COLNE ROBOTICS Co. Ltd.

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ZEAKER is a small, low cost computer controlled robot vehicle designed to have all the normal functions of a "turtle" i.e. steering, lights, pen, horn and bump sensors but it is also capable of being expanded using photosensors for eyes to seek out or avoid light or to follow white lines etc; with a complex sound generator for special noises à la R2D2, and with computer speech.

It will easily interface to most popular microcomputers and can be programmed in a high level language like BASIC, although a modular language like FORTH or PASCAL would be better.

Under program control Zeaker can go forward, backwards or rotate right or left on the spot; it has two navigation lamps: port and starboard (or eyes if you prefer) which can be turned on or off; a speaker which can emit a high or low tone or a combination of both; 6 tactile sensors which can detect a collision with an object in Zeaker's path and finally but not least a pen which can be lowered or raised to enable Zeaker to draw Turtle Graphics. The up or down state of the pen is indicated by a lamp on the top of Zeaker.

Zeaker was designed to run on a table top, but will also run on smooth floors and because of this and to keep down the cost, the controlling electronics and power supply are contained in a separate box linked to Zeaker by a 2 metre umbilical cord (16 way ribbon cable). This separate box ('Zeaker Control Station') is linked to the microcomputer by two short ribbon cables.

DESCRIPTION OF ZEAKER (VEHICLE)

Zeaker's chassis is a modified ABS plastic box inside which are two electric motors complete with gearboxes, one driving each of the two wheels; a small speaker for the horn and a solenoid to lower the pen.

Mounted in the lid of the box are the navigation lamps, or eyes (red and green l.e.d.s), the socket (SK1) to connect the umbilical cord and the pen status l.e.d. (yellow) whilst on the outside are the four Aluminium Fenders which when touched compress foam plastic blocks and make contact with screw heads in the side of the box, thus forming 16 simple switches which are paralleled into 6 groups (Fig. 11). Underneath at the front is a plastic "toe" to give Zeaker stability.

DESCRIPTION OF ZEAKER CONTROL STATION

The Control Station contains 4 Nicad C-cells to provide the power for Zeaker. This eliminates all the safety problems with mains powered equipment and thus it may be left without fear in the hands of the youngest child. Using Nicads also leads to a more compact power supply unit and a fully charged set will power Zeaker for at least 4 hours but including thinking time, human's and Zeaker's, this will easily stretch to 8 hours. To recharge the Nicads the computer's power supply can be used, the ZX-81 power supply simply plugs in the side and trickle charges the Nicads through a lamp which also acts as a reminder that the supply is on. The ZX-81 power supply will recharge the Nicads overnight.

A printed circuit board holds the driver transistors which switch on the motors, lights and solenoid. A 556 dual oscillator is used to provide the tones for the horn whilst a 74LS03 Quad NAND i.c. wired as a set/reset latch prevents the motors being switched into reverse as well as forward. On the front panel is a switch which isolates the control electronics from the Nicads and acts as an "off" switch for Zeaker. No robot (leastways with present technology) should be without an "off" switch.

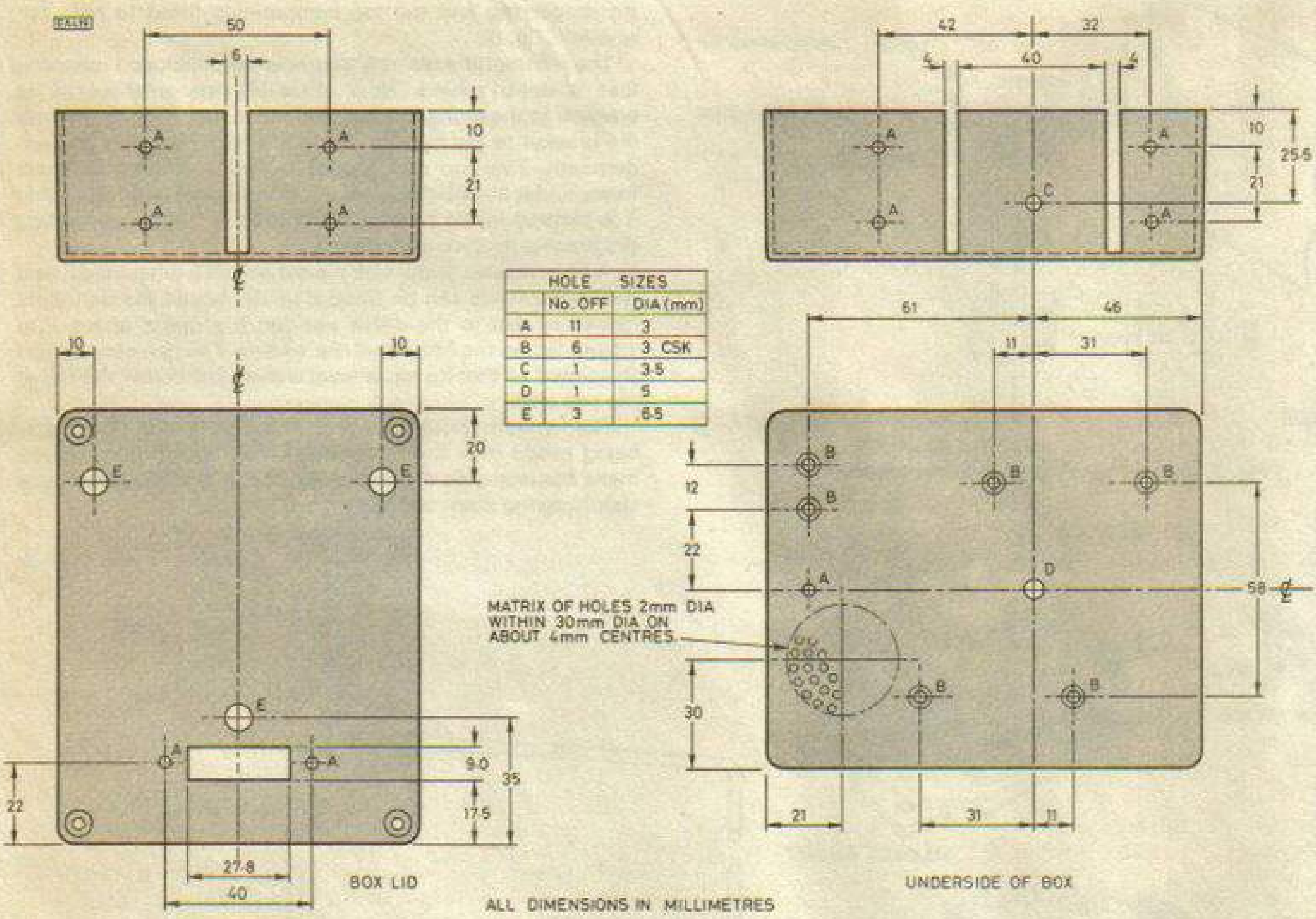
VEHICLE CONSTRUCTION

First, the box should be modified as shown in Fig. 1, then the metal Fenders should be made and bent to shape using the template drawings in Fig. 2. The solder tags should be attached as shown in Fig. 3 and the bends checked again. Make up the pen arm and bracket (Fig. 4), once again this drawing can be used as a template for bending the pen arm. A corner of one of the motor gearboxes (Fig. 5) should be removed. (This will be the starboard motor assembly.) The motors and gearboxes should be assembled using only 4 of the black plastic gears with the long end of the small motor shaft shortened so the shaft is 39mm in length. Next press on the white gear wheel and put on the spacers. Assemble the gearbox and secure the end cap with polystyrene cement (for plastic kits) (Fig. 6). (Note 1)

ZEAKER

MICRO-ROBOT

PART 1 **DAVID BUCKLEY**



HOLE SIZES		
	No. OFF	DIA (mm)
A	11	3
B	6	3 CSK
C	1	3·5
D	1	5
E	3	6·5

Fig. 1. Cutting and drilling details for Zeaker's chassis

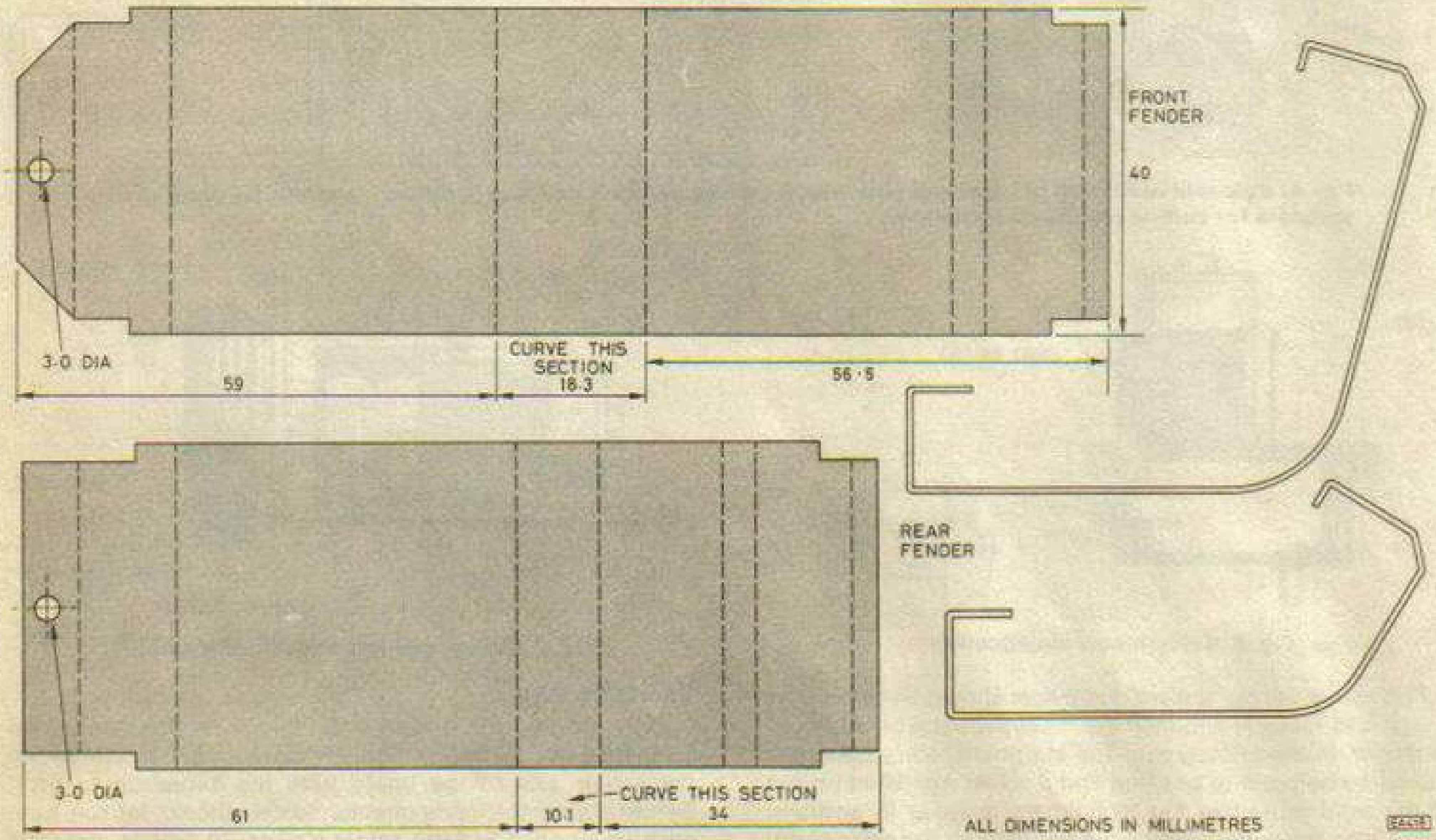


Fig. 2. Fender cutting and bending details. Note this drawing is full size and can be used as a template for cutting and bending the fenders

