CYCLOPS

PART SIX

by L. C. Galitz

This is the sixth and concluding article in the series concerning robots and cybernetic devices, and it describes the circuit operation and construction of the conditioned reflex circuits. Also dealt with is the battery charger unit.

IN LAST MONTH'S ISSUE THE BASIC OPERATION OF THE conditioned reflex circuitry was described, after which the circuit for the conditioned reflex unit was published, as Fig. 27, together with the Components List. Fig. 27 should now be consulted, since its operation will next be discussed in detail.

CIRCUIT OPERATION

In Fig. 27, the area enclosed by the dotted line is built on the new Veroboard panel, and above and below the dotted line are existing components such as RLA/4, RLB/1, RLC/1 and their contacts. There are also new components such as X2, the magnetic sensor, S4 and S3. The operation of the circuit is fairly straightforward, apart from a few details which are somewhat unusual – these are explained below.

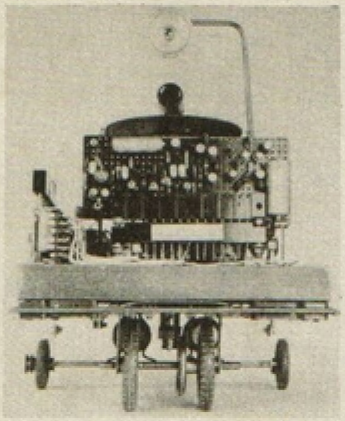
The output from the inhibit Ss gate triggers the differential monostable via R26 and C6. The two monostables in this circuit have a diode in the collector of the transistor which is normally turned off. This is to ensure that if there is a momentary reduction in the supply rail voltage, these diodes will be reverse biased, and the potential on the collectors of TR17 and TR22 will be held up by the charge across C7 and C9 respectively. This prevents spurious triggering of the monostables.

The extension monostable is fired directly by X2, a reed switch acting as a magnetic sensor, via C8. R37 holds the X2 end of C8 negative until the switch is triggered. The output of this monostable passes to the base of TR20, whilst the output of the differential monostable passes to TR19. These two transistors, along with R30, form the coincidence And-gate, using the current sinking logic principle. In other words, the emitters of the transistors are kept near the earth potential unless *both* transistors cut off, and this only happens when both bases are negative, which in turn only occurs when both monostables have fired at the same time. At all other times, the current through R30 is sunk to earth via either or both transistors. The output of the gate passes via D5 and R31 to the summing capacitor. D5 prevents the capacitor discharging through the gate when it is closed, and R31 allows the capacitor to charge up only by a certain amount every time the gate opens. S4 is wired across the summing capacitor and is labelled 'Forget' – it is used when one wishes to erase Cyclops' memory of previous experiences and start afresh on a new experiment.

TR23 in the common collector mode acts as a current amplifier for the summing capacitor. In the emitter circuit of this transistor is wired a potentiometer which sets the threshold level of the Schmitt trigger formed by TR24, TR25 and associated components. It so happens that all three outputs from the Schmitt trigger require the inverted function rather than the normal one, and therefore the output is taken from the first collector.

It will be noticed that the time-constant resistor for the extension monostable is split into two halves, R34 and R35. The junction between the resistors is connected via D7 to the output of the Schmitt trigger. When the Schmitt trigger is in its unfired state the cathode of D7 is negative and the diode conducts, reducing the effective overall time-constant resistance. When the Schmitt trigger fires, this diode is reverse biased, and both resistors come into normal operation. In the prototype, the two monostable quasi-stable periods were seven and ten seconds respectively.

The first output And-gate, the inhibit En gate, consists of TR26, and TR27 and R44. This gate operates in similar fashion to the coincidence And-gate. The output of this gate passes directly to TR28, the relay driver, and it has the usual diode to prevent relay transients damaging the driving transistor. The bases of the transistors forming the And-gate couple directly to the Schmitt trigger output and the monostable output respectively. This is possible because the transistors operate in the common collector mode and therefore have a high input impedance.



