EVERYDAY ELECTRONICS and computer PROJECTS

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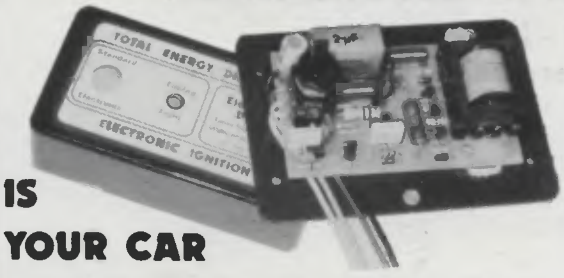

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EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 5 MAY 1984

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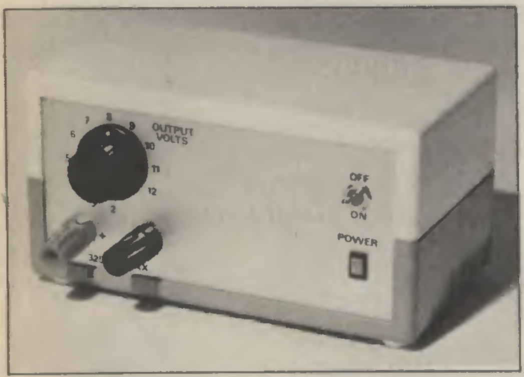

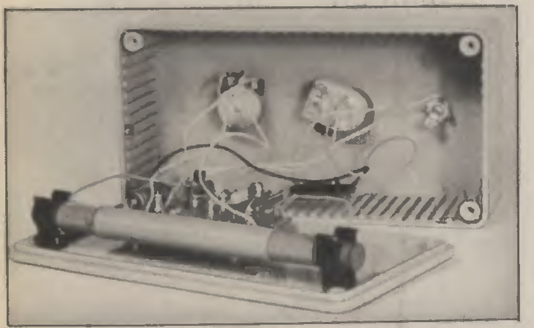

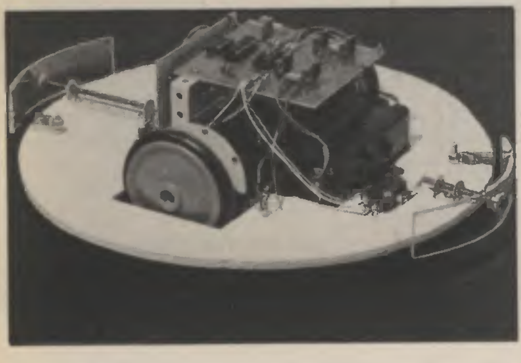

PROJECTS

SERIES

FEATURES

Our June 1984 issue will be published on Friday, May 18. See page 323 for details.

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EVERYDAY
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VOL. 13 NO. 5 MAY 1984

ROBOTICS

THIS issue of EE carries our first step into robotics with the "vehicle" in our *Microcomputer Interfacing Techniques* series. This step is a significant one and will lead to other projects in this area. We do not see a big market for expensive androids at the present time but we do expect to see small robotic arms being introduced to schools, colleges and industry for educational and development purposes.

Our buggy is relatively cheap and easy to build and can provide a fascinating involvement in control applications for microcomputers. We believe that many computer users are now tiring of just playing games—great fun though they are—and that this project will extend the fun element while developing new software skills and understanding.

As regular readers will be aware the whole *Microcomputer Interfacing Techniques* series has been designed to provide practical assistance in connecting computers to the outside world. Many computer hobbyists may have read the series with interest but resisted the temptation to actually build any projects and get involved in a practical way: We suggest that this project is the one to take you over the edge. Not only will it be fun to build but should provide hours of entertainment and learning for all the family.

Another project which has always been a must for the novice is a small radio. We are sure many of our more experienced readers remember the thrill of tuning in your first station on a set made with your own hands. Perhaps it is the thrill of capturing radio waves out of the "air", or of being able to listen to distant stations for next to nothing. Maybe familiarity with radio has diminished the excitement for modern youngsters but we still feel such a project would give many novice constructors quite a kick. Why not try it and see?

SHORTAGE

Recent reports in the industrial electronics press indicate that the consumer industry is about to face a shortage of high technology chips. While this should not affect the constructor whose interest lies in the non-microprocessor projects those with aspirations to building any MPU-based system or add-on would be well advised to buy components as soon as possible.

Many manufacturers have sold their entire production of memory and microprocessor chips for the remainder of 1984 and stories of "black market" prices of up to six times the list price are filtering through from the States. Needless to say we will watch component availability on the products we publish but we cannot promise that chips we use will continue to be available at all times. Delivery time from manufacturers is often 16 weeks and 40-plus weeks is being quoted on some devices now. Plan ahead if you can.

We wonder how chip shortages might affect sales of microcomputers next Christmas.

Mike Kenward

Back Issues
Certain back issues of EVERYDAY ELECTRONICS are available worldwide price £1·00 inclusive of postage and packing per copy. Enquiries with remittance should be sent to Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF. In the event of non-availability remittances will be returned.

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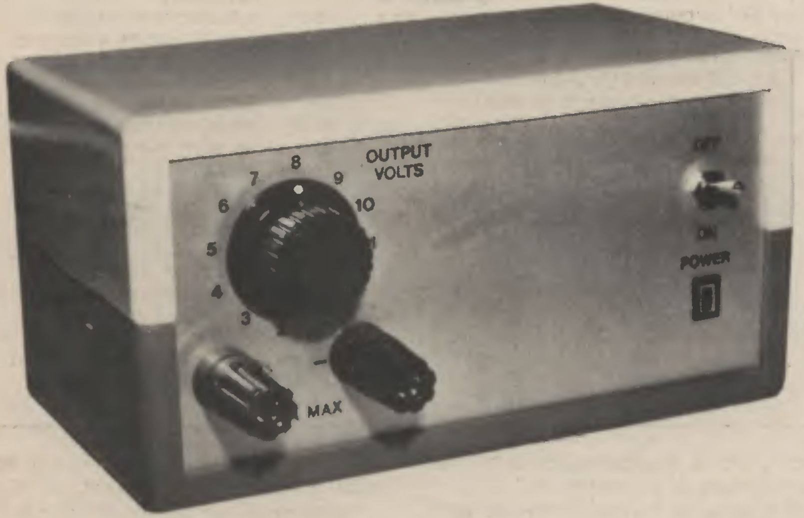
EXPERIMENTER'S POWER SUPPLY UNIT



BY S. NIEWIADOMSKI

An essential piece of laboratory equipment for the experimenter with the output switchable from 2 to 12V in 1V steps thus invalidating the need for an expensive voltmeter. Maximum output current of 325mA.