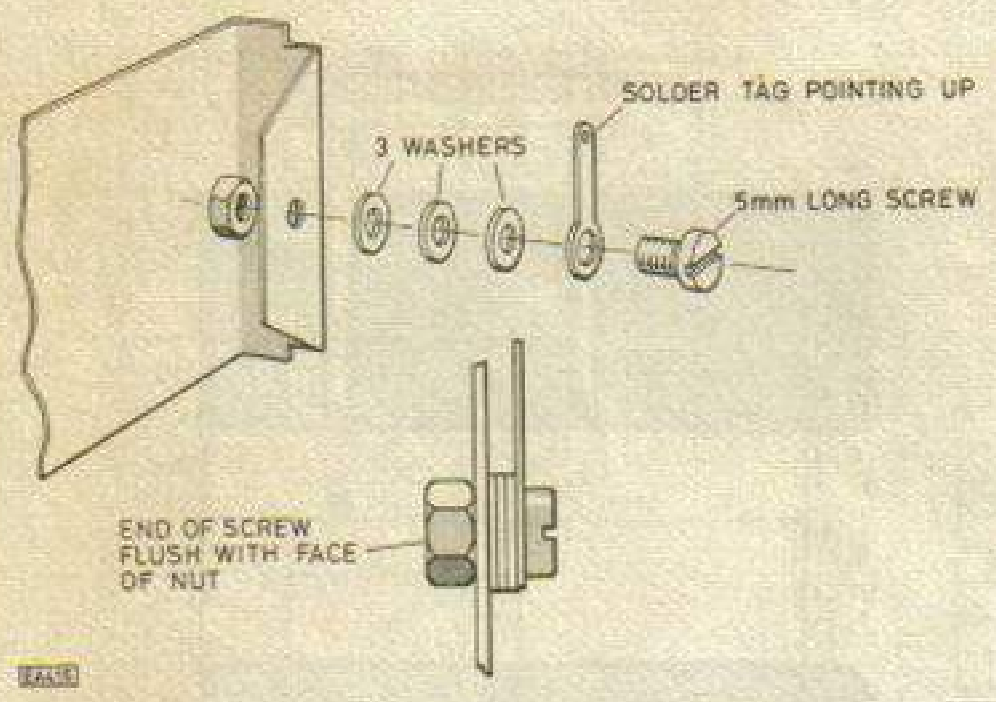


Fig. 3. Method for attaching solder tags to fenders

the solder tag and the toe components fitted to hold the speaker (Fig. 8). (Note 2).

The left motor assembly can now be positioned checking that it doesn't bind. Now assemble the solenoid in its bracket, fit the plunger extension and spring (Fig. 4) and bolt the bracket to the bottom of the box fixing the pen arm underneath. The pen arm should be loose enough to move freely under solenoid control. Fit the pen and make sure that it is centred in the hole at the bottom of the box, adjusting the bracket position accordingly. (Note 3).

A nylon washer should be placed on each wheel shaft and then the wheels can be fitted (Fig. 6). Adjust the pen in its holder so that in the down position it projects about 1 to 1½mm below the bottom of the wheels. The pen can then be shortened so that its top is level with or just below the top of the pen arm.

The Fenders should just drop in the slots of the box, after being eased over the foam pads. They should push in and make contact with the pillars very easily and the foam pads should spring them out again.

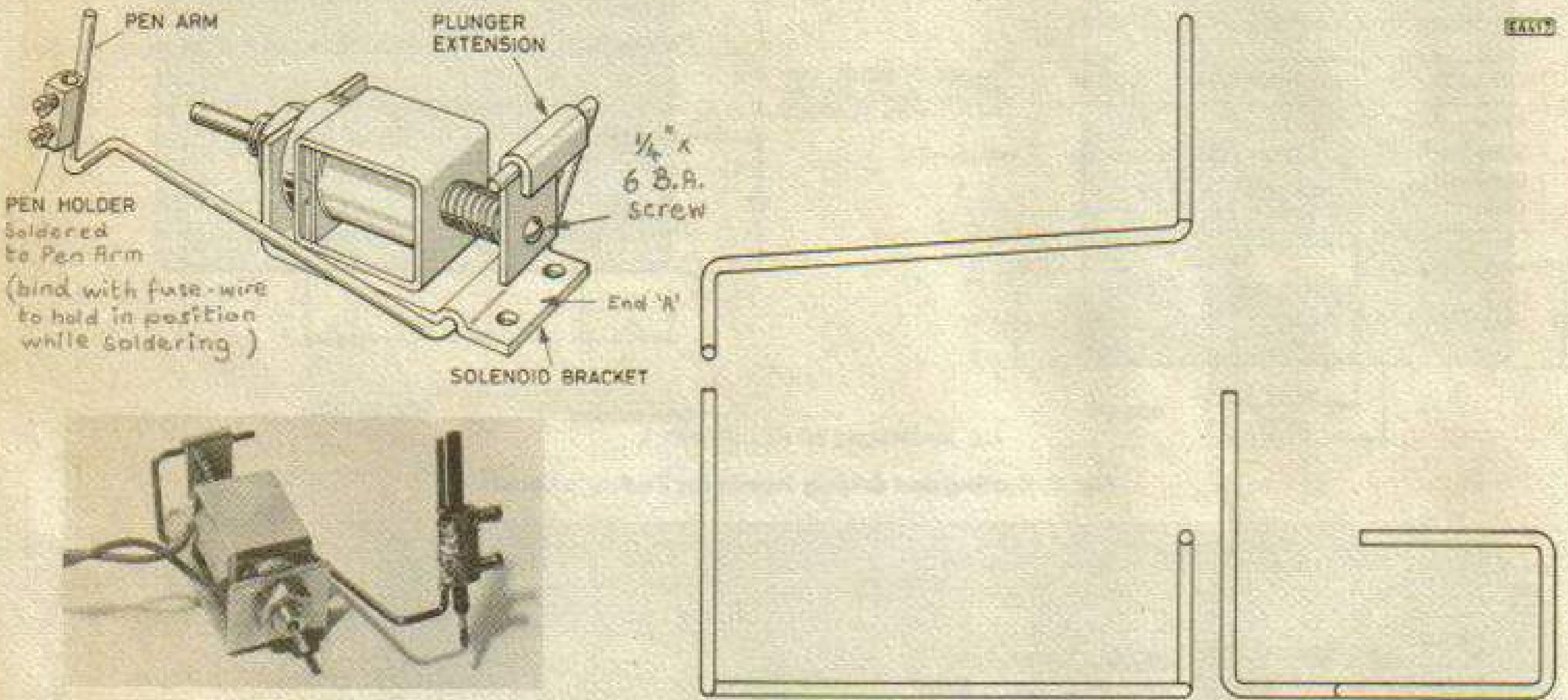


Fig. 4. Solenoid mounting bracket and pen arm. Note the pen arm drawing is full size and can be used as a template for cutting and bending the arm

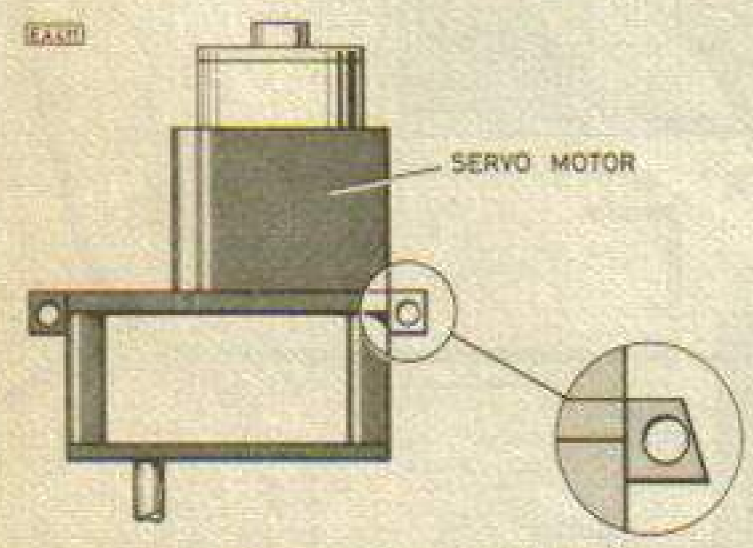


Fig. 5. Servo motor modification

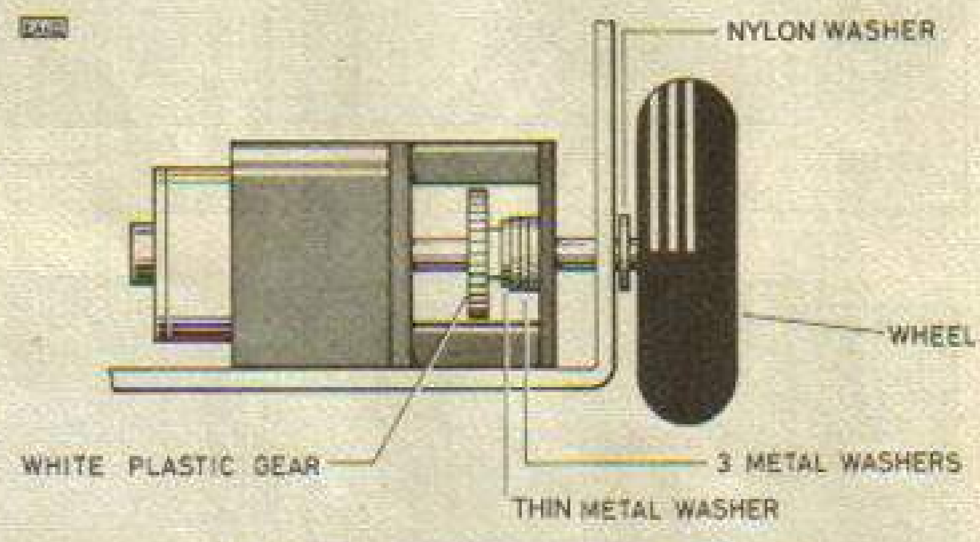


Fig. 6. Motor, gearbox and wheel assembly

The tactile sensor screws and pillars should be fitted next (Fig. 7 and Table 1) and then the foam pads can be mounted as shown in the photograph. The starboard motor assembly should be bolted into position and a solder tag fitted on top of the front mounting lug to hold the speaker in position. Check that the output shaft does not bind on the sides of the case hole. The speaker can now be fitted in position under