On the other hand, the transistors forming the 'instigate conditioned response' gate, TR29 and TR30, are in the common emitter mode, and they connect to the Schmitt trigger output and the Sn input via resistors. As with the previously mentioned gate there is a relay driver, TR31, wired directly to the output of the gate, again with the usual protection diode. From the output of this gate passes a wire to S3(c), and from this switch to the base of TR15 in the inhibit Ss gate, so that the automatic reinforcement feedback loop is inhibited when the switch is set to the 'magnetism means light' mode.

The other two sections of S3, which is the mode selector switch, occur in the input switching of Ss, and in the output switching of Es, in the 'touch' mode, Ss is connected via S3(a) to the make contact of RLA2, of which the common contact and the break contact are already in the basic reflex circuitry. (See Fig. 14, published in Part 3). At this point it should be noted that the positive lines of both the learn circuitry and the basic reflex circuitry are joined together. In the 'light' mode, Ss connects to the make contact of RLC1; the common contact connects to the earth line via RLA2. (This is just for convenience when wiring – it could connect straight to the earth line).

When switched to the 'touch' mode the Es output passes to pin 6 of the basic reflex circuitry socket via S3(b), i.e. to the base of TR1, which operates RLA/4; and, when switched to the 'light' mode, the Es output passes directly to RLC/1 coil. The output from En always goes to RLB/1 so that, when En is activated, Cyclops' motors cut off until the extension monostable reverts to its normal state.

It can now be appreciated why relays RLB/1 and RLC/1 were specified as having dual coils – in each case, one relay coil appears in the basic reflex circuitry and the other coil appears in the conditioned reflex circuitry. The isolation of the two coils helps keep the two sets of circuits separate.

The arm of S3(a) connects to the base of TR16, one of the two transistors in the 'inhibit Ss' gate. Resistor R23 keeps this transistor cut on until the appearance of the pulse from either RLA2 or RLC1.

COMPONENTS

All resistors and capacitors are standard components as specified in the Components List, which was published last month. The diodes are all silicon, and D5 should be chosen to have a high back resistance to limit discharging of the summer capacitor. Transistors TR19 and TR20 are n.p.n. silicon planar, with the leads having the e-c-b sequence. TR26 and TR27 are normal n.p.n. transistors, whilst all the others are p.n.p. transistors. The monostable transistors may have to be selected, as some cause spurious triggering of the circuit – in other words, some transistors have a property of being more susceptible to noise than others. The writer encountered this problem with some of the transistors he had on hand, but quite a number worked quite satisfactorily, giving no trouble at all. It is possible that the risk of spurious triggering could be reduced by adding a bypass capacitor, of around 0.047μF, across the supply rails, although this was not found necessary by the writer, who had little difficulty in finding suitable transistors.

TR23 should be selected for low leakage – a transistor with too high a leakage would cause C10 to discharge too quickly. This capacitor may also have to be selected for low leakage, and although capacitors working well below their rated voltage have in general a lower leakage figure, the author found no trouble with the several samples tried, which were working at half rated voltage in the circuit.

COMPONENTS

Resistors

R1	2.2kΩ ½ watt
R2	27Ω ½ watt (see text)
R3	330Ω 1 watt
R4	2.2kΩ ½ watt
R5	27Ω ½ watt (see text)
VR1	15Ω potentiometer, wirewound, preset

Capacitor

C1	1,000μF electrolytic, 20 V. Wkg.

Transformer

T1	Mains transformer, secondary 12V at 0.5A. Douglas type MT111AT

Semiconductors

TR1	AC127
TR2	AD161
TR3	AC127
D1–D6	Silicon diodes (see text)
W1	Bridge rectifier 24–36V, 1A

Switches

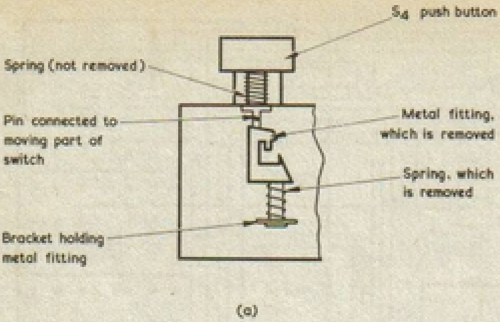
S1-S4	s.p.s.t. toggle

Neon

NE1	Neon bulb assembly with integral series resistor.

