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<th>LOWEST PRICE YET</th>
<th>LARGEST RANGE EVER</th>
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<tr>
<td>1 AMP (TO-3 can)</td>
<td>7 AMP (STUD)</td>
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#### NEW SILICON RECTIFIERS TESTED

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<th>Description</th>
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<td>Fast Switch Planar</td>
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Vol. 21 No. 5

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Electronic Siren
by W. Kemp

S.C./O.C. Tester Using an I.C.
(Suggested Circuit No. 205)
by G. A. French

Trade News

Solid-State Time Delay Unit
by B. T. Hathaway

Can Anyone Help?

News and Comment

Hand Held 2-Way Radiophone
by F. G. Rayer, G30GR

"Rubber Zener" Circuits
by G. Short

3-Stage Preselector
by James S. Kent

Sequential Flasher for Christmas Lights
by R. J. Caborn

Trade Review—Trio Communications Receiver
Model 9R-59DE

Switch-on Delay for TV
by D. B. Hulse, A.M.Inst.E.

Understanding Radio
(Schmitt Phase Inverter)
by W. G. Morley

In Your Workshop
(Stabilised Power Supply, 0.5 to 16V output)

Semiconductor Materials,
by J. B. Dance, M.Sc.
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 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.

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 TR1 is derived from the negative supply line via R1, and base current to TR2 is derived from the positive supply line via R3 and TR1. Thus, if S1 is open-circuit no base current will flow to TR1 and this transistor will be cut off and, since TR1 is cut off, no base current can flow in TR2 and that transistor will be cut off also. If S1 is now closed TR1 will begin to conduct, thereby supplying base current to TR2 and driving that transistor hard on; as TR2 is driven hard on a large part of the supply voltage will be dropped across R2, causing TR2 collector to move towards zero volts with respect to the negative supply line. This excursion will be communicated to TR1 base via C1, thereby driving TR1 hard on, until both transistors become saturated. C1 then charges up rapidly via the two transistors until a point is reached at which the base current of TR1 starts...
to decrease. This decrease in current is then transmitted, in amplified form by way of TR2, R2 and C1, back to TR1 base, so that a regenerative action takes place and both transistors cut off. C1 then discharges, with a fairly long time constant, via R1, until TR1 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 TR1, this being achieved by either varying the value of R1 or the voltage that is fed to the low end of R1. In either case the frequency of operation will rise as the base current is increased, i.e. as R1 is reduced, or as the low end of R1 is made more negative.

The circuit can be switched off either by disconnecting the battery supply, or by opening S1. In the latter case both transistors will switch off, and the only current consumed will be the leakage currents of TR1 and TR2 which, assuming that silicon transistors are used, will normally be less than 1µA.

The full circuit diagram of the electronic siren is shown in Fig. 2. Here, TR1, TR2, R2, R3 and C1 correspond to the similarly marked components of Fig. 1, but the main timing resistor is split into two parts given by R1 and R5. The junction of these two resistors is connected to the positive supply.
The circuit will oscillate at a fairly low frequency. At the junction of \( R_1 \) and \( R_5 \) will be close to that of \( S_i \) is closed, \( C_2 \) will be discharged and the potential line via \( C_2 \) and \( C_3 \), \( R_4 \). Thus, at the moment that \( C_2 \) 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 \( S_i \) 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, whereinupon 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 \( S_i \) 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 Vero-board, which measures 2½ x 3¾in 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 \( TR_1 \), \( TR_2 \), \( R_1 \), \( R_2 \), \( R_3 \), \( R_4 \), \( C_1 \), \( C_3 \), \( C_4 \), \( S_1 \) (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

—Editor.

*If desired, transistors \( TR_4 \) and \( TR_5 \) 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.
Resistors
(All fixed values \( \frac{1}{4} \) watt 10%)

- \( R_1 \) 120\( \Omega \)
- \( R_2 \) 270\( \Omega \)
- \( R_3 \) 180\( \Omega \)
- \( R_4 \) 1k\( \Omega \)
- \( R_5 \) 82k\( \Omega \)
- \( R_6 \) 1k\( \Omega \)
- \( R_7 \) 820\( \Omega \)
- \( R_8 \) 820\( \Omega \)
- \( RV_1 \) 5k\( \Omega \), skeleton pre-set potentiometer

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

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

- \( C_1 \) 0.01\( \mu F \)
- \( C_2 \) 100\( \mu F \) electrolytic, 12V wkg.
- \( C_3 \) 1\( \mu F \) electrolytic, 12V wkg.
- \( C_4 \) 16\( \mu F \) electrolytic, 12V wkg.
- \( C_5 \) 0.1\( \mu F \)
- \( C_6 \) 16\( \mu F \) electrolytic, 12V wkg.
- \( C_7 \) 100 to 250\( \mu F \) electrolytic, 12V wkg.