ONE of the first things a newcomer to electronics learns is that powering circuits from batteries can be expensive and inconvenient. It is easy to leave a circuit accidently switched on overnight and find the batteries flat next day.

So a mains powered variable d.c. supply is a must to the serious constructor and experimenter. This Power Supply provides a cheap and easy solution to this problem and additionally, has educational value in the use of an operational amplifier as an output driver.

The unit has 11 preset voltage settings from 2 to 12V at up to 325mA output current. Its output is short circuit protected and since the voltage is switched, a voltmeter is not required, considerably reducing the cost of the instrument. A novel feature is the use of a power operational amplifier which provides the output current without the use of an additional device.

On the prototype, the output voltage was found to be within 0·1V of the expected value at all switch positions.

POWER OP-AMP

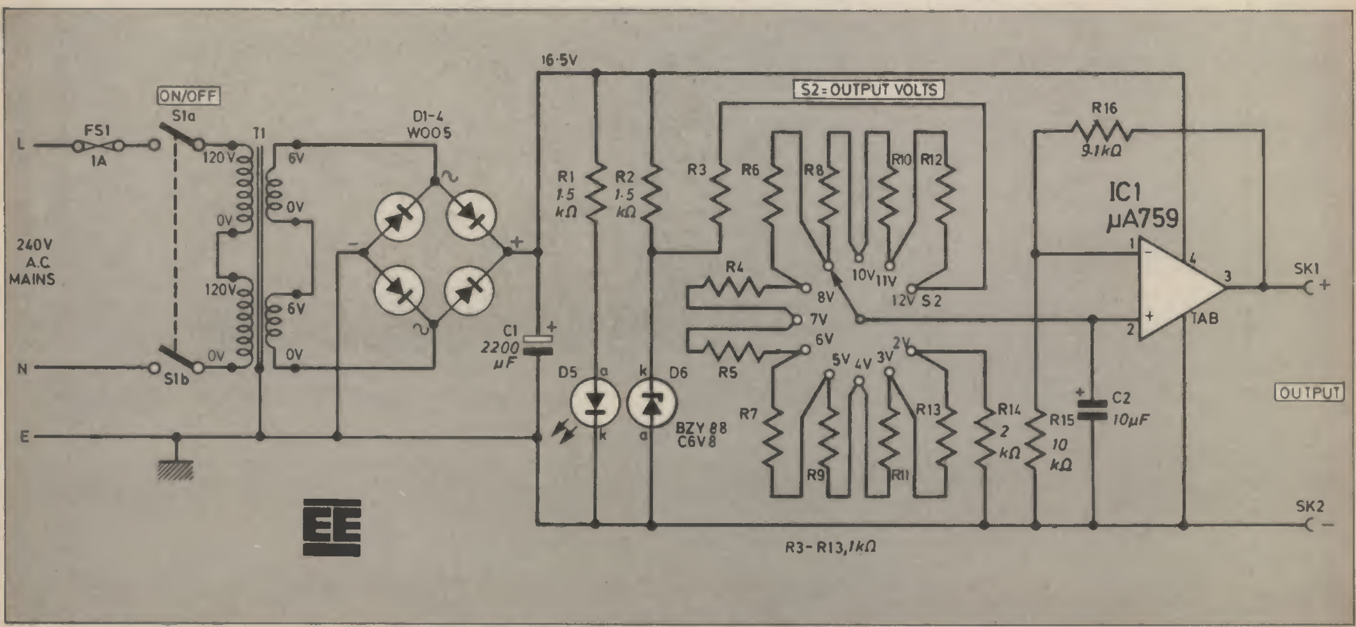
The µA759 is a power operational amplifier manufactured by Fairchild. It operates like a 741 op-amp, having a very high open loop gain and high input resistance. It also has an output stage capable of supplying up to 325mA. This makes it suitable for many applications such as audio amplifiers, servo amplifiers and power regulators. Like any conventional operational amplifier, its closed loop gain is defined accurately by the ratio of feedback resistors.

The features of the µA759 which make it specially suitable for use in a power supply are firstly, its output current capability; secondly, its output is short circuit protected and thirdly, it is internally protected against thermal overload. Care has to be taken to use an adequate heatsink so that the temperature of the device does not rise above that which will cause the thermal shutdown to operate. The dissipation in the device is at its highest at low output voltages and high current.

CIRCUIT DESCRIPTION

The full circuit diagram of the unit is shown in Fig. 1. T1 is the mains step down and isolation transformer. Its primary is fed from the mains via the anti-surge fuse FS1 and the mains ON/OFF switch, S1. The transformer used on the prototype has split primary windings so that it can be used on 120V mains. In this country, the two windings

Fig. 1. Circuit diagram of the Experimenter's Power Supply Unit.



are connected in series. Similarly the secondary consists of two windings each giving 6V r.m.s. which are also connected in series. A transformer with a single 12V r.m.s. secondary is also suitable.

The secondary feeds the bridge rectifier D1 to D4 and smoothing capacitor C1. An unregulated d.c. voltage of 16·5V at no load and 15·5V at 325mA output appears on C1. R1 supplies about 10mA to the front panel mounted light emitting diode D5 which indicates when the unit is switched on.

Current is supplied to the 6·8V Zener diode D6 by R2, allowing about 6·5mA to be split between D1 and the resistor chain R3 to R13. The voltage across the resistor chain is maintained stable by D6 despite changes in the supply.

