE

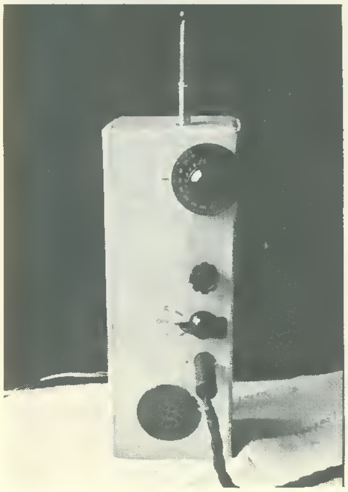
by F. G. RAYER, G3OGR

This little transmitter-receiver, which must only be used by amateurs holding the requisite transmitting licence, is specifically designed to provide communication whilst carrying out field strength tests and the like at a distance from the main transmitter.

This transmitter-receiver was made for 2-way conversation with the main station for tests up to ½ mile or so. Valves were used rather than transistors for low cost, and to obtain immediate results without experiment or tricky adjustments.

The Circuit

The circuit (shown in Fig. 1) employs three B7G battery valves. V_1 is a crystal controlled oscillator and feeds a telescopic whip aerial. L_1 is a coil for 40, 80 or 160 metre bands, as desired. It is attached to terminals and can be easily changed to suit the crystal. V_2 is the receiver detector, employing the same coil, L_1, which is tuned by VC_1 on both Transmit and Receive. VR_1 adjusts G2 voltage to control volume. V_3 is the modulator, being driven by T_1 secondary and employing auto-bias from R_4. The current for the carbon microphone is taken from the filament battery.



The unit fitted in its case

The Transmit-Receive switching is extremely simple. The 3-way switch, S_1, has a central "Off" position, with no filaments on. With the switch at "Receive", l.t. is applied to V_2 only, to provide reception. Placing the switch at "Transmit" supplies l.t. to V_1 and V_3 filaments, as well as to carbon microphone and primary of T_1.

Any available crystal for the 7-7.1, 3.5-3.8, or 1.8-2 Mc/s bands may be used. Coils for these three bands are described later, but only a single coil need be wound if operation is to be always on one band. This band will be that for which crystals are available, or which is used by the home transmitter or mobile transmitter with which aerial, field strength or other tests are to be made.

The receiver output is for medium or high impedance phones. A headset, worn separately, is more convenient than fitting an earpiece to the equipment. VR_1 is rotated from zero, as required, for suitable volume. Full rotation of VR_1 (maximum G2 voltage in V_2) does not, incidentally, give best volume.

L_2 is the primary of a small speaker matching transformer intended for use with a valve output stage, the 3Ω secondary being unused. Any component able to carry about 15mA should do. T_1 was a surplus carbon microphone transformer. The small type of speaker transformer, as once used with battery pentode output valves and having a ratio of about 50:1, will also be satisfactory. The low resistance winding acts as primary. The microphone is an inexpensive surplus handset type.

The h.t. is 67.5V and the l.t. 1.5V. The h.t. and l.t. batteries were kept separate in a pack, so that any batteries to hand could be employed, if desired. Suitable batteries are the Ever Ready Alldry 35 for the 1.5V supply and the Ever Ready B101 for the 67.5V supply.

Power And Range

The power input to V_1 is around 0.5 to 0.6 watt. The whip aerial fitted was nearly 3ft long when extended. At the main station the aerial is likely to be a dipole, end-fed wire, vertical, or other conventional system, and power input here will be up to 10 watts on 160 metres, and up to 150 watts on the 80 and 40 metre bands. One of the various popular communications-type or similar receivers will normally be used at the main station. In these circumstances, the range of the Radiophone is quite adequate. The receiving range of the Radiophone can be enormously extended by fitting a small loop on L_1, this being inserted between V_2 anode and R_3, with a 500pF capacitor from the junction of R_3 and the loop to the l.t. negative line. VR_1 then acts as a reaction or regeneration control. If regeneration is absent, reverse the connections to the loop. The loop should have as few turns as possible.

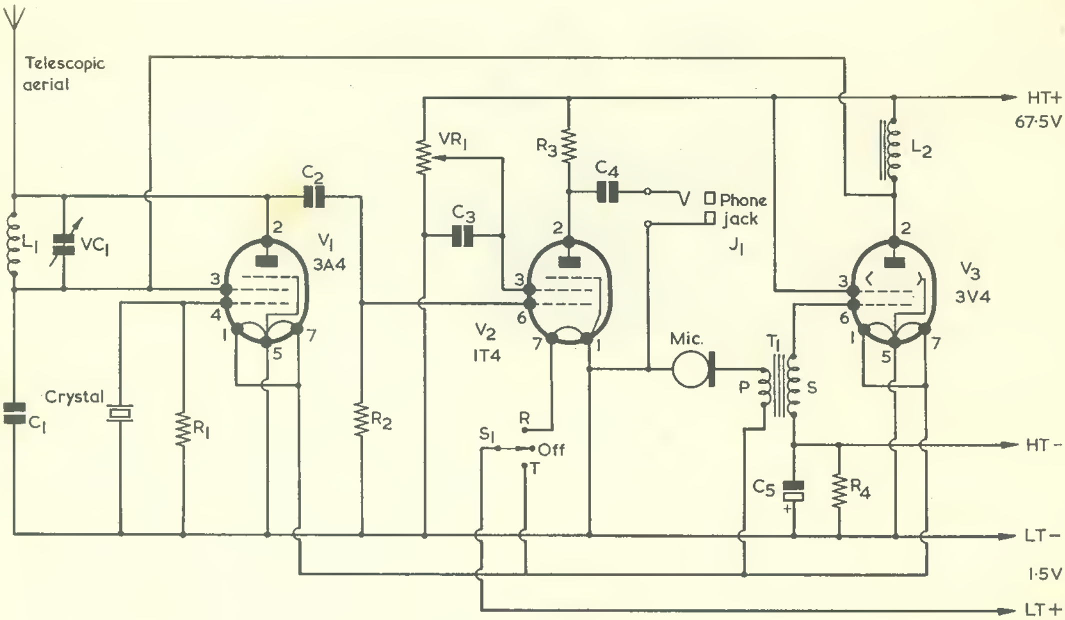


Fig 1. The circuit of the Radiophone

There is no significant difference to transmission when this reaction circuit is added.

For reports on field strength, as from a loaded vertical transmitting aerial or other system, a suitable receiving aerial is set up as far as practicable from the transmitting aerial. This receiving aerial may be vertical, end-connected horizontal, or a short or full-length dipole with centre feeder, as appropriate. Its output is fed to a tuned circuit, diode, and microammeter, upon which field strength readings are taken in the usual way. The 2-way Radiophone is intended to relay results of such tests or similar experiments, and not for actual signal strength tests..

Construction

The prototype was assembled on a piece of hardboard painted with shellac varnish.* Fig. 2 gives details of assembly and construction. All parts including the switch, VR_1 and VC_1 are on the same panel. Valveholder holes can be made with a ⅝in punch as used for aluminium etc., or with a ⅝in bit. There is not much free space, so it is wise to check the layout with the actual components first, especially those used for L_2 and T_1, before cutting out the panel.

The microphone is mounted in a hole which provides a tight push fit, and leads are soldered to its rim and back contact. A tag is placed under one nut securing each valveholder, and these tags are then wired together for the l.t. negative line, as there is no metal chassis. The bolt and tag anchoring C_5, R_4 and the h.t. negative lead are insulated from other circuits so as not to short-circuit R_4.

* The "hot" terminal for L_1 and the mounting for the whip aerial should, preferably, be insulated from this material, which may exhibit excessive leakage under damp conditions.—Editor.

COMPONENTS

Resistors
(All fixed values ½ watt 10%)
- R_1 100kΩ
- R_2 2.2MΩ
- R_3 47kΩ
- R_4 220Ω
- VR_1 250kΩ potentiometer, linear track

Capacitors
- C_1 2,000pF, silver-mica
- C_2 25pF, silver-mica
- C_3 2,000pF, paper or plastic foil, 150V wkg.
- C_4 0.01μF, paper or plastic foil, 150V wkg.
- C_5 100μF, electrolytic, 6V wkg.
- VC_1 75pF, air-spaced, type C804 (Jackson Bros.)

Inductors
- L_1 See text
- L_2 Small valve output transformer, secondary unused
- T_1 Carbon microphone transformer

Valves
- V_1 3A4
- V_2 1T4
- V_3 3V4

Sockets
- J_1 Phone jack socket
- 3 B7G valveholders
- 1 crystal holder

Crystal
160, 80 or 40 metre band crystal

Batteries
- 1.5 volt battery
- 67.5 volt battery

Switch
- S_1 Single-pole, 3-way switch

Miscellaneous
- Carbon microphone (see text)
- Telescopic aerial, about 3ft extended
- Insulated panel
- 2 knobs (for VR_1 and S_1)
- 1 knob with scale (for VC_1)
- Wire, battery connectors, etc.

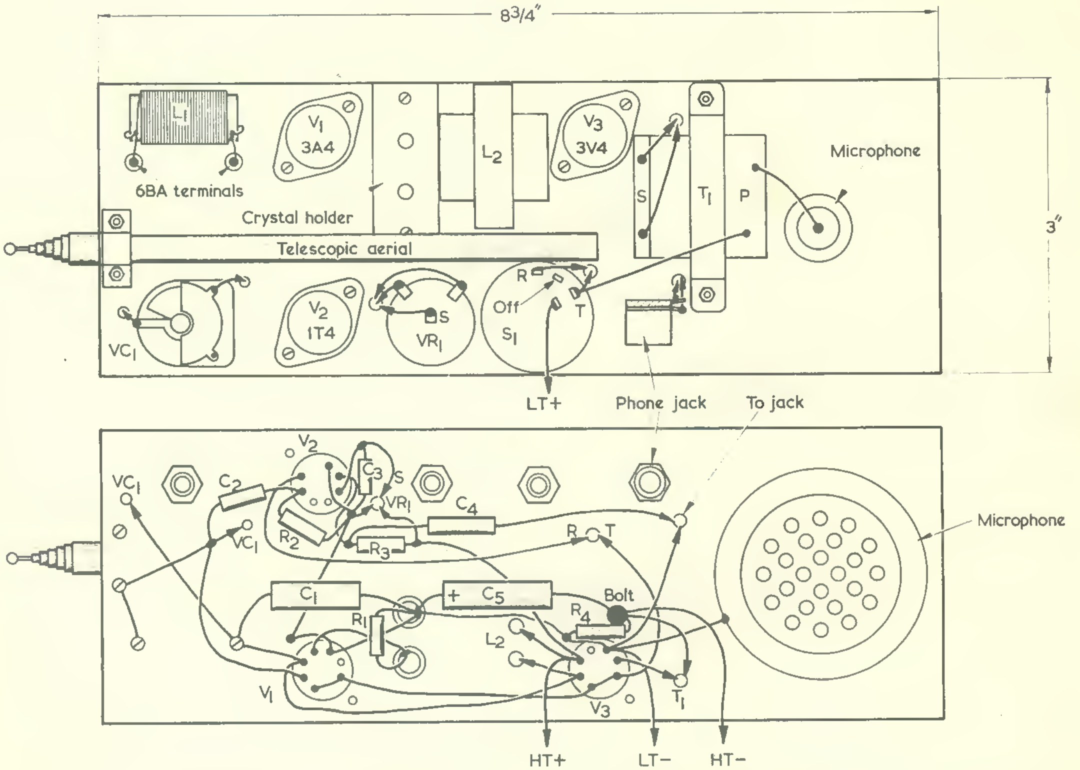


Fig. 2. Showing how the components are assembled and wired on either side of the panel

The battery cord consisted of thin flex, with black for h.t. negative, brown for l.t. negative, white for l.t. positive, and red for h.t. positive. A small metal clamp bolted near V_3 secured the leads.

In Fig. 2, "R" and "T" are the Receive and Transmit contacts of the switch, whilst "S" is the slider of VR_1. The spindles of VC_1, VR_1 and the switch project through the front of the case and a small scale or dial for VC_1 is helpful. The switch knob should have "Receive", "Off" and "Transmit" positions marked on the case. A hole in the case allows the phone jack plug to be inserted, and an aperture is cut over the microphone position.

Tank Coils

One coil is required for each band. The coils have short wire ends and are mounted by securing these under 6BA terminals, as shown in Fig. 2. Ferrite cores were used for the large coils to reduce the size and number of turns. Other coils which can be made to resonate with VC_1 should also be satisfactory.

The 40 metre band coil has 40 turns of 24 s.w.g. enamelled copper wire wound side-by-side on an insulated tube ½in in diameter and 1¼in long. For 80 metres, a piece of ferrite rod of ⅜in diameter and 2in length was used. The 80 metre coil has 21 turns of 22 s.w.g. enamelled copper wire wound side-by-side, and the ends are secured with adhesive tape. The 160 metre band coil consists of 46 turns of 26 s.w.g. double cotton covered wire wound side-by-side on a ⅜in by 2½in ferrite rod.

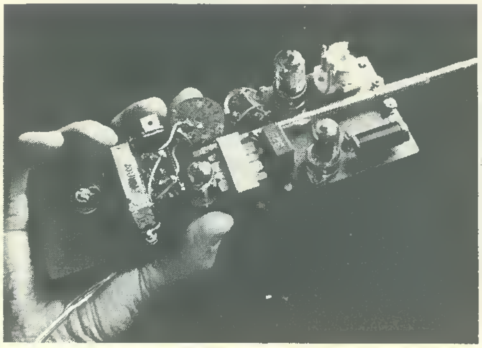
Testing

The current drain on Receive is small, it being 0.05A from the l.t. supply and about 1mA to 2mA from the h.t. battery according to the setting of VR_1.

To check operation on Transmit, insert V_1 and connect a meter in series with one h.t. lead. Use a coil and crystal for the same band. H.T. current is around 20mA with the circuit not oscillating, falling to 8mA to 10mA when VC_1 is tuned to produce oscillation. With the whip aerial extended, note the tuning position which corresponds to minimum h.t. current. This will be about correct for the crystal and coil in use. VC_1 is tuned slightly off the minimum current position, in the usual way with crystal oscillators of the type used here, so that the oscillator starts reliably when switched on. Tuning is not very critical.

With V_3 also inserted, and using a 67.5V h.t. battery, h.t. current should be around 15mA, or a little higher, when VC_1 is tuned for near-minimum current. The bias across R_4 will be about 3.5V. On Transmit, the l.t. drain is slightly over 0.3A. With the filaments off, there is a slight h.t. drain due to VR_1, so the h.t. battery should be disconnected when the equipment is put aside for any length of time. Alternatively, an extra pole on the switch could be used to break the h.t. circuit when the Radiophone is switched off.

In normal use VC_1 can be tuned without an h.t. meter. Transmission will cease at settings of VC_1 (if any) which result in cessation of oscillation. If the main station uses the same frequency, as is preferred, VC_1 can be approximately peaked for reception, although it does not tune sharply. To check transmission



The compact and neat appearance of the completed transmitter-receiver

without an h.t. meter and at a distance rotate VC_1 stating readings at intervals. Then switch to Receive and obtain from the main station a receiver S-meter report showing the best setting. If this is noted, it can be used for the same crystal and coil in future.

Coils wound as described above were satisfactory for all the 40 metre band, most of 80 metres and the low frequency end of 160 metres. On 160 metres and possibly on 80, the windings may have to be changed slightly to suit crystals near the band edges. An initial test will soon show this. It may be added that an input to V_1 of 10mA at 60V equals 0.6 watt.

To give an idea of the ease of construction, the author's prototype was completed and tested in a single evening. The author's case, also made in this period, was strictly utility, consisting of thick card folded and glued into the required shape. A more robust case can, of course, be readily made from thin wood, Paxolin sheet, or any other insulating material.

"RUBBER ZENER" CIRCUITS

by G. SHORT

In this article, our contributor describes different techniques for obtaining zener controlled power supplies, the techniques being finally combined in a practical stabilised power supply circuit offering 0–24V at currents up to 1A. It is important to note that the output transistor can operate at full rated dissipation for some output requirements and must be mounted, with good thermal contact, on a large heat sink.

ZENER DIODES ARE CONVENIENT SOURCES OF stabilised voltage, but they have their limitations. Their voltage is fixed, and their output current is limited by the permitted power dissipation of the diode. However, both these limitations can be overcome, and a single low-voltage, low-current zener diode can be made to provide a wide range of both voltage and current.

This is, of course, the function of stabilised power supply. But without going the whole hog and building an elaborate stabiliser some of the advantages are obtainable by the use of circuits which "stretch" the voltage or current of the zener.

Increased Current

The time-honoured way of getting more than the prescribed current is shown in Fig. 1 (*a*). If, in the off-load condition, R_1 allows the maximum rated zener current to flow, then when a load is connected nearly all this current can go to provide base input current to the transistor. The output current is the base current multiplied by the large-signal current amplification factor (h_{FE} or "d.c. beta") of the transistor. Thus, if the zener can pass up to 21mA, but will work with 1mA, up to 20mA can flow into the base before stabilising action fails. If h_{FE} is 50, the load current can be 1A. Obviously, if we are to utilise such a large output TR_1 must be able not only to pass 1A but to provide the necessary amplification while doing so. (This is just a rather laboured way of saying it must be a power transistor!)