Miscellaneous

Mica washer and insulating bushes (for TR2)
Multi-way cable
Chassis, tagboard, etc., (see text)



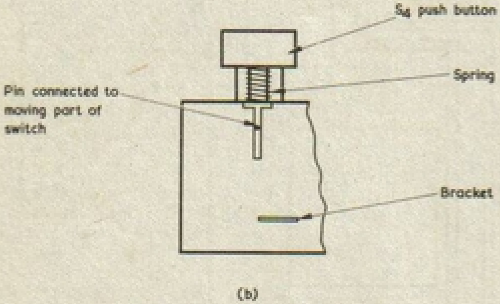


Fig. 28 (a). Switch S4 before modification
(b). How the switch appears after modification

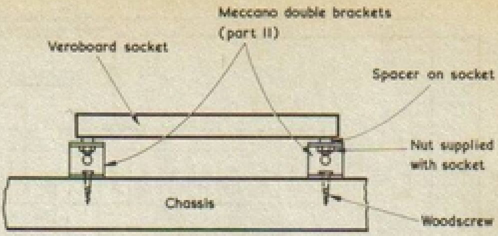


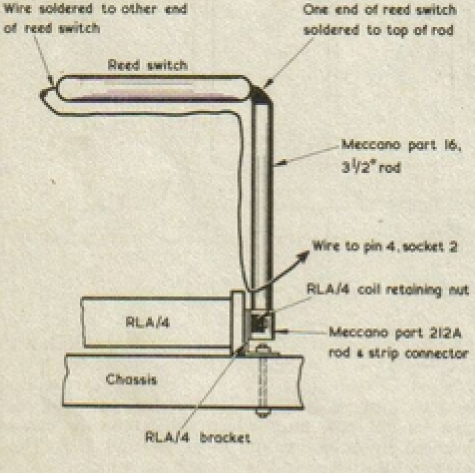
Fig. 29. Mounting the 15-way Veroboard socket. This is a view from the front of Cyclops

X2 is an R.S. Components reed switch, and the Veroboard connector used by the author was a Painton 15-way component. If difficulty is experienced in obtaining this connector a 16-way edge connector (Home Radio Cat. No. BTS45) could be employed with a 16-way piece of Veroboard, as was suggested for the board that is already fitted to Cyclops. The 16th way would, of course, be ignored when wiring up. Details of the relays RLB/1 and RLC/1, and of S3 and S4, were given in Part 3 of this series. However, although S3 is of the press-to-changeover, press-to-changeback, as on the switch-bank obtained, S4 is of the press-to-changeover, release-to-changeback variety, and was modified by removing a small metal fitting and a spring on the back of the switch. Details of this modification are shown in Fig. 28. Alternatively, separate switches can be obtained and mounted on the main control panel.

Battery BY3 is exactly the same as BY1, a Deac 6V 225mA/H rechargeable battery, but, as mentioned in Part 3, could be an Ever Ready PP1.

CONSTRUCTION

If the reader has obtained the Painton 15-way connector, this is mounted on the baseboard using a pair of Meccano double brackets as shown in Fig. 29. If the alternative 16-way connector is employed, this may be fitted in the same way as was the connector for the first board. The reed switch is next mounted using a Meccano rod, and rod and strip connector. Details of



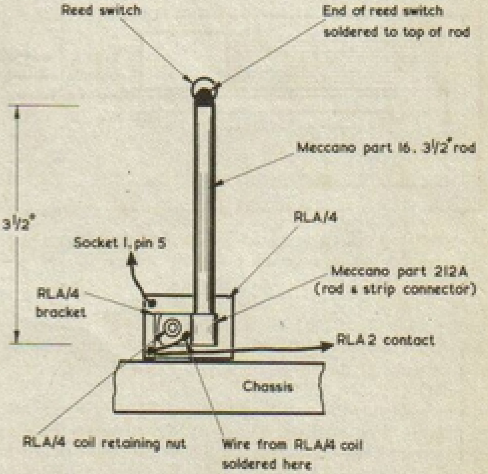


Fig. 30 (a). View from rear, showing the method of mounting the reed switch
(b). Another view, from the right side, of the reed switch mounting