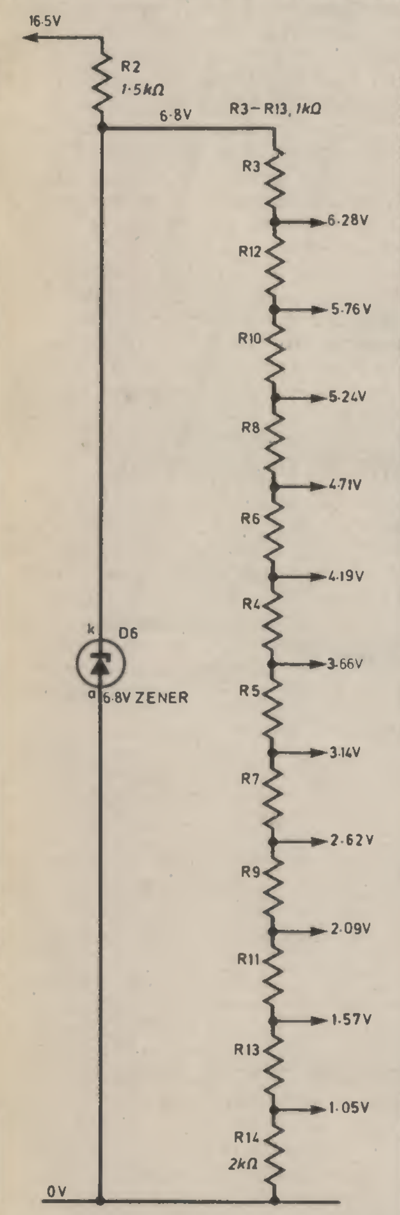


Fig. 2. The potential divider chain around S2. D6 establishes a reference voltage and points along the chain give voltages, that when multiplied by the gain of IC1 (set at 1·91 by R15 and R16), give the output voltages.

COMPONENTS

See Shop Talk page 313

Resistors

R1,2	1·5kΩ (2 off)
R3–13	1kΩ (11 off)
R14	2kΩ
R15	10kΩ
R16	9·1kΩ

All ¼W carbon ±5%

Capacitors

C1	2200µF 25V elect.
C2	10µF 16V tantalum bead

Semiconductors

D1–4	W005 1A, 50V bridge rectifier
D5	rectangular red l.e.d. plus mounting bezel
D6	BZY88 C6V8 6·8V, 500mW Zener
IC1	µA759 power op-amp

Miscellaneous

S1	d.p.d.t. miniature mains toggle
S2	1-pole, 12-way midget rotary (11 ways used)
T1	6VA mains transformer, 12V or 0-6V, 0-6V secondary
FS1	1A, 20mm anti-surge fuse plus panel mounting holder
SK1	4mm insulated screw terminal, red
SK2	4mm insulated screw terminal, black

Verobox, 155 x 85 x 80mm (type 202–21042L); 0·1in matrix stripboard, 24 strips by 17 holes; knob, 20mm diameter; grommet; P-clip; mains cable; mains plug; 7/0·2mm p.v.c. sleeved wire; p.v.c. sleeving; solder tags (6 off); M3 screws and nuts (to mount T1); M2·5 screw and nut (to mount IC1); stick-on rubber feet (4 off).

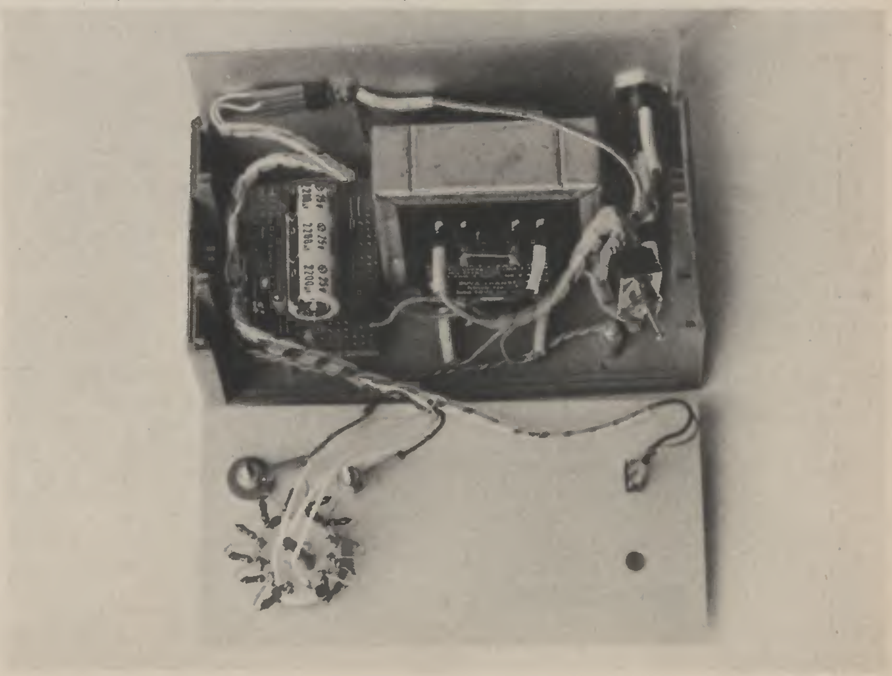
The number of 1-kilohm resistors and the 2-kilohm resistor in the chain mean that voltage steps of 0·52V are tapped off by the rotary switch S2 (see Fig. 2). Capacitor C2 holds the previous voltage level on pin 2 of IC1 when rotating S2 until the new position is reached. This means that a break-before-make component can be used for S2 without the output voltage becoming uncontrolled when being changed.

R15 and R16 are the operational amplifier feedback resistors, defining the voltage gain of the circuit. Their values are chosen to give a gain of 1·91 which when multiplied by 0·52 (the input step value) gives the output step value of 1V.

The unregulated supply is connected to the power supply pin of IC1. Ripple on this pin is smoothed out by the ripple rejection of the operational amplifier and the stabilising action of D6.

SK1 and SK2 are 4mm screw terminals to which the positive and negative outputs are connected. The negative supply to IC1 is the tab of the package and is bolted directly to the back panel to provide a heatsink. This arrangement means that the negative output is earthed. If a floating output is required the tab of IC1 must be insulated from the case earth.

The completed prototype Power Supply with front panel removed. Note how the cable form permits the withdrawal of the panels without the need for desoldering.