A modification to provide variable voltage is shown in Fig. 1 (*b*). The output voltage can be varied from zero up to something approaching the zener voltage, and current amplification is also obtainable. But there is a limitation. Unless the slider of RV_2 is at the end of its track, some resistance is put effectively in series with the base, and this reduces the available base current. This resistance reaches $\frac{VR_2}{4}$ with the slider at the half-way point, and voltage regulation suffers. For example, if RV_2 is

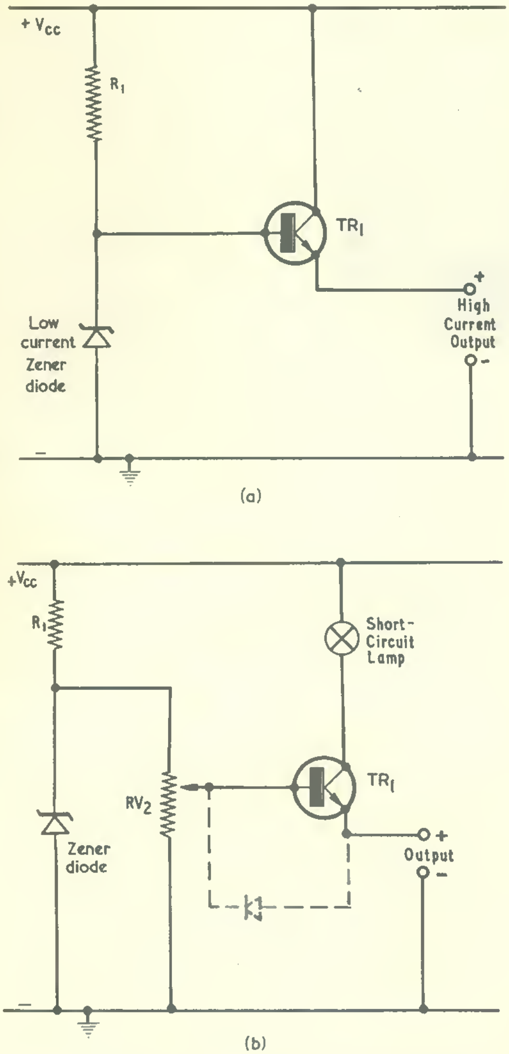


Fig. 1. Arrangements for "stretching" zener output: (a) increased current, fixed voltage; (b) increased current and variable voltage

$4k\Omega$, and the base current can reach 20mA, there is a loss of anything up to 20V, which is ridiculously large and probably exceeds the zener voltage anyway. So what happens is that the output voltage falls towards zero.

Despite this disadvantage, the circuit of Fig. 1 (*b*) is often a perfectly adequate means of obtaining a semi-stabilised variable voltage supply, so let's look at it a bit more closely before we go on to something more expensive. The maximum output voltage is the zener voltage (call it V_Z less the base-emitter voltage of the transistor (usually called V_{BE}). If TR_1 is a silicon transistor, V_{BE} is 0.5–1.5V, and if it's germanium, 0.1—1V.

The diagrams follow the author's usual practice of showing a positive upper rail and n.p.n. transistors, but obviously one could use a p.n.p. transistor with a negative upper supply line and reverse the zener. If only the stabilised output is required, it couldn't matter less which arrangement is used, since the output leads can be swapped round to provide positive or negative upper lines. But if the unstabilised supply is to be used *simultaneously* with the stabilised output it does matter, and one arrangement will be preferable, depending on whether the load requires a positive or negative upper rail. In the final practical circuit which appears at the end of this article, the common rail is negative and the stabilised and unstabilised rails are positive.

In the circuits now being described the transistor dissipation is fixed by the load. The worst case is when the load is very low and the current high. (These conditions are often met with in experiments, and are known as short-circuits!) Unless precautions are taken, the transistor then dissipates a power given by $I_C \times V_{CC}$, and if the slider of RV_2 is at the top, $I_B = V_{CC}/R_1$ very nearly and so $I_C = h_{FE} V_{CC}/R_1$. Hence the maximum possible transistor collector dissipation is $P_C = V^2_{CC}h_{FE}/R_1$. If $V_{CC} = 10V$, $R_1 = 50\Omega$, and $h_{FE} = 100$, then $P_C = 100 \times 100/50 = 200W$. This sort of power is inclined to make the transistor become a little on the warm side, and quickly. To guard against overcooked transistors, it is advisable to put a current-limiting resistance in the collector circuit. A lamp (as in Fig. 1 (*b*)) is convenient, since it drops little voltage at low currents and gives a warning light at high ones. The highest collector dissipation now occurs when the supply voltage is shared equally by the lamp and the transistor. Suppose the transistor can dissipate 5W safely. Then if $V_{CC} = 10V$, a collector safety resistance of 5Ω is indicated, and it will drop 5V at 1A and dissipate 5W. Something like a 6V 6W

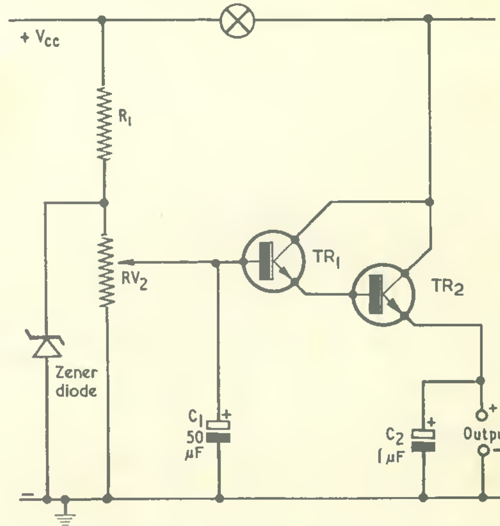


Fig. 2. Compound emitter follower (Darlington pair) for improving regulation

lamp will do. The price paid for safety is reduced output current.

Protective Diode

What's the diode of Fig. 1 (*b*) for? It plays no part in the stabilising action, in fact no part at all in the operation of the circuit. And it is reverse biased by the base-emitter voltage drop of TR_1.

The diode is included as a result of bitter experience, in the shape of the mysterious demise of TR_1. The circuit worked all right one day, but not on the next day. TR_1 had developed a base-emitter short-circuit. Why? Base-emitter short-circuits are a common result of applying too big a reverse bias to the base-emitter junction of a transistor. But surely, there's nothing in Fig. 1 (*b*) to cause such a reverse bias? Quite right there isn't. But just suppose the stabiliser is being used to supply a piece of equipment which has a large smoothing capacitor between its positive and negative terminals. Now switch off the stabiliser, removing V_{CC}. The base of TR_1 is now at the same potential as the negative line, but the emitter is held positive by the charge on that large smoothing capacitor. If the resulting reverse bias (V_{EB}) is big enough, the base-emitter circuit breaks down, and the capacitor discharges through it and RV_2, burning out the transistor in the process. Unless, that is, the extra diode is there, in which case it just provides an easy discharge path which bypasses the transistor.

The diode isn't *always* necessary. Some transistors, such as the old-fashioned alloy types, will stand almost as much reverse voltage on their bases as on their collectors. Planar transistors have a V_{EB} rating of 5V or less, and a diode is needed. Worst of all are diffusion transistors (AF115, etc.), which have V_{EB} ratings of less than 1V. Even a diode may not protect these, and they are not really suitable for use in this type of circuit.

Darlingtons

A way out of the problems due to the resistance inserted by RV_2 is to use a transistor with an enormous h_{FE}, so that practically no base current is drawn and so very little voltage is lost even when the load current is high. The best transistors now available have h_{FE} approaching 1,000, but they are all low-power types (BC109, 2N3707, etc.). A way out is the compound emitter-follower or Darlington pair of Fig. 2. Here the effective h_{FE} is the product of the individual h_{FE} values. Very high values are obtainable. For example, if TR_1 were a high-beta planar with $h_{FE} = 500$, and TR_2 a power transistor with $h_{FE} = 50$, the overall h_{FE} would be 25,000. For an output current of 1A, only 1/25mA of base current need flow into TR_1. Even if RV_2 were 100kΩ, only 1V would be lost. The regulation of the output voltage is much improved, but the maximum output voltage is reduced, since there are now two base-emitter drops. The effect of RV_2 on the output resistance is reduced, and the zener current is now less dependent on the load current, which makes for better constancy of the zener voltage itself. If the supply is mains-derived, ripple on the $+V_{CC}$ line

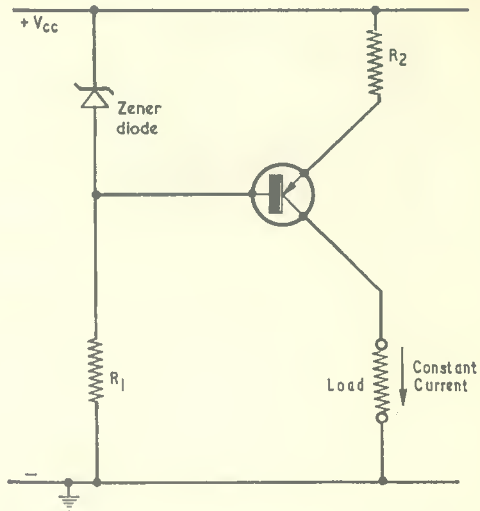


Fig. 3. Constant-current circuit. The current is determined by the zener diode and R_2

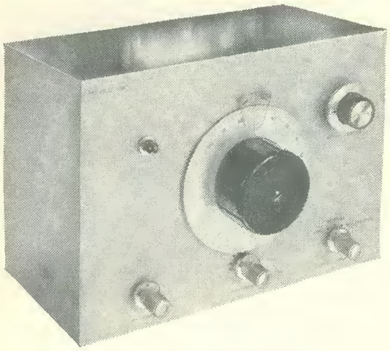
can be vastly reduced by adding C_1, and this also reduces the a.c. output impedance. Unfortunately, with certain combinations of transistors and loads, h.f. oscillation is then possible, but is easily suppressed by connecting a small capacitance C_2 across the output.

Increasing The Output Voltage

The above circuits are of no use if an output voltage greater than the zener voltage is required. The author's answer to this problem is unusual, in that he first uses the zener to make a constant *current* generator, as in Fig. 3 This generates a constant current (i.e. independent of the load resistance) of $(V_Z = V_{BE})/R_2$. Rather, it's constant until the drop in the load approaches $(V_{CC} - V_Z)$, when there isn't enough voltage left to operate the transistor.

To make use of this in a constant *voltage* supply, all you have to do is, in effect, make RV_2 of Fig. 2 the load of the constant current source, as in Fig. 4 where it appears as RV_4. Fig. 4 shows a practical design for 0 – 24V at up to 1A and incorporates the features previously discussed. If the B-5000 is mounted firmly, and with good thermal coupling, on to a really large heat sink, it will dissipate 25W, which is what it will have to do if 1A is drawn at a very low output voltage. But if high currents are only needed when the output voltage is high, the output transistor dissipates little power. In the present case, the dissipation falls off to almost nothing as the output approaches 24V, 1A, because under these conditions practically all the supply voltage is dropped across the lamp and the load. If more than 1A is drawn, the lamp will act as a (rather expensive) fuse. There is, of course, no reason why a 1A fuse or cut-out should not be installed as well as the

Continued on page 295



3-STAGE PR

by JAMES S

Our author describes an interesting experimen considerable variation by the constructor. This to 31.5 M

MANY SHORT WAVE LISTENERS, ESPECIALLY those who have fairly recently commenced the hobby, are often equipped with an inexpensive receiver which is virtually a "4+1" (i.e. frequency changer, i.f. amplifier, detector/a.g.c., output + rectifier). Faults inherent in the design of such receivers—produced to a low price specification—are mainly lack of selectivity and sensitivity due to the damping effect of the aerial on the grid tuned circuit of the first stage and the total absence of a tuned r.f. amplifier that would preselect the required signal and apply this in amplified form to the input of the frequency changer stage.

Multi-grid frequency changer valves such as triode-hexodes and triode-heptodes tend to exhibit a high noise level with relatively small gain, and added to this disadvantage is the fact that there is an inherent noise level apparent in any receiver even under no-signal conditions, this noise emanating from the normal operation of the valves themselves. It follows therefore that any signal being received must overcome, or be greater than, the generated internal valve noise in order to become audible and therefore intelligible to the operator. If this condition is not met, then any amount of subsequent amplification after the frequency-changer stage is of no avail. The solution to this problem is therefore to precede the first stage of such a receiver with an r.f. stage (preselector), or stages, having as low a noise level as possible and as much gain with stability as can be obtained.

A preselector will also eliminate second channel interference, which is very prevalent on the short wave ranges of superhets having only one tuned circuit between the aerial and the frequency-changer. Second channel signals are those which are higher in frequency than the required signal by twice the i.f., and they can break through to the frequency-changer if only one r.f. tuned circuit is provided, whereupon they cause whistles and similar interference. A good preselector can completely eliminate second channel interference by ensuring that only the desired signal reaches the aerial input of the receiver.

In the design presented here, the first stage, $V_{1(a)}$, is connected in a grounded grid configuration that will effectively (a) present a low impedance input to the aerial and (b) isolate the damping effect of the aerial from its anode tuned circuit. Provision is made however for this arrangement to be altered by operation of the switch $S_{1(a), (b)}$, and this point will be dealt with later.

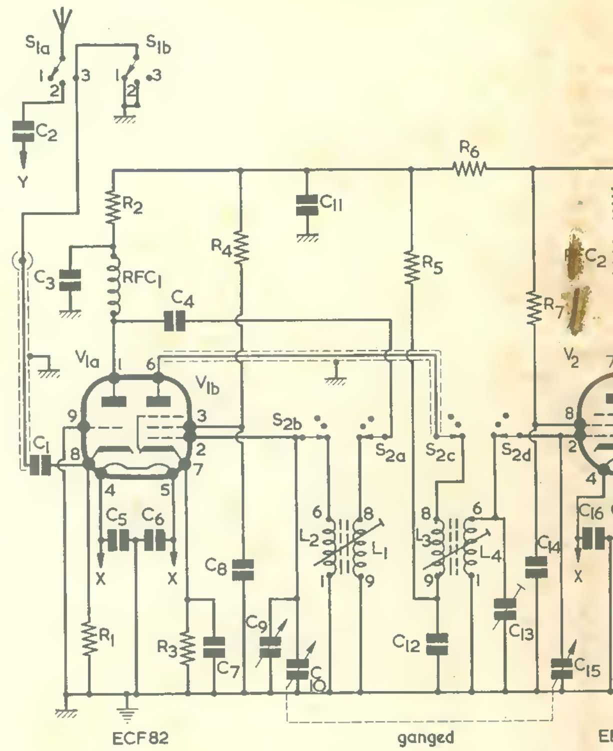


Fig. 1. The circuit of the

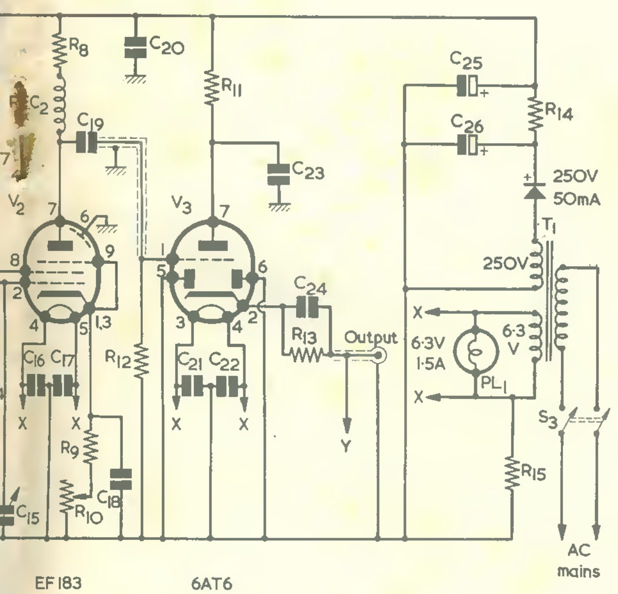
RESELECTOR

IES S. KENT

Cover Feature

rimental preselector which may be subjected to . This 3-valve design covers the frequencies 1.67 31.5 Mc/s.

The stage providing most of the r.f. gain in this unit is that incorporating V_2, this being an EF183 variable-mu frame-grid pentode having a mutual conductance of 12.5mA/V. The gain of an r.f. amplifier can be theoretically shown to be approximately proportional to the mutual conductance of the valve used, and it can be seen therefore that the EF183 is ideally suited for such an application.



of the 3-stage preselector

The last stage of the preselector is given by V_3, a cathode follower consisting of a 6AT6 double-diode-triode connected here as a triode. This stage provides a voltage gain of slightly less than unity but owing to the high gain available from the preceding stages this small loss is of no consequence. The valve is intended to provide a correct impedance match, at all frequencies, between the first two stages of the preselector and the receiver input terminals.