Miscellaneous

- Loudspeaker, 5\( \Omega \) 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 C4 and, with S1 open, connect the 9 volt battery in place and check that the circuit draws a current of less than 2μA. Next, close S1 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, S1 should be opened and C2 should be soldered in place. When S1 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 S1 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 R6, D1, RV1, C5, and C6 in place, and then, reconnect the earpiece between the negative supply line and the positive side of C6. Check that the siren operates in the manner already described by closing and opening S1, and that the volume of the signal can be varied by means of RV1. If results are satisfactory, remove the earpiece from the circuit.

Now wire TR3, TR4, TR5, TR6, R7, R8, C7 and the link in place and, with S1 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 C7 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 S1, and ensuring that a reasonably high volume (about 250mW) of output is available. Also confirm that the volume can be varied by means of RV1, 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, S1 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 S1 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.
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 TR1 to TR4 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, TR1 and TR2 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 TR3 and TR4 offer similar gate facilities, and since they operate independently of TR1 and TR2, 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...
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 (M1 and R2) 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 B2. Terminal 4 of the I.C. connects to this negative supply line whilst terminal 8 connects, via one pole of on-off switch S1, 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 TR1 (Fig. 1) being connected, via its series 450Ω resistor, to the collector of TR3. Similarly, terminal 3 of the I.C. is connected to terminal 7, which means that the base of TR3 is connected, via its series 450Ω resistor, to the collector of TR1.

We thus have transistors TR1 and TR3 coupled together in the following fashion: TR1 base is d.c. coupled to TR3 collector, and TR3 base is d.c. coupled to TR1 collector. As a result, TR1 and TR3 form a flip-flop which can exist in one of two stable states. One of these is TR1 conductive and TR3 non-conductive, and the other is TR3 conductive and TR1 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 R2 and the 0–100μA meter M1, and is connected to terminal 7 of the I.C. In consequence, the voltmeter indicates the voltage on the collector of TR1. R2 is adjusted so that the meter gives its full-scale deflection of 100μA when TR1 is non-conductive; and it was found with the prototype circuit that the reading given when TR1 became conductive was then approximately 8μA. The current drawn by M1 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 TR2 or TR4 as applicable. If TR1 is non-conductive and 1.5 volts positive is applied to terminal 2, TR2 becomes conductive, reduces the voltage on TR1 collector and causes the flip-flop to change over. On removal of the 1.5 volts positive from terminal 2, TR1 remains conductive and TR3 remains non-conductive. To bring the flip-flop back to its previous state, 1.5 volts positive is applied to terminal 5. Transistor TR4 then becomes conductive, reduces the voltage on TR3 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, TR1 becomes conductive and a reading lower than 10μA is given in meter M1. If, then, 1.5 volts positive is applied to terminal 5, TR1 becomes non-conductive and meter M1 gives full-scale deflection.

In the tester being described, full-scale deflection in M1 indicates the fault condition.

**Short-Circuit Testing**

The function of push-button S2 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 to cell B2 to terminal 2 of the I.C. After the flip-flop has been reset by S2, further pressing of this switch has no effect.

When function switch S3 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 S3 is set to the lower position ("O.C."), whereupon the lower test terminal connects to the negative supply line and Ri connects to the 1.5 volt positive line. If a connection exists across the test terminals, a current of 10mA will then flow through R1 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 R1, 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 0.05μF 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 lead-outs 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 S3 and R2. S3 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, B2 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 R2, this should be set to insert maximum resistance when switching on the tester for the first time. The rather low readings initially given in M1 should still be adequate to show whether the flip-flop is working correctly. The flip-flop is then put in the state where TR1 is non-conductive, and R2 is adjusted for f.s.d. in the meter. If desired, R2 may be replaced afterwards by a fixed 1/4 watt resistor of the appropriate value. In the prototype, the final adjusted value in R2 was 17kΩ.

