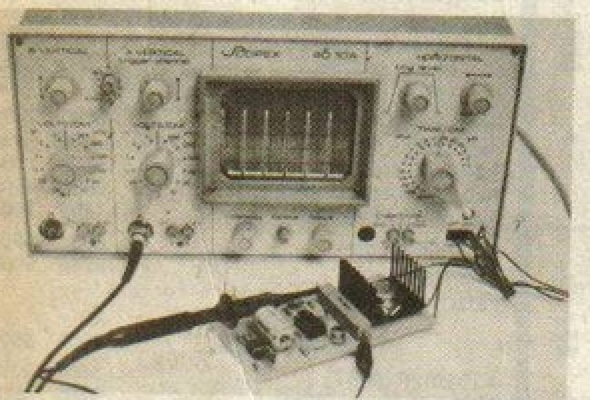
Hebot III

The HEBOT series reaches its conclusion with this article. Here we describe the inductive wire-tracking circuitry with full circuit details. There is also a simple constant-current nicad charger. Full details of all the circuit interconnections are given with notes for expansion. HEBOT is an open-ended project and there is plenty of scope for development. News is beginning to reach us of the two hundred or so HEBOTs already built and we feel sure this is just the start. If you have made any improvements or alterations to YOUR HEBOT we would very much like to hear from you. Watch HOBBY ELECTRONICS for further developments!



You can monitor the loop output current with an oscilloscope.

IN THIS FINAL ARTICLE we will deal with the points arising from the previous two months' designs. Judging from sales of the chassis, we estimate that there may be over two hundred Hebots or sons of Hebot roaming around Britain already. We have seen three of them constructed from kits which all worked first time so if you are having trouble check your soldering and make sure you have inserted all the wire links and connected the flying leads.

Before we go on to look at the monster we have created, a couple of points need to be cleared up. Though we used rechargeable nicad cells to power our Hebot, the circuitry will work quite happily with plus and minus six volt supplies when powered by dry batteries. Unfortunately no pads were provided on PCB1 for the x, y outputs of IC8. Simply solder directly to the copper track between pins 2, 3, and 9, 10 (the x and y outputs respectively).

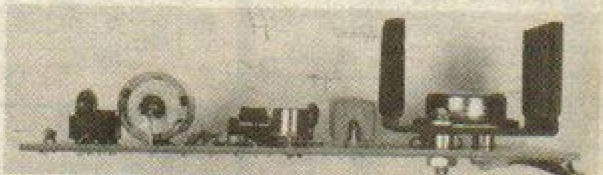
The second PCB is easier to mount above the first if capacitors C3, 4 are mounted so that they lie sideways. Also, to increase the gain of IC1, 2, 470k resistors should be mounted in parallel with input resistors R1, 2. There are no other changes to make on the first board.

On the second board, capacitors C1 and C10 have caused some problems. These capacitors should have a working voltage of at least ten volts. A 47µ capacitor may be used in place of either component. Resistor R4 should be changed from 100k to 270k and R5 from 820R to 8k2.

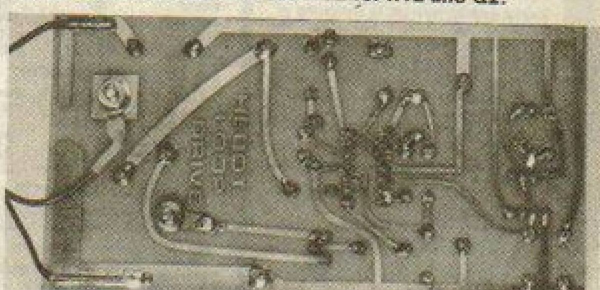
Following tests with Hebot tracking a wire energised by the loop driver circuit, it was found that capacitors Cx were unnecessary and wire links should be inserted in their place. Also flying leads should be used to connect pin E to G and F to H as shown in Fig. 1 of the December issue. If you use the REMCON sensor kit it should be assembled and connected as shown in our photographs.

