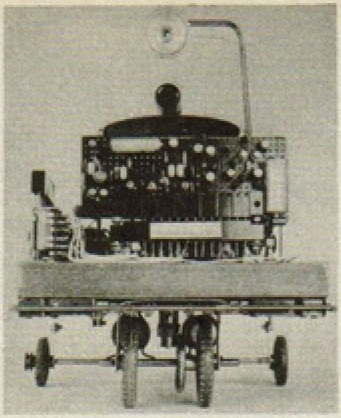
# CYCLOPS



## PART THREE

by

L. C. Galitz

**This article is the third in a series dealing with robots and cybernetic devices, and it continues with the construction details of Cyclops. This month, a description of the basic reflex circuitry is given**

In the first article in this series it was stated that Cyclops is positively tropic towards light of a moderate intensity, and negatively tropic towards light of a high intensity. He is also negatively tropic towards material objects, and the touch stimulus should override the effects that any particular light stimulus produce.

### BASIC OPERATION

Reference to Fig. 13 will show how this is accomplished. The output from the photocell which forms Cyclops' eye is fed to a pre-amplifier, after which it passes to three Schmitt triggers. Following the Schmitt trigger with the highest threshold (i.e. lowest sensitivity) is an inverter, the output of which passes to one input of each of two two-input And-gates. The other input of each And-gate connects to one of the other Schmitt trigger outputs. The output of the upper And-gate in Fig. 13 operates a relay which inhibits the scan motor, and the output of the lower And-gate passes to another relay which inhibits both scan and drive. Under no-light conditions, therefore, there will be zero output from each of the three Schmitt triggers, and there will thus be a logic one from the inverter, resulting in each gate having a logic nought on one input, and a logic one on the other input.

Under these conditions, neither scan nor drive is inhibited, and Cyclops will explore the terrain randomly. If he then comes across a light some distance away, and if it is of sufficient brilliance to operate the Schmitt trigger with the lowest threshold, there will

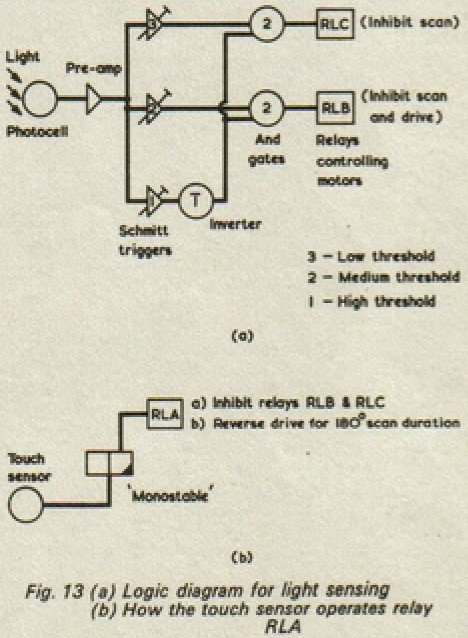



*Fig. 13 (a) Logic diagram for light sensing (b) How the touch sensor operates relay RLA*

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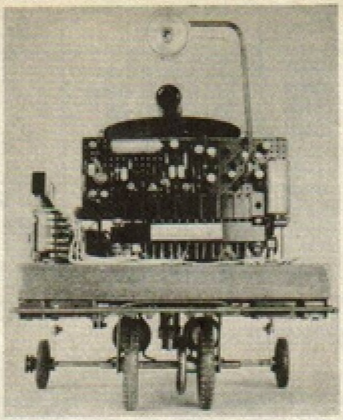

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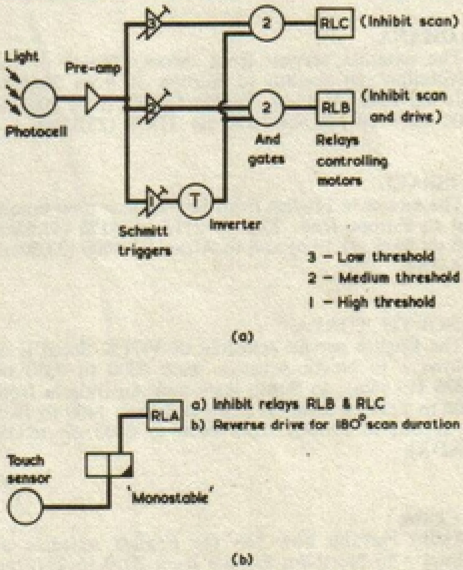