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 B2 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.
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 (9¼ in x 9½ in square by 4½ 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/Ohmometer

The Knight KG-640 Volt/Ohmometer 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 50µA 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

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(All fixed values 1/2 watt, 10%)</td>
<td></td>
</tr>
<tr>
<td>R₁</td>
<td>22 kΩ</td>
</tr>
<tr>
<td>R₂</td>
<td>3.3 kΩ</td>
</tr>
<tr>
<td>R₃</td>
<td>470 Ω</td>
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<td>RV₁</td>
<td>680 kΩ, skeleton preset</td>
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<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Value</th>
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</thead>
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<td>C₁</td>
<td>100 μF electrolytic, 15V wkg.</td>
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</tbody>
</table>

<table>
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<tr>
<th>Semiconductors</th>
<th>Type</th>
</tr>
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<tr>
<td>TR₁</td>
<td>ST140 (Sinclair)</td>
</tr>
<tr>
<td>TR₂</td>
<td>ST141 (Sinclair)</td>
</tr>
<tr>
<td>TR₃</td>
<td>ST141 (Sinclair)</td>
</tr>
<tr>
<td>D₁</td>
<td>OA200 or OA202</td>
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<tr>
<td>D₂</td>
<td>OA200 or OA202</td>
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<tr>
<th>Relay</th>
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<tr>
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<th>S₁ s.p.s.t. on-off switch</th>
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</table>

<table>
<thead>
<tr>
<th>Battery</th>
<th>B₁ 9-volt battery</th>
</tr>
</thead>
</table>

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

DECEMBER 1967
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 (TR1 and TR2) “rising-voltage” generator which drives a voltage-sensitive transistor “switch” (TR3) 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 Vout is nearly equal to Vsupply, there is only a negligible increase in Vout 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 Vsupply. 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 R1, Rv1 and C1, and is variable. The output of this part of the unit is fed to TR1, TR2 and R2, TR1 and TR2 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 R2. 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 R1, Rv1 and C1.

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 C1. 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
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, D1 and D2 are in series with the TR3 emitter-base "diode", so that forward current only begins to flow when the voltage at TR3 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 TR3 base. Thus, as the exponential rising voltage across R2 increases, a similar voltage appears between TR3 base and the negative supply line, but virtually no current flows in TR3 until about 2.2 volts is reached. Once this voltage is reached, however, a further increase of only 200mV is needed to drive TR3 sharply on and operate the relay that is used as its collector load. R3, in series with TR3 base, prevents excessive base current from damaging the transistor as the exponential voltage from R2 rises above the "trigger" level for TR3.

Using this system of relay operation a sharp switching action is obtained in TR3 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
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 RV1 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 S1. RV1 should be adjusted to insert minimum resistance and S1 should then be closed. If the circuit is functioning correctly, the relay should operate approximately 2 seconds after S1 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 RV1, the circuit being re-set between each timing period by opening S1 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 C1 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 S1 of Fig. 1, or it may be a separate switch ganged with S1 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 S1 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 S1 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. 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.

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.

(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, C1, 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 rechargeable 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, 12, 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.
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 Oman, 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

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.

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 \( V_C_1 \) on both Transmit and Receive. \( V_R_1 \) adjusts \( G_2 \) 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 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. \( V_R_1 \) is rotated from zero, as required, for suitable volume. Full rotation of \( V_R_1 \) (maximum \( G_2 \) 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 \( 3 \Omega \) 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 \( R_4 \), with a 500pF capacitor from the junction of \( R_5 \) and the loop to the l.t. negative line. \( V_R_1 \) 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.

The unit fitted in its case
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, VRi and VCi are on the same panel. Valveholder holes can be made with a fin punch as used for aluminium etc., or with a fin bit. There is not much free space, so it is wise to check the layout with the actual components first, especially those used for L2 and T1, 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 I.t. negative line, as there is no metal chassis. The bolt and tag anchoring C5, R4 and the h.t. negative lead are insulated from other circuits so as not to short-circuit R4.

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* The "hot" terminal for Li and the mounting for the whip aerial should, preferably, be insulated from this material, which may exhibit excessive leakage under damp conditions. —Editor.
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 V3 secured the leads.

In Fig. 2, "R" and "T" are the Receive and Transmit contacts of the switch, whilst "S" is the slider of VR1. The spindles of VC1, VR1 and the switch project through the front of the case and a small scale or dial for VC1 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 VC1 should also be satisfactory.

The 40 metre band coil has 40 turns of 24 s.w.g. enameled copper wire wound side-by-side on an insulated tube ¼ in in diameter and 1½ in long. For 80 metres, a piece of ferrite rod of ½ in diameter and 2½ in length was used. The 80 metre coil has 21 turns of 22 s.w.g. enameled 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 ½ in by 2½ in 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 VR1.