From the points discussed it will be seen that the present design has the effect of providing a high r.f. gain with a low noise level, of eliminating second channel interference, and of providing a correct impedance match into the receiver.

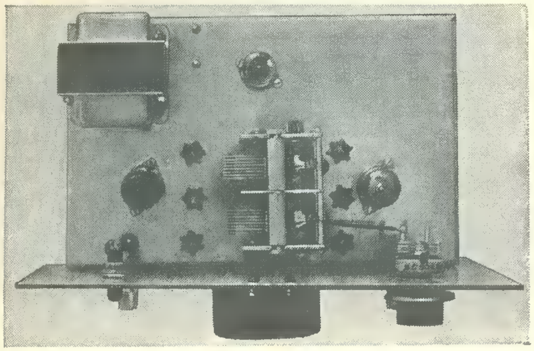
Circuit

The circuit is shown in Fig. 1 and from this it will be seen that the aerial switching is arranged such that a choice is given of three positions: (1) aerial disconnected both from preselector and receiver; (2) aerial connected direct to receiver input and (3) aerial connected to preselector input.

At position 1 of $S_{1(a)}$ the aerial is disconnected from both inputs whilst $S_{1(b)}$ causes the preselector input to be earthed to chassis. At position 2 of $S_{1(a)}$ the aerial is fed direct to the receiver input, by-passing the preselector, via the capacitor C_2; whilst $S_{1(b)}$ causes the preselector input to be still earthed. At position 3 of $S_{1(a)}$ the aerial is fed direct to the preselector input via the capacitor C_1, whilst at position 3 of $S_{1(b)}$ no connection is made.

The writer employs position 1 of the aerial switch to mute the preselector whilst carrying out calibration checks and frequency measurements with a 100 kc/s crystal standard loosely coupled into the aerial circuit of the receiver. The 100 kc/s marker points may then be resolved with much greater ease since they are not masked by external signals. When operating, it is very convenient to be able to cut the input to the preselector in this manner. If a transmitter is installed, position 1 of the aerial switch may also be selected during trasmissions.

As specified, $S_{1(a)}$, $_{(b)}$ is a 2-pole 3-way component. A 4-pole 3-way miniature rotary switch with 2



Above-chassis view showing the positions of the main components

poles unused may, alternatively, be employed here, and such a component is readily available from suppliers. A 4-pole miniature switch was, in fact, used in the prototype.

When operating the preselector with $S_{1(a)}$, $_{(b)}$ in position 2, where the aerial feeds directly to the receiver, gain control R_{10} must be adjusted to its minimum gain setting.

With the preselector in use, signals are fed to the cathode of the triode section of $V_{1(a)}$ via the capacitor C_1, this section of the valve operating in the grounded grid mode. The signals from $V_{1(a)}$ anode are applied via the coupling capacitor C_4, to $S_{2(a)}$ and thence to the primary winding of an aerial coupling coil selected by this latter switch, and shown as L_1. Only one coil is shown in the circuit diagram, for reasons of clarity although there are, in fact three such coils, each covering a differing range of frequencies and switched into circuit by the sections of S_2.

It will be noted that the valves have their heaters bypassed to chassis via 5,000pF capacitors. These capacitors completely eradicate any difficulties due to hum and also prevent unwanted r.f. couplings along the heater line. Resistor R_{15} maintains the heater circuit close to chassis potential. The bias supply for $V_{1(a)}$ is obtained via the resistor R_1 whilst the anode h.t. supply is derived via R_2 and RFC_1. The h.t. supply to V_1 is decoupled from the remainder of the circuit by the resistor R_6, capacitors C_{11} and C_{20} providing the requisite bypass to chassis.

The grid of $V_{1(b)}$ is connected both to switch $S_{2(b)}$, which selects the frequency range required, and also to C_9 and C_{10}. The small value capacitor C_9 is panel-mounted and acts as a trimmer control to bring this stage into resonance at the same frequency as the tuned circuit of the following stage. The second tuned winding is shown as having trimmer C_{13} connected across it. There is one trimmer for each of the three coils actually fitted in the L_3, L_4 position, making three trimmers in all. The trimmers are adjusted, in conjunction with the iron dust cores of the coils, so that the coils cover the desired frequency ranges, these being approximately 1.67 to 5.3 Mc/s for Range 3, 5 to 15 Mc/s for Range 4 and 10.5 to 31.5 Mc/s for Range 5. The main tuning control is provided by the 2-gang capacitor C_{10}, C_{15}.

Whilst dealing with the coils it should be mentioned that, due to the high gain provided, some instability was experienced on Range 3 when R_{10} was set to offer maximum gain. Should a similar type of instability be apparent with other units built up to the circuit, it may be cleared by connecting a resistor between pin 6 of the Range 3 coil in the L_1, L_2 position and chassis, the value of the resistor being just sufficiently low to prevent oscillation. In the writer's case the resistor fitted here had a value of 5.1kΩ. The resistor is not shown in the Components List or in the circuit diagram as it may not be required in all instances and its value is experimental.

Returning to the signal as it passes through $V_{1(a)}$ and $V_{1(b)}$, the combination C_9, C_{10} and L_2 selects the signal required and passes it to the grid of $V_{1(b)}$. After amplification it is then fed to $S_{2(c)}$ and coil L_3.

The h.t. supply for the anode of $V_{1(b)}$ is obtained via R_5 and L_3 (bypassed to chassis by capacitor C_{12}) and through switch $S_{2(c)}$. The screen grid supply is via R_4, bypassed to chassis by capacitor C_8, and the required bias supply is provided by the components R_3 and C_7. It will be noted that the bias supply to $V_{1(b)}$ has not been made variable. Constructors preferring gain control of both stages may like to try the effect of connecting the earthy end of R_3 to the centre tag (slider) of the gain control R_{10}. Some adjustment with respect to the value of R_3 may probably be required, a higher value than that shown in the Components List being experimentally connected in the first instance.

The grid of V_2 is connected to the variable capacitor C_{15}, the trimmer capacitor C_{13} and the tuned winding L_4, this combination further selecting the required signal. The amplified signal at the anode of V_2 is fed via coupling capacitor C_{19} to the grid of the cathode follower stage, V_3. It should be noted here that pins 1, 3 and 9 of V_2 are connected together externally and taken, via R_9 to the slider of R_{10}, which provides the variable bias required for gain control. The cathode bypass capacitor is C_{18}. The anode h.t. supply is provided via R_8 and RFC_2, and the screen-grid supply via R_7 with C_{14} as bypass capacitor.

The internal screen, pin 6, is connected direct to chassis as shown.

The 6AT6 double-diode-triode is connected into circuit as a triode, both diodes being strapped to chassis. Any other triode or double-triode, such as the ECC82 for example, strapped as a single triode could be used if to hand although some variation of component values associated with the valve would probably be required.

The output of the preselector is taken to the coaxial socket via the components R_{13} and C_{24} from the cathode of this stage, h.t. supply to the anode

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 10% except where stated)

R_1 150Ω
R_2 33kΩ
R_3 100Ω
R_4 100kΩ
R_5 5.6kΩ
R_6 4.7kΩ
R_7 33kΩ
R_8 5.6kΩ
R_9 100Ω
R_{10} 5kΩ, 1in with switch
R_{11} 5.6kΩ
R_{12} 470kΩ
R_{13} 1kΩ
R_{14} 3kΩ 2 watt
R_{15} 1MΩ

Valves

V_1 ECF82 (Mullard)
V_2 EF183 (Mullard)
V_3 6AT6 (Brimar)

Valveholders
B9A (2 off ceramic with centre spigot)
B7G (1 off ceramic with centre spigot)

Coils
Miniature Dual-Purpose (Denco Ltd.) Blue, Ranges 3, 4 and 5 (2 sets)

Capacitors

C_1 1,000pF ceramic
C_2 200pF silver mica
C_3 1,000pF ceramic
C_4 100pF silver mica
C_5 5,000pF ceramic
C_6 5,000pF ceramic
C_7 0.01μF tubular (Mullard)
C_8 0.01μF tubular (Mullard)
C_9 25pF variable, type C804 (Jackson Bros Ltd.)
C_{10} 310pF variable, 2-gang, type E (Jackson Bros. Ltd.)
C_{11} 0.1μF tubular (Mullard)
C_{12} 0.1μF tubular (Mullard)
C_{13} 25pF trimmer (3 off)
C_{14} 0.01μF tubular (Mullard)
C_{15} 310pF variable, ganged with C_{10}
C_{16} 5,000pF ceramic
C_{17} 5,000pF ceramic
C_{18} 0.01μF tubular (Mullard)
C_{19} 100pF silver mica
C_{20} 0.1μF tubular (Mullard)
C_{21} 5,000pF ceramic
C_{22} 5,000pF ceramic
C_{23} 0.02μF tubular (Mullard)
C_{24} 0.01μF tubular (Mullard)
*C_{25} 32μF electrolytic, 350V wkg.
*C_{26} 16μF electrolytic, 350V wkg.
3, 4 and 5. (2 sets)
(*Contained in single can with mounting clip)

Mains Transformer
Secondaries: 250V, 50mA; 6.3V, 1.5A; type 6BR10
(H. L. Smith & Co. Ltd.)

R.F. Chokes
2.5mH type CH1
(H. L. Smith & Co. Ltd.)

Knobs
See text

Chassis
$8\frac{1}{2}$ x $5\frac{1}{2}$ x $2\frac{1}{4}$in
(H. L. Smith & Co. Ltd.)

Panel
$9\frac{1}{2}$ x 7in
(H. L. Smith & Co. Ltd.)

Miscellaneous
5 $\frac{3}{8}$in grommets
1 $\frac{5}{8}$in grommet
2 3-way tag-strips

Dial and Drive
6:1 Slow Motion Drive, Part No. 4489, Jackson Bros. Ltd. (Home Radio Ltd. Cat. No: DL3A)

Panel Lamp Assembly
Type LES (H. L. Smith & Co. Ltd.)
6.5V, 0.15A

Rectifier
250V, 50mA, contact-cooled
(H. L. Smith & Co. Ltd.)

Coaxial Sockets
2 off

Switches
*S_1(a), (b) 2-pole, 3-way
*S_2(a), (b), (c), (d) 4-pole, 3-way
S_3 2-pole 1-way (ganged with R_{10})
(*see text)

being via R_{11}, C_{23} providing decoupling to chassis.

The cathode circuit for V_3 is completed by the aerial input components in the receiver and it is, therefore, necessary for the receiver aerial input circuit to provide a d.c. path for the cathode current of V_3. This will be automatically provided in conventional receivers by the coupling winding for the aerial coil. It is essential, for safety reasons, that the receiver has a chassis isolated from the mains. *The output of the preselector must, on no account, be directly coupled to a receiver whose chassis is connected to one side of the mains supply.*

The power supply is an integral part of the unit and includes mains transformer T_1, this being a fully shrouded chassis mounting component. T_1 is followed by a contact-cooled metal rectifier

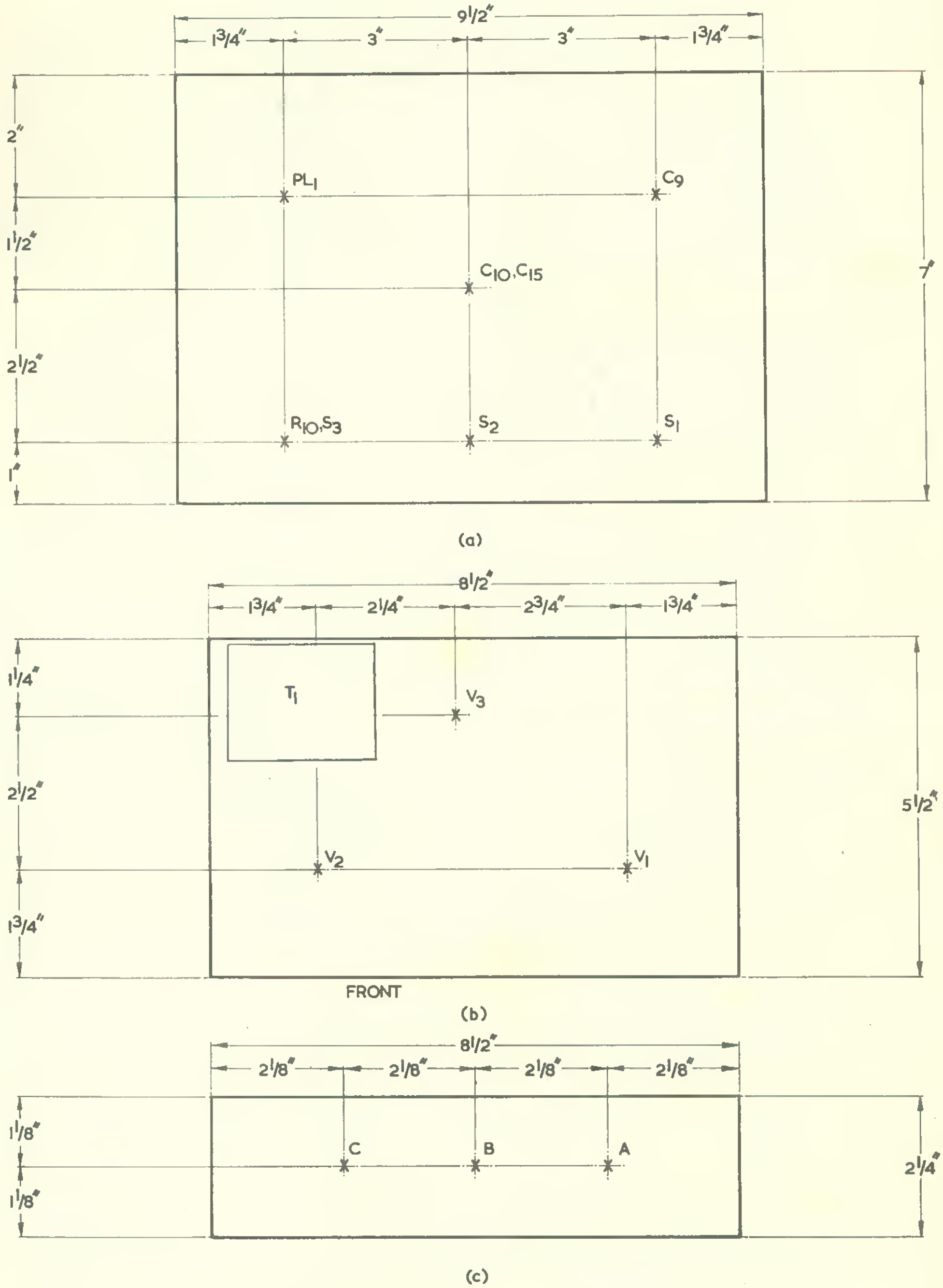


Fig. 2 (a). Drilling dimensions for the front panel
(b). Top view of the chassis, showing valveholder positioning
(c). The three holes needed on the rear apron

and the smoothing components R_{14}, C_{25} and C_{26}.

The heater supply has the panel-mounted pilot lamp PL_1 connected across it and a twisted pair is then taken to each valve in turn. Connection to the a.c. mains supply is via the on/off switch S_3, this switch being an integral part of the gain control R_{10}.

Construction

Drilling points for the front panel are shown in Fig. 2 (*a*) and the front cover illustration provides a visual indication of the completed panel. The final position of the spindle for the 2-gang capacitor will depend on the actual component used but the dimensions shown in the diagram will be correct if the specified part (see Components List) is used. Drilling details for the dial cursor are provided with the dial drive specified.

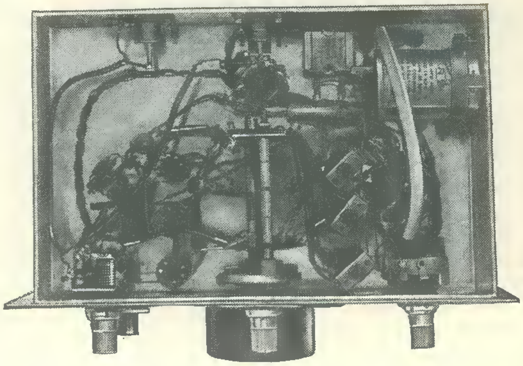
Suitable knobs can be obtained from H. L. Smith & Co. Ltd. The main requirement here is that the three lower knobs should be of a small diameter type, so that the centre knob fitted to S_2 will clear the lowest part of the dial. Panel-Sign transfers could be used on the front panel where desired and the panel itself painted or cellulose sprayed with the chosen colour. As shown on the front cover, no such embellishments were made at the time of photographing, although these have since been added by the writer.

Fig. 2 (*b*) shows the positions of the three valveholders. The appropriate holes should be initially drilled and then cut out with a chassis cutter; B9A for V_1 and V_2, and B7G for V_3. When mounted, V_1 valveholder should have pin 4 nearest the front, V_2 valveholder should have pin 1 nearest the front and V_3 valveholder should have pin 2 nearest the front. It will be found helpful to fit a 3-way tag-strip (centre tag earthed) under the rear mounting nut of V_1 and V_2 valveholders.