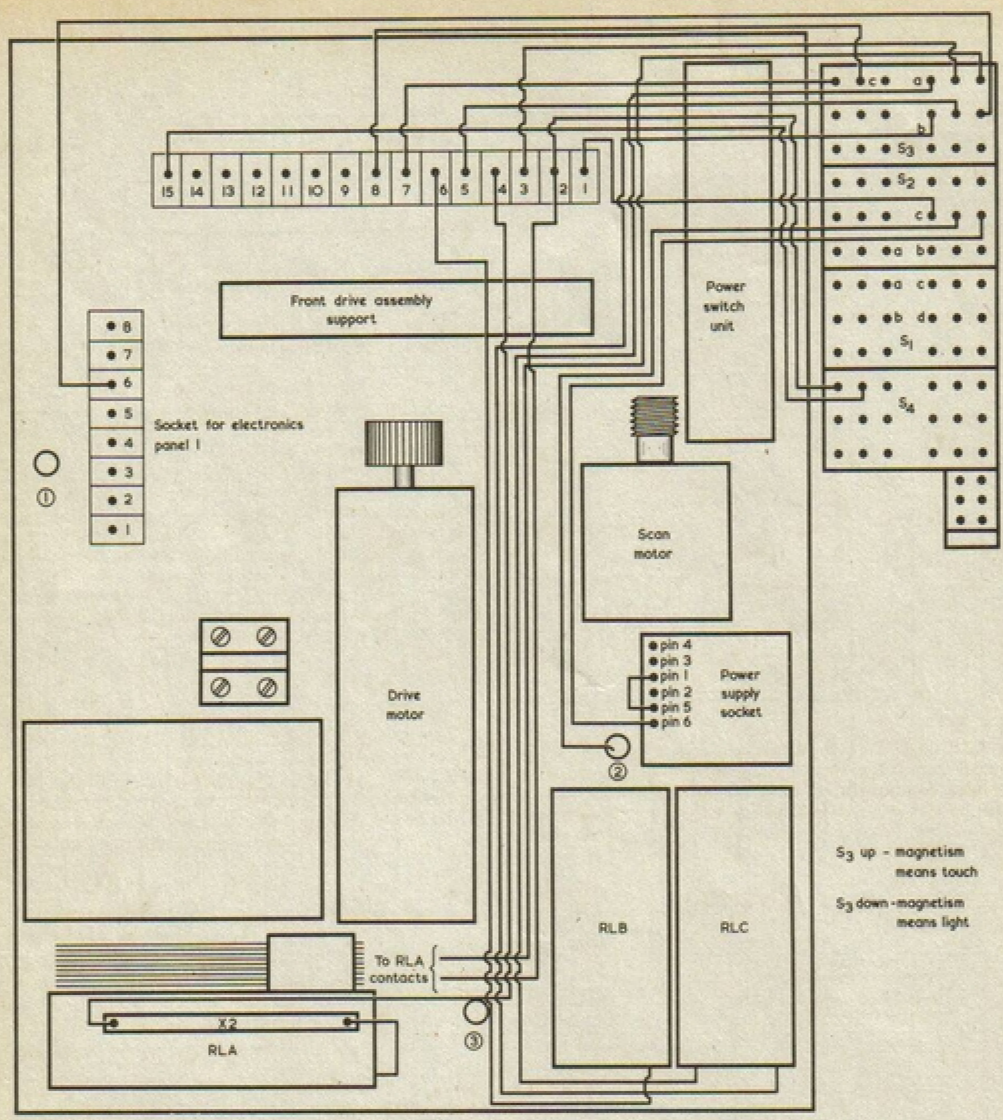


Fig. 31. The additional wiring on the main baseboard. As it is difficult to interpet diagrams in which the wires run closely together, as here, it is advisable to check against the circuit of Fig. 27 during wiring

how this assembly is built, and how it is mounted on the coil retaining nut of RLA/4 are given in Figs. 30(a) and (b).

The additional wiring can be carried out according to Fig. 31. Fig. 32 gives details of the wiring to the pins of the relays, which is not shown in sufficient detail in Fig. 31. It should be noted that the centre contact of RLC1 must be connected to the electronics earth, and the make contact of RLC1 should be connected to S3 (a). If the reverse is done, the circuit will not function correctly.