To check operation on transmit, insert V1 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 VC1 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. VC1 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 V3 also inserted, and using a 67.5V h.t. battery, h.t. current should be around 15mA, or a little higher, when VC3 is tuned for near-minimum current. The bias across R4 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 VR1, 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 VC1 can be tuned without an h.t. meter. Transmission will cease at settings of VC1 (if any) which result in cessation of oscillation. If the main station uses the same frequency, as is preferred, VC1 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 VC₁ 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 V₁ 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, R₁ 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 (hₑₑ 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 hₑₑ is 50, the load current can be 1A. Obviously, if we are to utilise such a large output TR₁ 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 RV₂ 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 RV₂ is
Low current Zener diode

High Current Output

4kΩ, 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 \( I_C = h_{FE} \cdot V_{CC}/R_1 \). Hence the maximum possible transistor collector dissipation is \( P_C = V_{CC}^2 \cdot h_{FE}/R_1 \). If \( V_{CC} = 10V \), \( R_1 = 50Ω \), 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
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 TR₁.

The diode is included as a result of bitter experience, in the shape of the mysterious demise of TR₁. The circuit worked all right one day, but not on the next day. TR₁ 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 Vcc. The base of TR₁ 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 (VₑB) is big enough, the base-emitter circuit breaks down, and the capacitor discharges through it and RV₂, 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 VₑB rating of 5V or less, and a diode is needed. Worst of all are diffusion transistors (AF115, etc.), which have VₑB 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.

**Darlington**

A way out of the problems due to the resistance inserted by RV₂ is to use a transistor with an enormous hFE, 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 hFE 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 hFE is the product of the individual hFE values. Very high values are obtainable. For example, if TR₁ were a high-beta planar with hFE = 500, and TR₂ a power transistor with hFE = 50, the overall hFE would be 25,000.

For an output current of 1A, only 1/25mA of base current need flow into TR₁. Even if RV₂ 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 RV₂ 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 +Vcc line can be vastly reduced by adding C₁, 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 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 \( (V_z = V_{be})/R_z \). 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 RV₂ of Fig. 2 the load of the constant current source, as in Fig. 4 where it appears as RV₄. 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...
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 $S_1(a)$, and this point will be dealt with later.
The stage providing most of the r.f. gain in this unit is that incorporating V2, this being an EF183 variable-mu frame-grid pentode having a mutual conductance of 12.5 mA/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.

The last stage of the preselector is given by V3, 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 S1(a) the aerial is disconnected from both inputs whilst S1(b) causes the preselector input to be earthed to chassis. At position 2 of S1(a) the aerial is fed direct to the receiver input, bypassing the preselector, via the capacitor C2; whilst S1(b) causes the preselector input to be still earthed. At position 3 of S1(a) the aerial is fed direct to the preselector input via the capacitor C1, whilst at position 3 of S1(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 transmissions.

As specified, S1(a), (b) is a 2-pole 3-way component. A 4-pole 3-way miniature rotary switch with 2
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 \( R_{FC1} \). 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 \( R_3 \) 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 \( C_{9} \) 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 \( R_{FC2} \), 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...
Resistors
(All ¼ watt 10% except where stated)
R1 150Ω
R2 33kΩ
R3 100Ω
R4 100kΩ
R5 5.6kΩ
R6 4.7kΩ
R7 33kΩ
R8 5.6kΩ
R9 100Ω
R10 5kΩ, 1 in with switch
R11 5.6kΩ
R12 470kΩ
R13 1kΩ
R14 3kΩ 2 watt
R15 1MΩ

Valves
V1 ECF82 (Mullard)
V2 EF183 (Mullard)
V3 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
C1 1,000pF ceramic
C2 200pF silver mica
C3 1,000pF ceramic
C4 100pF silver mica
C5 5,000pF ceramic
C6 5,000pF ceramic
C7 0.01µF tubular (Mullard)
C8 0.01µF tubular (Mullard)
C9 25pF variable, type C804 (Jackson Bros Ltd.)
C10 310pF variable, 2-gang, type E (Jackson Bros Ltd.)
C11 0.1µF tubular (Mullard)
C12 0.1µF tubular (Mullard)
C13 25pF trimmer (3 off)
C14 0.01µF tubular (Mullard)
C15 310pF variable, ganged with C10
C16 5,000pF ceramic
C17 5,000pF ceramic
C18 0.01µF tubular (Mullard)
C19 100pF silver mica
C20 0.1µF tubular (Mullard)
C21 5,000pF ceramic
C22 5,000pF ceramic
C23 0.02µF tubular (Mullard)
C24 0.01µF tubular (Mullard)
*C25 32µF electrolytic, 350V wkg.
*C26 16µF electrolytic, 350V wkg.