*Fig. 13 (a) Logic diagram for light sensing*
*(b) How the touch sensor operates relay RLA*

now be logic ones on both the inputs of the upper And-gate, this being the one whose output operates the relay which inhibits scan only. In consequence, Cyclops will stop exploration and commence homing into the light as detailed in the first article.

When he comes sufficiently close to the light source the medium threshold Schmitt trigger also fires, whereupon both And-gates have logic ones on each of their inputs. The lower And-gate operates the relay which inhibits drive as well as scan. Thus Cyclops will stop in front of the light to 'recharge his batteries'.

Should the light be so powerful as to 'dazzle' him, the high threshold Schmitt trigger will fire as well as the other two. However, the inverter inverts the output of the high level Schmitt trigger and thus, in this situation, the And-gates have logic ones on the inputs connected to the low and medium threshold Schmitt triggers, but logic noughts on the inputs connected to the inverter, Therefore the scan and drive inhibition is itself inhibited, causing Cyclops to ignore extremely bright lights.

The touch sensor consists of microswitches at the ends of each side of the chassis, making eight microswitches in all. Bars are fixed between the buttons of the two microswitches on each side of the chassis, so that when Cyclops bumps one of his sides on an object, either one or both microswitches operate. All the microswitches are wired in parallel and go to the input of the obstacle-avoiding circuitry which, on receiving an input, operates a relay via a monostable. This relay disconnects the coils of the other two relays, so that any inhibition of drive and/or scan is itself inhibited. The third relay also reverses the drive direction of the main drive motor, and therefore, on bumping into an obstacle, irrespective of whether Cyclops is scanning, homing into a light, or even recharging his batteries, he will reverse, execute a turn, and then move off in the direction opposite to the one in which he was moving when encountering the obstacle. The latter feature is accomplished by arranging the duration of the monostable to be equal to the time the scan motor takes to turn the main drive assembly through 180°.

## THE CIRCUIT

It is necessary now to turn to the circuit diagram given in Fig. 14.

The 'monostable' operating the avoid mechanism consists of R1, C1, D1, TR1, relay coil RLA/4 and contact RLA1. When any of the touch sensor microswitches operates, R1 is connected to the negative rail via the microswitch contacts and the normally closed contacts RLA1. This connection causes C1 to charge up quickly and TR1 then operates the relay, being turned on by the voltage across C1. Contacts RLA1 open and C1 discharges through the base circuit of TR1, until TR1 eventually switches off and RLA/4 de-energises. By now, Cyclops will have managed to extricate himself from most objects, but in some tricky circumstances, e.g. the family cat, he may still be entangled. If a touch sensor closes once more he will move forward very briefly in the time it takes to charge C1 again. In some cases this will free him but otherwise he will go through the avoid cycle again until he does eventually free himself. This short jerk between cycles is due to contacts RLA1, and it often proves useful when negotiating difficult situations.