At this stage the Veroboard panel may be dealt with. This measures 2 by 5in. and has 13 strips, each with 33 holes. If the Painton 15-way connector is to be used, the area bounded by the holes K7, M7, K27 and M27 must be cut out, after which the connector can be mounted by enlarging the holes L6 and L28. These holes are illustrated in Fig. 33 and 34, which show the component and copper sides of the board respectively.

Next, cut the strips as indicated in Fig. 34. In wiring the board several points need to be observed. One of the lead-outs of R46 passes through the hole F17 (at which

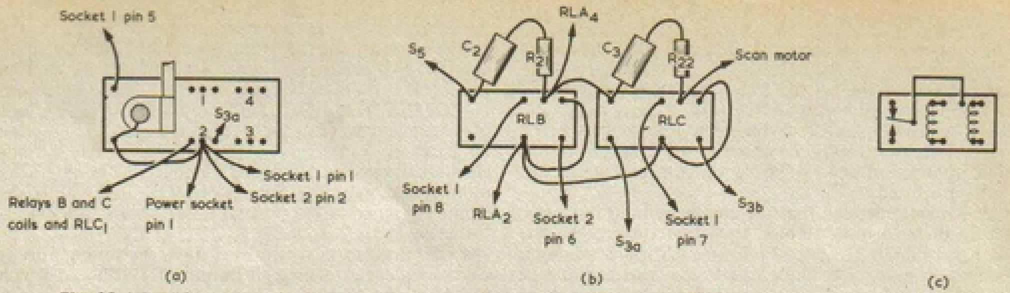


Fig. 32 (a). Wiring at RLA2. The additional connections are to S3 (a) and RLC1
(b). Connections to relays RLB and RLC. Th's includes existing wiring. RLB and RLC are wired in the mode shown here so that fields from separate coils assist each other. (It may be necessary to alter the existing wiring to the coils to achieve this)
(c). Pin designation for relays RLB and RLC