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

Knobs
See text

Chassis
8 ½ x 5 ½ x 2 ½ in
(H. L. Smith & Co. Ltd.)

Panel
9 ½ x 7 in
(H. L. Smith & Co. Ltd.)

Miscellaneous
5 ½ in grommets
1 ½ in grommet
2 3-way tag-strips

Coaxial Sockets
2 off

Switches
*S1(a), (b) 2-pole, 3-way
*S2(a), (b), (c), (d) 4-pole, 3-way
*S3 2-pole 1-way (ganged with R10)
(* see text)

being via R11, C23 providing decoupling to chassis.
The cathode circuit for V3 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 V3. This will be automatically provided in con-
ventional 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 con-
nected to one side of the mains supply.
The power supply is an integral part of the unit
and includes mains transformer T1, this being a
fully shrouded chassis mounting component. T1
is followed by a contact-cooled metal rectifier

0 DECEMBER 1967
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 PL1 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 S3, 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 S2 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 valve-holders. The appropriate holes should be initially drilled and then cut out with a chassis cutter; B9A for V1 and V2, and B7G for V3. When mounted, V1 valveholder should have pin 4 nearest the front, V2 valveholder should have pin 1 nearest the front and V3 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 V1 and V2 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 ½in grommets, the mains input leads to the primary passing through the hole nearer the front. Three further holes with ½in grommets are required in the chassis, two for the connections to the fixed vanes of C10, C15, and one for the twisted 6.3 volt pair to the pilot lamp. The two tuning capacitor connection holes are on the V1 side of this component, and it should be noted that C10 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 ½in overhang either side of the chassis itself and this was done so that the unit, once completed, could be 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 ⅝in 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, S3, 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 S2. 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 V1 side of the chassis. On the front wafer the bottom (farthest away from the chassis underside) single pole 3-way section is employed as S2(c). On the centre wafer, the single pole 3-way section nearer V1 is employed as S2(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-earthly tags soldered direct to pin 6 of the coil concerned, the earthly 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 $\frac{1}{2}$ by $\frac{1}{4}$ in, 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.

294 THE RADIO CONSTRUCTOR
"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 RV2 is set up to produce 26V at the collector of TR1. Also shown in the diagram are the lead-outs of TR1 and TR2 together

![Diagram](image)

**Fig. 4.** Wide-range variable supply TR1 drives a constant current through RV4, 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**

<table>
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<th>Resistors</th>
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<th>Description</th>
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<tr>
<td>R1</td>
<td>10kΩ ½ watt 5%</td>
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<tr>
<td>RV2</td>
<td>150Ω variable, preset</td>
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</tr>
<tr>
<td>R3</td>
<td>270Ω ½ watt 10%</td>
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<tr>
<td>RV4</td>
<td>2.5kΩ potentiometer, ½ watt</td>
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<tr>
<td>C2</td>
<td>1μF electrolytic, 36V wkg.</td>
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<td>TR1</td>
<td>2N3702</td>
<td></td>
</tr>
<tr>
<td>TR2</td>
<td>BC107B</td>
<td></td>
</tr>
<tr>
<td>TR3</td>
<td>B-5000</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Germanium diode, OA71, etc.</td>
<td></td>
</tr>
<tr>
<td>ZD1</td>
<td>4.7V 5% zener diode, e.g. OAZ200</td>
<td>(N.B. The three transistors are available from Amatronix, Ltd.)</td>
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<tr>
<td>L1</td>
<td>6V 6W lamp and holder (see text)</td>
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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 TR3. 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.

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 S1 is open. When this switch is closed, S1(b) applies the lamp supply to the lamp switching circuit and S1(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 R1. Due to the presence of Q across the coil, relay A takes a short time to energise. When it energises, contacts A2 complete the lamp supply circuit to lamp L1, which then becomes illuminated.

At the same time, contacts A1 apply the positive relay supply voltage to coil B/2 via R2. After a delay due to the presence of C2 across its coil, relay B energises. Its contacts B2 cause lamp L2 to be illuminated and its contacts B1 allow the positive relay supply voltage to be fed to coil C/2 via R3.