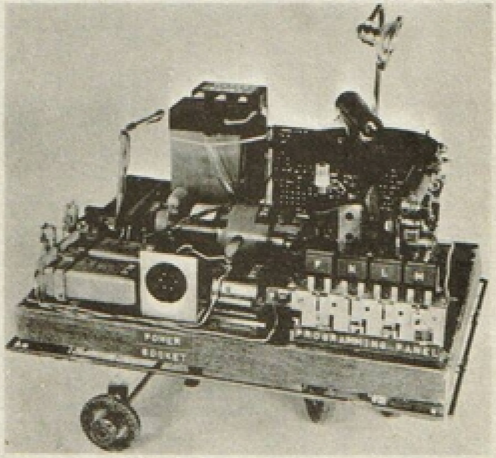
The photocell X1 and resistor R2 form a potential divider at the base of the pre-amplifier, TR2. This is in the common collector mode, offering high input impedance and high current gain. Wired in its emitter circuit are three preset potentiometers, the wipers of each passing to a Schmitt trigger. These potentiometers set the threshold values for the triggers. The first Schmitt trigger consists of TR3, TR4 and R4 to R8. Due to the fact that the inverted output of this trigger is required, the output is taken from the first collector rather than the second. The second Schmitt trigger consists of TR5, TR6 and R9 to R13, whilst the third Schmitt trigger consists of TR13, TR14 and R16 to R20. The outputs from these latter two Schmitt triggers are taken from the usual collectors, i.e. those of TR6 and TR13 respectively.

The two And-gates are formed by TR7, TR8, TR11, TR12, R14 and R15. These four transistors are n.p.n. types, and the gates operate by using the current sinking logic mode. In order for the output of each gate to be negative, i.e. at logic one, both transistors must be cut off, and as they are n.p.n. devices, both transistors require a negative bias on their bases for this to occur. In all other cases, the current through the emitter resistor is 'sunk' through either one or both transistors.

The output of each gate passes to a relay driver transistor working in the common collector mode, and there is the usual diode across the relay coil preventing transients from damaging the driving transistor.

The common coil connection of the relays is taken via a break contact, RLA2, of RLA/4; and thus, when the obstacle avoiding circuitry comes into action, both RLB/1 and RLC/1 cut out.

The rather elaborate on/off switching is due to the fact that two on/off switches are used in the prototype. One switch, S1, switches on the basic reflex circuitry only, whilst the other, S2, switches on the learn circuits




*Side view of Cyclops. The Veroboard assembly in front of the eye support unit, and the horizontal device (actually a dry reed switch) behind the accumulator, are added after the circuitry described in this and next month's issue has been completed*