VEHICLE PCB

The vehicle p.c.b. with the component layout shown in Fig. 10. The components are mounted on the solder side of the board with the exception of SK1. Before fitting the components, solder should be run onto each square pad to form solder bumps. The diode, resistors and RF chokes should then be soldered, blobbing the ends of

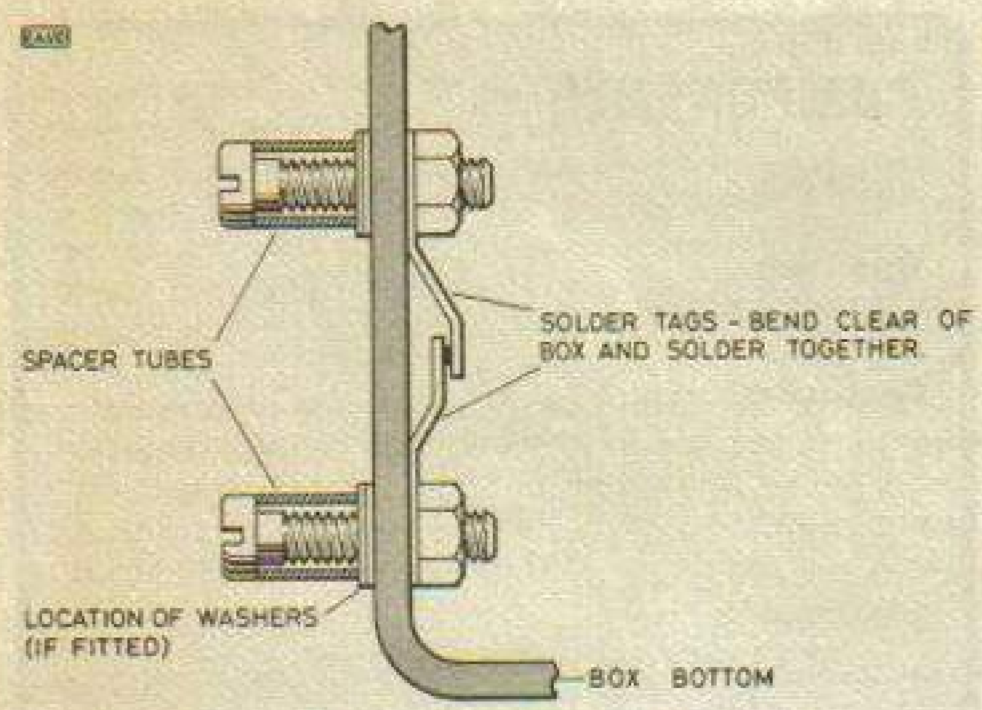


Fig. 7. Tactile sensor contact assembly

Top and bottom contact points are identical

LOCATION	SPACER LENGTH
Front	3mm
Side front	7mm (6mm spacer + 2 washers)
Side rear	6mm (do not overtighten this position)
Rear	3mm

Table 1

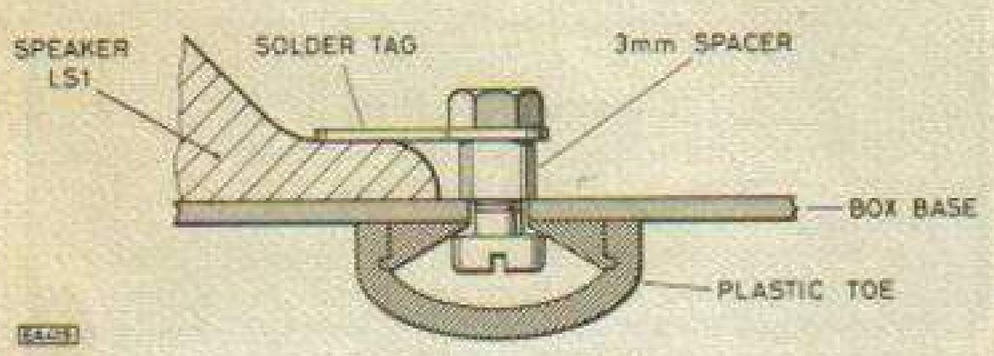
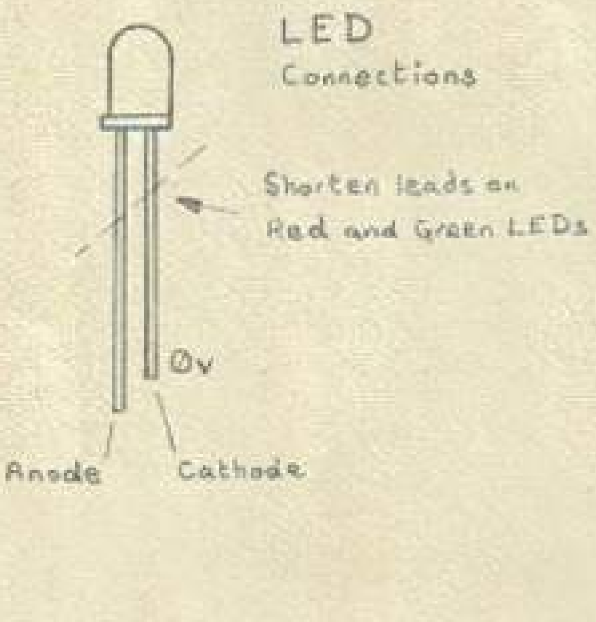


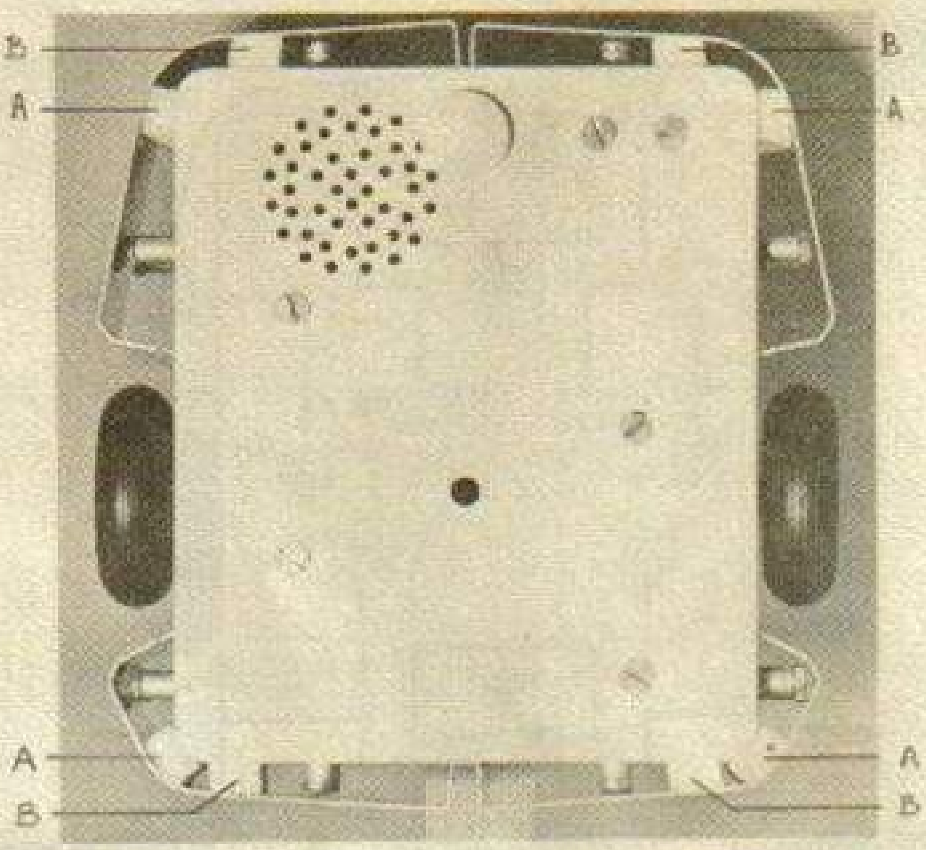
Fig. 8. Toe assembly

FOAM PADS

The foam pads should run vertically starting 3 mm above the bottom of the box.

Pads A are 25 mm long.
Pads B are 10 mm long.





Photograph showing the position of the foam pads

the leads into the solder bumps (Fig. 10). The 16-way Molex connector (SK1) should be fitted from the opposite of the board and soldered in place. (Note 4)

The p.c.b. should be bolted onto the lid of Zeaker using two nylon washers over the p.c.b. tracks. The l.e.d.s and link wires to the p.c.b. can be soldered next with the leads of the centre l.e.d. bent down and soldered to the two adjacent pads.