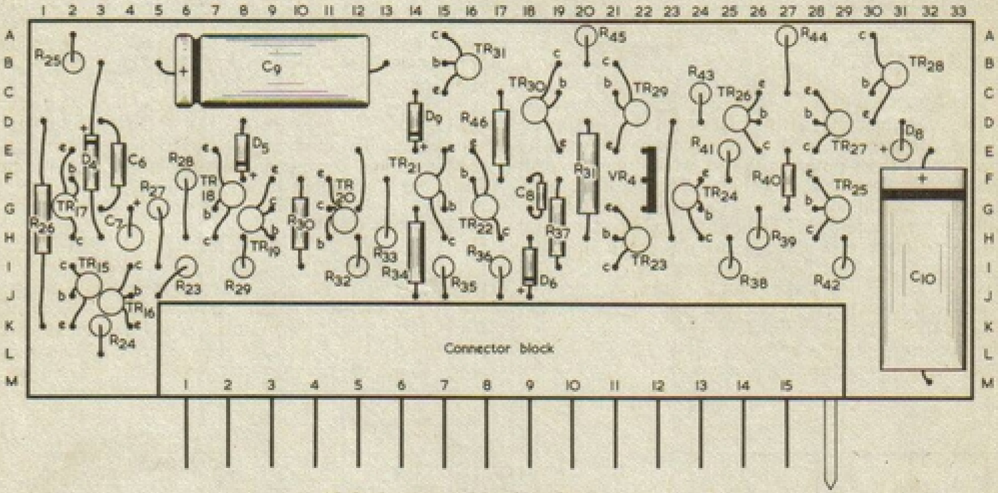


Fig. 33. Components side of Veroboard panel No. 2

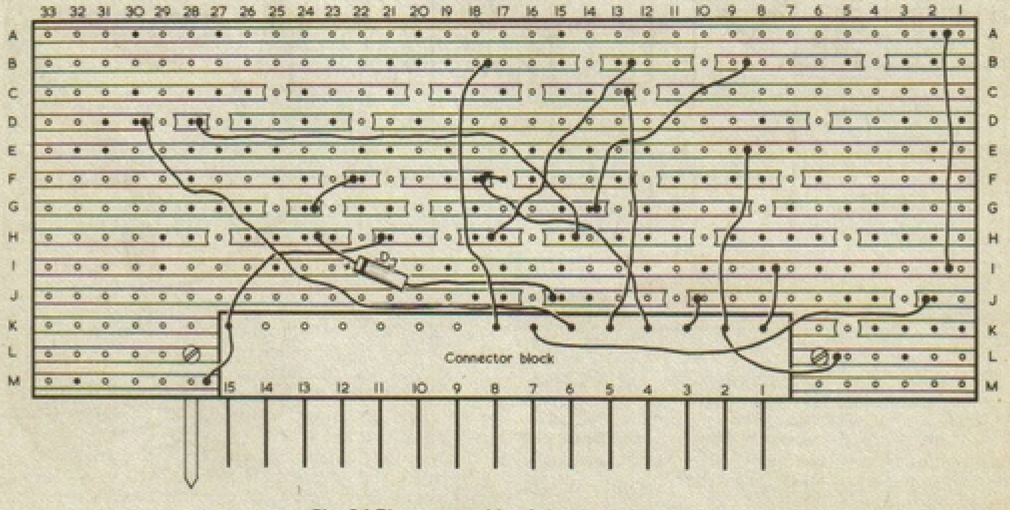


Fig. 34. The copper side of the Veroboard panel

the copper strip has been cut) and connects to the copper strip adjacent to F18. Diode D7 is mounted on the copper side of the board. There are, also, a number of links on the copper side of the board, these consisting of insulated wires soldered direct to the copper strips. Where possible, component lead-outs adjacent to the link connection points should be soldered before the links are fitted.

It is recommended that the circuit be built in stages; firstly the two monostables, then the coincidence gate and the inhibit Ss gate. Following this, the summer, Schmitt trigger, and finally, the output gates should be built. As each stage is completed the circuit can be tested. Any errors can be checked easily, because any faults that develop must be in the stage after the one previously tested. The polarities of the capacitors, diodes and transistors should be carefully checked before testing. When the circuit has been fully built and tested, the final setting up can take place.

SETTING UP

It may be found that minor difficulties occur during testing, and these may crop up due to tolerance spreads in the components used. There is only one resistor specified in the Components List which may need its value slightly changed, and that is R26. If this value is too small, Ss will not inhibit; if the value is too large, Ss will not trigger reliably. The author found that it was easiest to start with the resistor too small in value. Connect TR15 base to the negative rail via a 1kΩ resistor, and trigger the Ss input, increasing the value of R26 until the differential monostable does not fire. If, then, TR15 base is connected to the positive rail by a 10kΩ resistor, the differential monostable should trigger reliably every time Ss input is applied.

The monostable resistors governing the time-constant in the prototype were 6.8kΩ for the differential monostable, and two 15kΩ in series for the extension monostable. These give monostable quasi-stable periods of 0.6 seconds calculated, against 0.8 seconds in actual fact, for the differential monostable; and 8.6 seconds calculated, against 10 seconds in fact, for the extension monostable with the Schmitt trigger fired. With the Schmitt trigger in the normal unfired state, the monostable period is 7 seconds.

In the prototype, with R31 at 1kΩ, the summer needs six coincidences to give an output of 4 volts, at which potential the threshold of the Schmitt trigger is set. However, this figure is based on measurements obtained with coincidences made one immediately after the other. In normal operation, approximately ten coincidences are required before the Schmitt trigger fires. Constructors may wish to vary the value of R31 to make the number of coincidences required more or less. VR4 sets the Schmitt trigger threshold, and in the prototype this potentiometer was set to operate the trigger upon receiving an output of 4 volts from the summer.

Now the conditioned reflex unit should be complete, and Cyclops should behave in a more intelligent manner, modifying his actions to suit his environment, and he should be enjoying himself more than he did during his uneducated days.

CHARGING UNIT

In one of the photographs accompanying Part 1 of this series, Cyclops was shown having his batteries charged by a special charging unit coupled up to the 6-way power socket. Although any suitabe method of charging the batteries may be employed, readers may prefer to use the charging unit employed by the author.