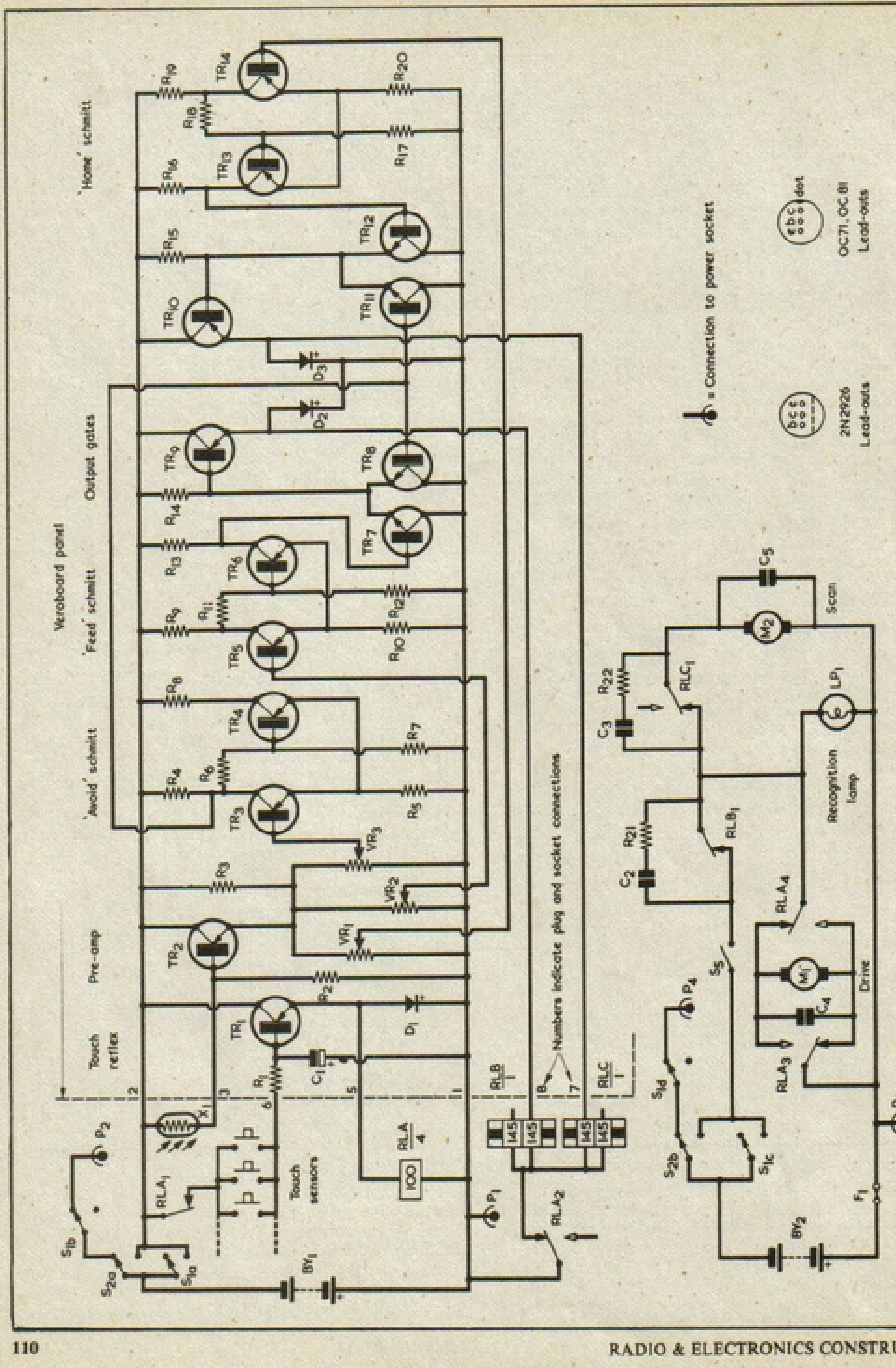



*Fig. 14. Circuit for the basic reflex operations of Cyclops*

## COMPONENTS

*Resistors*

(All fixed values ½ watt 10%)

| | |
|---|---|
| R1 | 1kΩ |
| R2 | 47kΩ |
| R3 | 47kΩ |
| R4 | 4.7kΩ |
| R5 | 470Ω |
| R6 | 22kΩ |
| R7 | 10kΩ |
| R8 | 4.7kΩ |
| R9 | 4.7kΩ |
| R10 | 470Ω |
| R11 | 22kΩ |
| R12 | 10kΩ |
| R13 | 4.7kΩ |
| R14 | 1kΩ |
| R15 | 1kΩ |
| R16 | 4.7kΩ |
| R17 | 10kΩ |
| R18 | 22kΩ |
| R19 | 4.7kΩ |
| R20 | 470Ω |
| R21 | 10Ω |
| R22 | 10Ω. |
| VR1 | 10kΩ potentiometer, skeleton |
| VR2 | 10kΩ potentiometer, skeleton |
| VR3 | 10kΩ potentiometer, skeleton |

*Capacitors*

| | |
|---|---|
| C1 | 50μF electrolytic, 12 V.Wkg. (may require adjustment) |
| C2 | 0.1μF Mullard polyester, 125 V.Wkg. |
| C3 | 0.1μF Mullard polyester, 125 V.Wkg. |
| C4 | 0.1μF Mullard polyester, 125 V.Wkg. |
| C5 | 0.1μF Mullard polyester, 125 V.Wkg. |

*Semiconductors*

| | |
|---|---|
| TR1 | Any p.n.p. transistor capable of driving relay, e.g. OC81 |
| TR2–TR6 | Any p.n.p. transistor, eg. OC71 |
| TR7, TR8 | 2N2926 |
| TR9, TR10 | As TR1 |
| TR11, TR12 | 2N2926 |
| TR13, TR14 | As TR2–TR6 |
| D1–D3 | Any silicon diode, e.g. OA200 |