We have arranged our Hebot to perform a 'random walk' until it sees a light (We used a desk lamp placed at ground level) Hebot then steers towards the light unless its pick-up coils detect electromagnetic radiation from an energised loop. Then Hebot will follow the wire loop. If at any time Hebot collides with an obstacle then the normal manoeuvre circuitry takes over to steer Hebot out of trouble. The connections to achieve this behaviour are detailed below.

Note the 470k resistors mounted in parallel with the servo input resistors.



Allow some clearance from the PCB for R12 and Q2.



There are connections to both sides of Q2 collector. We used solder-tags.

The connections to the manoeuvre circuitry remain the same;
pins 2, 3, IC8 to pin 4, IC4
pins 9, 10, IC8 to pin 11, IC4
pin 12, IC11 (Avoid) to pin 13, IC3 random walk' is achieved by connecting: A to pin 1, IC4
B to pin 12, IC4
+ve supply to pin 10, IC3
the letters refer to pins on the second board
for light seeking connect:
P to pin 14, IC4
Q to pin 5, IC4
the phototransistor collectors connect to N (from right sensor) and O (from left sensor). T to pin 11, IC3

The emitters both go to the negative supply and pins are provided on the board.
The connections for wire tracking are:
I to pin 15, IC4
J to pin 2, IC4
M to pin 12, IC3

Hebot's sensors were made from reed relay actuating coils with a resistance of 1.5k. No cores were found to be necessary. The right sensor connects to pin C while the left sensor connects to pin D. The free ends of the sensor coils should be connected to the adjacent pins which are electrically identical with pin 1, IC1.

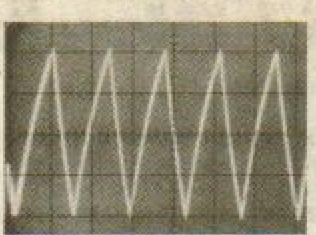
You should now have used all the inputs to IC4. IC5 is not used and this position may be left vacant. The remaining pins of IC3 should be connected as follows. Pins 1, 2, 3, 4 should be connected to the negative supply. This can be simply achieved by soldering a piece of tinned copper wire across all four pins down to the negative pin as shown in our photos. Pins 14, 15 of IC3 remain unconnected.

Our Hebot emits a sqeak when it detects light. To achieve this connect pin Y to pin T. There are now two connections to pin T. This is okay. You can spot when Hebot detects the wire loop by connecting pin S to pin M. The LED will illuminate when the pick up coils are within range of an energised loop. Also, of course, control is transferred to the wire following circuitry unless Hebot encounters an obstacle.

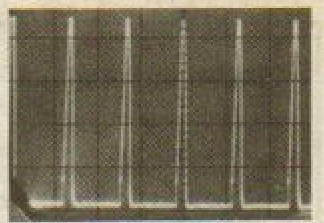
With the Hebot circuitry interconnected as described above, you will have a free roaming robot which can negotiate obstacles, steer towards a light and follow a wire around your home. We found that reliable operation could be obtained with wire-sensor separations of over one inch so Hebot should cope with the thickest pile carpets (though the prototype has an annoying habit of filling itself with fluff!).

The loop driver circuit should be constructed in the usual way. Though not essential, use of our PCB will greatly facilitate construction. Our photos tell all really. We found best operation was achieved with peak currents of 2.5A which gave a mean current drain of 350mA. Under these conditions Q2 hardly gets warm at all. RV1 works in reverse; when fully clockwise there is no output. About mid-way should produce the desired results.

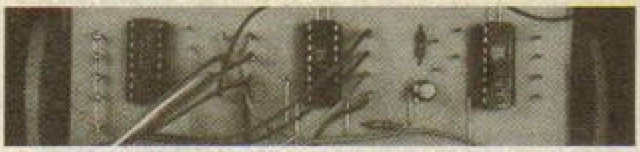
At this stage of development Hebot is an autonomous machine capable of very engaging behaviour. There is plenty of room for development. Board one will support a further four levels of control enabling more circuits to be accommodated on the chassis or control to be relinquished to an on-board micro-processor or via a link to your home computer. The possibilities are infinite and remember . . . We HAVE the technology! **HE**