VEHICLE WIRING

All the top and bottom solder tags on the contact-points should be linked as should the side-rear and rear contact-

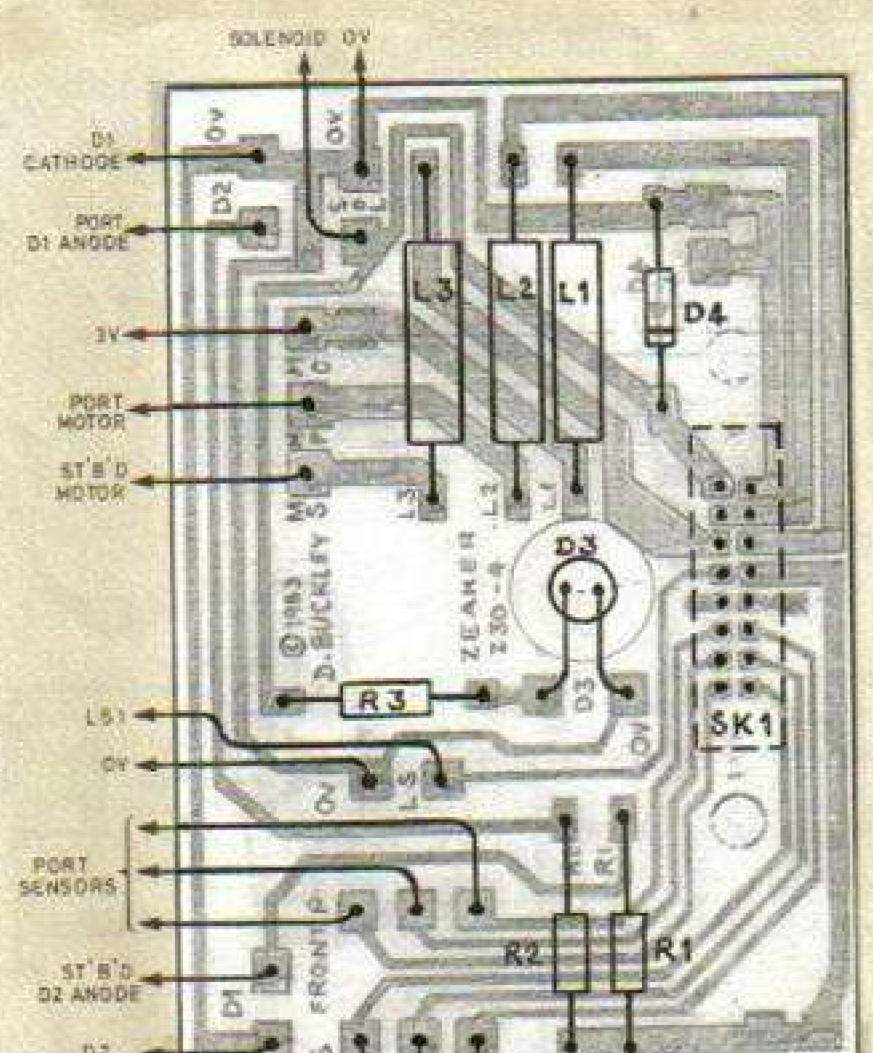


Fig. 10. Component layout

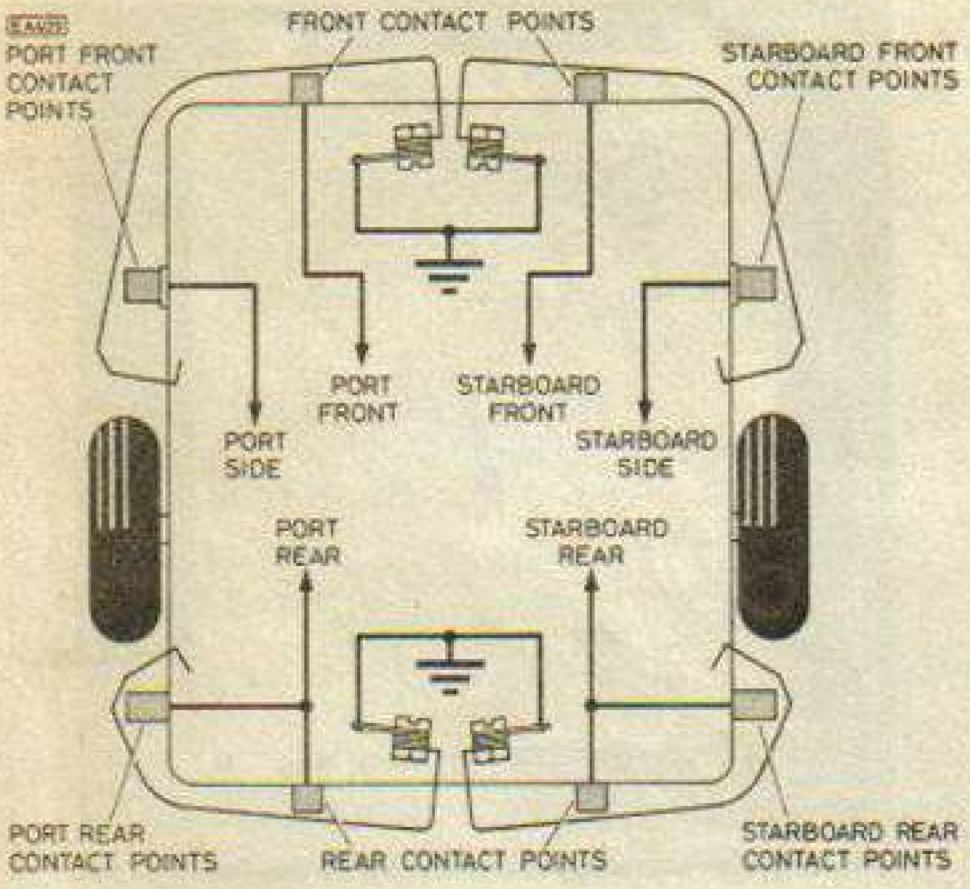


Fig. 11. Location of Zeaker's tactile sensors

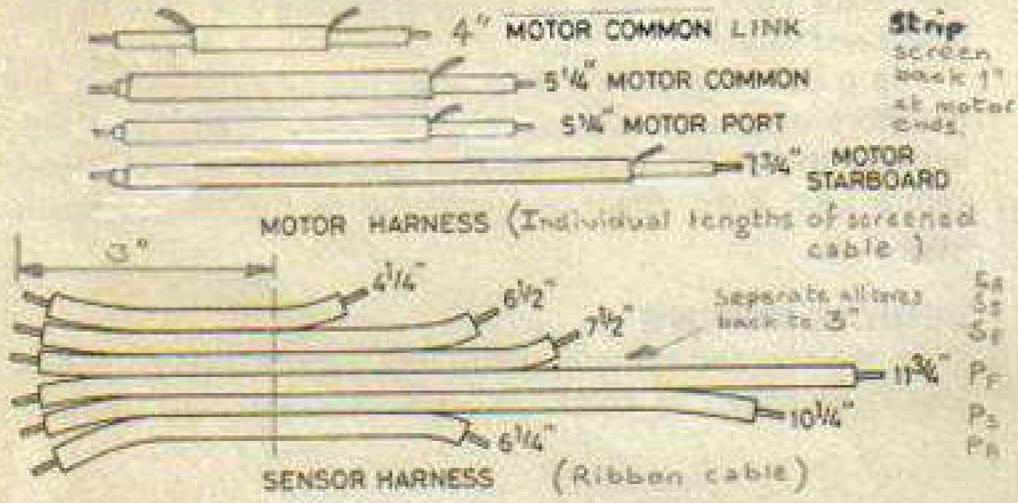


Fig. 12. Motor and Sensor harnesses

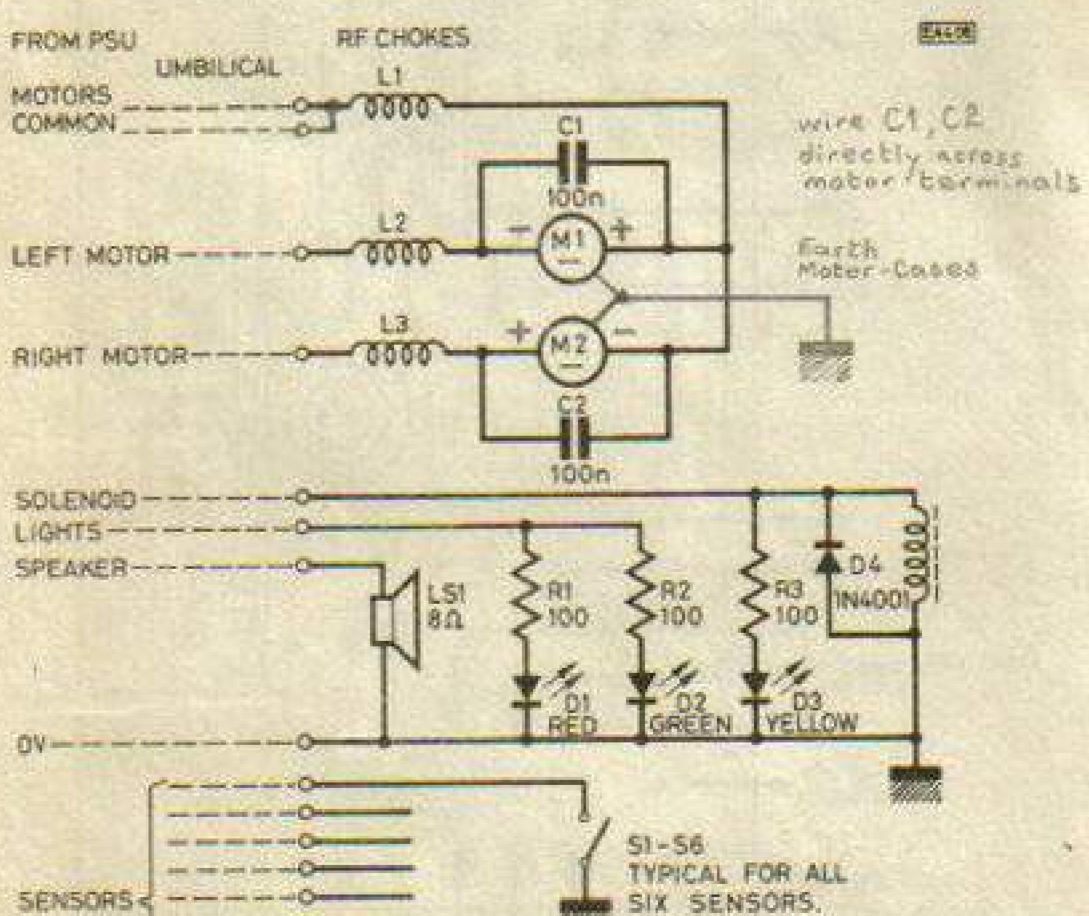


Fig. 13. Wiring diagram for the vehicle

COMPONENTS . . .