*Photocell*

| | |
|---|---|
| X1 | ORP12 |

*Switches*

(S1 to S4 are available from G. W. Smith & Co. (Radio) Ltd., 3 Lisle St., London, W.C.2. as a complete unit, described as a 'Standard 4-Button Press-Button Unit'. This offers more contacts than are required for the present application. The 8 microswitches are also available from G. W. Smith & Co. (Radio) Ltd.)

| | |
|---|---|
| S1 | 4-pole changeover |
| S2 | 3-pole changeover |
| S3 | 3-pole changeover |
| S4 | Single-pole, push-to-make release-to-break |
| S5 | s.p.s.t., slide switch |
| 8-off | microswitches, Bonella single-pole normally open |

*Relays*

(All relays are available from G. W. Smith & Co. (Radio) Ltd.)

| | |
|---|---|
| RLA | Post Office 3000 relay, 100Ω coil, 3 break-before-make changeover contacts, 1 break contact |
| RLB, RLC | Sealed Siemens High Speed Relay, 145Ω + 145Ω coil, 1 changeover contact |

*Lamp*

| | |
|---|---|
| LP1 | 6.3V, 0.3A, m.e.s. lamp |

*Connectors*

| | |
|---|---|
| Power Supply: | Bulgin P194 6-way plug and socket (Home Radio Cat. No. P194) |
| Veroboard: | R. S. Components 8-way edge connector (Home Radio Cat. No. BTS41) |

*Batteries*

| | |
|---|---|
| BY1 | 6V 225 mA/H Deac rechargeable battery (Ripmax Ltd.) |
| BY2 | 6V 2 A/H accumulator, e.g. Yuasa MBC1-6 6N2-2A (Motor-cycle dealers). |

*Miscellaneous*

Verobard, 0.15 in. matrix, 3¾ in. × 2¼ in., 14 strips × 24 holes
1-off Meccano perforated strip, part 2a
1-off Meccano perforated strip, part 3
1-off Meccano perforated strip, part 6a
1-off Meccano coupling, part 63
2-way connector block
Tank clip (for securing BY1) (Ripmax Ltd.)
1-off fuse and holder rated at 5A if accumulator not used
Insulating washers
Perspex brackets
Rods
Torch reflector
Photocell tube

in addition. The contacts of S2 which control the learn circuits will be discussed in a later article. When both switches are in the off position. the battery terminals are connected to a power supply socket for recharging purposes. Because higher voltages are used for recharging than the batteries supply normally, it it was felt that this safety measure which allows the charger to be connected to the batteries only when both switches are off, was desirable. Naturally, if normal batteries are to be used, or if the learn circuitry is either to be omitted or switched on all the time, the switching can be made less complex.

There was also a need in the prototype for the electronics to be switched on without power being supplied to the motors, and S5 is used when Cyclops is to be run whilst 'paralysed'. This feature is useful in all

versions of the robot for such purposes as setting the various thresholds, and for testing the electronics; and therefore should be included.

The motor circuitry is quite straightforward. RLC1 cuts power to the scan motor, whilst RLB1 cuts power to the drive motor and to the recognition lamp. Contacts RLA3 and RLA4 reverse the direction in which the drive motor runs. Fuse F1 is included to protect BY2, whilst C2, C3, R21 and R22 and relay contact spark suppressors. C4 and C5 are included to limit interference from the motors.

## COMPONENTS

All resistors and capacitors are standard components as specified in the accompanying Components List. The diodes are all silicon, and all the transistors apart from TR7, TR8, TR11 and TR12 are p.n.p. silicon or germanium. Transistors TR7, TR8, TR11 and TR12 are silicon planar n.p.n. devices, and due to the Veroboard configuration, should be the types having plastic enclosures with the wires in the e-c-b sequence. A suitable type is the 2N2926. X1 is an ORP12 light dependent resistor. The Veroboard connector block and the power supply socket are as specified in the Components List.