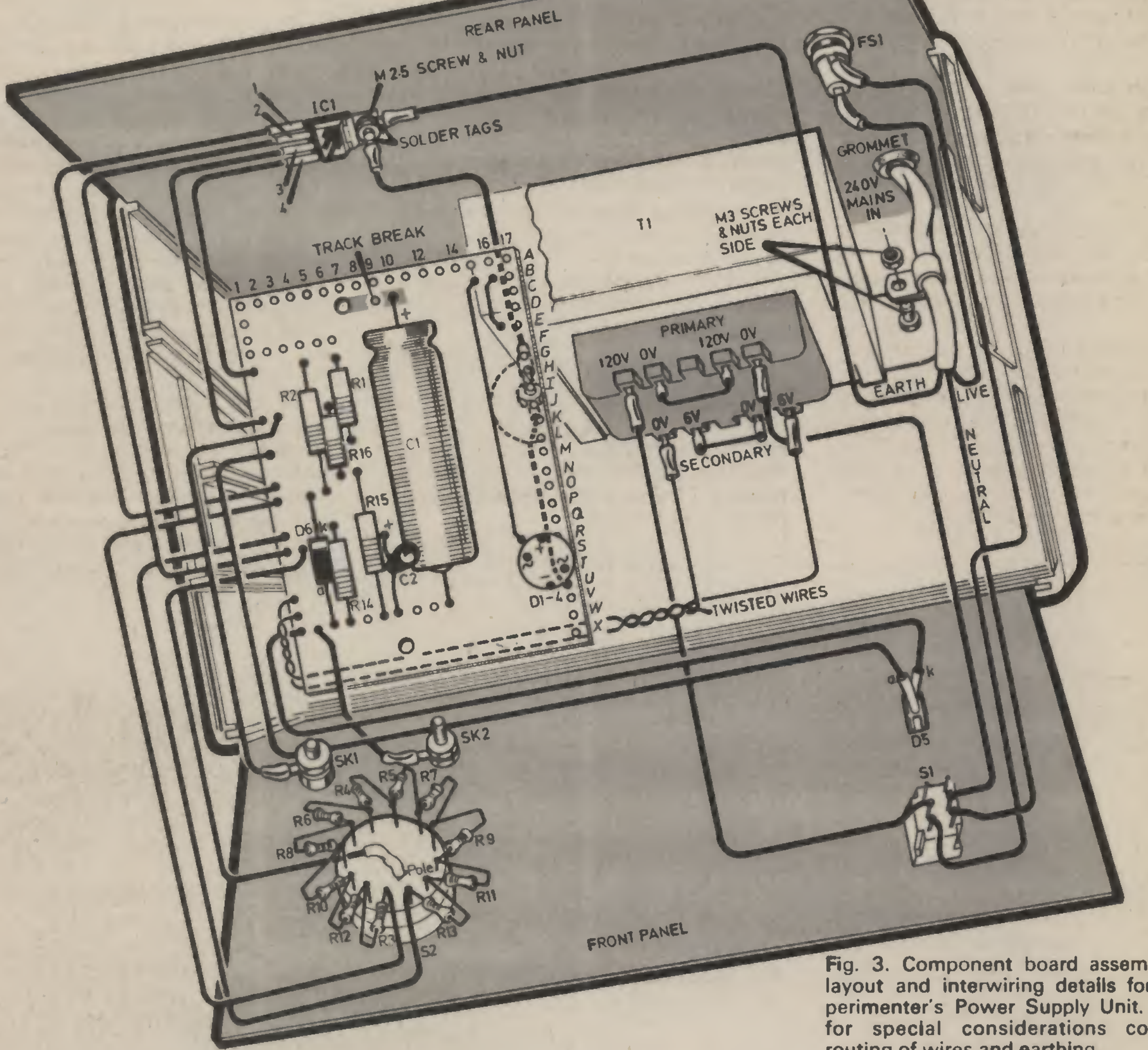


Fig. 3. Component board assembly, case layout and interwiring details for the Experimenter's Power Supply Unit. See text for special considerations concerning routing of wires and earthing.

CONSTRUCTION

CIRCUIT BOARD

The prototype unit was constructed on a piece of stripboard (24 strips by 17 holes) mounted in a Verobox, 155 × 85 × 80mm, which also houses the transformer. The layout of the stripboard is shown in Fig. 3. No trackside view is shown as only one break is required at location *B9*. The two mounting holes are positioned to line up with the moulded bosses in the base of the case.

The leads of the bridge rectifier D1 to D4 have to be preformed to suit the layout and this component must be mounted quite low into the board to avoid it hitting the fixing stud of SK2 when construction is complete.

The transformer is mounted in the other side of the base of the box as shown. It is positioned to the rear to allow for the switch and l.e.d. and also to allow for the fuseholder and mains cable grommet.

CASE

The drilling details of the front and rear panels are shown in Fig. 4. These are the anodised aluminium panels that are supplied with the Verobox. The rectangular cut-out for the l.e.d. (D5) may be replaced with a hole if a standard l.e.d. and mounting clip is used.

The rotary switch, on/off switch, l.e.d. and terminals SK1 and SK2 are mounted on the front panel. Note that SK1 (the positive) screw terminal is mounted so that it is isolated from the panel (with the bushes supplied) but SK2 (the negative) is secured so that it makes contact (the plastic bush on the threaded mounting stud is not used). These terminals require a "keyhole" cut-out to prevent them turning.

S2 is a 12-way, break-before-make midget rotary switch of which 11 ways are used. This type of switch has an adjustable stop and to set it, the mounting nut must be removed and the special washer with a tab on it lifted out of the recess. The tab is then inserted into the hole marked "11" and the washer is pushed back into the recess.

Resistors R3 to R13 are soldered directly to the terminals of S2 and note that R3 actually uses terminal "12" as this position is not required.

The back panel carries IC1, the fuseholder and the cable grommet. IC1 is mounted directly to the panel (no isolating kit required) with M2·5 fixings.