VEHICLE

Resistors
R1, R2, R3 100 (3 off)

Capacitors
C1, C2 100n (2 off)

Semiconductors

D1	0·2 in red l.e.d.
D2	0·2 in green l.e.d.
D3	0·2 in yellow l.e.d.
D4	IN4001

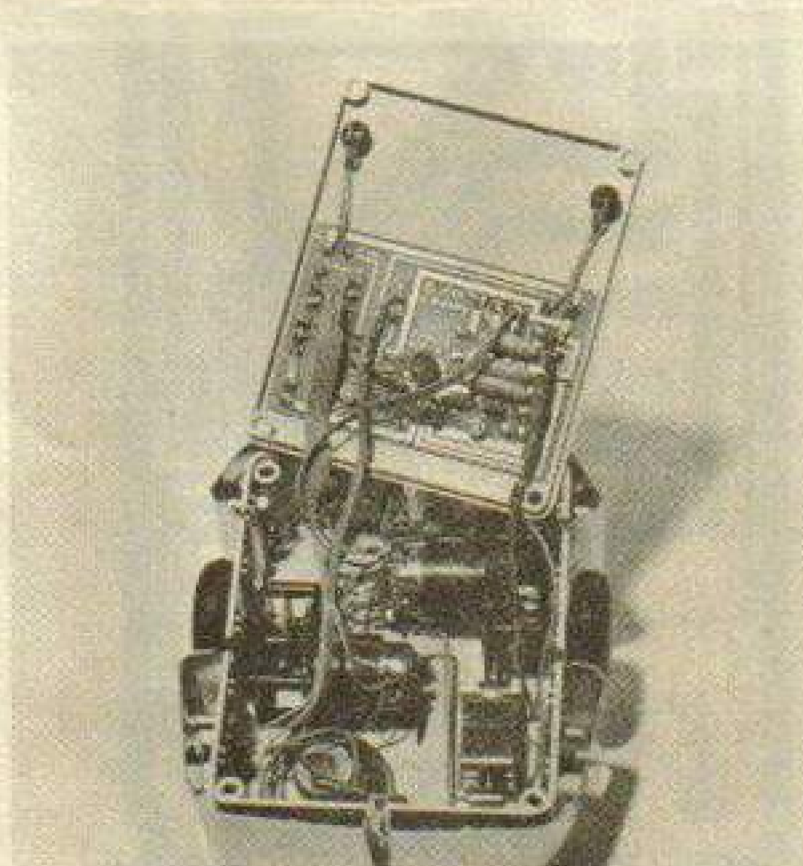
Inductors
L1, L2, L3 1 amp RF chokes (3 off)

Miscellaneous
ABS plastic box (120 × 100 × 45mm)
Cover cap for toe
Micro Mold 38 × 13 wheel (2 off)
Como motors and gearboxes, small (2 off)
Keyswitch Varley 5V solenoid SM00
1½in. dia. 8 ohm speaker
Pen holder—centre from 5A connector block
Clips for l.e.d.'s (3 off)
Molex connector 5332 series 16 pin
Aluminium for fenders, plunger extension and solenoid mounting bracket
Rod for pen arm
Fender foam pads (self-adhesive draught excluder)

Speaker Harness

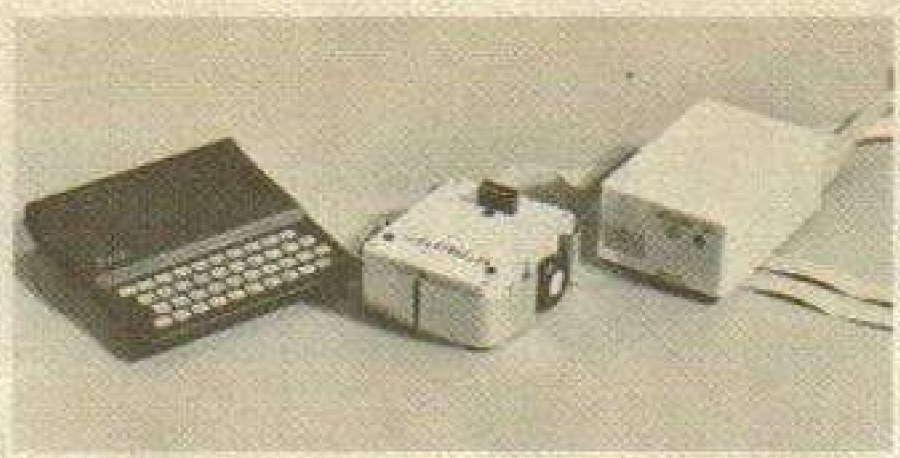
Øv Links

Front and Rear - Fender links	3"
Rear - Fender to Port - Motor-case	3"
Starboard - Motor-case to Speaker	2"
Speaker to Front - Fender	3"



Internal view of the vehicle

Motor Harness and PCB are now changed slightly from photograph.



The Zeaker Vehicle together with its Control Station and a ZX-81

FORWARD

STARBOARD / PORT

SENSOR PORT FRONT 1	SENSOR PORT SIDE 3	SENSOR PORT REAR 5	SENSOR SPARE (a) 7	SPEAKER 9	MOTOR STARB'D 11	MOTOR COMMON (2·5V) 13	SOLE-NOID 15
SENSOR STARB'D FRONT 2	SENSOR STARB'D SIDE 4	SENSOR STARB'D REAR 6	SENSOR SPARE (b) 8	LIGHTS 10	MOTOR PORT 12	MOTOR COMMON (2·5V) 14	0V 16

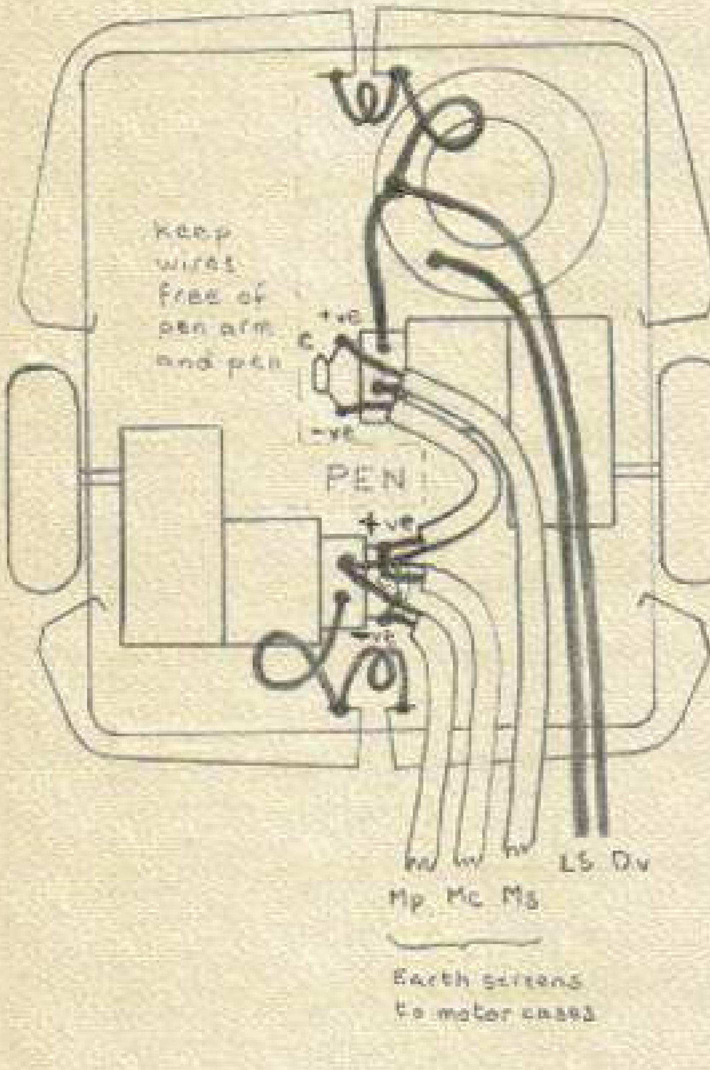
CABLE CHANNEL

Fig. 14. Molex connector pin allocations (viewed from copper side (below) of p.c.b.)

points (Fig. 11). The 6-way harness can then be fitted to the contact-points starting with the longest lead at the Front Port contact-point and then fit the speaker harness, finish the interwiring and fit the motor wires. Then slot the fenders into position and solder the fender links. Finally solder the harnesses to the appropriate pads on the p.c.b. (Fig. 13). The solenoid leads should be cut to $5\frac{1}{4}$ inches, twisted together and soldered into place on the p.c.b. Check that when the lid is shut none of the wires foul the fenders and that they can be pushed in to make contact as before.