Relay RLA/4 is a G.P.O. 3000 type having a 100Ω coil and four sets of contacts. Three of these must be changeover and break before make, even though RLA2 is at the moment only used as a break contact. Later on, the make contact will be used as part of the learn circuits. The fourth contact need only be a break contact. Relays RLB/1 and RLC/1 are both identical, and are sealed Siemens high-speed relays having dual coils. These are chosen because, firstly, high speed action is required, especially for RLC/1, since if scanning cuts out too late, Cyclops will miss the light source. Secondly, dual coils were used because it is then much easier to isolate the basic reflex circuitry from the learn circuitry, which comes later. Switches S1 to S4 were, in the prototype, all in one bank. (S3 and S4 are used in the learn circuits). The bank consists of four push-button switches. The two centre ones are interdependent, i.e. if one is pushed the other releases; and the two outside ones are independent, being of the push-to-make push-to-break variety, one of which was modified to be push-to-make release-to-break. However, if it is so desired, the switches could all be independent of one another, and mounted on a control panel. S5 is a miniature slide switch. The recognition lamp LP1 is as specified in the Components List, and is mounted in a reflector taken from an old torch.

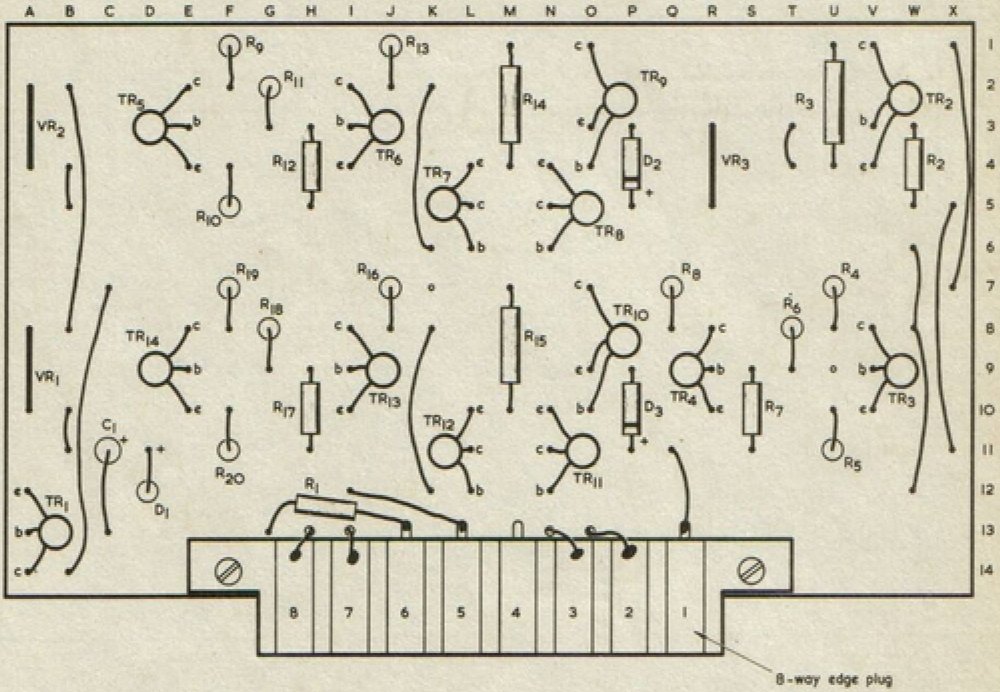



*Fig. 15. The component side of the Veroboard which carries the basic reflex electronics*