WIRING

The mains cable enters through the grommet and is clamped to one of the transformer fixings with a P-clip. The live wire (brown) is taken to the fuse and then to on/off switch S1. The neutral (blue) is wired directly to the switch. The primary of T1 is then wired to the other side of the switch.

The earth wire (yellow/green) is routed to the fixing screw of IC1 via a solder tag. The earth is then wired to a mounting screw on T1 and onto the component board (ref. *U*17). The front panel will be earthed via SK2.

All interwiring details are also given in Fig. 3. Note that most joints are sleeved as this not only improves the appearance but also acts as strain relief to aid reliability.

When wiring from the component board to the front panel, the wires should be long enough to allow this panel to be withdrawn if necessary. The connection from the board to the secondary of T1 is made with a twisted pair of wires and these are kept away from all other wires. This helps prevent mains pick-up.

When complete, the wiring can be neatly held together (with the exception of the a.c. side) with spiral cable wrapping or lacing cord.

TESTING

When construction is complete, check all wiring carefully *particularly* that associated with the mains. If everything is in order, switch on and D5 should light. Check that the voltage across C1 is about 16·5V. Also check that D6 has 6·8V across it. Now connect a voltmeter to the output terminals and rotate S2 through all its settings. If an analogue voltmeter is used the output voltage should appear to be indistinguishable from the nominal voltages expected. A digital voltmeter should show differences of only about 0·1V.

Since the current limiting circuit is built into IC1, no testing of it is really necessary. High power resistors of appropriate values can be connected to the output to draw up to 325mA to check the regulation of the supply. For the 12V range, a 27 ohm, 4 watt resistor will draw the maximum current.

The regulation on the prototype was extremely good; at a nominal 10V, the output fell by only 0·01V on increasing the current from 0 to 325mA.

CIRCUIT MODIFICATIONS

It is worthwhile to mention some possible modifications to the circuit which might make the power supply more versatile.

An output current ammeter could be included in series with the positive output terminal. This gives a useful indication of the operation of the circuit being powered. If an infinitely variable output voltage is required, then replace the resistor chain of R3 to R13 with a 10 kilohm linear potentiometer. The front panel can still be marked with the output voltages or a moving coil d.c. voltmeter of suitable range could be connected across SK1 and SK2.

Higher output voltages can be obtained by using a transformer with two secondary windings of say 9V r.m.s. connected in series. The maximum allowable supply voltage for IC1 is 36V. Remember that the built-in features of IC1 make it virtually indestructable so if you do blow it up, send it back to where you bought it! □

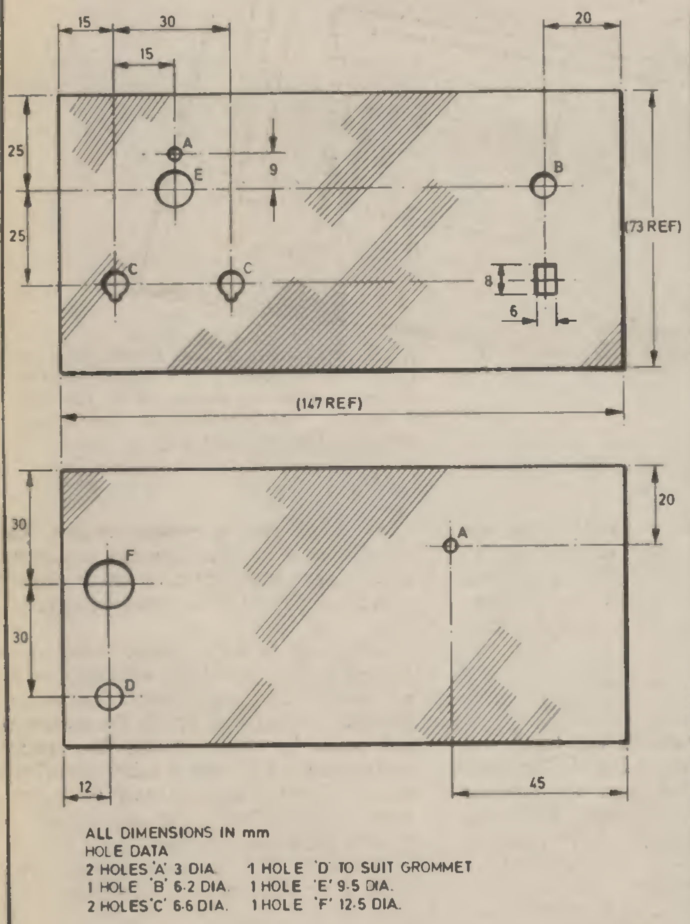
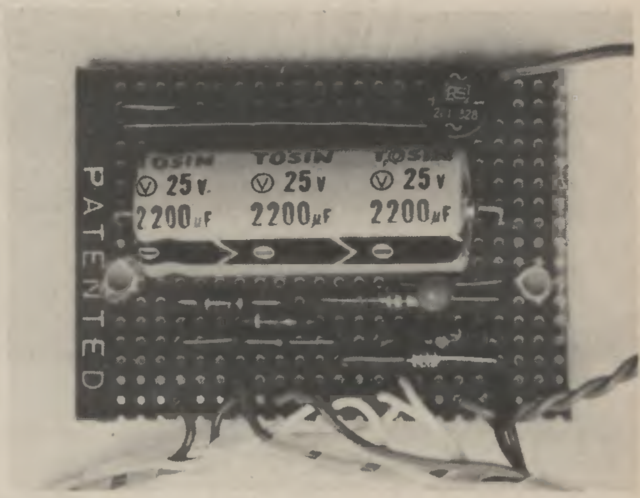
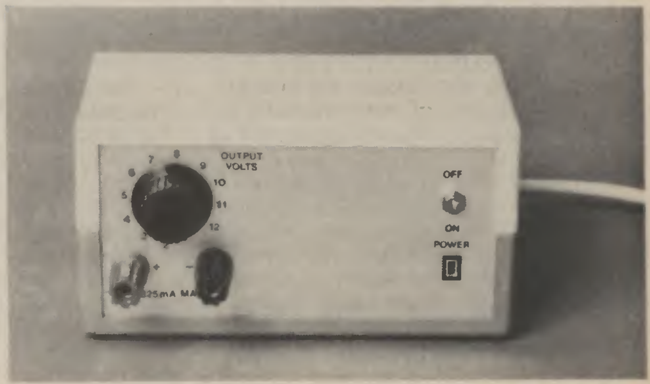