VEHICLE CHECKOUT

Using a signal/pin allocation diagram (Fig. 14) check with a multimeter that each of the sensor lines is shorted to 0V when the appropriate contact pillar meets the fender and that upon release there is an open circuit. Apply +5V to the solenoid pin and check that the solenoid clicks in and lowers the pen, similarly check the lights with +5V. Applying 2V ($1\frac{1}{2}$V will do) between motor common and the motor lines check that −ve voltage on the port motor line makes the motor go forward and +ve makes it go in reverse and check that a +ve voltage on the starboard motor line makes it go back and −ve makes it go forward i.e. to go forward port line is −ve and starboard line is −ve



Vehicle main wiring

VEHICLE CONSTRUCTION
Supplementary Notes

1 When the gearbox is assembled there should be a slight amount of axial play in the gearbox output shaft. (but not more than 0.5 mm)

2 Make sure that the solder tags holding down the speaker are not near the speaker cone.

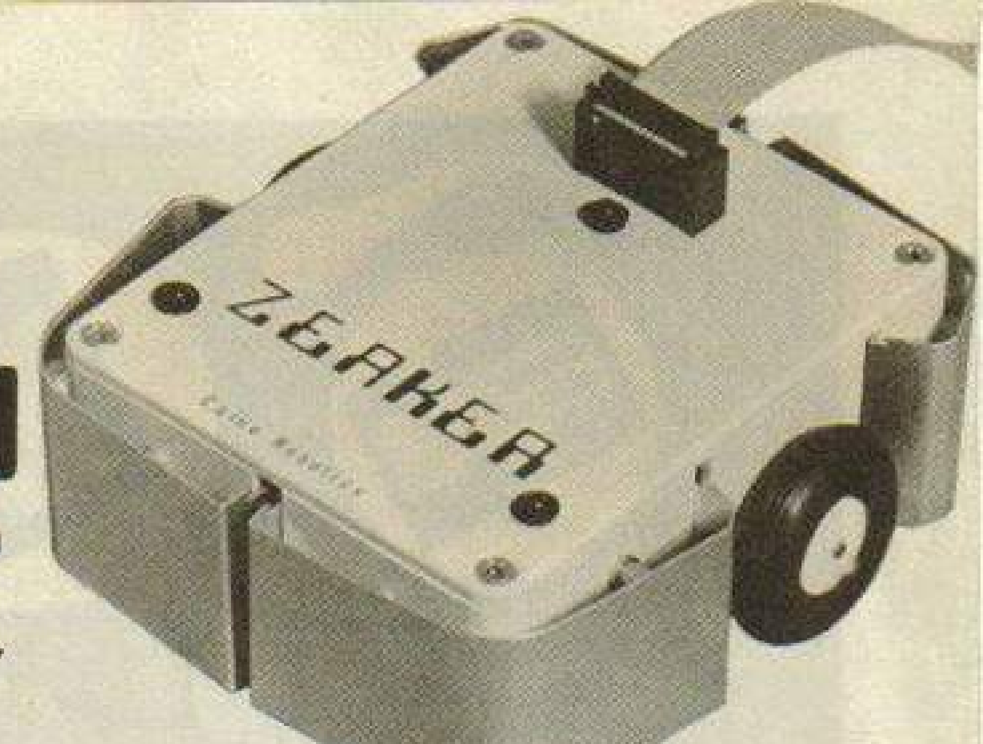
3 If the pen arm does not move freely, insert a thin piece of paper under End 'A' of the solenoid bracket, making sure that it does not go so far as to touch the pen-arm. (Fig. 4)

4 Make sure that the Diode D4 is the correct way round with the band as shown in Fig. 10. Incorrect connection will damage the Zeaker Control Station electronics.

ZEAKER

MICRO-ROBOT

PART 2 **DAVID BUCKLEY**



IN the Control Station the holder for the four C-cell Nicads is bolted to the bottom of the box (actually the lid, but the box is used upside down). The Nicad supply on/off switch and indicator l.e.d. are fitted to the front of the box. The 3·5mm jack socket for the charger and the charge indicator lamp are fitted to the side of the box.

The three 16 way ribbon cables (two to the computer interface board and the umbilical to Zeaker) leave the box through cut outs in what is now the lid, these should be of a size such that the ribbon cable is just clamped when the box is closed.

CONTROL STATION CIRCUIT DESCRIPTION

The circuit (Fig. 1) can be divided into two distinct parts: the computer READ port and the computer WRITE port. For the ZX-81 both these ports are memory mapped at address 16383 decimal.

Dealing first with the READ port. Data lines D0 to D7 are normally held high by resistor pack IC3. Lines D6 and D7 terminate on pads inside Zeaker and are not used hence D6 and D7 are always high. The remaining lines D0 to D5 terminate at the insulated pillars set into the sides of Zeaker and indicate the state of the tactile sensor switches, a low data line implying that Zeaker is touching something (see table of sensor codes). All the fenders are connected to 0V and on impact with an obstacle a fender will move in and make contact with one or more pillars, hence shorting the respective data lines to 0V.

Turning now to the WRITE port. D0, D1 control the port drive motor; D1, D2 control the starboard drive motor; D4 the pen; D5 the lights; and D6 and D7 the horn.

One end of the port drive motor goes to the centre tag of the battery and the other to the junction of TR3 and TR4. Turning on TR4 will cause the motor to run forwards and turning on TR3 will cause it to run in reverse.

D1 high is port motor forwards and D0 high is port motor reverse. IC1a and IC1b are wired as a set reset latch which ignores the condition D0 high and D1 high, so preventing destruction of TR3 and TR4.

When D0 goes high the output of IC1a goes low, so turning on TR2 which turns on TR3, when D0 is low TR2 is held off by R2 and R3. TR1 is normally held on by R1 and R4 and so shorts TR4 base to earth but when D1 goes high the output of IC1b goes low and turns off TR1, TR4 is now able to turn on by base current through R5.

The operation of the starboard motor is similar.

Data line D4 high turns on TR9 which turns on TR10, switching on the solenoid which lowers the pen. The l.e.d. D3 provides indication that the solenoid is activated. Diode D4 is to short out the inductive high reverse voltage when current through the solenoid is halted by TR10 turning off.

Data line D5 high turns on TR11 which turns on TR12, lighting D1 and D2, the red and green l.e.d.s.

Data lines D6 and D7 control the horn, via the reset lines of IC2 which is wired as two astables. The frequency components R20, R21, C2 and R22, R23, C3 were chosen by experiment so that the tones sounded right when both are on together. C4 is the usual blocking capacitor.

CONTROL STATION PCB

The p.c.b. for the control station is shown in Fig. 2 with the component layout shown in Fig. 3. The resistors by the 556 are mounted on end but the others are mounted flat. There are a number of wire links to be soldered in place and these are best done with insulated wire. None of the transistors need heatsinks and are all mounted vertically. The three 16 way flying leads can be soldered directly into the p.c.b. but it is easier to use headers on the leads and plug them into the p.c.b.

CONTROL STATION CHECKOUT

The easiest way is to plug the read and write cables into the interface board.

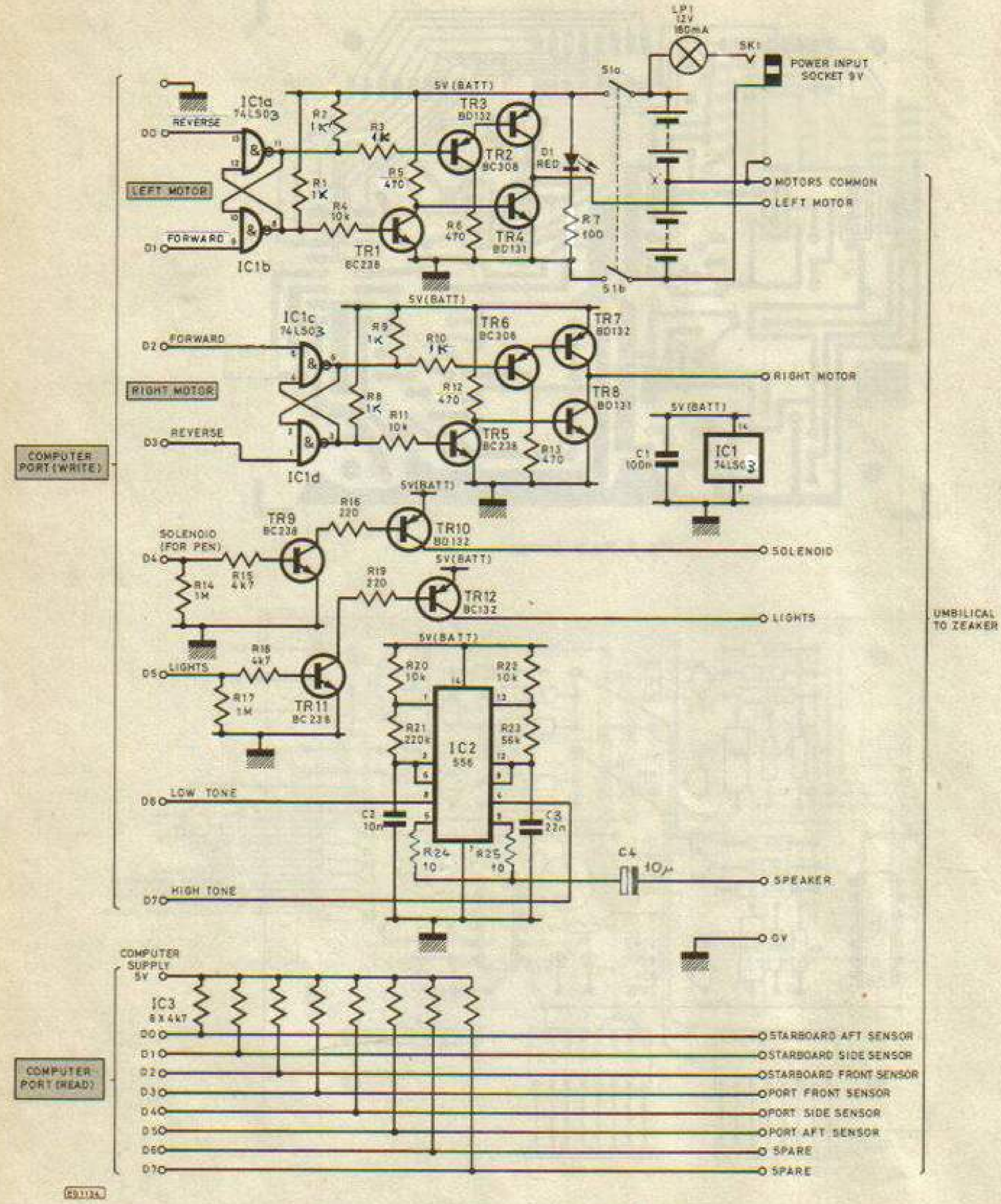


Fig. 1. Circuit diagram of the Control Station

and check that the computer still works. The computer is only connected to the control station and Zeaker by the 0V line and the data lines from the buffer chips on the interface board so this shouldn't be a problem.

Plug the umbilical into Zeaker and POKE the interface board port with zero; this turns off all the outputs. Now switch on the 5V supply and nothing should happen. POKE the port with the various control codes (Table 1) and check that Zeaker functions. When any of the BD power transistors are turned on there should only be about 0·2 volt between collector and emitter and about 0·1 volt between collector and emitter of their driving transistors.