Relay C energises, after a delay due to capacitor C3. Its contacts C2 cause lamp L3 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 C4, 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 C1, 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 C1 to C5 time to discharge sufficiently for their relays to de-energise. A further delay to allow C2 to C5 to become adequately discharged is given by C6 across coil F2 and R1 and C1. 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 C6 larger in value than C1 (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 S1 there is a short delay after which relay A energises and lamp L1 lights up. After a further delay relay B energises and lamp L2 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 C6 discharging and, then, the subsequent delay due to R1 and C1, all the capacitors C2 to C5 are adequately discharged and the sequence recommences with relay A energising and lamp L1 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 C2 to C4 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

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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.

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TRADE REVIEW . . .

TRIO COMMUNICATIONS RECEIVER MODEL 9R-59DE

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 (¾ 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  
Selectivity: ± 5 kc/s at —50dB (±1.3 kc/s at 6dB)  
B.F.O. Frequency: 455 kc/s ± 2.5 kc/s

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

### 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  
- $V_3$ 6AQ8 oscillator  
- $V_4$ 6BA6 1st i.f. amplifier  
- $V_5$ 6BA6 2nd i.f. amplifier  
- $V_6$ 6BE6 product detector  
- $V_7(a)$ 6AQ8 B.F.O.  
- $V_7(b)$ 6AQ8 1st a.f. amplifier  
- $V_8$ 6AQ5 audio output

**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.

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 S₁ is the existing mains on-off switch on the set. With S₁ switched on a current flows through the thermistor TH₁ and the parallel branch comprising the relay coil and R₁ via relay contacts RL-2. The initial (cold) resistance of the thermistor and the parallel resistance of the relay coil and R₁ 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 R₁ 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 TH₁, 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 R₁.

The writer employed a 10 watt resistor for R₁ 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**

<table>
<thead>
<tr>
<th>R₁</th>
<th>3kΩ (see text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH₁</td>
<td>Thermistor type CZ2, or equivalent</td>
</tr>
<tr>
<td>RL₁</td>
<td>Relay type MK2P, 230 VAC energising (Keyswitch Relays Ltd., Cricklewood Lane, London, N.W.2)</td>
</tr>
<tr>
<td>Octal valveholder</td>
<td></td>
</tr>
</tbody>
</table>
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.

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**CARTOON**

**HUCKLE**

10kΩ: "How are you?"

1.5Ω: "Not so good, my resistance is low"

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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, in practice, consist of a double-triode) sharing the common cathode resistors R2 and R3. R2 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 V1 by way of R1 and to the grid of V2 by way of R5. These two resistors may have values of the order of 1MΩ. The lower cathode resistor, R3, has a much higher value than R2 and may be, typically, 20kΩ or more.

Resistors R4 and R5 are nominally equal in value and form the anode loads for V1 and V2. They may have the values normally provided as anode loads for these valves when working as voltage amplifiers. C1, C3 and C4 are a.f. coupling capacitors. C2 has a low reactance at audio frequencies and could be, typically, 0.1μF.

If a positive-going input signal is applied via C1 to the grid of V1 this valve draws greater current, with a consequent increased voltage drop across R4, and across R2 plus R3. Thus, the anode goes negative (providing one of the output signals) whilst the cathode goes positive.

Since the cathode of V1 connects to the cathode of V2, the latter goes positive also. At the same time, the potential on V2 grid remains fixed, due to the presence of C2. 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 V2 cathode results in a reduction of anode current in this valve. Less voltage is therefore dropped across R5 and the anode of V2 goes positive, thereby providing the second output signal.

We have seen, then, that by applying a positive-going signal to the grid of V1 we obtain a negative-going output signal at the anode of V1 and a positive-going output signal at the anode of V2. Similar reasoning will demonstrate that a negative-going input signal results in a positive-going output signal from V1 and a negative-going output signal from V2. 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 R3 has a high value of resistance. In practice, an ECC83 would represent a good choice for V1 and V2, and R3 should have a value of the order just mentioned. When R4 and R5 have exactly equal values the output from V2 anode is always slightly lower than that from V1 anode. The amplitudes can be balanced in practice by making R5 some 2% to 4% greater than R4.