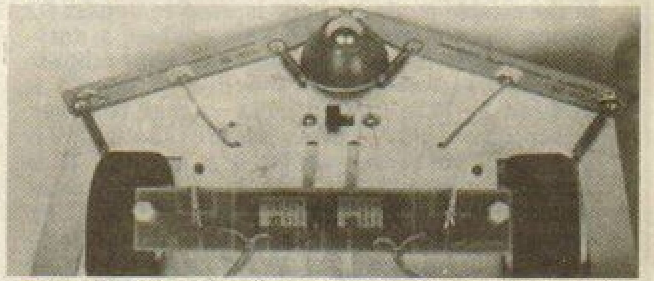
triangle waveform across C2.



output waveform across R12.



The connections to IC3 and IC4. Note the shorting link at the side of IC3.



The pick-up coils and photo sensors mount conveniently on one PCB.

How it Works

Hebot how it works — loop driver

Hebot is able to follow a wire laid on the floor by detecting the magnetic field produced by current pulses flowing in the wire. We tried a number of different arrangements and found that Hebot could follow a single wire carrying current pulses of about two amps at a frequency of around seven hundred Hertz. By using more turns of wire in the loop, accurate tracking can be achieved at lower currents. However, it is difficult to lay out a loop consisting of more than two or three turns of wire and the system chosen represents the best compromise.

Resistor R10 and zener ZD1 provide a stabilised 15 V supply which is smoothed by C1. A 700Hz signal is generated by IC1; a 555 timer configured in the astable mode. A diode is used to bypass R2 during the charging cycle. This enables a duty-cycle of 50% to be obtained. The approximate triangle waveform at the junction of R2, C2 is buffered by IC2b, a unity gain voltage follower, and appears at pin 7. A bias voltage of about 7.5 V is available at pin 14 and supplies IC2a and RV1. IC2a acts as an inverting amplifier with a gain of about 20 whose input is the triangle waveform from IC2b. Adjustment of RV1 enables the output of IC2a to be offset. In this way, the signal at pin 1 may be varied from 0v to positive peaks of up to 12 V. The remaining section of IC2 together with Q1, 2 and R11, 12 forms a voltage to current convertor. For each volt across R9 at the input pin 10 of IC2c, one amp will flow in a piece of wire connected between the positive supply and the collector of Q2. The maximum voltage that can appear at IC2a output is limited to 12 V with a 15 V supply by the op-amp characteristics. Potential divider R8, 9 limits the input to IC2c to 4 V and maximum output current, in a working circuit, is thus limited to 4A.

A suggested power supply is included here. Though the average current is less than 500mA with peak currents of 2½ A, the circuit may demand currents of up to 4A. For this reason, quite high current components have been chosen. If you have a current-limited power supply that can provide 15 V at 500mA you can connect it in place of the bridge-rectifier and transformer. Use good quality components for the capacitors to cope with the high current pulses.

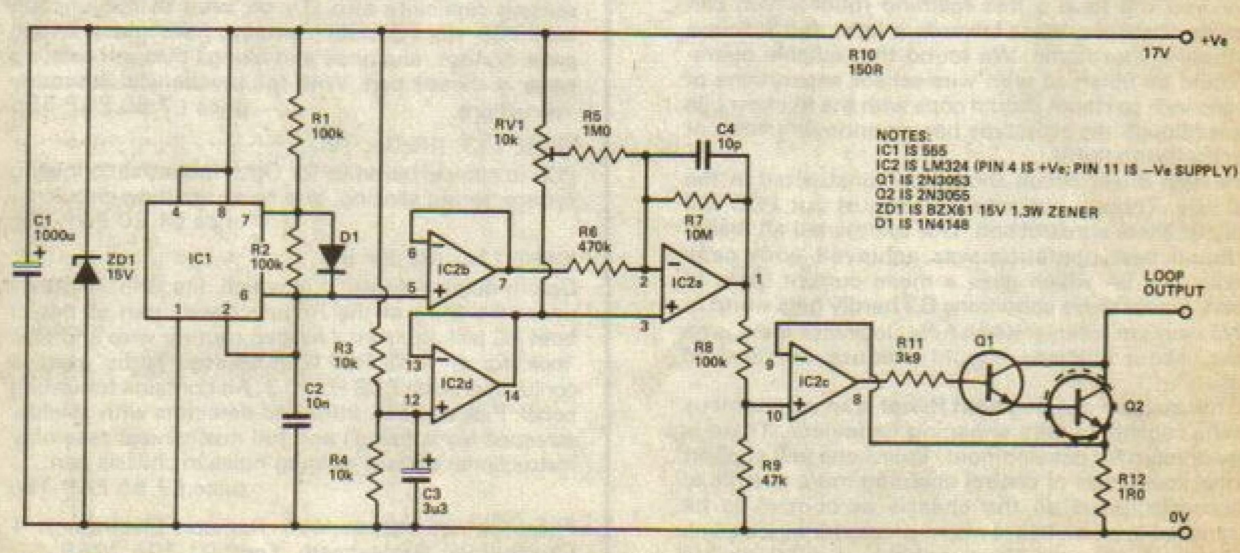
We tried loops of several shapes and sizes with good results. Hebot can cope with turns of up to one foot radius. Power should be supplied to the loop by twisted wires or figure of eight speaker cable. In this way the fields from the two supply wires cancel out and Hebot will not try to climb into your power supply.