PROGRAMMING ZEAKER

To program Zeaker all that is needed is a computer with an 8-bit output latch and an unlatched input port with 6 or 8

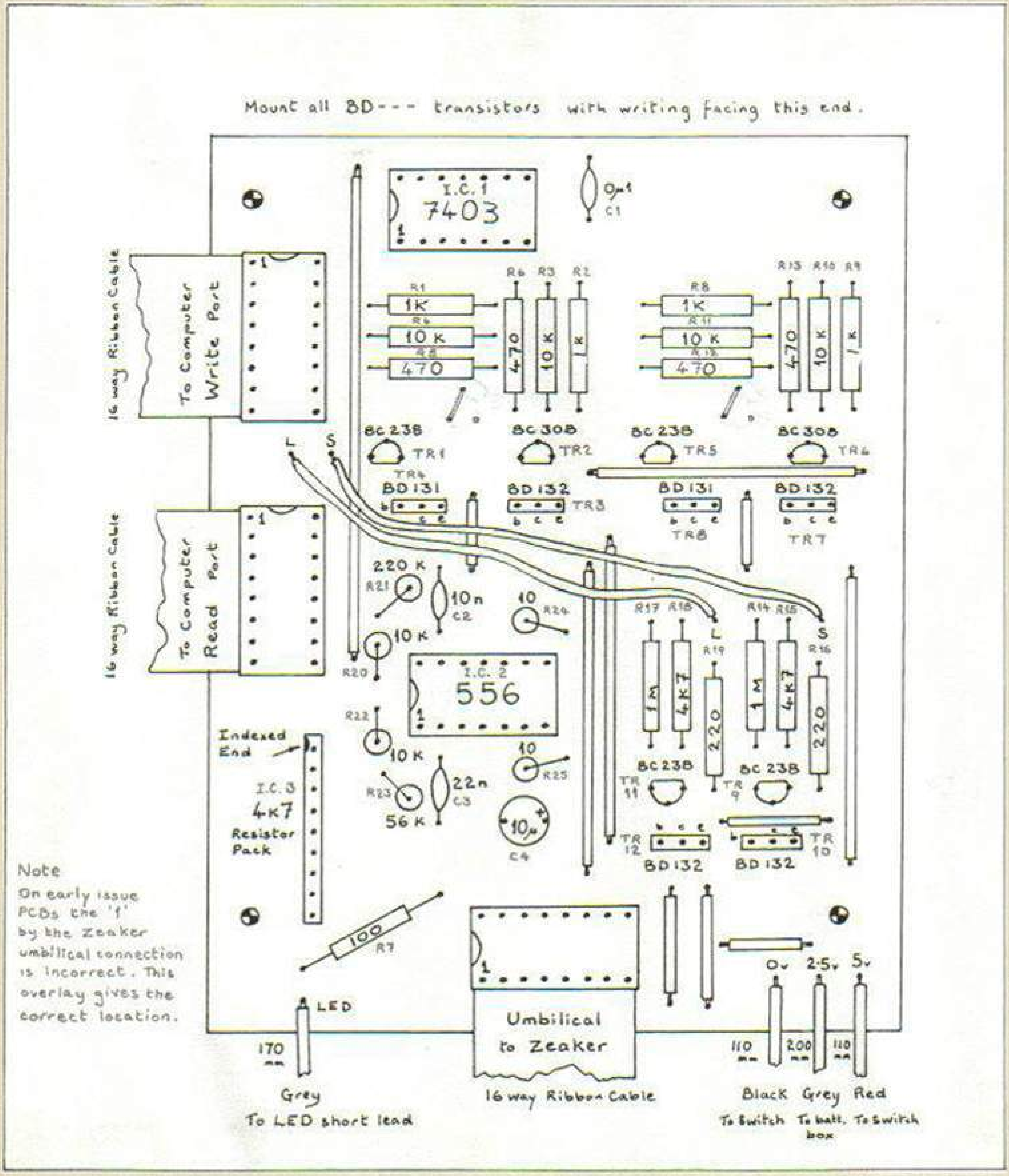


Fig. 3. Component layout

bits (6 for the unexpanded Zeaker). The particular way that these are available will depend upon the microcomputer and interface used. The signal allocation for the output and input connector leads are shown in Fig. 5.

Writing (POKEing for a memory mapped port) a word to the port sets the respective bits of the output latch. Reading (PEEKing) the port will return the status of the bump sensors.

A list of the control codes and their effect is given in Table 1. Any combination of control codes can be written to the port and Zeaker will be controlled by their combined effect e.g. writing a 2 will set the port motor to forwards and writing a 4 will set the starboard motor to forwards, hence writing 6 (=2+4) will set both motors on forwards. Writing 38 (=6+32) will set both motors on forwards and also switch on the lights.

COMPONENTS . . .

CONTROL STATION

Resistors

R4,R11 R19,R20,R22	10k (6 off)
R1,R2,R8,R9,R10	1k (4 off)
R5,R6,R13,R12 ⅓W 5%	470 (4 off)
R7	100
R14,R17 ¼W 2%	1M (2 off)
R15,R18 ¼W 5%	4k7 (2 off)
R16,R19 ¼W 2%	220 (2 off)
R21 ¼W 5%	220k
R23 ¼W 5%	56k

All resistors ⅓W 5% carbon except where otherwise stated

R24, R25	10 (2 off)

Capacitors

C1	100n ceramic disc
C2	10n ceramic disc
C4	10µ 16V elect
C3	22n ceramic disc

Semiconductors

D1	red l.e.d.
TR1,TR5,TR9,TR11	BC238 (4 off)
TR2,TR6	BC308 (2 off)
TR3,TR7,TR10,TR12	BD132 (4 off)
TR4,TR8	BD131 (2 off)
IC1	74LS00
IC2	556
IC3	pack of 8 commoned resistors RS type 140 271

Miscellaneous

ABS plastic box 150 × 100 × 60mm
Battery holder for 4 C-cells
Nicad C-cells (4 off)
MES lampholder
MES 12V 280mA bulb
Double pole on/off switch
3·5mm jack socket
16 pin d.i.l. IDC header (5 off)
16 pin d.i.l. sockets (3 off)
14 pin d.i.l. sockets (2 off)
3 metres of 16 way grey ribbon cable
Molex 16 pin JD connector to mate with the 5332 series connector on Zeaker

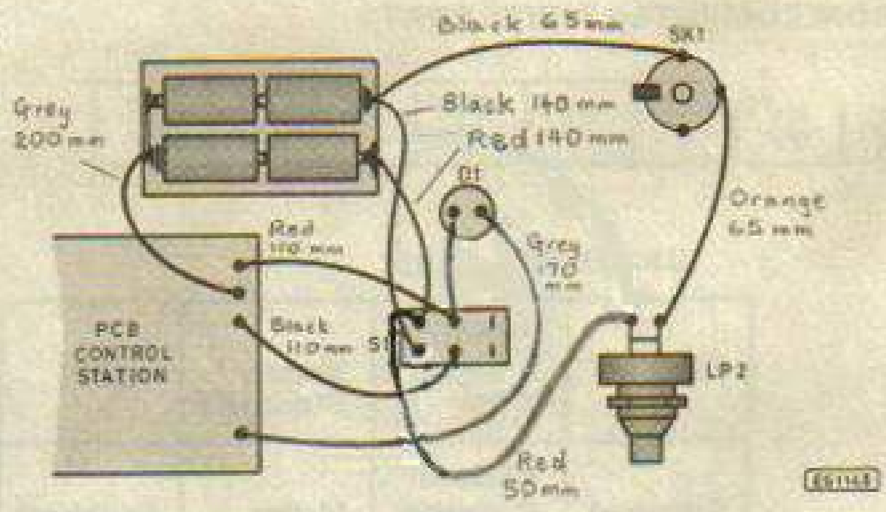
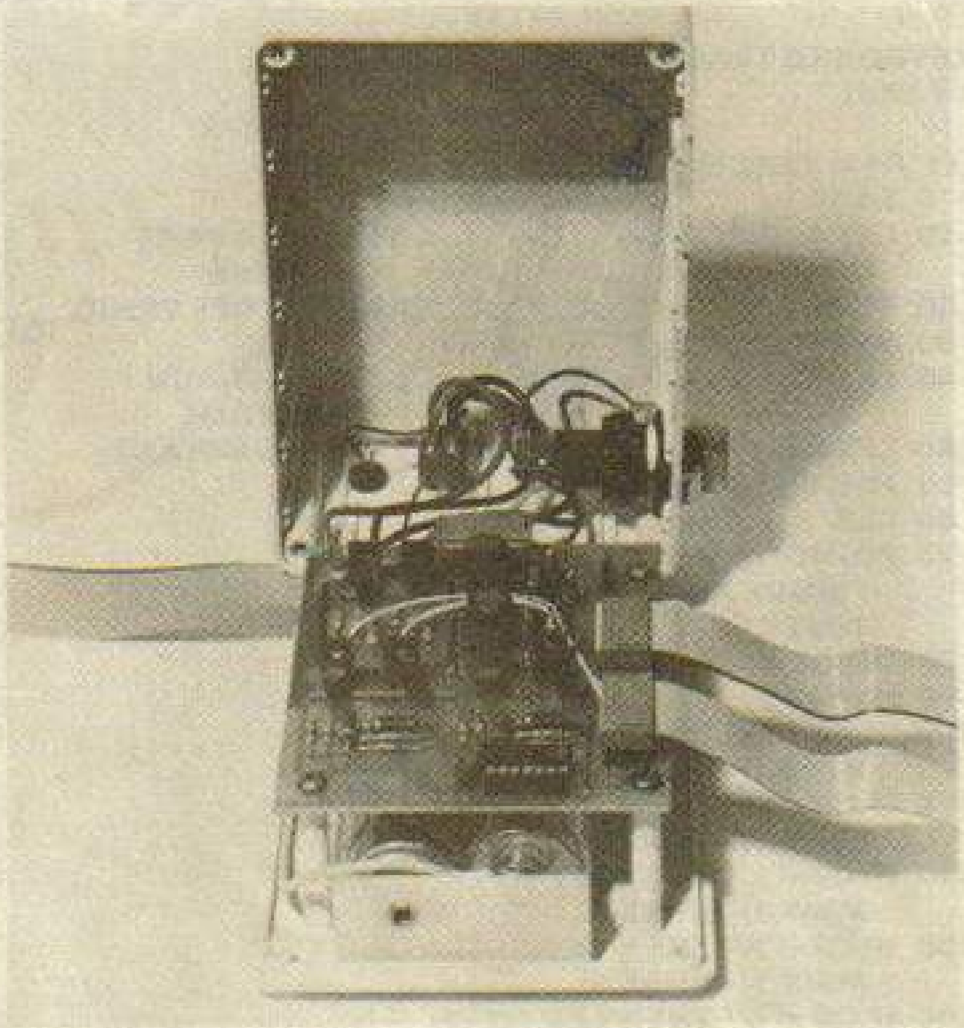
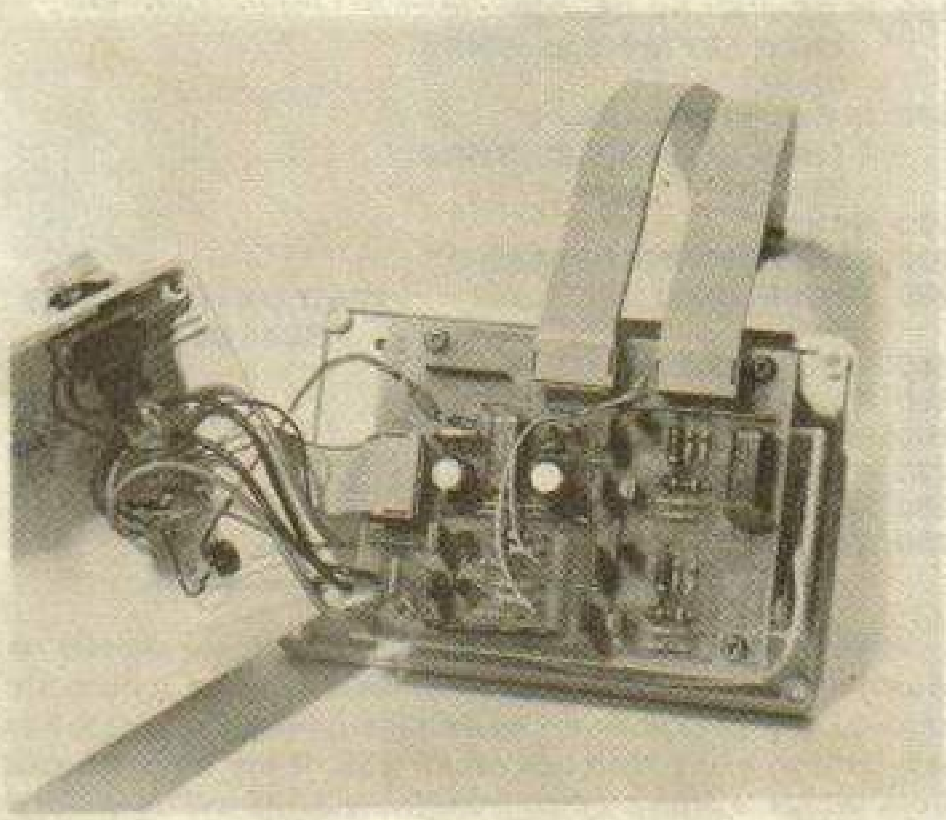