The holes for the mains transformer and its leads may be marked out by using the component itself to indicate the positioning required. The two chassis holes for the leads from the transformer should be fitted with $\frac{3}{8}$in grommets, the mains input leads to the primary passing through the hole nearer the front. Three further holes with $\frac{3}{8}$in grommets are required in the chassis, two for the connections to the fixed vanes of C_{10}, C_{15}, and one for the twisted 6.3 volt pair to the pilot lamp. The two tuning capacitor connection holes are on the V_1 side of this component, and it should be noted that C_{10} is the section of the 2-gang capacitor which is nearer the panel. The hole for the pilot lamp wire is immediately beneath the pilot lamp holder when the chassis and panel are assembled. The contact-cooled rectifier is mounted below the chassis at the rear, midway between the output socket and the dual electrolytic capacitor C_{25}, C_{26}. The latter is fixed to a side apron in the position shown in the photograph of the underside.

The positions of the coils depend upon the type of switch employed, and this point is discussed later.

It will be noted that the front panel has a $\frac{1}{2}$in overhang either side of the chassis itself and this was done so that the unit, once completed, could be



Below-chassis view of the completed preselector showing the positions of the coils, smoothing capacitors and contact-cooled rectifier

inserted into a wooden shelf adjacent to the receiver with the sides and top of the front panel secured by means of small chromium-domed wood screws into the wooden surround. Alternative methods, such as the fitting of the preselector into a metal case, may require different measurements to the panel overhang than are shown here.

Fig. 2 (*c*) shows the chassis rear apron drilling details, hole A taking a $\frac{3}{8}$in grommet for the a.c. mains power input lead. The earth wire of this lead (green) should be connected to chassis, and the red and black wires connected to the correct tags of the on/off switch, S_3, integral with the gain control R_{10}. Hole B is for the preselector/aerial output, this being fitted with a coaxial socket. Hole C is for the aerial input to the preselector, and is also fitted with a coaxial socket.

Coil Positioning

An important component in the preselector is the switch S_2. It is necessary here to have a switch with individual wafers which are well spaced from each other. Such switches are expensive, but the writer was able to locate a surplus item available from H. L. Smith and Co. which meets present requirements admirably and which retails at a fraction of the cost of a new, specially designed, component. He is informed that H. L. Smith and Co. have ample stocks of this switch for those who may require to purchase it for building the unit. The switch has three wafers spaced as shown in the photograph of the chassis underside. The rear wafer has two separate switch sections mounted on a single quadrant of the Paxolin, and the switch should be mounted so that this quadrant is towards the V_1 side of the chassis. On the front wafer the bottom (farthest away from the chassis underside) single pole 3-way section is employed as $S_{2(c)}$. On the centre wafer, the single pole 3-way section nearer V_1 is employed as $S_{2(b)}$. On the rear wafer, either of the single pole 3-way sections nearer V_1 is employed as $S_{2(a)}$. The single pole 3-way section on the rear wafer nearer V_2 is used as $S_{2(d)}$. Constructors are strongly advised to use a continuity meter when identifying the switch contacts as it is easy to make mistakes. The switch knob selects Range 3 when turned fully clockwise, with Range 4 in the central position. Some of the switch sections on the H. L. Smith component are left unused.

Readers employing an alternative switch are recommended to use a 3-wafer component with approximately the same switch section positioning.

The coils take up positions as close to whatever switch is employed as will allow for convenience in wiring. The three coils for L_1 and L_2 are on the V_1 side of the switch and the three coils for L_3 and L_4 are on the V_2 side of the switch. In both instances the Range 3 coils are nearest the panel, the Range 4 coils are in the centre and the Range 5 coils are at the rear. The three trimmers for C_{13} have their non-earthy tags soldered direct to pin 6 of the coil concerned, the earthy ends connecting to a chassis bus bar wire running alongside the coils.

One important point which should be observed when wiring up is that the centre spigots of all three valveholders should be connected to chassis. The writer found it helpful to solder a small tinplate square, about ½ by ½in, to the centre spigot and pin 6 of V_2, this straddling the valveholder between the grid and anode pins. This provides a measure of screening, and the chassis ends of components such as C_{16}, C_{17}, etc., may be conveniently soldered to the bottom edge of the tinplate square. Obviously, the tinplate square must not short-circuit to any of the valve pins.

The illustrations of the above and below chassis views of the preselector provide adequate information on the method of construction and the siting of the main components but in view of the (to the beginner) complexity of the switch wiring, this design is *not* recommended as a unit that the comparative novice should undertake to construct.

Connection to the receiver should be via a short length of coaxial cable, the metal braiding of which should be connected to the chassis, via the coaxial plug, of both the preselector and the receiver.

In operation, the preselector has been found to perform to the writer's satisfaction over the entire range. In common with most units of this type efficiency above the 21 Mc/s band tends to fall off a little, the answer at these frequencies being, of course, a converter unit.

"APPLICATIONS OF MICRO-ELECTRONICS"

A symposium entitled "Applications of Micro-electronics" will be held in Birmingham on 27th March 1968. It will be supported by an exhibition of equipment appropriate to the subject from 26th to 28th March. The emphasis of this event will be on the point of view of designers, manufacturers and users of equipment. A series of eight papers will each discuss the design factors featured in a particular application where micro-circuits have been found to offer a favourable solution. In particular comparisons will be drawn between equipment designs using discrete components and those using micro-circuits. Together the papers will cover a wide field of application ranging from computers to industrial electronics and measuring instruments. The discussion will be directed towards an impartial exchange of views on the economic, manufacturing and performance aspects of equipment.

The arrangements are jointly in the hands of the IEE South Midland Centre, Electronics and Control Section and the West Midlands Section of the Institution of Electronic and Radio Engineers.

Further details of the programme and registration forms may be obtained in December from the Hon. Secretary of the Organising Committee:—

G. K. Steel, B.Sc., D.I.C., M.I.E.E.,
Electrical Engineering Department,
The University of Aston in Birmingham,
Gosta Green,
BIRMINGHAM 4.

Enquiries from those wishing to exhibit equipment would also be welcomed.

"RUBBER ZENER" CIRCUITS

Continued from page 287

lamp. But none of these can give complete protection against sudden overloads. In theory the lamp should limit the short-circuit output current to 3A lamps in series, and very timid ones use a whacking great 36Ω 36W resistor instead, and so make the supply safer than safe—at the expense of current output.

In Fig. 4, variable resistor RV_2 is set up to produce 26V at the collector of TR_1. Also shown in the diagram are the lead-outs of TR_1 and TR_2 together

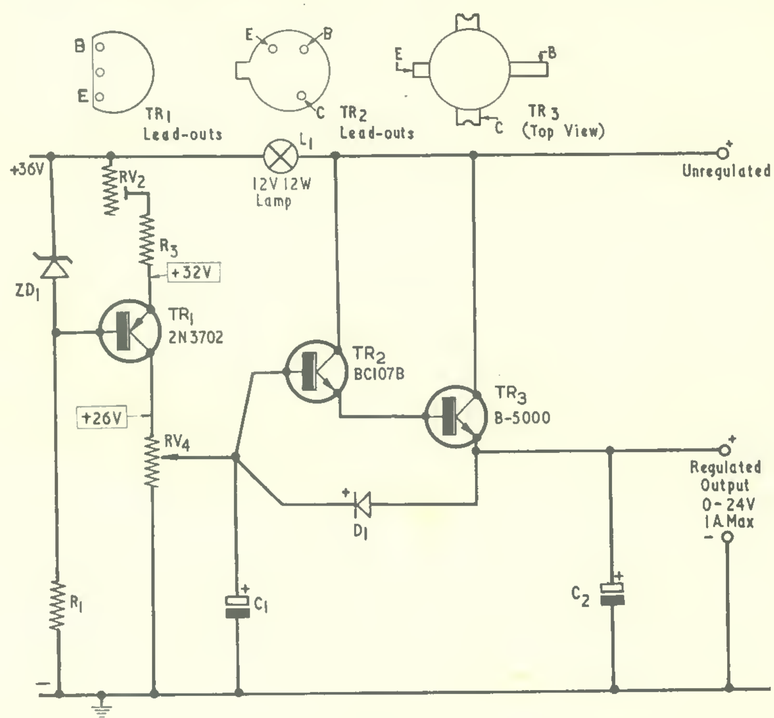


Fig. 4. Wide-range variable supply TR_1 drives a constant current through RV_4, and this enables a constant potential to be picked off and taken to the output pair. The 36V supply is normally, of course, obtained from a conventional mains power unit circuit

COMPONENTS

Resistors
- R_1 10kΩ ½ watt 5%
- RV_2 150Ω variable, preset
- R_3 270Ω ¼ watt 10%
- RV_4 2.5kΩ potentiometer, ½ watt

Capacitors
- C_1 25μF electrolytic, 36V wkg.
- C_2 1μF electrolytic, 36V wkg.

Semiconductors
- TR_1 2N3702
- TR_2 BC107B
- TR_3 B-5000
- D_1 Germanium diode, OA71, etc.
- ZD_1 4.7V 5% zener diode, e.g. OAZ200

(N.B. The three transistors are available from Amatronix, Ltd.)

Lamp
L_1 6V 6W lamp and holder (see text)

or less, and the B-5000 can take a 3A peak. But the lamp may not burn out fast enough, or it may arc over in the process. Timid constructors can put two with a *top* view indicating the terminals of TR_3. With this transistor all connections are made on the same side of the sink as the transistor body. ✷

SEQUENTIAL FLASHER FOR CHRISTMAS LIGHTS

By R. J. CABORN

Intended for the experimenter with experience of relays and their operation, this article describes a sequential light switching circuit which can operate as many lights as are required.

SEQUENTIAL LIGHT SWITCHING CIRCUITS ALWAYS provide an interesting novelty. This is particularly true at this time of year when they may be used, for instance, to control the lights around the Christmas tree. Alternatively, the sequential lights may be used to flash a message in sections, each letter or part of the message being illuminated in turn. A sequential switching system is also attractive for shop premises, where it may be used for advertising purposes.

The sequential switching circuit described here is capable of controlling as many lamps as is desired, each lamp requiring a relay with two normally-open contact sets and an electrolytic capacitor to provide a delay. Two further relays, one with one normally-open contact set and one with two normally-closed contact sets, together with two further electrolytic capacitors, are needed for terminating the sequence.

It is assumed that the reader is familiar with relay circuits and their operation. No specific relay type is specified since, provided the type employed has a coil resistance of 500Ω or more, and is capable of energising at some 12 volts or less, the choice is not at all critical. It should be mentioned, however, that the energising voltage just referred to is applicable for a d.c. supply of around 24 volts. If a d.c. supply of higher voltage is used, the relays employed may energise at voltages higher than 12. As will be gathered after the functioning of the switching circuit has been described, its flexibility enables a wide range of variations to be made in operating voltages and components. A further point is that all the relays used need not be of the same type. Different types can be very easily accommodated by varying the capacitance and resistance for each relay coil circuit.

The Circuit

The sequential switching circuit appears in the accompanying diagram, this being drawn to accommodate four lamps. The circuit uses the "detached" method of presentation, in which each relay coil is represented by a rectangle designated by a letter over a figure. The letter identifies the relay, and the figure the number of contact sets. Each contact set, which may appear anywhere in the diagram, is then identified by its letter followed by a serial number. Thus, the rectangle designated B/2 is the coil of relay B, and its contact sets are indicated as B1 and B2. All contact sets are shown in the position they take up when the associated relay is de-energised.

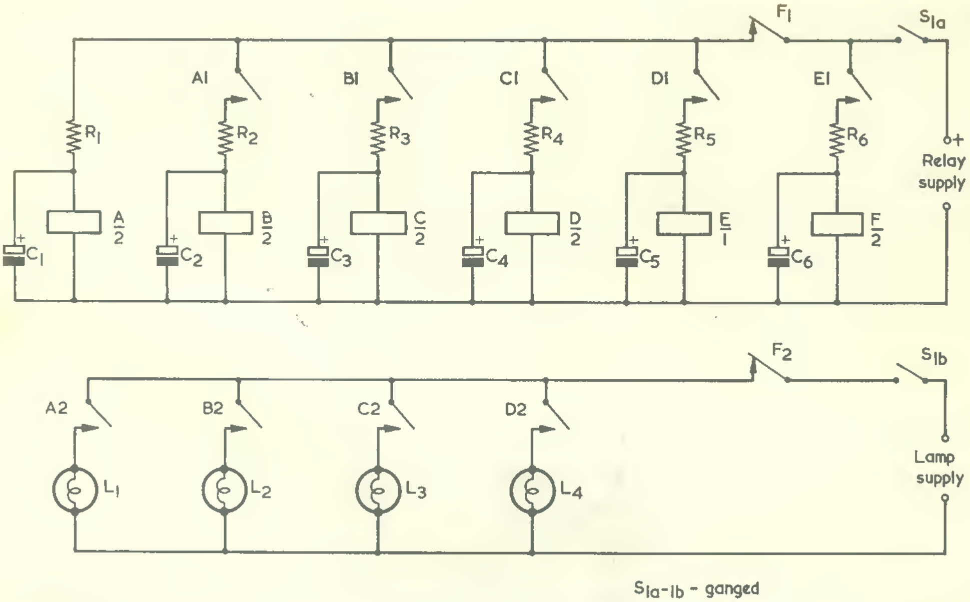
Initially, switch S_1 is open. When this switch is closed, $S_{1(b)}$ applies the lamp supply to the lamp switching circuit and $S_{1(a)}$ applies the positive side of the relay energising supply to the normally-closed contacts F1. The d.c. supply is now fed to relay coil A/2 via resistor R_1. Due to the presence of C_1 across the coil, relay A takes a short time to energise. When it energises, contacts A2 complete the lamp supply circuit to lamp L_1, which then becomes illuminated.

At the same time, contacts A1 apply the positive relay supply voltage to coil B/2 via R_2. After a delay due to the presence of C_2 across its coil, relay B energises. Its contacts B2 close and cause lamp L_2 to be illuminated, whilst its contacts B1 allow the positive relay supply voltage to be fed to coil C/2 via R_3.

Relay C energises, after a delay due to capacitor C_3. Its contacts C_2 cause lamp L_3 to be illuminated and its contacts C1 apply the relay positive supply voltage to R4 and coil D/2.

After a further delay, due to C_4, relay D energises. All the lamps are now illuminated and the first part of the sequence is over. Contact D1 applies the positive supply voltage to relay E and, after a delay, this relay energises. Its contacts E1 then apply the positive supply voltage to the coil of relay F.

After a period, relay F energises, whereupon its contacts F2 break the supply to the lamps, which are then abruptly extinguished. At the same time, contacts F1 also break the positive relay supply circuit to relays A to E and, after a short delay due



The circuit of the sequential flasher, employed for controlling four lamps. Component values are discussed in the text

to the charged capacitors connected across them, these de-energise. When relay E de-energises, its contacts E1 break the positive supply to relay F which, after a short period, also de-energises. Its contacts F2 complete the lamp supply circuit, but no lamps light since the relays A to D are now de-energised. Also, contacts F1 re-apply the positive relay supply to the energising circuits for relays A to E and, after a delay due to the presence of C_1, relay A energises and the next sequence starts.

It is necessary to employ two relays, E and F, instead of one to terminate the sequence for the following reason. If one relay were employed its normally-closed contacts would have to break its own energising circuit and, with the electrolytic capacitor across its coil, its armature would tend to take up a position which alternated between the just open and just closed condition. With the two relays, relay F does not break its own energising circuit. Instead, it breaks the energising circuit to relay E, and there is a short delay before contacts E1 open to de-energise relay F. A further point is that, after contacts F1 open, the short delay given before relay E de-energises gives the capacitors C_1 to C_5 time to discharge sufficiently for their relays to de-energise. A further delay to allow C_2 to C_5 to become adequately discharged is given by C_6 across coil F/2 and R_1 and C_1. The de-energise period of relay F should always be longer than the de-energise period of relay A and this point can be covered by making C_6 larger in value than C_1 (assuming both relays are the same type). The de-energise period of relay F should also be longer than that of relay D, otherwise there is a risk of relay E energising after contacts F1 close again.

Summing up the operation of the circuit, the sequence proceeds in the following manner. On closing S_1 there is a short delay after which relay A energises and lamp L_1 lights up. After a further delay relay B energises and lamp L_2 lights up. The process continues to relay D being energised and all the lamps being alight. All the lamps remain illuminated for a relatively long period until relay E and then relay F energises. The lamps are then abruptly switched off and relays A to E de-energise independently. After a pause given by capacitor C_6 discharging and, then, the subsequent delay due to R_1 and C_1, all the capacitors C_2 to C_5 are adequately discharged and the sequence recommences with relay A energising and lamp L_1 lighting up.