Nicad charger

If you have used nickel-cadmium cells to power your Hebot, you will need a charger. We have included the circuit of a suitable charger which will supply a constant current of 40 mA. R2 is the nearest preferred value. With 450mA/H cells a charging current of 45mA should be applied for fourteen hours. Assuming a Vbe of 0.6 V for Q1 then the theoretical value of R2 to produce a current output of 45 mA is 13.333 ohms. You can check the current by inserting a meter in place of the cells and adjust R2 accordingly. A 120R resistor in parallel with R2 would produce the calculated value of 13.333 ohms.

About 18 V is developed across C1. The charging current flows via the cells through Q2, R2. Transistors Q1, 2 form a stabilised current sink. Current flow is determined by choice of R2. A current will flow sufficient to produce a voltage of 0.6 V across R2. This tends to turn on Q1 which 'steals' base drive current tending to turn off Q2. In this way the system reaches a stable operating point.

No PCB is given as the circuit is so simple. A small heatsink should be used with Q2. No other precautions are necessary.



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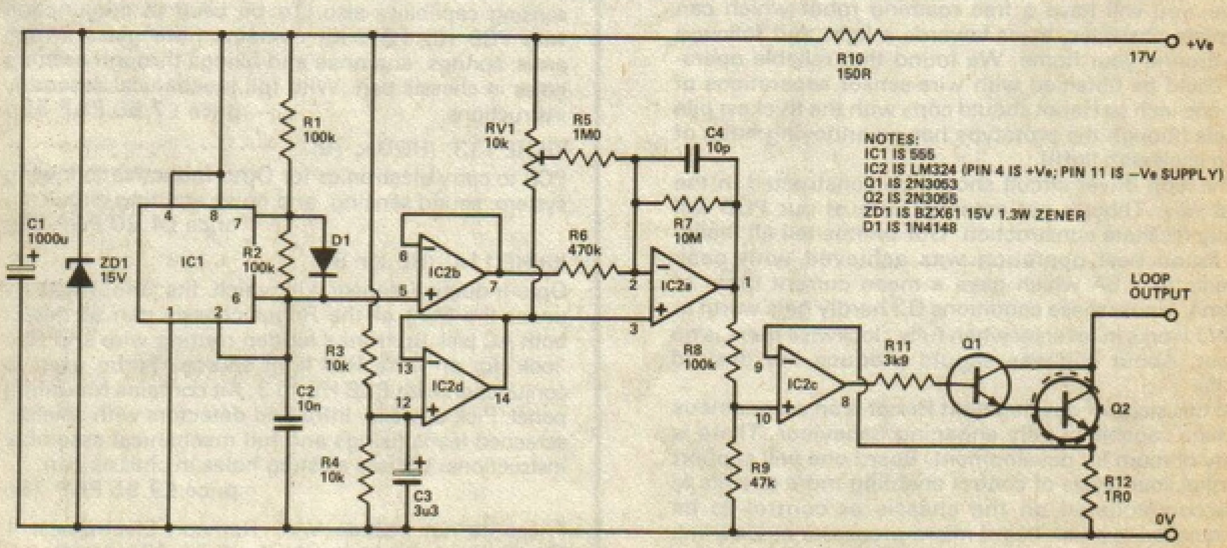


Fig. 1. The loop driver circuit.