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.
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
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 selectivity 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 R1 and R2 in series across the output terminals, the voltage across R1 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 R1, 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) must always be greater than the signal applied to the input terminals in Fig. 3 (a). By adding resistors R1 and R2 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:

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

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

Since R1 and R2 form a fixed potentiometer, the fraction of the output voltage appearing across R1 is $$\frac{V_{out}}{R_1 + R_2}$$. Let us call this fraction n. The voltage appearing across R1 is thus nV_out.

V_in is greater than V_g by the signal voltage across R1, 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, V_in 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.
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.

As he wrenched viciously at the controls of the record-player chassis, Dick exclaimed, "Blimey, that is something," he remarked. "What output voltage does it give?"

"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," replied Smithy. "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..."
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."

"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 C1. 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 C1, 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 S1 to the mains transformer, this having a secondary voltage of 17. The secondary voltage is passed to the bridge rectifier given by D1 to D4, and a rectified d.c. voltage then appears across the 1,000μF reservoir, C1."

"That's fine," said Dick. "It's the stuff after C1 that worries me!"

"In that case," replied Smithy, "we shall now proceed from C1 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 TR1. 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, TR1 has its base held at a fixed potential by way of D5. D5 is a silicon diode and it is caused to pass about 50mA in the forward direction by R1. So a nice steady voltage of around 0.6 is dropped across D5 and the base of TR1 is continually maintained at this potential relative to the positive...

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*Fig. 1. The circuit of Smithy's stabilised power supply. The output current is limited to 100mA or 300mA according to the position of S2. The values of R2 and R3 have to be found experimentally, the process being explained in the text.*
supply line from the bridge rectifier."

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

"Not really," replied Smithy. "The minimum hrE 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 D3 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 S2 in my circuit is in the '100mA' position only R2 appears between the emitter of TR1 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 S2 is in the '300mA' position R3 connects across R2, 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 R2 and R3."

"They have to be found experimentally," explained Smithy. "Although they could, I suppose, be calculated. The resistance between TR1 emitter and the positive supply line should have a value which causes the voltage across D3 minus the voltage across the base-emitter junction of TR1 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 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 calculation we 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 TR1 in the circuit. When S2 is in the '100mA' position a current of 100mA flows in the collector circuit of TR1 all the time regardless of the voltage on that collector. And, when S2 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, TR1 provides the constant collector current selected for it by S2 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 D5.

"Now this," he continued, "is a 16 volt zener diode which is fed via R4 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, R5, to the 5kΩ potentiometer, R4. In consequence, any nearly 16 volts across R4. 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 TR2, which is a small ACY19 transistor; and the emitter of TR2 connects to the base of TR3, which is another OC36 power transistor. The output voltage appears between the emitter of TR3 and the negative supply line."

"TR2 and TR3?" 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 TR1 is connected to the emitter of TR3. Provided that no load is connected to the output terminals, the constant current from TR1 collector flows through TR3 all the time. At the same time, the voltage on TR3..."

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emitter is always about 0.3 volts positive of the voltage on the slider of R4 due to the base-emitter voltage drops in TR2 and TR3. In consequence, the output voltage of the unit can be varied by adjusting R4.

"I suppose," said Dick reflectively, "that using two emitter followers after R4 instead of just one gives you better voltage regulation."

"Oh, definitely," agreed Smithy. "The current flowing in R4 must always be much greater than the current changes in the base it supplies. Otherwise, the reference voltage provided at R4 slider would change by an unacceptable amount due to varying base currents. As you'll see in a moment, we expect TR3 to give a steady output voltage for emitter current changes from zero to 300mA. Assuming a minimum gain in this transistor of 30, we expect TR3 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 TR2 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 10mA flows through TR3, 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 TR3 emitter is approximately equal to the input impedance at TR2 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 TR3?" he asked.

"You said just now that the constant current from TR1 collector flows through TR3 all the time."

"No I didn't," retorted Smithy.

"What I said was that the constant current flows in TR3 provided that no load is connected to the output terminals. When we connect a load, the current in TR3 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 S2 is set to the '300mA' position and that R4 is adjusted to give any convenient output voltage. A current of 300mA then flows through TR3. (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 TR3. 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 TR3. If we then adjust the variable resistor to consume 300mA, all the current will flow in it and none will pass through TR3 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, TR1 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 R4 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 S2 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 C1," said Dick. "Once you've put S2 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 D5 and D6."

"True enough," agreed Smithy. "As a result, the only changes in..."
voltage applied to \( R_5 \) 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 \( T R_1 \) and \( T R_3 \)."