Delay Periods

The delay period before relays B to E energise can be of the order of a second or so whereupon the whole sequence takes about 8 seconds to complete. This is an appreciable time and the resultant display will be quite effective. The energising delay required in relay A need be only sufficient to ensure that C_2 to C_4 are adequately discharged before relay A energises at the start of a new sequence. The energising delay for relay F may be about 2 to 4 seconds.

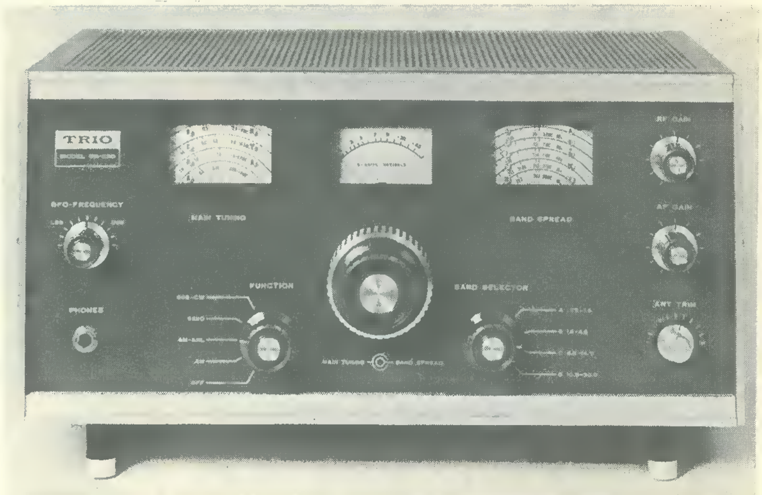
The d.c. supply for the relays should have a voltage at least twice the energising voltage of any relay. The required series resistance and parallel capacitance needed for each relay may then be found experimentally. The series resistance must first be determined, and this should have a value which just allows the relay to energise reliably when the supply is applied. Varying values of capacitance are then tried across the coil until the desired delay is obtained. As a guide, a P.O. 3000 relay with a 500Ω coil has an energising delay of about 1 second when the series resistor is 750Ω, the parallel capacitor is 500μF and the supply voltage is 17. A capacitance of about 1,000 to 2,000μF is required if this relay is employed for relay F. In general, lower values of capacitance will be required for relays with coils having higher resistance. The capacitors must, of course, have working voltages equal to or greater than the voltage appearing across the relay coil to which they connect.

The accompanying diagram shows 4 lamp-controlling relays, but the circuit application may be employed for fewer or more lamps and relays. It is merely necessary for one contact of one relay to apply energising voltage to the next, and for one contact of the last lamp-controlling relay to apply energising voltage to the first of the two end relays which terminate the sequence.

As a final note, if the lamp supply is obtained from the mains, all the contact sets in the lamp switching circuit must have insulation suitable for mains voltages, and all precautions against accidental shock when handling the equipment must be observed.

TRADE REVIEW . . .

TRIO COMMUNICATIONS RECEIVER MODEL 9R-59DE



The Trio Communications Receiver Model 9R-59DE. The receiver is supplied complete with alternative front mounting feet and a headphone plug. Provision is made on the rear apron of the chassis for remote control when used with a transmitter

This Japanese communications receiver, recently released in this country by Lasky's Radio Ltd., is of pleasing appearance—see illustration—and exhibits a performance that is well up to the manufacturer's specifications (given below). It was apparent that, with the model supplied to us, a lot of forethought and planning had gone into the design of this receiver and we found several unusual features not listed by the makers. Of these, that which appealed to us most was the inclusion of a pre-wired valveholder which only required the fitting of an OA2 (150V) stabiliser tube to provide the separate oscillator (½ 6AQ8) with a stabilised h.t. supply. In addition to this very easy modification we noted a pre-punched section of the chassis (valveholder and crystal holes) in which the purchaser can very rapidly assemble a 100 kc/s crystal oscillator. Moreover, the r.f. and i.f. gain control has an integral switch at the maximum gain position to which may be wired the 100 kc/s oscillator valve cathode as an on/off control—a circuit for this being given in the receiver handbook. Again, provision is made on the rear chassis apron for the mounting of a coaxial aerial input socket as an alternative to the normal screw type.

The circuit comprises 8 valves and 7 diodes, printed circuit techniques being used for the r.f. and i.f. strips. Two mechanical filters ensure a high degree of selectivity. One half of the 6AQ8 oscillator is unused and the manufacturer suggests, in the receiver handbook, that this could be employed as a cathode follower providing the input to the mixer stage.

Of particular appeal to us are the bandspread scales, these being accurately calibrated for each amateur band from 3.5 to 28 Mc/s once the main tuning dial has been set to the required position. Immediately after switching on, we found the calibration of the receiver to be only a few kc/s out throughout the entire tuning range, the true frequencies being slightly low in frequency of those shown on the dial. Provision is made for correct calibration by easy access to the coilpack through holes under the receiver cabinet, a printed guide to cores and trimmers being affixed alongside. A few moments spent in lining-up with a 1 Mc/s crystal oscillator soon corrected matters.

The electrical bandspread and the main tuning dials also have graduated 0–100 scales for logging and frequency reading purposes. Thus, the bandspread 0–100 scale represents, on 40 and 80 metres, 5 kc/s per division; on 15 and 20 metres, 20 kc/s per division; and on 10 metres, 50 kc/s per division. In this manner, the frequency of any amateur station may be read off the bandspread dial.

The noise limiter circuit was found to be extremely effective, the spiky Loran pulses on Top Band being completely smoothed out when the ANL was brought into use.

The S-Meter may be accurately aligned by means of a 500Ω potentiometer mounted on the chassis rear apron, the method of doing this being explained in the receiver handbook. The meter gives readings up to 60dB above S9 for whichever mode of reception the function switch is set.

The product detector (6BE6) readily resolves s.s.b. transmissions and a panel-mounted trimmer to adjust b.f.o. frequency provides selection of upper or lower sideband reception of these signals.

On the 8Ω speaker output circuit, provision is made for the speaker to be muted when a headphone plug is inserted into the headphone jack.

As received, the a.c. mains input selection switch is set to 230V 50 c/s, but this point should be checked by the purchaser before connecting the receiver to the mains supply—a large warning notice to this effect is included inside the packing case lid. The receiver is extremely well-packed and is protected with a tough clear plastic cover ensuring trouble-free transit.

The well-designed panel layout is finished in light grey, to contrast with the dark grey of the perforated case, the latter ensuring adequate ventilation.

Owing to the careful design and liberal use of screening frequency drift, after the initial first few minutes after switching on, was found to be completely absent. In fact, with the model supplied to us, and with the OA2 stabiliser fitted, we found that complete frequency stabilisation was reached in a few minutes.

Needless to say, this receiver stays in our possession!

The Trio 9R-59DE may be obtained from Lasky's Radio Ltd., 3-15 Cavell Street, Tower Hamlets, London. E.1, at 36 Gns plus 12/6 carriage and packing.

Trio Communications Receiver Model 9R-59DE
Manufacturer's Specifications

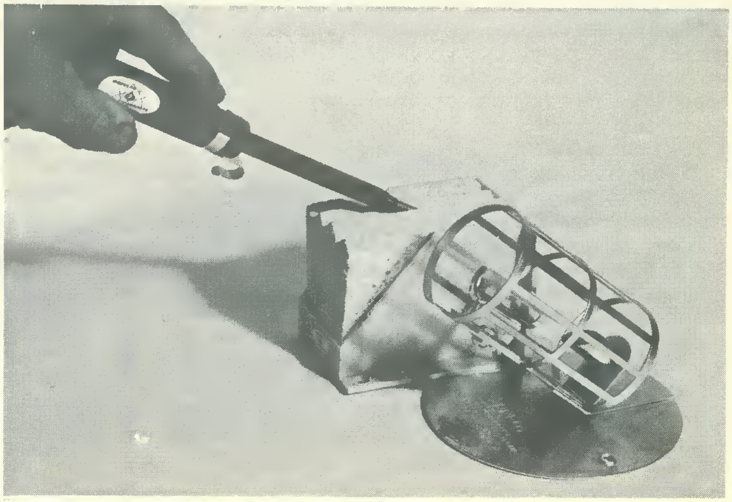
Frequency Ranges: Band A 550—1600 kc/s
Band B 1.6—4.8 Mc/s
Band C 4.8—14.5 Mc/s
Band D 10.5—30 Mc/s
Bandspread: Calibrated electrical
Aerial Input: 50—400Ω impedance
Audio Power Output: 1.5 watts
Sensitivity: 2μV for 10dB s/n ratio at 10 Mc/s
Selectivity: ± 5 kc/s at —50dB (±1.3 kc/s at 6dB)
B.F.O. Frequency: 455 kc/s ±2.5 kc/s

Speaker Output: 4 or 8Ω
Headphone Output: Low impedance
Power Consumption: 45W
Valve Line-Up: V_1 6BA6 r.f. amplifier
V_2 6BE6 mixer
V_3 ½ 6AQ8 oscillator
V_4 6BA6 1st i.f. amplifier
V_5 6BA6 2nd i.f. amplifier
V_6 6BE6 product detector
$V_{7(a)}$ ½ 6AQ8 B.F.O.
$V_{7(b)}$ ½ 6AQ8 1st a.f. amplifier
V_8 6AQ5 audio output

Diodes 1—7: S-Meter, noise limiter, a.m. detector, a.g.c. voltage doubler and rectifier, h.t. rectifiers.

A NEW BENCH SOLDERING STAND

A neat new soldering aid is now available from Henri Picard & Frère Ltd. It consists of a holding stand for a soldering iron combined with a tip cleaning sponge. These cleaners can also be supplied separately.



The soldering stand holds the iron at a convenient angle in an insulated socket which retains the heat of the tip. The iron is further protected by a cylindrical metal guard.

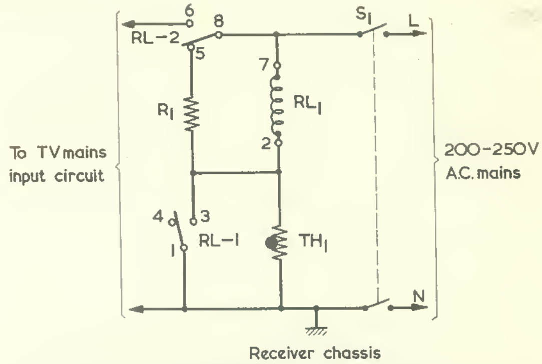
The tip cleaning sponge is kept moist from a water reservoir beneath it. It is shaped to allow quick one-stroke cleaning and, if regularly used, will help to prolong the life of the iron by preventing corrosion.

The price of the Lerloy Soldering Stand is 41/0d.
The Cleaner alone is 14/6d.

Switch-On Delay for TV

D. B. Hulse, A.M.Inst.E

In some of the older TV receivers employing a valve h.t. rectifier, damage can occur if the receiver is switched off then switched on again when the h.t. reservoir capacitor has discharged but the rectifier cathode is still at full emitting temperature. This article describes a neat delay circuit which ensures that switch-on under these conditions is automatically delayed



The circuit of the delay unit. Switch S_1 is the on-off switch already fitted in the receiver. The numbered points identify the pins of the octal valveholder into which the relay fits. Relay contacts are shown in the de-energised position

RECENTLY, AN ARGUMENT TOOK PLACE IN THE writer's home between his two young daughters, aged 6 and 2½, as to whether the TV set should remain on, or go off, following the completion of a programme. The elder decided that it should be switched off, and this she did. With a lightning reaction from the younger the set was immediately switched on again, with the result that both internal fuses (mains and h.t.) were blown, and the h.t. rectifier valve rendered useless.

Subsequent to the two culprits being packed off to bed, and the later fitting of a new valve and fuses, the writer decided that some form of delay subsequent to switching on the set could possibly prevent future damage. After a search through the spares box, and checking out several designs, the very simple but effective circuit shown in the accompanying diagram was made up.

Circuit Operation

Switch S_1 is the existing mains on-off switch on the set. With S_1 switched on a current flows through the thermistor TH_1 and the parallel branch comprising the relay coil and R_1 via relay contacts RL-2. The initial (cold) resistance of the thermistor and the parallel resistance of the relay coil and R_1 ensure that the voltage across the relay coil is below the minimum pull-in value. As the thermistor warms up, due to the current flowing through it, its resistance decreases which, in turn, increases the voltage across the relay coil. After a time the voltage across the coil is sufficient to energise the relay, and its contacts then perform three functions. First, power is switched through to the receiver; second, resistor R_1 is open-circuited; and third, the thermistor is short-circuited. The reason for the second and third functions is that the resistor and thermistor are no longer required after the timing is completed. It is essential, in the case of TH_1, that this component be allowed to cool in order to regain its initial high resistance. If the receiver is later switched off and then on again, the mains supply is not applied to its circuits until the delay period has once more elapsed.

The relay employed is a Keyswitch (Omron) type MK2P, which plugs into an octal valve base. It is fitted with 2 sets of changeover contacts, and the coil is rated at 230 volts, 2.5mA, 50 c/s. In the circuit diagram, the numbers 1 to 8 relate to the pin connections on the octal base.

The thermistor used had an initial resistance at room temperature (around 20°C) of 5kΩ. This coincides with the Brimar type CZ2 characteristic, and other manufacturers' data may also coincide. Delay times can, in any case, be varied by altering the value of R_1.

The writer employed a 10 watt resistor for R_1 but, in view of the fact that after several repeated operations the temperature of this resistor increased very slightly only, it should be possible to use a lower wattage type (e.g. 3 to 5 watts).

It is emphasised that the above components were to hand. No doubt other types of a.c. relay could be used providing the initial voltage across the coil is

COMPONENTS

R_1	3kΩ (see text)
TH_1	Thermistor type CZ2, or equivalent
RL_1	Relay type MK2P, 230 VAC energising (Keyswitch Relays Ltd., Cricklewood Lane, London, N.W.2)
Octal valveholder	

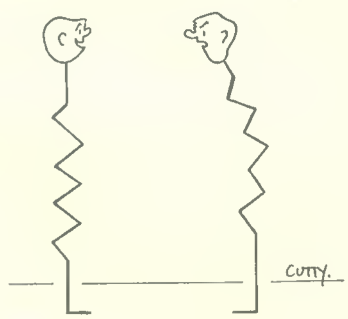
well below the pull-in value. Alternative relays may necessitate a change in the values of R_1 and/or HT_1. The relay specified may be obtained from the suppliers quoted in the Components List.

With the author's components the delay given when initially switching on the receiver from cold is 20 to 25 seconds. If the receiver is switched off after having reached full operating temperature then immediately switched on again, the delay is around 10 seconds due to the increase in ambient temperature around the thermistor. During this 10 second period (and during the last 10 seconds or so of the initial switching-on delay) relay chatter increases in volume until the relay energises. This appears to be the only objection to the circuit, but it can be overlooked in view of the fact that it is only present for about 10 seconds. Indeed, the writer's family and friends find it quite amusing.

As already stated, the intention was to provide a delay circuit of a simple nature compatible with reliable operation. The circuit does suffer one inherent disadvantage, this being given by the fact that very little or no delay is available if the set is switched off and immediately switched on just after the relay has energised, because the thermistor will not then have cooled sufficiently. (Provided that the thermistor is cool by the time that the h.t. rectifier reaches emitting temperature, this should not be too great a disadvantage.—EDITOR.)

One final point relates to the thermistor. It is well to position this component as far away from direct heat as possible, due to its inherent response to temperature. Also, all components must, of course, be fitted *inside* the TV cabinet, since their connections are at mains potential.

CARTOON CHUCKLE



10kΩ: "How are you?"
1·5Ω: "Not so good, my resistance is low"

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Schmitt Phase Inverter

by W. G. Morley

In last month's issue we continued our discussion of phase-splitters by dealing with the "Paraphase" and see-saw circuits, together with several developments of the latter. This month we complete our examination of phase-splitters by describing the Schmitt phase inverter, after which we will introduce the subject of negative feedback.

The Schmitt Phase Inverter

A further type of phase-splitter, commonly referred to as the *Schmitt phase inverter*, is illustrated in Fig. 1. In this diagram we have two similar triodes (which may, in practice, consist of a double-triode) sharing the common cathode resistors R_2 and R_3. R_2 functions as a common cathode bias resistor and, because it passes the cathode current of both valves, has half the value which would be used by either triode operating as a voltage amplifier on its own. Bias is applied to the grid of V_1 by way of R_1 and to the grid of V_2 by way of R_6. These two resistors may have values of the order of 1MΩ. The lower cathode resistor, R_3, has a much higher value than R_2 and may be, typically, 20kΩ or more.

Resistors R_4 and R_5 are nominally equal in value and form the anode loads for V_1 and V_2. They may have the values normally provided as anode loads for these valves when working as voltage amplifiers. C_1, C_3 and C_4 are a.f. coupling capacitors. C_2 has a low reactance at audio frequencies and could be, typically, 0.1μF.