Parts List

RESISTORS (All ¼W, 5%)	
R1, R2, R8	100k
R3, R4	10k
R5	1M0
R6	470k
R7	10M
R9	47k
R10	150R
R11	3k9
R12	1R0 10W

POTENTIOMETER	
RV1	10k horiz. preset

CAPACITORS	
C1	1,000 electrolylic
C2	10n polyester
C3	3µ3 tantalum
C4	10p polystyrene

SEMICONDUCTORS	
Q1	2N3053
Q2	2N3055
D1	1N4148
ZD1	BZX61 15V 1.3W
IC1	555
IC2	LM324

POWER SUPPLY	
12V	3A transformer
4A	bridge rectifier
4R7	10W resistor
2x	4,700µ 25V

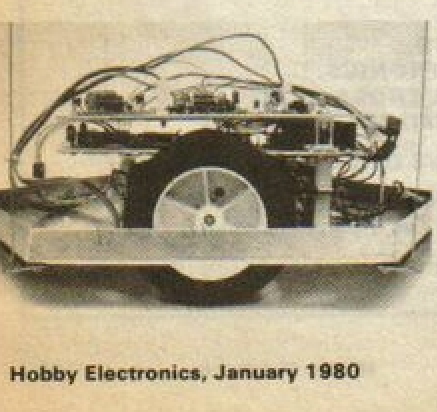
CHARGER

RESISTORS (All ¼W 5%)	
R1	1k0
R2	15R

CAPACITORS	
C1	1,000µ 25V

SEMICONDUCTORS	
Q1	BFY50
Q2	TIP33A
BR1	1A 50V bridge rectifier

transformer 12V 100mA



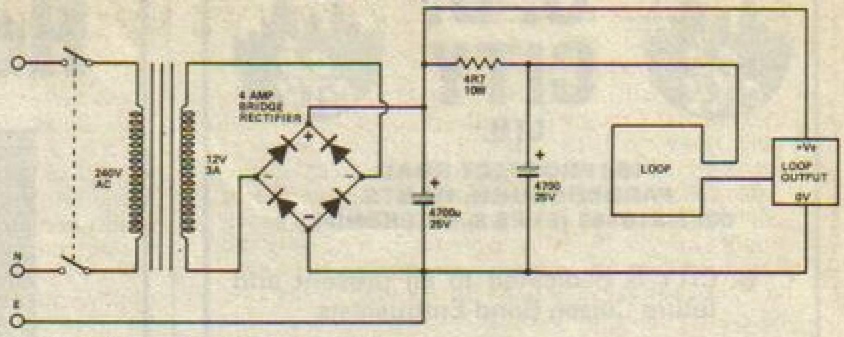


Fig. 2. Interconnections for the loop driver.

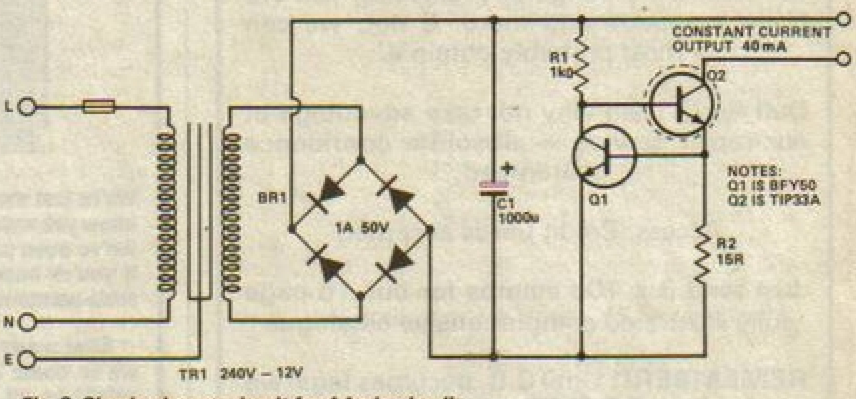


Fig. 3. Simple charger circuit for AA nicad cells.