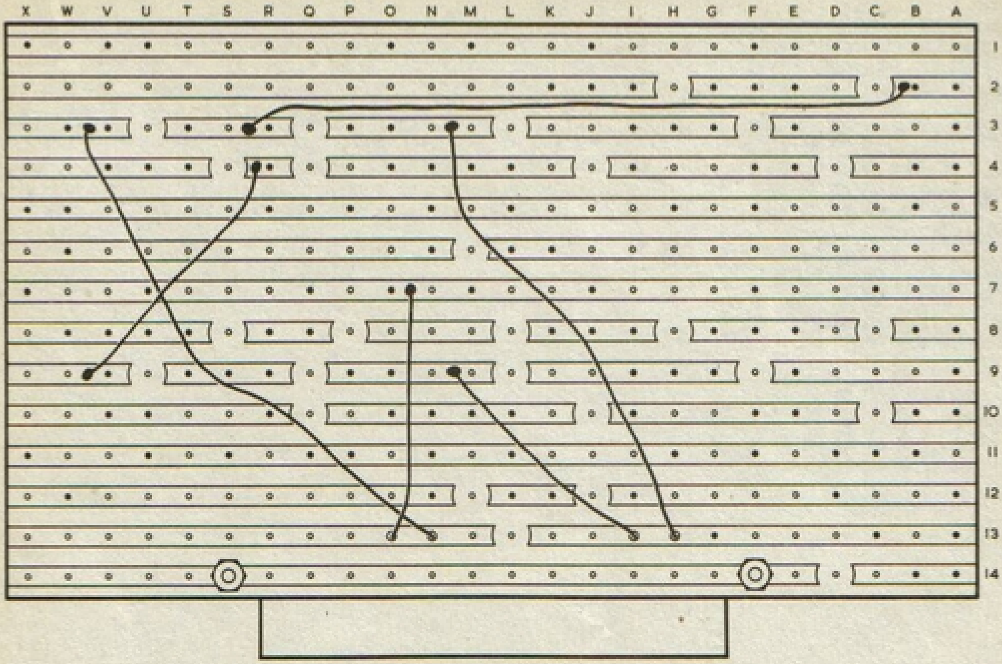



*Fig. 16. The copper side of the Veroboard. Note that the links are soldered to the strips between holes and not at the holes themselves*

Battery BY1 is a 6V 225mA/H Deac, whilst BY2 is a 6V 2A/H accumulator. On the other hand, if the expense of buying rechargeable power sources is not desired, BY1 could be a PP1, and BY2 could be an Ever Ready 'Lantern' battery type 996. However, both of these are too large to fit in the existing positions on the chassis, and the latter would have to be redesigned to take the batteries if this option was chosen. The fuse F1 is integral with the accumulator, but if batteries are chosen, it must be fitted separately.

## VEROBOARD ASSEMBLY

The area of the circuit diagram to the right of the dotted line in Fig. 14 is built on a piece of 0.15 in. Veroboard having 14 strips with 24 holes. This fits into an R.S. Components 8-way edge connector, and a suitable plug for this is required. If necessary, this plug may be cut out, from a further piece of 0.15 in. Veroboard, to the shape shown in Fig. 15, which shows the component side of the board. The copper side is shown in Fig. 16.

If desired, constructors may wire up the board completely, following Figs. 15 and 16. Alternatively, they may prefer to wait until the main chassis wiring has been completed (to be described in Part 4) whereupon they can then proceed by mounting the components on the board in stages. In this case, the preamplifier should first be built, and then tested. Next, each of the Schmitt triggers should be built, and tested by short-circuiting the top of the respective potentiometer to the negative rail and varying the position of the wiper whilst monitoring the output of the Schmitt trigger. The latter should, at a particular position of the wiper, suddenly jump from approximately 0.75 volt to about 5.5 volt. Finally, the And-gates and relay driver transistor stages should be built and tested. If construction and testing is carried out in this way, all the links and wires should be added *last*. The avoid circuitry (TR1, R1, C1 and D1) may be left till later.

Whatever method of Veroboard assembly is employed, it is first of all necessary to secure the 8-way edge plug to the panel at holes F14 and S14 by means of 6BA nuts and bolts. These two holes will require enlarging for this purpose. Then, the breaks in the Veroboard strips are made, as in Fig. 16, using a spot face cutter or a suitable drill. It should be noted that R1 connects to strip 13 at G13. The wires that pass through to the edge plug at holes H13, I13, N13 and O13 are insulated and do *not* make contact with the strip. The wires used must have insulation that does not melt readily when soldering at the plug tags. The polarities of the diodes and the transistor connections particularly those for TR7, TR8, TR11 and TR12 should be carefully checked.

A Components List accompanies this article, and it should be noted that some of the items listed are referred to in Part 4 of this series, which will be published next month.

(To be continued)