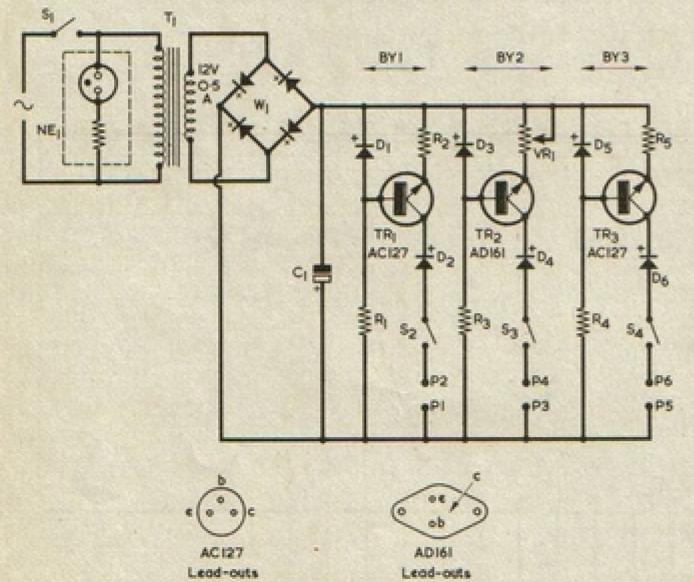


Fig. 35. The circuit of the battery charging unit

CYCLOPS

Brief details of this unit will now be given.

The circuit of the unit appears in Fig. 35. The a.c. mains input to T1 primary is switched by S1. The secondary output of 12 volts is rectified by W1 and smoothed by C1. The rest of the circuit consists of three constant current devices, one for each battery to be charged.

Considering the first constant current device, TR1 is germanium; therefore D1, a silicon diode with a voltage of about 0.7 volt across it, is sufficient to provide a constant voltage to TR1 base, TR1 being wired in the common base mode. R1 supplies sufficient current through the diode to swamp the current taken by TR1 base even when TR1 is passing the full constant current. As TR1 is in the common base mode, the constant current is set by the emitter resistor R2. S2 allows the charging current to be switched on and off. Diode D2 is in circuit to isolate the battery should the unit be disconnected from the mains. When this occurs D2 becomes reverse biased.

The same circuit description applies to the two other constant current devices.

The sections charging the Deac batteries BY1 and BY3 are set to give 27mA by adjusting the resistors R2 and R5. In the prototype the value required for these two resistors happened to be 27Ω exactly. The transistors used are AC127's. The section charging BY2 is set to 200mA by adjusting VR1. This section uses an AD161 power transistor.

The charging unit is built in a 6 by 4in. aluminium chassis, with S1 to S4 and the neon indicator mounted on the front panel. The electronics is built on a 2×10-way tagboard. The AD161 is bolted direct to the chassis, employing a mica washer and two insulating bushes for insulation of its collector in the usual manner. Each AC127 (which has an isolated envelope) is secured to chassis with the aid of a heat clip, which also functions as a bracket. The preset variable resistor, VR1, is mounted inside the chassis so that, once set, it cannot be accidentally disturbed. This component should be adjusted to insert maximum resistance before it is initially set up. Its resistance is then reduced until the desired 200mA charging current is achieved. A multi-way cable from the unit connects to a 6-way plug matching the power socket on Cyclops.

The mains transformer T1 is a Douglas MT 111AT offering 12 volts at 0.5amp. This is available from G. W. Smith & Co. Ltd., 3 Lisle St., London, W.C.2. Diodes D1 to D6 are any silicon diodes, but it must be remembered that D4 has to be able to pass 200mA.

The reason for including switches S2, S3 and S4 is simple. Sometimes the Cyclops electronics are run to test them without the motors, or the learn circuitry is not switched on. In either case, one battery has not been used and is still fully charged from the last time it was plugged into the charging unit. That battery is not then charged during the next charging period, it being switched out of the charging circuit by the appropriate switch.

The accompanying Components List shows the parts required for the charging unit.

CONCLUSION

The present series of articles on Cyclops is now concluded. However, further work has been carried out since these were written, and modifications are available which teach Cyclops how to earn his living and how to give him fits of neurotic depression when encountering hard times! These modifications will be described in a few months' time and it is suggested that readers retain the copies of *Radio & Electronics Constructor* in which the present series has appeared since reference will be made to the diagrams in these. ■