If a positive-going input signal is applied via C_1 to the grid of V_1 this valve draws greater current, with a consequent increased voltage drop across R_4, and across R_2 plus R_3. Thus, the anode goes negative (providing one of the output signals) whilst the cathode goes positive.

Since the cathode of V_1 connects to the cathode of V_2, the latter goes positive also. At the same time, the potential on V_2 grid remains fixed, due to the presence of C_2. A cathode going positive relative to its control grid has the same effect as a control grid going negative relative to its cathode, and so the positive excursion of V_2 cathode results in a reduction of anode current in this valve. Less voltage is therefore dropped across R_5 and the anode of V_2 goes positive, thereby providing the second output signal.

We have seen, then, that by applying a positive-going signal to the grid of V_1 we obtain a negative-going output signal at the anode of V_1 and a positive-going output signal at the anode of V_2. Similar reasoning will demonstrate that a negative-going input signal results in a positive-going output signal from V_1 and a negative-going output signal from V_2. The circuit provides, in consequence, two out-of-phase outputs and so meets the first requirement of a phase-splitter.

The two outputs will have very nearly equal amplitudes if the triodes have a high amplification factor and if R_3 has a high value of resistance. In practice, an ECC83 would represent a good choice for V_1 and V_2, and R_3 should have a value of the order just mentioned. When R_4 and R_5 have exactly equal values the output from V_2 anode is always slightly lower than that from V_1 anode. The amplitudes can be balanced in practice by making R_5 some 2% to 4% greater than R_4.

Although the cathodes have an unbypassed cathode resistor, there is not the same heavy degeneration as occurs with the split-load phase-splitter because, in this case, almost equal currents of opposite phase flow in the resistor. The gain offered by the circuit for either output is, in fact, about half of the gain which would be provided by one of the triodes used as a normal voltage amplifier. Both output impedances are equal.

Two advantages of the Schmitt phase-splitter are that it is inherently self-balancing, and that there are no coupling capacitors between the two valves which could cause unbalance at the lower audio frequencies.

An interesting version of this phase-splitter is shown in Fig. 2, this being due to Mullard Limited.* The circuit of Fig. 2 functions in the same basic manner as that of Fig. 1, and it should be noted that the grid of the right hand triode has the same bias potential as the grid of the left hand triode by way

* "Circuits For Audio Amplifiers" (and other Mullard publications) published by Mullard Limited.

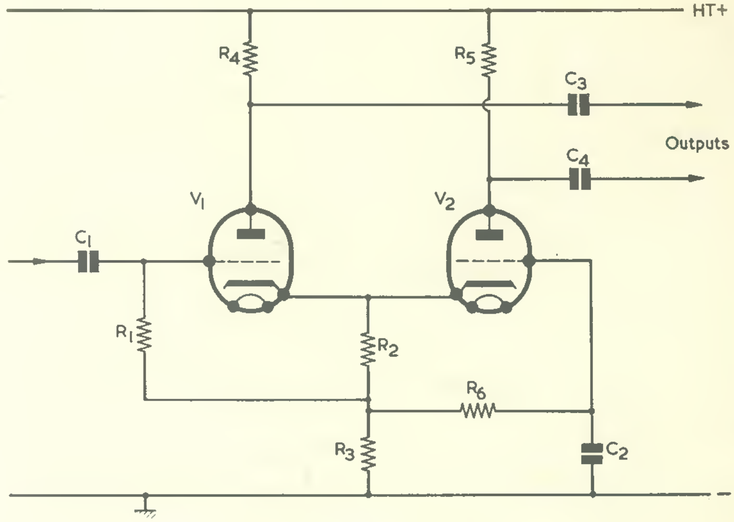


Fig. 1. The Schmitt phase inverter

of the 1MΩ resistor connected between them. The main difference between Fig. 2 and Fig. 1 is that the input coupling capacitor is omitted, and the grid of the left hand triode connects directly to the anode of a preceding EF86 voltage amplifier pentode. Although the grids of the two triodes are now considerably positive of chassis, the current which flows in the valves is limited by the cathode and anode resistors. The cathodes take up a potential positive of the two grids which provides a bias corresponding to the current which flows in the cathode resistor, and the circuit is thereby self-biasing. Nevertheless, it is still desirable that the voltage on the grids be such that the bias obtained brings the two triodes on to the centre of their linear working characteristics. In the Mullard application the EF86 is so operated that its anode is about 80 volts positive of chassis, the h.t. potential applied to the upper ends of the two triode anode loads being 410 volts.

As a note on terminology it should be mentioned that the Schmitt phase-inverter is also referred to as the *cathode coupled phase-splitter*.

Negative Feedback

We have referred, in a number of earlier articles in this series, to amplifiers having *positive feedback*. In most of the examples we have considered the positive feedback is sufficient to cause the amplifier to become an oscillator. We have also seen positive feedback applied, by means of a reaction circuit, to a grid leak detector. In this instance, the degree of positive feedback applied to the detector (which functions also as an amplifier) is capable of being

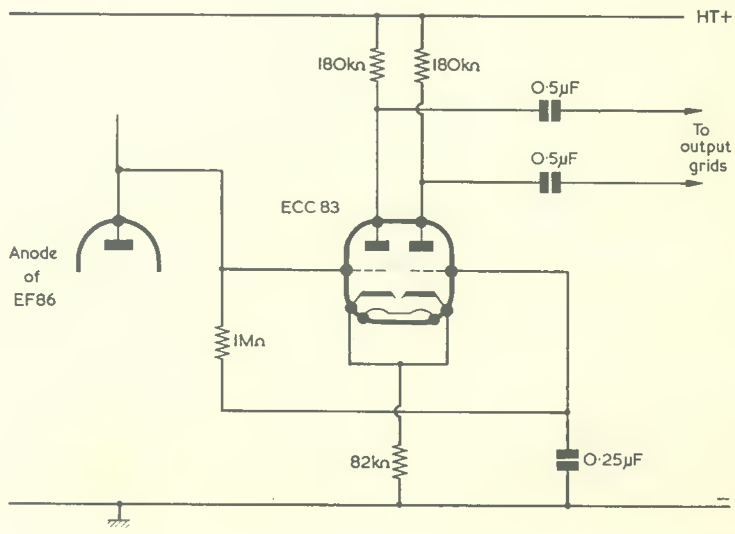


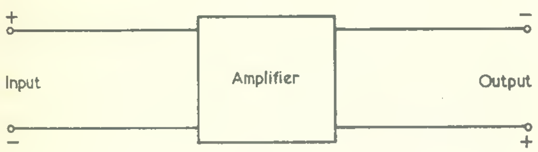
Fig. 2 Another version of the Schmitt phase inverter. The two 180kΩ anode load resistors are matched to within 5% and it is recommended that the following 470kΩ grid resistors for the push-pull output valves (not shown here) be similarly matched. (Acknowledgement: Mullard Limited)

controlled so that the detector is just short of going into oscillation, whereupon the positive feedback very nearly cancels out the "losses" in the tuned circuit feeding the detector, and this tuned circuit becomes capable of exhibiting a very high effective Q with correspondingly high slectivity and sensitivity.

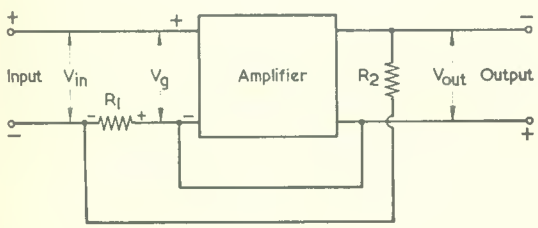
With *negative feedback* we apply a fraction of the output signal to the input of an amplifier in anti-phase. That is, the signal fed back is 180° out of phase with the input signal to the amplifier.

Fig. 3 (*a*) illustrates a straightforward amplifier to which no negative feedback is applied. If a signal input voltage is fed to the two input terminals in this diagram, an amplified signal voltage appears at the output terminals. Plus and minus signs have been added at the input and output terminals, these indicating the polarities of the signals during one half-cycle of the input signal.

In Fig. 3 (*b*) we connect resistors R_1 and R_2 in series across the output terminals, the voltage across R_1 now being inserted between the lower input terminal and the corresponding input point of the amplifier. Again we have plus and minus signs to indicate signal polarities and we now add three terms to indicate signal voltage amplitudes. These are V_{in}, to indicate the signal voltage applied to the input terminals of Fig. 3 (*b*); V_g, to indicate the signal voltage applied to the amplifier proper (the subscript "g" infers an input control grid circuit); and V_{out}, to indicate the signal voltage at the output. It will be seen that, due to the polarity of the fraction of the output signal which appears across R_1, an out-of-phase signal voltage is inserted in series with V_{in} and the input of the amplifier, with the result that V_{in} must always be greater than V_g. In other words, to achieve the same output voltage the signal applied to the input terminals in Fig. 3 (*b*)



(a)



(b)

Fig. 3 (a). A simple amplifier without negative feedback (b). By adding R_1 and R_2 in the circuit shown here, negative feedback is provided between the input and output terminals

must always be greater than the signal applied to the input terminals in Fig. 3 (*a*). By adding resistors R_1 and R_2 in the manner shown in Fig. 3 (*b*), we have introduced negative feedback, with the consequence that the overall gain—from input to output terminals—has been reduced.

The loss of gain resulting from negative feedback is, of course, a disadvantage but, as we shall show next month, the negative feedback provides a number of important advantages which considerably outweigh this disadvantage, particularly with respect to audio frequency amplifiers. Indeed, the major practical application of negative feedback is to improve the performance of a.f. amplifiers, or of other low frequency amplifiers which are required to provide a low-distortion output.

Before concluding this month, a simple and interesting mathematical exercise will demonstrate one of the results of adding negative feedback to the amplifier of Fig. 3 (*a*) so as to give the circuit of Fig. 3 (*b*).

The voltage gain of the amplifier proper is V_{out} divided by V_g and we may denote this by the letter A. Thus:

$$A = \frac{V_{out}}{V_g}$$

$$\text{or, } V_{out} = AV_g$$

Since R_1 and R_2 form a fixed potentiometer, the fraction of the output voltage appearing across R_1 is $R_1/(R_1 + R_2)$. Let us call this fraction n. The voltage appearing across R_1 is thus nV_{out}.

V_{in} is greater than V_g by the signal voltage across R_1, so:

$$V_{in} = V_g + nV_{out}.$$

Substituting for V_{out} from our previous equation, we get:

$$V_{in} = V_g + nAV_g$$

$$= V_g(1 + nA).$$

Thus, Vin has to be $(1 + nA)$ times greater than V_g to achieve the same output; or, the negative feedback has caused V_{in} to be divided by $(1 + nA)$ before application to the amplifier proper. The expression $(1 + nA)$ is sometimes referred to as the *feedback factor*.

It follows that the overall gain with feedback is A divided by $(1 + nA)$, i.e.

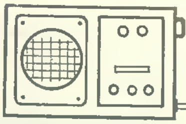
$$\text{Overall gain} = \frac{A}{1 + nA}$$

If the product of A and n is large we then encounter the remarkable fact that, regardless of the gain of the amplifier without feedback, the overall gain with feedback is always nearly equal to 1/n. For instance if n is 1/20 (whereupon 1/n = 20) then for A = 2,000 we have an overall gain of 19.8, for A = 1,000 we have an overall gain of 19.6 and for A = 500 we have an overall gain of 19.2.

Next Month

In next month's issue we shall continue with the subject of negative feedback.

In your work-shop



As usual, Christmas finds Dick and Smithy heavily embroiled in the extra repair work which always appears at this time of the year. Fortunately, they manage to spare the last hour of the day to discuss the latest addition to the Workshop test equipment—Smithy's ingeniously designed stabilised power supply.

"TALK ABOUT THIS BEING THE season for burying the hatchet," snorted a perspriing Dick as he wrenched viciously at the controls of the record-player on his bench. "What *I'd* like to do right now is to bury my hatchet in the head of the geyser at the factory who dreamed up these push-on knobs that can't be flaming well pulled off again!"

At last the final knob came free, whereupon Dick feverishly removed the record-player chassis from its cabinet and grabbed his testmeter prods.

From which statement and occurrence two facts may be deduced. First, that the time was such that a general demeanour of benevolence and good will was expected from Dick. And, second, that Dick was far too pushed to provide it.

If we now add the information that the date was December 23rd and that the Workshop was to be closed on the morrow all becomes clear. As occurred every year just before Christmas, the Workshop was completely inundated with television sets, radio receivers and record-players which had decided to become faulty immediately prior to the Great Day. Thus, whilst the general public outside gradually relaxed before settling down for the Christmas holiday, and even the Christmas Card counter at Woolworth's showed signs of diminishing business after the three months it had been open, Dick and Smithy laboured mightily at the repair of the domestic electronic equipment which was essential for the festivities at the neighbouring Yuletide family firesides.

Stabilised Supply

But, as must inevitably happen, diligence and hard labour won through, and in the latter part of the afternoon the Serviceman and his assistant suddenly found themselves staring unbelievingly at a 'For Repair' rack which was now completely empty.

"Stap me," said Dick incredulously, as he tottered back wearily to his stool, "we've done it!"

"We have indeed," agreed Smithy, mopping his brow. "I never thought we'd have been able to get all that lot cleared out before packing-up time. And it's a bit too near Christmas right now for me to particularly relish doing any overtime."

The pair fell silent for some moments as they recovered from the Herculean labours of the morning and afternoon. Dick glanced at the Workshop clock, then brightened.

"Well, there's one good thing, anyway," he remarked. "We've still got an hour to go yet!"

"Have we?" commented Smithy, surprised. "We must have been fixing those sets a lot faster than I'd realised. Oh well, if we've got an hour to spare we can take things easy for a while. That hour also gives me a chance to introduce something new to you."

"Something new?"

"That's right," said Smithy, as he reached into the cupboard at the side of his bench. "Now, what do you think of this?"

Dick looked curiously at the small chassis which Smithy placed carefully on his bench. This sported, on its front panel, a large red terminal, a large black terminal, a toggle switch, and two control knobs, whilst on its top surface were two power transistors mounted on a heat sink, a mains transformer and a number of small components wired up neatly on a groupboard.

"What is it?"

"This," announced Smithy proudly, "is the Workshop Stabilised Power Supply. I've been knocking it up at home during odd periods and I just managed to finish it off last night. Up till now, we've been too busy today for me to show it to you and explain how it works."

"Stabilised power supply, eh?" said Dick thoughtfully. "What output voltage does it give?"

"There's a continuously variable control which provides an output from about 0.5 to 16 volts," replied Smithy. "Which is just the job for working with transistor gear."

"That should be jolly useful," remarked Dick, interested. "What's the maximum output current?"

"Now that," pronounced Smithy, "is where we come to the crafty bit! With the circuit I've used here it's possible to adjust the power unit so that it offers any maximum output current you like up to 300mA. It gives a well regulated output for currents below the figure you've set it up for, but it simply refuses to pass any current above that figure. This means that, if you're using the unit for experimental work, it's impossible for the equipment connected to it to suffer any damage due to too high a supply current. On this particular model I've fitted a 2-way switch to select maximum output currents of 100mA and 300mA, which should be adequate for our requirements in the Workshop. But the circuit can be easily altered to give any other maximum output currents, up to 300mA, that you may want."

Dick looked impressed.

"Blimey, that *is* something," he said. "What happens if I set it up to 10 volts at a maximum current of 300mA and draw, say, 275mA from it?"

"You get 10 volts."

"And if I draw 300mA from it?"

"The output voltage drops to zero. But if you reduce the load current to 275mA again the output immediately reverts to 10 volts."

"Gosh! It sounds as though you could even short-circuit the output terminals of the unit with a piece of wire!"

"You can," replied Smithy cheerfully. "The output voltage will then merely drop to zero and 300mA will flow through your piece of wire. If the power supply had been set to 100mA, then 100mA will flow through the wire. I must add

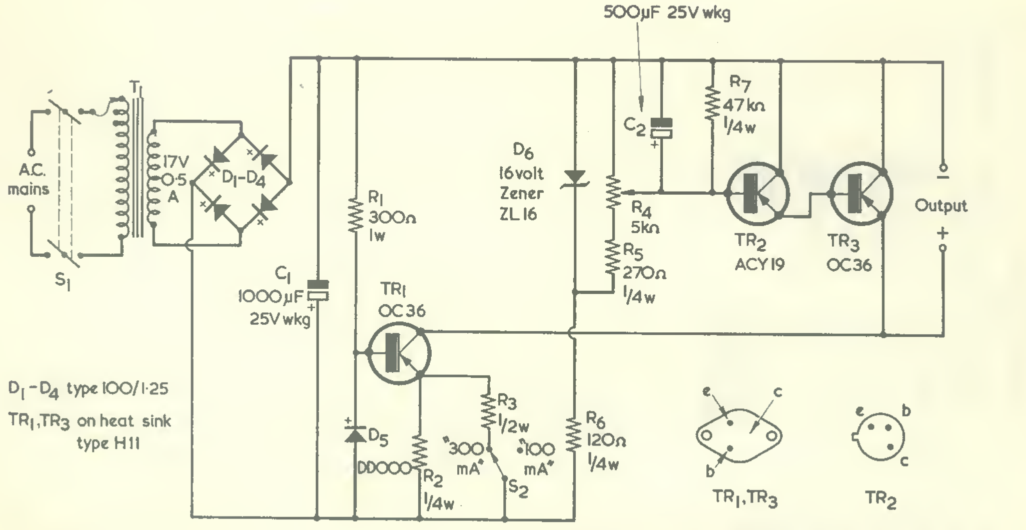


Fig. 1. The circuit of Smithy's stabilised power supply. The output current is limited to 100mA or 300mA according to the position of S_2. The values of R_2 and R_3 have to be found experimentally, the process being explained in the text

that all this will happen regardless of the output voltage to which the power supply had been set up before you put the short-circuit on."