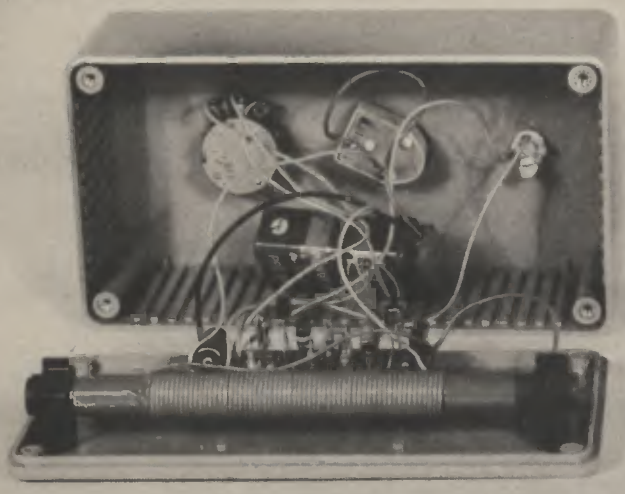
Fig. 4. The front and rear panel drilling details. Note that these panels are supplied with the specified case.



The finished component board (above) and the front panel labelling of the Experimenter's Power Supply Unit (below).



Vari~cap A.M. Radio



BY R.A. PENFOLD

tuning voltage of only about 7 to 8 volts being adequate.

This enables the tuning voltage to be obtained using a 9-volt battery supply without any voltage step-up circuitry, and a.m. varicap diodes now represent a really viable alternative to conventional tuning methods.

The simple t.r.f. (tuned radio frequency) radio described in this article covers the full medium waveband in a single tuning range. The output is for a crystal earphone, and good volume and sensitivity are obtained by using the popular ZN414 integrated circuit plus a simple high gain audio stage. A simple varicap tuning circuit is used, and the whole receiver is powered from a single PP3 size 9-volt battery.

VARIABLE capacitance (varicap) diodes have been in use for many years now, but they are mainly used in v.h.f. designs. This is partially because varicaps have the advantage, at v.h.f., that they can be positioned close to the tuning coils, with the tuning control situated as far away from the varicaps and coils as one wishes.

VARICAP TUNING

This is simply because varicaps are tuned by a d.c. tuning voltage, and there is no real limitation on the length of a lead carrying a d.c. signal. On the other hand, using an ordinary tuning capacitor necessitates the fitting of the tuning coils close to the tuning gangs, since the leads to the variable capacitor are carrying v.h.f. signals, and the small inductance in even quite short connecting leads could easily cause a malfunction.

This makes the component layout very critical, and it can be a little awkward to achieve a satisfactory layout.

However, even though varicaps do not have this advantage in a.m. (medium and longwave) radios where the lower signal frequencies render lead lengths of relatively little importance, they still represent a neat and attractive alternative to ordinary tuning methods.

The reason for the lack of varicap tuning in a.m. radios is mainly due to the lack of suitable devices. An a.m. receiver requires a much larger maximum tuning capacitance than v.h.f. types, and the ratio of maximum to minimum capacitance is also substantially larger for a.m. sets. Most varicaps give totally inadequate capacitance swings.

VARICAP PERFORMANCE

A few varicaps having adequate performance for a.m. applications were introduced a number of years ago, but they failed to achieve popularity due to their fairly low *Q* (magnification factor) values and more importantly, they required inconveniently high maximum tuning voltages of as much as 27 volts in some cases. More recent devices are much better in both respects with *Q*s of around 200 to 500 being typical, and a maximum

CIRCUIT DESCRIPTION

The circuit diagram of the receiver is shown in Fig. 1, and the varicap tuning diodes are D2/3 which are in a single device called the KV1236. These are used in the usual back-to-back arrangement and are connected direct across the ferrite aerial (L1). The latter is tuned over slightly more than the full medium-wave broadcast band by the series capacitance of D2 and D3.

R1 and D1 provide a stabilised 7·5 volt supply, and VR1 gives a continuously variable 0 to 7·5 volt output at its wiper. This voltage is used to tune the set, and VR1 is, of course, the tuning control. R2 couples the output of VR1 to the tuning diodes and prevents VR1 from heavily damping the aerial tuned circuit.

DEPLETION LAYER

Varicap diodes are basically the same as ordinary silicon diodes, and the tuning voltage reverse biases both diodes so that an insulating *depletion layer* is formed

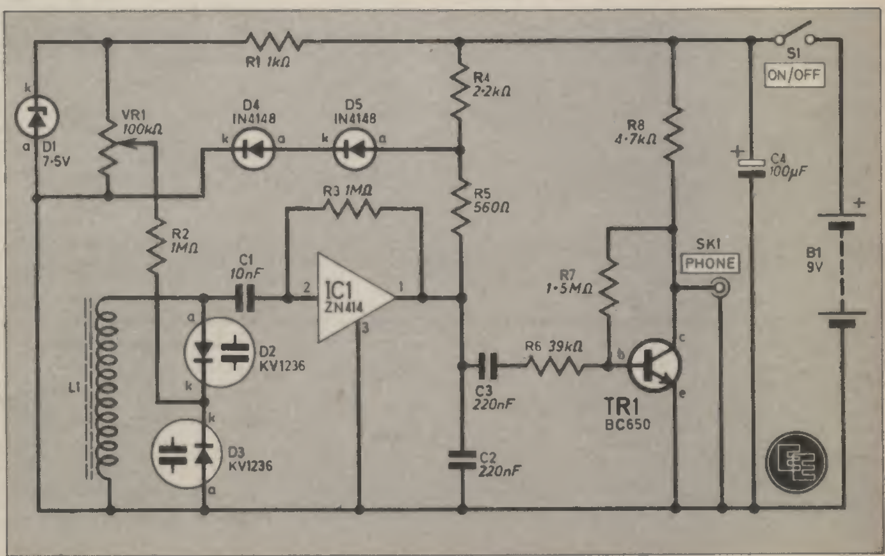
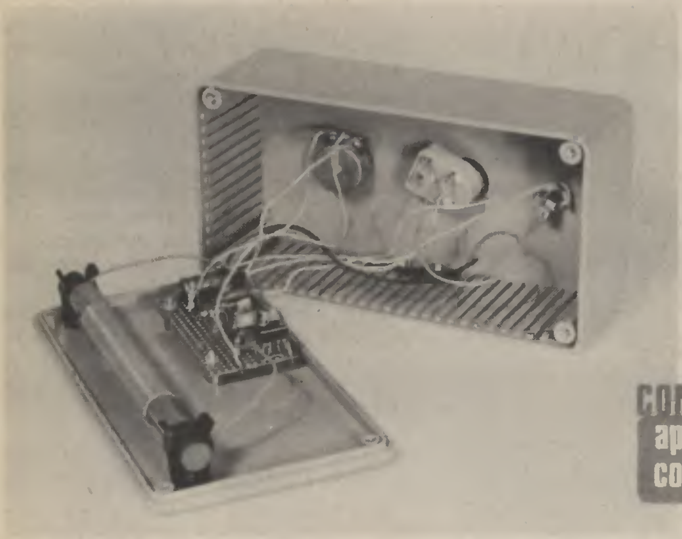