Fig. 4. Wiring diagram



Note PCB layout is now slightly different, see Fig.3.



Interior views of the Control Station showing the battery housing and the p.c.b. mounting details

FROM COMPUTER WRITE PORT

D7	D6	D5	D4	D3	D2	D1	D0 (Pin 1)
0V	0V					5V	5V

TO COMPUTER READ PORT

D7	D6	D5	D4	D3	D2	D1	D0 (Pin 1)
0V	0V					5V	5V

UMBILICAL CORD

0V	Motor Common 2.5V	Motor Port	Lights	Sensor Spare D7	Sensor Starboard Rear D0	Sensor Starboard Side D1	Sensor Starboard Front D2
Solenoid	Motor Common 2.5V	Motor Starboard	Speakers	Sensor Spare D6	Sensor Port Rear D5	Sensor Port Side D4	Sensor Port Front D3 (Pin 1)

Fig. 5. PSU DIL headers Signal Allocations

KEYBOARD TEACH PROGRAM
1K ZX81

```
                                      COMMENTS
(1 REM TEACH/DOIT)
  5 FAST
 10 LET A=16383 ---------------- 16383 IS PORT
                                   ADDRESS
 20 POKE A,0 ------------------- SWITCH OFF VEHICLE
 30 DIM M$ (10,2)
 40 LET K1=.6 ------------------ STRAIGHT RUN
                                   CONSTANT
 50 LET K2=.61 ----------------- TURN CONSTANT
 60 FOR S=1 TO 10
 65 CLS
 70 PRINT "TEACH", "STEP";S,
      "MOVE AND DIST/ANGLE/
      TIME"
 80 INPUT C$
 90 INPUT D
100 IF C$="F" THEN LET
      M$(S,1)=CHR$ 6
110 IF C$="B" THEN LET
      M$(S,1)=CHR$ 9
120 IF C$="L" THEN LET
      M$(S,1)=CHR$ 5
130 IF C$="R" THEN LET
      M$(S,1)=CHR$ 10
140 IF C$="S" THEN LET
      M$(S,1)=CHR$ 0
150 LET M$(S,2)=CHR$ D
160 IF C$="F" OR C$="B"
      THEN LET M$(S,2)=CHR$
      (DxK1)
170 IF C$="R" OR C$="L"
      THEN LET M$(S,2)=CHR$
      (DxK2)
210 NEXT S
220 PRINT "TO DOIT PRESS D"
230 PAUSE 50000                  WAIT UNTIL ANY KEY
                                   PRESSED
240 FOR S=1 TO 10
250 POKE A,CODE M$(S,1)
260 PAUSE CODE M$(S,2)
270 NEXT S
280 POKE A,0
290 GOTO 230
```

When a port is read the resulting number will depend on which if any of the six sensor switches are closed. If none is closed i.e. if Zeaker is not touching anything then all 8 bits will be high and a read will return 255. If say the starboard front sensor is pressed then from Table 3, D3 will be low and hence a read will return 247. If both front sensors are pressed in then both D2 and D3 will be low and hence a read will return 243.

RANDOM MOVE PROGRAM
1K ZX81

```
                                      COMMENTS
  1 REM RANDOM MOVE
 10 LET A=16383 ---------------- 16383 IS PORT
                                   ADDRESS
 20 POKE A,0 ------------------- SWITCH OFF VEHICLE
 30 PRINT "PRESS S TO STOP"
 40 IF INKEY$="S" THEN
      GOTO 200
 50 PAUSE 5
 60 POKE A,32+6 ---------------- SWITCH ON LIGHTS
                                   AND FORWARD
 70 PAUSE 5
 80 POKE A,5
 90 LET B=PEEK A
100 IF B=255 THEN GOTO 40
110 POKE A,64+9 ---------------- LOW HORN AND
                                   BACKWARDS
120 PAUSE 30
130 IF B>247 THEN GOTO 170
140 POKE A,128+5 --------------- HIGH HORN AND
                                   LEFT
150 PAUSE 50xRND --------------- RANDOM TURN TIME
160 GOTO 40
170 POKE A,128+10 -------------- HIGH HORN AND
                                   RIGHT
180 PAUSE 50xRND --------------- RANDOM TURN TIME
190 GOTO 40
200 POKE A,0 ------------------- SWITCH OFF VEHICLE
```

CONTROL CODES

1	Port back
2	Port forward
4	Starboard forward
8	Starboard back
16	Solenoid on
32	Lights on
64	Horn 1
128	Horn 2
192	Horn 1 plus Horn 2

Table 1

SENSOR CODES

$\overline{D0}$	Starboard sensor Aft closed
$\overline{D1}$	Starboard sensor Side closed
$\overline{D2}$	Starboard sensor Front closed
$\overline{D3}$	Port sensor Front closed
$\overline{D4}$	Port sensor Side closed
$\overline{D5}$	Port sensor Aft closed
$\overline{D6}$	Spare
$\overline{D7}$	Spare

Table 2

It is reasonably easy to determine which sensors are closed by subtracting the return value from 255 and transforming the result into binary. For the previous example of both front sensors closed this returns 243. Now $255-243=12=8+4=2^3+2^2$ hence data lines 3 and 2 are at 0V which from Table 2 means that both front sensors are closed.

Although this may seem a complicated procedure to go through each time, remember a computer controls Zeaker and it will do all the tiresome calculations.

The initial software consists of two short programs, one which allows you to build a simple pattern and repeat it and the other lets Zeaker find its own way around obstacles, and two longer programs, which are available from Colne, one of which allows several patterns to be built up and joined together and the other allowing Zeaker to memorise its environment and to avoid obstacles sensibly.

For the initial ZX81 version of Zeaker the two short programs will each fit into 1K of memory and so can be run on an unexpanded ZX81. Writing a 1K program to control Zeaker from BASIC does not allow the full range of Zeaker's capabilities to be used. However, the two ZX81 1K programs here should give an idea of the ease with which Zeaker may be controlled from BASIC.

PROGRAM NOTES

Encoding the move code and time of move into the character array M$ saves 80 bytes over using the numerical array. Against this must be set the 18 bytes for the CODE, CHR $ and $ used in the listing, resulting in 62 bytes saved. The program just fits in 1K and can be edited and run. Report code 4 (out of memory) comes up most of the time but should be ignored. The program can store up to 10 moves and prompts for the move.

F=Forward	and	Distance millimetres
B=Backward		Distance millimetres
R=Rotate Right		Angle degrees
L=Rotate Left		Angle degrees
S=Stop		Time in 50th second

To escape from the program press break.

The constants K1 and K2 should be fine tuned to the particular vehicle. The maximum value of any entry in M$ is 255 and hence entering numbers greater than this in response to the prompt will cause the program to halt with an error code.

FURTHER DEVELOPMENTS

Although all 8 data read lines are connected to Zeaker only 6 of them are actually used, the remaining two terminate at pads by the Molex connector on the p.c.b. in the lid of Zeaker.

It is intended that these spare lines should be used to interface to add-on circuitry which will enable Zeaker to follow a white line, induction loop cable or simply seek or avoid light or heat.

Also instead of sending just the horn tones down the umbilical cord to the speaker it is possible to connect the output of a complex sound generator or a computer speech board to a pad by the umbilical cord connection on the p.s.u. board and Zeaker will be able to chuff along like a steam train or emit some more appropriate sound. It could also give a running commentary on its progress e.g. "Forward", "Right", "Left", "Ouch"! "Hit something at Left Front" etc.

Whilst Zeaker is relatively simple it is capable of quite complex interactions with its environment and in many respects it is only limited by the ingenuity of the controlling software. ★