"But surely," protested Dick, "short-circuiting the output terminals must cause *some* damage in the power supply."

"Not in *this* power supply it won't," replied Smithy, giving the chassis a fond paternal pat with his hand. "This one's designed to give a specific maximum output current which cannot be exceeded. Recapping on what I said a little earlier the unit is, in consequence, capable of protecting any equipment which is connected to it. If, for instance, you have a gadget which, when working correctly, draws 80mA, then you switch the power supply to 100mA maximum output current. Should something go wrong with the equipment and it starts to draw an increased current, then the power supply will automatically ensure that the increased current cannot exceed 100mA."

Constant Current Device

"I'd certainly like to know how this supply of yours works," said Dick enthusiastically. "Is it all your own design?"

"Not entirely," replied Smithy modestly. "I was inspired to dream up the principle from two of G. A. French's recent 'Suggested Circuits'. I combined two separate ideas from these in the present unit. Incidentally, this power supply unit makes quite an interesting little project for the home-constructor, as it's quite simple to put together and layout is not at all critical. As a matter of fact I bought some of the parts from a home-constructor supplier myself, because they aren't normally encountered amongst ordinary servicing spares. Anyway, here's the circuit of the power supply if you'd like to have a look at it."

Smithy produced a sheet of paper from his drawer and laid it on the surface of his bench. Dick walked over, squatted down beside the Serviceman, and concentrated on the circuit Smithy had drawn out. (Fig. 1).

"Well," he pronounced, after a minute's diligent study. "I'm O.K. from the a.c. mains input up to the bridge rectifier and C_1. But after that I'm stymied, mate!"

"Fair enough," chuckled Smithy. "I'll go through the circuit with you then."

"Pray do."

Smithy frowned.

"You're getting very polite all of a sudden," he remarked suspiciously. "What's happening?"

"I'm just beginning to get the Christmas spirit."

Smithy settled himself more comfortably on his stool.

"I must confess I'm beginning to feel a bit that way myself," he remarked lazily. "And it's nice to think that it's Christmas Eve tomorrow and there's no more work to do. Anyway, let's get back to this circuit of mine. You've already said that you're O.K. up to C_1, the 1,000μF electrolytic, so I'll just go very briefly through that bit. The a.c. mains is applied via the on-off switch S_1 to the mains transformer, this having a secondary voltage of 17. The secondary voltage is passed to the bridge rectifier given by D_1 to D_4, and a rectified d.c. voltage then appears across the 1,000μF reservoir, C_1."

"That's fine," said Dick. "It's the stuff after C_1 that worries me!"

"In that case," replied Smithy, "we shall now proceed from C_1 in an easterly direction; whereupon we arrive at the current limiting and voltage stabilising parts of the circuit. I'll deal with the current limiting part first, whereupon I must ask you to cast those beady eyes of yours upon TR_1. This is an OC36 power transistor which is operated in the grounded base mode."

"Hang on a minute," interrupted Dick. "That rings a bell somewhere! Didn't you tell me some time ago that a grounded-base transistor offers a constant collector current?"

"I did," confirmed Smithy. "Actually, it was two months ago, when we were nattering about transistor a.f. output stages in mains-driven equipment. Now, TR_1 has its base held at a fixed potential by way of D_5. D_5 is a silicon diode and it is caused to pass about 50mA in the forward direction by R_1. So a nice steady voltage of around 0.6 is dropped across D_5 and the base of TR_1 is continually maintained at this potential relative to the positive supply line from the bridge rectifier."

"Isn't 50mA rather a high current?"

"Not really," replied Smithy. "The minimum h_{FE} of an OC36 is 30 and we want constant currents from its collector up to 300mA. So the base voltage shouldn't alter for changes of base current up to 10mA. By passing 50mA through D_5 we ensure, with a very adequate margin, that changes of 10mA in base current will have negligible effect on the voltage across the diode."

"How do you adjust the constant collector current?"

"By varying the emitter current," answered Smithy. "And you do this by putting different values of resistance between the emitter and the positive supply line. When switch S_2 in my circuit is in the '100mA' position only R_2 appears between the emitter of TR_1 and the positive supply line. This resistor has a value which causes the collector current to remain substantially constant at 100mA for all collector potentials from about 1 volt up to 18 volts or so. When S_2 is in the '300mA' position R_3 connects across R_2, thereby increasing the emitter current and causing the collector current to be substantially constant at 300mA over the same range of voltages."

"You haven't," objected Dick, "shown any values for R_2 and R_3."

"They have to be found experimentally," explained Smithy. "Although they *could*, I suppose, be calculated. The resistance between TR_1 emitter and the positive supply line should have a value which causes the voltage across D_5 minus the voltage across the base-emitter junction of TR_1 to appear across the resistance when the current flowing through the resistance is the base current plus the desired constant collector current."

"Thank you very much."

"Not at all."

"I'm much obliged."

"I have no doubt of it," grinned Smithy, "but I can now dispel that look of anguish which always appears on your face when you're confronted with anything more complicated than adding two and two together by saying that it's easier to find the value of emitter resistance experimentally than it is to bother to calculate it. Since there's bound to be a spread on the forward voltage across the diode and the gain in the transistor, calculations can only be approximate, which means that the calculated value will have to be finally trimmed to suit the particular diode and transistor used in any case. Anyway, I'll be returning to the emitter resistance later. What I now want to do is to summarise the action of TR_1 in the circuit. When S_2 is in the '100mA' position a current of 100mA flows in the collector circuit of TR_1 all the time regardless of the voltage on that collector. And, when S_2 is in the '300mA' position, a current of 300mA similarly flows all the time regardless of collector potential."

Voltage Control

"Half a mo," said Dick. "You seem to be emphasising that the appropriate constant current flows all the time. Why?"

"Because it does," replied Smithy simply. "As soon as you switch on the power supply, TR_1 provides the constant collector current selected for it by S_2 all the time. I'm emphasising this 'all the time' business because it's important to bear it in mind when considering the voltage stabilising part of the circuit. Which is what we are next going to do."

Smithy drew out a pencil and indicated zener diode D_6.

"Now this," he continued, "is a 16 volt zener diode which is fed via R_6 from the voltage appearing after the bridge rectifier. So we have a steady 16 volts dropped across the diode, this being applied via the low value resistor, R_5, to the 5kΩ potentiometer, R_4. In consequence, very nearly 16 volts appears across R_4. If we adjust the slider of this potentiometer we may then obtain any voltage between zero and nearly 16 volts positive, these voltages being with respect to the negative supply line. This varying voltage is applied to the base of TR_2, which is a small ACY19 transistor; and the emitter of TR_2 connects to the base of TR_3, which is another OC36 power transistor. The output voltage appears between the emitter of TR_3 and the negative supply line."

"TR_2 and TR_3," remarked Dick, "form a compound emitter follower pair, don't they?"

"They do," confirmed Smithy. "Since the two transistors are emitter followers, their emitters are always slightly positive of their bases. Also, the current gain of the combination is equal to the product of their individual gains. Now, don't forget that the collector of TR_1 is connected to the emitter of TR_3. Provided that no load is connected to the output terminals, the constant current from TR_1 collector flows through TR_3 all the time. At the same time, the voltage on TR_3

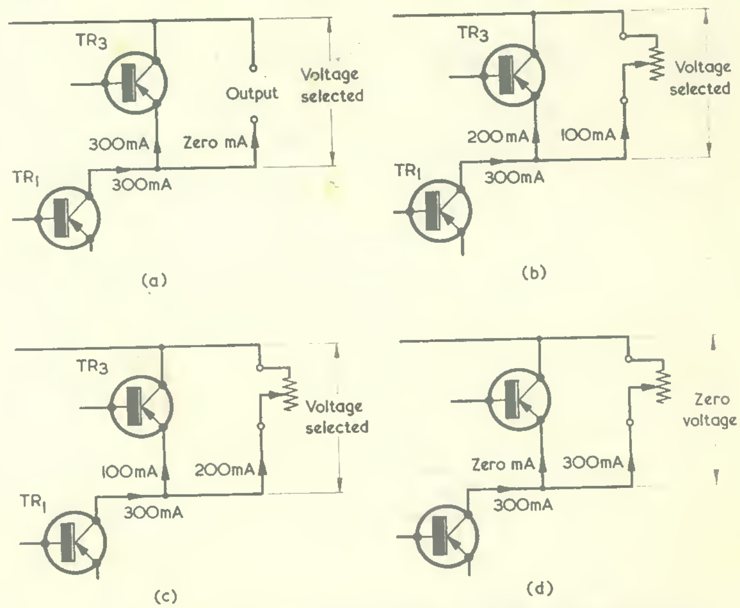


Fig. 2 (a). With S_2 in the "300mA" position and no output load connected, the constant current of 300mA flows through TR_3

(b). If a variable resistor is added as an output load and adjusted to draw 100mA, only 200mA flows through TR_3

(c). When the variable resistor draws 200mA, TR_3 current falls to 100mA

(d). Here the variable resistor is adjusted to draw the full 300mA current, whereupon there is zero current in TR_3 and the output falls to zero volts

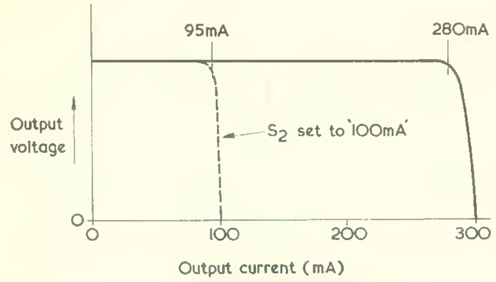


Fig. 3. Output voltage-current characteristic for any voltage selected by R_4. With S_2 set to "300mA", there is a drop of some 0.2 to 0.3 volts from zero current to 280mA, after which the voltage abruptly drops to zero at 300mA

emitter is always about 0.3 volts positive of the voltage on the slider of R_4 due to the base-emitter voltage drops in TR_2 and TR_3. In consequence, the output voltage of the unit can be varied by adjusting R_4."

"I suppose," said Dick reflectively, "that using two emitter followers after R_4 instead of just one gives you better voltage regulation."

"Oh, definitely," agreed Smithy. "The current flowing in R_4 must always be much greater than the current changes in the base it supplies. Otherwise, the reference voltage provided at R_4 slider would change by an unacceptable amount due to varying base currents. As you'll see in a moment, we expect TR_3 to give a steady output voltage for emitter current changes from zero to 300mA. Assuming a minimum gain in this transistor of 30, this argues that there can be corresponding changes in base current of the order of 10mA. The ACY19 in the TR_2 position has a minimum gain of the order of 80, with the result that the maximum current changes in *its* base circuit can be of the order of 10mA divided by 80, which is 125μA. A steady current of about 3mA flows through R_4, which is quite sufficient to swamp out changes as small as 125μA. Another factor which makes the use of two transistors attractive is that the output impedance at TR_3 emitter is approximately equal to the input impedance at TR_2 base divided by the overall current gain. This enables you to have output impedances which are, theoretically, exceptionally low."

But Dick's thoughts were now running on a different level.

"How can you have *varying* emitter currents in TR_3?" he asked. "You said just now that the constant current from TR_1 collector flows through TR_3 all the time."

"No I didn't," retorted Smithy. "What I said was that the constant current flows in TR_3 *provided* that no load is connected to the output terminals. When we connect a load, the current in TR_3 changes accordingly."

"This bit is puzzling me rather," confessed Dick. "What exactly *does* happen when you connect a load?"

"Let's assume," said Smithy in reply, "that S_2 is set to the '300mA' position and that R_4 is adjusted to give any convenient output voltage. A current of 300mA then flows through TR_3. (Fig. 2 (*a*)). We next connect a variable resistor to the output terminals to act as a load and set it up to consume a current of 100mA. (Fig. 2 (*b*)). The output voltage remains unaltered, but 100mA now flows through the variable resistor load and only 200mA flows through TR_3. We next adjust the variable resistor so that it consumes 200mA (Fig. 2 (*c*)). Again the output voltage remains unaltered but, this time, 200mA flows in the load and 100mA flows through TR_3. If we then adjust the variable resistor to consume 300mA, all the current will flow in it and none will pass through TR_3 at all. (Fig. 2 (*d*). In practice, the output voltage will commence to fall as the output current reaches some 280mA or so, and at 300mA the output voltage will be zero."

"Well, that's neat," commented Dick. "In other words, TR_1 just sits there in its corner preventing everything in its collector circuit from passing more than 300mA."

"Exactly," said Smithy, reaching for his pen and scribbling on the edge of his circuit diagram (Fig. 3). "The output voltage-current curve at all voltages selected by R_4 is like this. The output drops by only some 0.2 to 0.3 volts as current increases from zero to around 280mA After 280mA the curve abruptly falls to zero voltage at 300mA. You get the same abrupt drop near 100mA, of course, if S_2 should be in the '100mA' position."

Total Current

"There's something else," cut in Dick suddenly, "which I've just realised!"

"What's that?"

"It's the current drawn from the bridge rectifier and C_1," said Dick. "Once you've put S_2 in the position you want, this current remains fixed regardless of load current because it consists of the selected constant current plus the currents passing through D_5 and D_6."

"True enough," agreed Smithy. "As a result, the only changes in

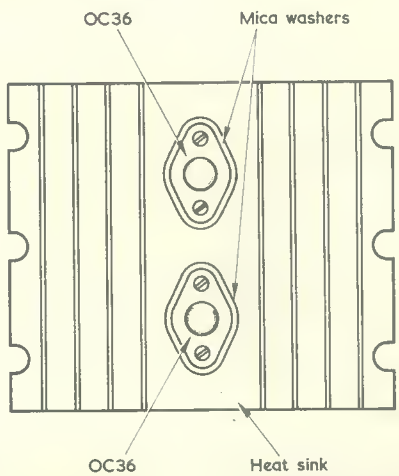


Fig. 4. In Smithy's unit the OC36's are insulated from the heat sink with mica washers and insulating bushes. The heat sink should be mounted with ribs vertical and with clear access to the air for cooling

voltage applied to R_6 and the zener diode are those due to fluctuations in the a.c. mains voltage. Variations in load current have no effect at all on the voltage applied to the zener circuit, which means that the zener diode can maintain a *really* steady reference voltage."

"There's another thing, I've just spotted," said Dick. "If there's no load connected, all the dissipation for the constant current is shared between TR_1 and TR_3."

"Now that," replied Smithy, "is rather an interesting feature of the circuit. If, for instance, no load is connected and the slider of R_4 is at the bottom end of its track, then about 16 volts appears across TR_3 and only about 2 volts appears across TR_1. So, virtually all the dissipation is given by TR_3. If, on the other hand, the slider of R_4 is right at the top end of its track there is only a very low voltage across TR_3 and nearly 18 volts across TR_1, whereupon almost all the dissipation has to be given by TR_1. With R_4 slider in the middle of its track the voltages across TR_1 and TR_3 are about equal and each has to provide the same amount of dissipation. Without a load, the total dissipation is always the same, and since this is shared between TR_1 and TR_3 it becomes attractive to mount these two transistors on a single heat sink. Without an external load, the heat sink then has to get rid of the same amount of heat regardless of the setting of R_4."

"That," remarked Dick, pointing to Smithy's chassis, "will be the heat sink you've used here, then?"

"Correct," agreed Smithy. "It's a ribbed heat sink type H11 with nominal dimensions of 4½ by 4 by 1 inch, and it's available from Henry's Radio, Ltd. As I told you earlier on, I got some of the parts for this unit through normal home-constructor channels. The two OC36's in my unit are mounted on this heat sink with mica washers and insulating bushes, which you can also obtain from Henry's Radio. (Fig. 4). My heat sink is bolted direct to the chassis and the use of mica washers ensures that there is no connection from any part of the circuit to the chassis. You could, however, bolt TR_3 direct to the heat sink without a mica washer, whereupon the chassis would become common to the negative output terminal. During initial tests of the circuit I found that the transistors were beginning to warm up appreciably when the constant current was 300mA and no load was connected and I decided that, since this power supply falls into the test gear category, it would be best to take a conservative approach and make 300mA the maximum current to be handled by the unit. With R_4 slider at the bottom end of its track, TR_3 then dissipates some 5 watts and, with R_4 slider at the top end of its track, TR_1 dissipates about the same number of watts. This dissipation is well within the ratings for the OC36, and the two transistors in my unit have stood up to it quite happily on a soak test. I must emphasise that the heat sink is *quite* essential. It should be mounted with the ribs vertical and with full access to the air. TR_2 doesn't need a heat sink, by the way; it is just soldered into circuit in normal fashion."