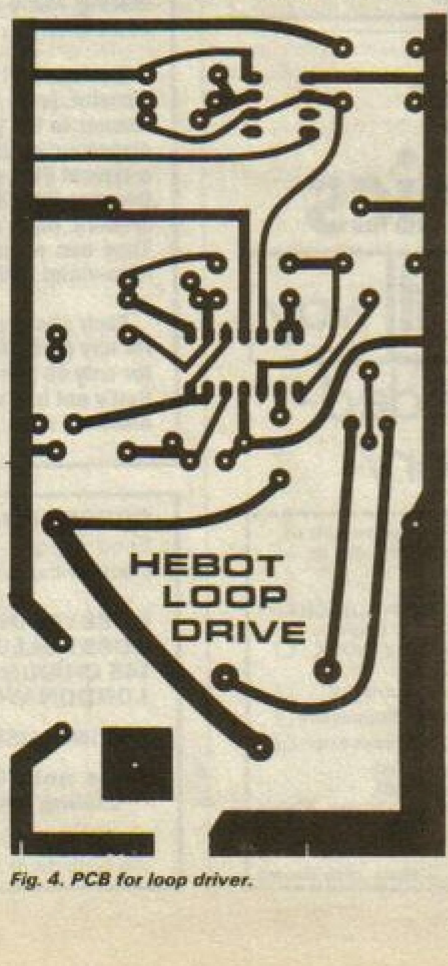


Fig. 4. PCB for loop driver.

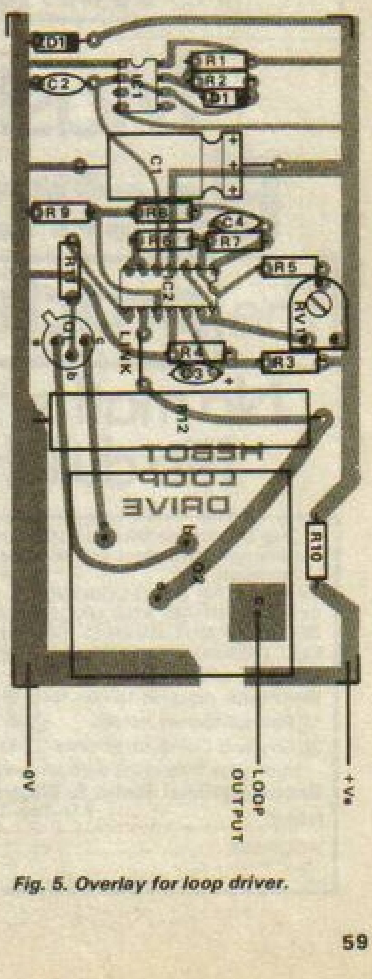


Fig. 5. Overlay for loop driver.

Parts List

RESISTORS (All ¼W, 5%)	
R1, R2, R8	100k
R3, R4	10k
R5	1M0
R6	470k
R7	10M
R9	47k
R10	150R
R11	3k9
R12	1R0 10W

POTENTIOMETER	
RV1	10k horiz. preset

CAPACITORS	
C1	1,000 electrolylic
C2	10n polyester
C3	3μ3 tantalum
C4	10p polystyrene

SEMICONDUCTORS	
Q1	2N3053
Q2	2N3055
D1	1N4148
ZD1	BZX61 15V 1.3W
IC1	555
IC2	LM324

POWER SUPPLY	
12V	3A transformer
4A	bridge rectifier
4R7	10W resistor
2x	4,700μ 25V