"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 \( T R_3 \) and only about 2 volts appears across \( T R_1 \). So, virtually all the dissipation is given by \( T R_1 \). 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 \( T R_3 \) and nearly 18 volts across \( T R_1 \). Whereupon almost all the dissipation has to be given by \( T R_1 \). With \( R_4 \) slider in the middle of its track the voltages across \( T R_1 \) and \( T R_3 \) 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 \( T R_1 \) and \( T R_3 \), 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 \( 4 \frac{1}{2} \) by \( 4 \) by \( 1 \) inches. 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 \( T R_1 \) 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, \( T R_3 \) then dissipates some 5 watts and, with \( R_4 \) slider at the top end of its track, \( T R_1 \) 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. \( T R_2 \) doesn't need a heat sink, by the way; it is just soldered into circuit in normal fashion."

"Why," asked Dick, "did you put \( R_3 \) 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 \( R_3 \)," 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 10\( \mu \)F electrolytic between \( R_4 \) slider and the negative supply line. (Fig. 5). Control of output voltage is then virtually instantaneous and the 10\( \mu \)F 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. 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 10\( \mu \)F capacitor as shown here.

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.
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, if not lower, than 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 TR3 falls off, you would 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 R4 should be a linear wirewound component. However, a pointer and scale which is calibrated in terms of output voltage. Alternatively you could add 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 D5 and this is a Lucas type DD000." "There are two other components as well," Dick reminded him. "R2 and R3."

"Oh yes, of course there are," replied Smithy, with a grimace of irritation at his own forgetfulness. "And they’re the most important of all. 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 R2 and R3. I then inserted a milliammeter between the collector of TR1 and the emitter of TR3. (Fig. 7). Next, starting with 6.8Ω I gradually reduced the resistance in the R2 position until the milliammeter indicated 100mA at all settings of R4. There should be negligible change in this current as R4 is adjusted, incidentally. In my case, the final value for R2 was 4.7Ω, which ties in rather nicely with the value you'd expect from the calculation I referred to earlier. I then set S2 for '300mA' and, starting with 3.9Ω, I gradually reduced the resistance in the R3 position until the meter indicated 300mA for all settings of R4. With my unit, the final value for R3 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 R2 and R3 sorted out," he continued, "I took the milliammeter out of circuit, connected the collector of TR1 to the emitter of TR3 and, with the voltmeter, checked that the correct range of output voltages was given as R4 was adjusted with S2 both on '100mA' and on '300mA'. There should be negligible change in output voltage as S2 is switched from one position to the other. The final test was to connect the milliammeter directly across the output terminals. This action gave as nearly a direct short and it indicated 100mA and 300mA for the corresponding positions of S2 at all settings of R4, 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 R2 and R3?"

"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 a voltage and then to gradually reduce the voltage across the output terminals, and continue increasing the value until the meter indicated 100mA and 300mA is temporarily inserted between the collector of TR1 and the emitter of TR3 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 D5 and this is a Lucas type DD000."
a resistance and then gradually reduce it. If too low a resistance is accidentally put in either the R2 or R3 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 Service-man 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. Dancee, 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...
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.

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

**Mastertape Box Clever**

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.

Moulded in the form of a book from black high-strength polypropylene, the box has grained front and back covers with an elegant gold-lettered brand label on the front. The brand name is repeated on the spine in a colour which identifies the thickness of the tape inside (red for Standard-Play, yellow for Long-Play, etc.) and this is also printed, together with the reel size and tape length, on a spine label. Both the front cover and the spine are hinged, with snap-in fasteners to keep the box closed in storage.

Apart from the reel of tape in its polythene envelope, the box also contains a printed index card and a tape clip, and is sealed for despatch in plastic film.

The three sizes presented in the new box are the 5 in, 5½ in and 7 in reels, in all thicknesses from Standard-Play to Triple-Play inclusive. Other reel sizes in the Mastertape range will continue in the present boxes for the time being.

With the introduction of the new box, Mastertape are also reorganising their distribution arrangements with the appointment of a number of regional wholesalers (list attached) from whom all supplies of branded Mastertape should be ordered.
STOP READING
start building
start SW listening

For only £28.6.23. you can build this exciting, instructive Short Wave Receiver. The Star Roamer kit looks and sounds professional—a beautifully finished charcoal grey cabinet and matching front with ham type operating features and performance. The perfect introduction to radio construction and ham techniques—the perfect gift for enthusiast and novice alike.

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