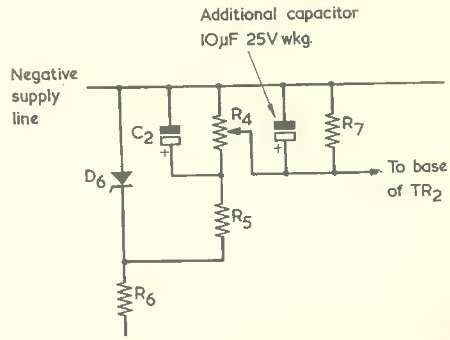


Fig. 5. With the circuit of Fig. 1, control of output voltage is slightly sluggish. If desired, this effect can be cleared by reconnecting the positive plate of C_2 to the lower end of R_4 track, and fitting an additional 10μF capacitor as shown here

"Why," asked Dick, "did you put R_5 in series with R_4? Wouldn't you get a wider range of output voltages with R_4 connected directly across the zener diode?"

"You only lose about 0.8 volts across R_5," replied Smithy. "Actually, there's a slight ripple voltage across the zener diode and this can find its way into the output if it isn't smoothed out. In my circuit, C_2, R_5 and the track of R_4 which appears below its slider provide the requisite smoothing. A slight snag with this arrangement is that control of output voltage becomes a little sluggish due to the high value of C_2, and the power supply takes about a second to reach any new output voltage selected by R_4. If you don't mind using a further electrolytic you can obviate the sluggish effect by connecting C_2 across R_4 and adding a 10μF electrolytic between R_4 slider and the negative supply line. (Fig. 5). Control of output voltage is then virtually instantaneous and the 10μF electrolytic still allows a nice low impedance to be presented at the output terminals."

"What," asked Dick, "is the function of R_7?"

"This resistor isn't really essential," admitted Smithy. "It just ensures that, if the slider of R_4 should momentarily become disconnected from its track, the output voltage will always tend to reduce."

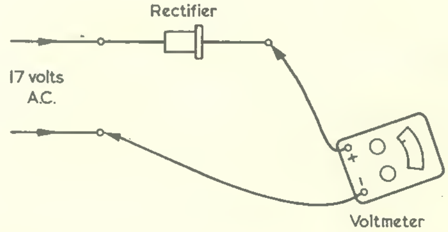


Fig. 6. When handling unfamiliar or unbranded rectifiers it is always a good plan to check polarity with a suitable a.c. source and a voltmeter before wiring into circuit. Forward deflection of the voltmeter needle indicates that it is the cathode (+) of the diode which connects to its positive terminal

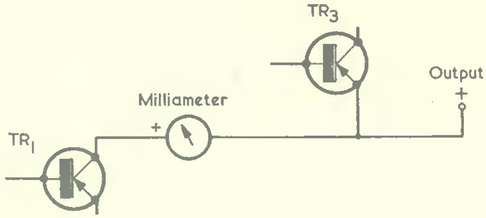


Fig. 7. When finding the values of R_2 and R_3, a milliammeter capable of reading 100mA and 300mA is temporarily inserted between the collector of TR_1 and the emitter of TR_3

Components

"You've certainly given some thought to this design of yours, Smithy," commended Dick. "Incidentally, would there be any point in adding a large-value electrolytic across the output terminals?"

"Not really," replied Smithy. "The output impedance should be at least as low, at a.f., as any normal electrolytic capacitor can provide. If you wanted a low output impedance at frequencies above several hundred kc/s, where the gain offered by TR_3 falls off, you *could* add a 0.1µF capacitor across the output terminals, and a low voltage ceramic component would do nicely here. For normal applications, however, there wouldn't be any point in adding such a capacitor."

"Fair enough," said Dick. "Are there any other points to consider so far as components are concerned?"

"Just a few," replied Smithy. "All the fixed resistors can be 10% types, and R_4 should be a linear wirewound component. However, a standard size carbon track potentiometer *can* be used for R_4 if it's a good reliable component and you're prepared to accept a shorter life than would be given with the wirewound type. R_4 can be given a pointer and scale which is calibrated in terms of output voltage. Alternatively you could add a voltmeter across the output terminals to indicate exactly what output voltage is being given. Rectifiers D_1 to D_4 are type 100/1.25 and D_6 is a ZL16, all of these being available from Henry's Radio. So also is a suitable inexpensive mains transformer, and I used a charger transformer type CT1 which has a secondary voltage of 17 at 1 amp, the latter being well in excess of the 0.5 amp actually needed. Incidentally, it is worthwhile following the usual practice of checking polarity before connecting D_1 to D_4 into circuit, and you can do this by putting each diode in series with the 17 volt a.c. from the transformer secondary and checking with a voltmeter. (Fig. 6). That's just one of the routine things I do with components of this nature which I haven't handled before, and it ensures that you don't accidentally apply reverse voltage to the reservoir capacitor. The only other component that's left is D_5, and this is a Lucas type DD000."

"There are two other components as well," Dick reminded him. "R_2 and R_3."

"Oh yes, of course there are," replied Smithy, with a grimace of irritation at his own forgetfulness. "And they're the most important of the lot, too! Well, now, my best approach here will be to tell you how I found the values for these in my own unit when I was getting this finalised. What I first did was to complete the construction of the unit with the exception of R_2 and R_3. I then inserted a milliammeter between the collector of TR_1 and the emitter of TR_3. (Fig. 7). Next, starting with 6.8Ω I gradually reduced the resistance in the R_2 position until the milliammeter indicated 100mA at all settings of R_4. There should be negligible change in this current as R_4 is adjusted, incidentally. In my case, the final value for R_2 was 4.7Ω, which ties in rather nicely with the value you'd expect from the calculation I referred to earlier. I then set S_2 for '300mA' and, starting with 3.9Ω, I gradually reduced the resistance in the R_3 position until the meter indicated 300mA for all settings of R_4. With my unit, the final value for R_3 was 2.4Ω which, again, tends to tie in nicely with what you'd expect from calculation. But different values will almost certainly be needed in other supply units made up to the circuit, and these will have to be found experimentally in the same manner that I did."

Smithy paused for a moment to collect his thoughts. "Now, after I'd got R_2 and R_3 sorted out," he continued, "I took the milliammeter out of circuit, connected the collector of TR_1 to the emitter of TR_3 and, with a voltmeter, checked that the correct range of output voltages was given as R_4 was adjusted with S_2 both on '100mA' and on '300mA'. There should be negligible change in output voltage as S_2 is switched from one position to the other. The final test was to connect the milliammeter directly across the output terminals. This acted as very nearly a direct short and it indicated 100mA and 300mA for the corresponding positions of S_2 at all settings of R_4, thereby showing that current limiting was taking place in the required manner. After which tests, I pronounced the power supply as being complete and working!"

"One minor point," put in Dick. "How did you do the gradual reduction in value business with R_2 and R_3?"

"I commenced," replied Smithy, "with a fixed resistor of the appropriate starting value then experimentally applied higher value resistors across it until I got the desired collector current. Alternatively, I could have tried different lengths of resistance wire. One thing is very important indeed. It is *essential* to start with too high

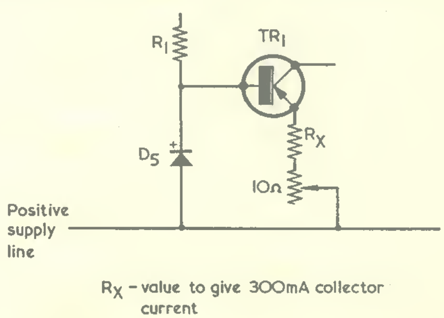


Fig. 8. A continuously variable maximum output current would be provided by modifying the emitter circuit of TR_1 to that illustrated here

a resistance and then *gradually* reduce it. If too low a resistance is accidentally put in either the R_2 or R_3 position, too high a constant collector current will be given, and this could well result in two OC36's and one testmeter being wrecked. So, this part of the operation must be done with extreme care. I should add that if anyone making up the unit wanted a *continuously* variable control of current up to 300mA he could initially find the value which causes 300mA constant current to flow. If this value of resistance were connected in series with a 10Ω variable resistor, the latter could then be used to control the maximum current from about 50 to 300mA." (Fig. 8.)

Christmas Spirit

Smithy reached over and pushed his power supply chassis to one side.

"Now, that's quite enough of matters electronic," he pronounced. "Let's start thinking about Christmas instead!"

Dick withdrew the fascinated gaze he had been applying to Smithy's supply unit.

"I was so tied up in this circuit of yours," he remarked, "that I'd almost forgotten it will be Christmas Eve tomorrow!"

Smithy leaned over and reached once more into the cupboard from which he had extracted the power supply unit. There was a pleasant tinkling as he straightened up and placed two glasses and a bottle on his bench. Gravely, the Serviceman charged Dick's glass then proceeded to fill his own.

"Here we are, my lad," he said warmly, handing Dick his glass, "and a very Merry Christmas to you as well."

"And the same to you," replied Dick appreciatively, as he sipped at the golden liquid. "A very Merry Christmas, indeed."

The pair rose.

"We must also," stated Smithy, "wish a truly Merry Christmas as well to all the readers who've put up with our monthly doings over the last year. A really Happy and Merry Christmas to all of you!"

"And let us finish 1967," chimed in Dick, "as we have done on so many previous Christmasses, by saying 'God Bless Us, Every One!"

Editor's Note

The two "Suggested Circuits" by G. A. French referred to by Smithy are "Improved Power Supply with Excess Current Protection" and "Parallel-R Series-C Computer".

SEMICONDUCTOR MATERIALS

By J. B. Dance, M.Sc.

Virtually all readers will be familiar with the uses of germanium and silicon in diodes and transistors, but many other semiconductor materials are now available and may be used to fabricate a wide variety of special devices.

Germanium and silicon (and, for that matter, diamond) fall into a group of quadrivalent elements (that is, their valency is four) at the centre of the periodic table of the elements. The valency of an element, incidentally, may be considered to be the number of arms which one atom of that element possesses to attach itself to other atoms. Silicon carbide is a combination of two quadrivalent elements. However, quite a number of other lesser known semiconductor materials can be formed from an element of group III of the periodic table and an element of group V. Examples of these so called III-V compounds are gallium arsenide, indium antimonide and indium phosphide. Other semiconductor materials can be formed from II-VI compounds, for example, cadmium sulphide, cadmium selenide and zinc sulphide. Some of the most important semiconductor materials are shown in the accompanying Table.

One of the most important properties of a semiconductor material is its energy band gap. This may be considered to be the energy which must be given to an electron in the material to allow it to overcome the forces which hold it in position in the crystal so that it can move freely under the influence of an electric field. Only free electrons and the "holes" which are formed with them can conduct electricity through the material. In germanium, electrons can acquire the energy necessary for free movement much more easily than in silicon, since the energy band gap in germanium is 0.66 volt, whereas that in silicon is 1.09 volt. (Although there may not appear to be very much difference between these values, the probability that an electron will become free diminishes extremely rapidly with increasing

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energy band gap values.) Pure germanium is therefore a much better conductor than pure silicon. In practice this means that the leakage current in a germanium diode or transistor is much greater than that in a similar silicon component at the same temperature.

As the temperature is raised, the number of free electrons in germanium increases so much that the material ceases to be useful at about 100°C. However, silicon, with its higher energy band gap, can be used at up to about 200°C in transistors, and other devices. On the other hand

Material	Energy Band Gap (volts)	Electron Mobility	Hole Mobility	Main Applications
Germanium	0.66	3900	1900	Diodes; transistors; tunnel diodes.
Silicon	1.09	1300	490	Diodes; transistors; silicon controlled rectifiers; field effect transistors; tunnel diodes; nuclear radiation detectors.
Gallium arsenide	1.43	6000	400	Infra red light emitting diodes; semiconductor lasers; tunnel diodes; Gunn effect devices.
Cadmium sulphide	2.45	200	60	Photoconductive cells; Nuclear radiation detectors.
Cadmium Selenide	1.7	200		Fast photoconductive cells.
Cadmium Telluride	1.4	700	50	
Gallium antimonide	0.7	4000	800	Low noise tunnel diodes.
Indium antimonide	0.17	70000	10000	Magneto-resistors; infra-red detectors.
Indium arsenide	0.33	30000	240	Hall effect devices; infra-red detectors.
Gallium phosphide	2.25	100	30	Light emitting semiconductor diodes.
Silicon Carbide	2.8	100	20	Special transistors for high temperatures.
Zinc Sulphide	3.6	100	10	A scintillator for nuclear radiation (Alpha).
Diamond	5.2	1800	1200	Early crystal counters for nuclear radiation.
Lead Sulphide	0.37	500	200	Photoconductive cells for infra-red radiation.
Indium phosphide	1.17	3400	50	
Aluminium antimonide	1.52	300	300	
Antimony Sulphide	1.7			
Bismuth Telluride				Thermoelectric generators.

germanium is the more useful for work at low temperatures.

The energy band gap is not the only important property of a semiconductor material. Two other properties are shown in the Table, namely the electron mobility and the hole mobility. These represent the ease with which electrons and holes move through the semiconductor material under an applied electric field. The lifetimes of the electrons and holes are also important.

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With the slogan "Box Clever", Mastertape (Magnetic) Limited recently launched a new kind of box for the three most popular sizes in their range of magnetic recording tapes.

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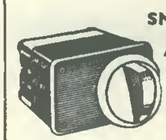

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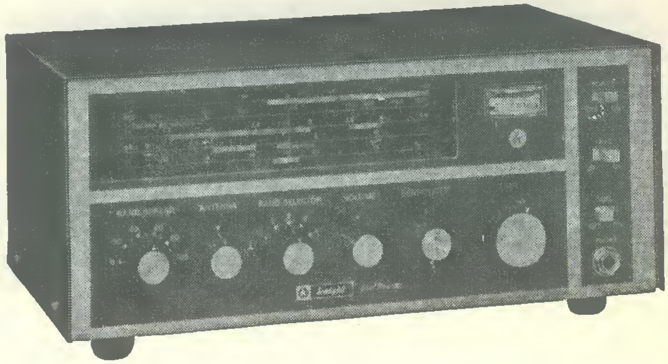

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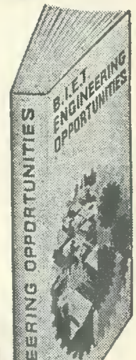

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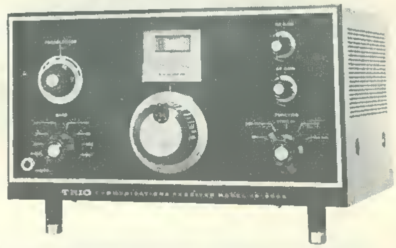

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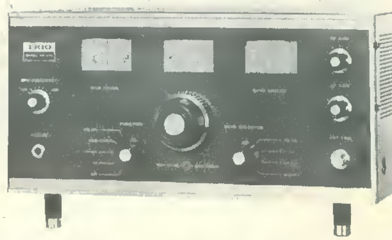

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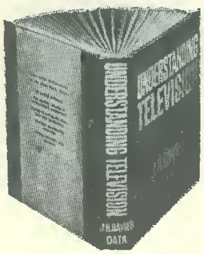

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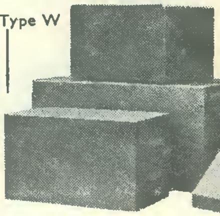

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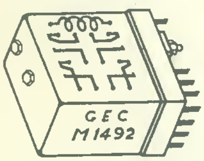

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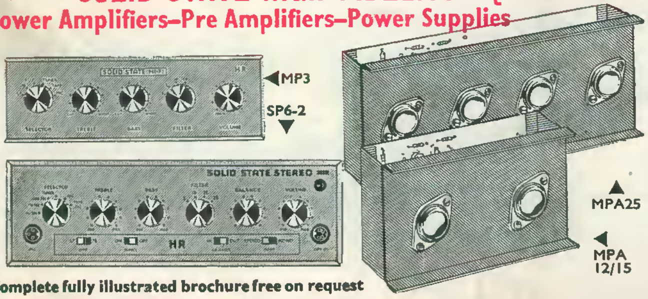

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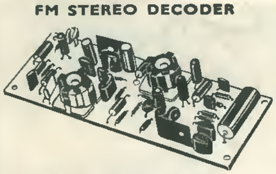

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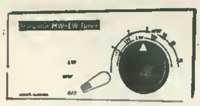

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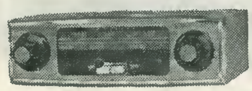

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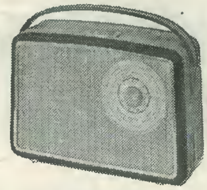

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