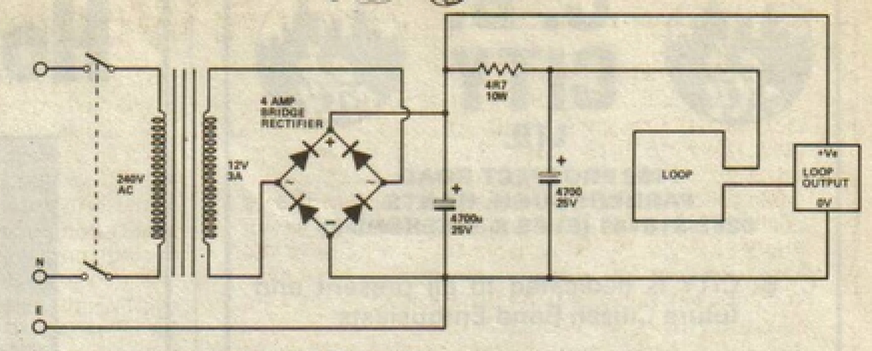
CHARGER

RESISTORS (All ¼W 5%)	
R1	1kO
R2	15R

CAPACITORS	
C1	1,000μ 25V

SEMICONDUCTORS	
Q1	BFY50
Q2	TIP33A
BR1	1A 50V bridge rectifier

transformer 12V 100mA



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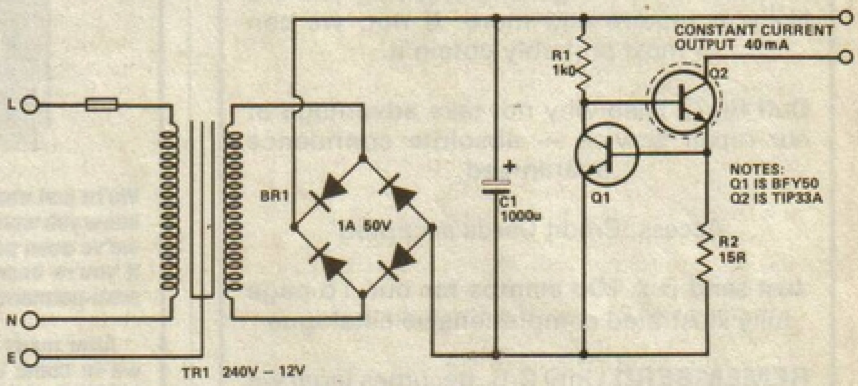

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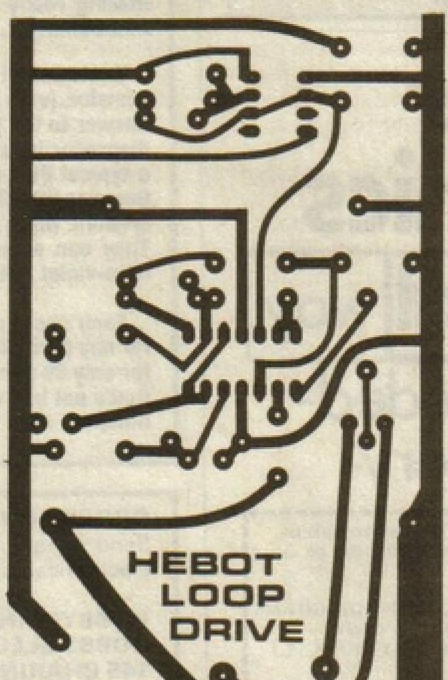

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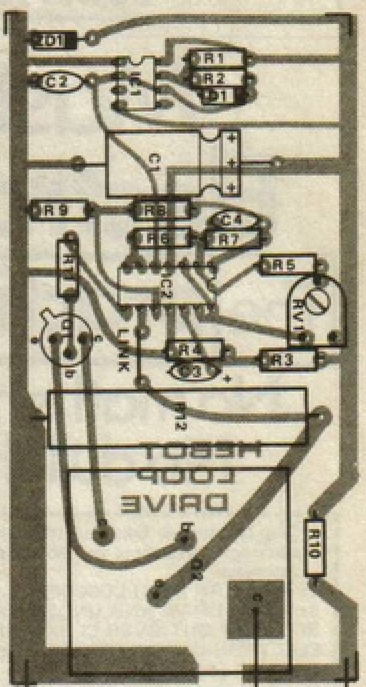

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