Fig. 1. Complete circuit diagram of the Vari-cap A.M. Radio.



Ferrite aerial and circuit board mounted on rear panel of the case.

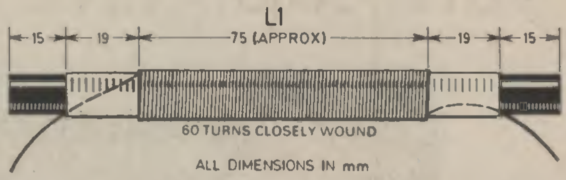


Fig. 2. Diagram showing construction details for the ferrite rod aerial.

COMPONENTS approximate cost £10

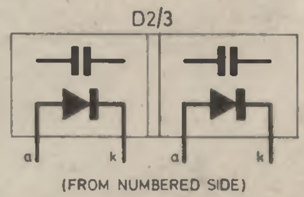


Fig. 4. Pinning details for the varicap device.

COMPONENTS

Resistors

R1	1kΩ
R2,3	1MΩ (2 off)
R4	2·2kΩ
R5	560Ω
R6	39kΩ
R7	1·5MΩ
R8	4·7kΩ

All $\frac{1}{4}$W carbon ±5%

See Shop Talk page 313

Capacitors

C1	10nF ceramic plate
C2,3	220nF polyester (2 off)
C4	100μF 10V elect.

Semiconductors

D1	BZY88 C7V5 400mW 7·5V Zener
D2,3	KV1236 dual varicap diode
D4,5	1N4148 (2 off)
IC1	ZN414 a.m. radio
TR1	BC650 *npn* silicon

Miscellaneous

VR1	100kΩ linear carbon potentiometer
S1	rotary on/off switch
SK1	3·5mm jack
B1	9V type PP3

Stripboard: 0·1 inch matrix size 12 strips by 25 holes; battery connector; plastic case size 150 × 100 × 50mm (ABS 2005); 140 × 9·5mm ferrite rod plus wire; tape and mounting clips; crystal earphone; control knobs; 6BA fixings.

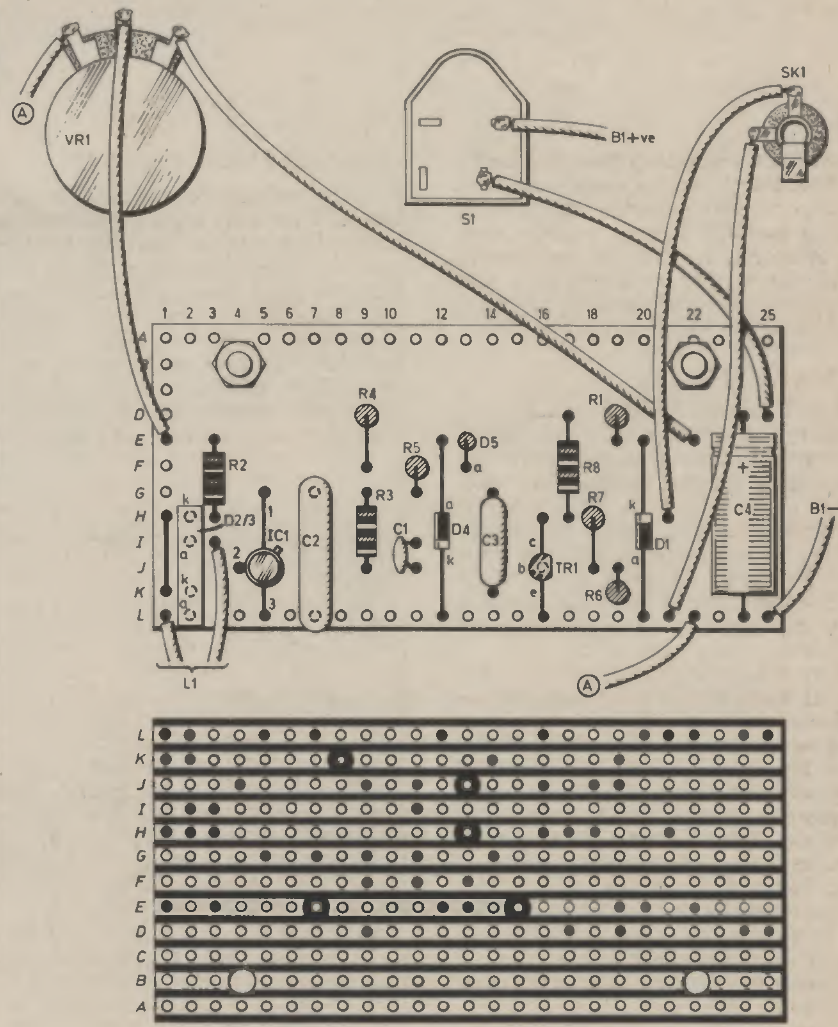
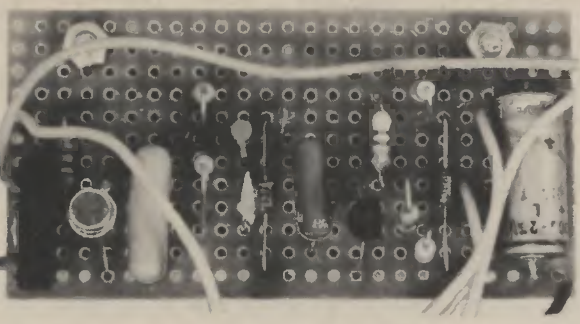


Fig. 3. Stripboard layout and external component wiring diagram.



Components mounted on the completed circuit board.

between the two pieces of semiconductor material that form each diode. In effect, the two pieces of semiconductor material are the plates of the capacitor and the depletion layer is the dielectric. The depletion layer increases in thickness as the reverse bias is increased, and the capacitance of the diode is consequently decreased.

It is not possible to simply use any silicon diodes for D2 and D3, since it is necessary for the diodes to provide certain capacitances at various reverse voltages with reasonable accuracy, and for the diodes to give a reasonable *Q*. Only a few modern varicaps are capable of giving satisfactory results in respect to this application where a large capacitance swing is required.

Each diode in the KV1236 device has a typical capacitance of 450pF at a reverse potential of 2 volts, falling to a capacitance of only 30pF with an 8·5 volt reverse bias. For series connected diodes both these capacitance figures are halved. The typical *Q* of the KV1236 is 200.

CONVENTIONAL CIRCUIT

Because of the use of varicap tuning, IC1 is used in a circuit which does not quite conform to the normal ZN414 configuration. C1 couples the *non-earthy* end of the ferrite aerial to the input of IC1 and R3 is used to bias IC1. R3 has been made somewhat higher in value than would normally be the case in order to minimise damping of the aerial. The circuit has been tried using several ZN414 i.c.s, and worked well in each case. Apart from the input coupling and biasing this part of the circuit is quite conventional.

The audio output from IC1 is coupled by C3 and R6 to a simple common emitter amplifier based on TR1. R6 is needed to prevent the output from TR1 becoming excessive in amplitude, which would cause clipping and severe distortion. It also introduces a degree of high frequency attenuation in conjunction with the input capacitance of TR1, and this reduces the risk of instability.

A crystal earphone can be driven direct from the collector of TR1 and no coupling capacitor is necessary here. The current consumption of the circuit is only about 5mA, or so, and this gives many hours of use from each PP3 battery.

CONSTRUCTION starts here

AERIAL

A home-constructed ferrite aerial is used in this design, although a ready-made type such as the Denco MW5FR can be used if preferred. In common with most ready-made ferrite aerials the Denco MW5-FR has a small coupling winding in addition to the main winding, and this should either be removed or just ignored.

Details of the home-constructed aerial are provided in Fig. 2, and this is based on a ferrite rod which measures 140mm long by 9·5mm in diameter. The winding consists of 60 turns of 7/0·2mm p.v.c. insulated connecting wire, or any similar multi-strand connecting wire. Bands of 19mm insulation tape are used to hold the winding in place, and the turns should be as closely wound as possible if the winding is to fit into the available space. Leave leadout wires about 100mm long.

Mount the completed ferrite aerial high up on the rear panel of the case using special mounting clips or *P* style cable clips of adequate diameter. Make sure that adequate space is left for the component panel to be fitted below the aerial.

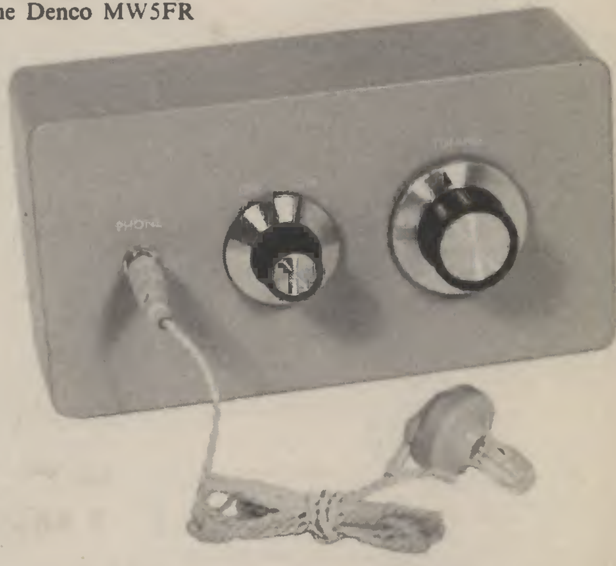
Note that the case must be made from plastic or some other non-metallic material that will not screen the aerial and prevent any significant signal pick up. The simple front panel layout of the set can be seen from the photographs.

COMPONENT PANEL

A 0·1 inch matrix stripboard measuring 12 strips by 25 holes is used to take most of the components, and Fig. 3 gives details of this board. It is constructed in the standard way with a board of the required size first being cut out using a hacksaw, after which the two 3·3mm diameter mounting holes and the five breaks in the copper strips are made. The latter can be made using a small hand-held twist drill if the special tool is not available.

The components can then be soldered into place with the semiconductor devices being left until the end. Fig. 3 gives details of the wiring of the set. Be careful to connect C4 and the semiconductors the right way round, and make sure that the single link wire (beside D2/3) is not accidentally omitted.

Complete all the point-to-point wiring before finally fitting the component panel onto the rear panel of the case using 6BA fixings. After a final thorough check of all the wiring the set is then ready for use, and no alignment whatever is required if the home constructed aerial described earlier is used.



Finished project with a crystal earphone fitted.

TRIAL AND ERROR

If a ready-made ferrite aerial is used it will be necessary to position the aerial coil on the rod correctly, in order to obtain full coverage to both ends of the medium-wave band.

This is really just a matter of trial and error, and the correct position will almost certainly be with the coil slid right to one end of the ferrite rod. As the set covers slightly more than the full medium-wave band the positioning of the coil will not be too critical. When the correct setting has been found, glue or tape the coil in place. □

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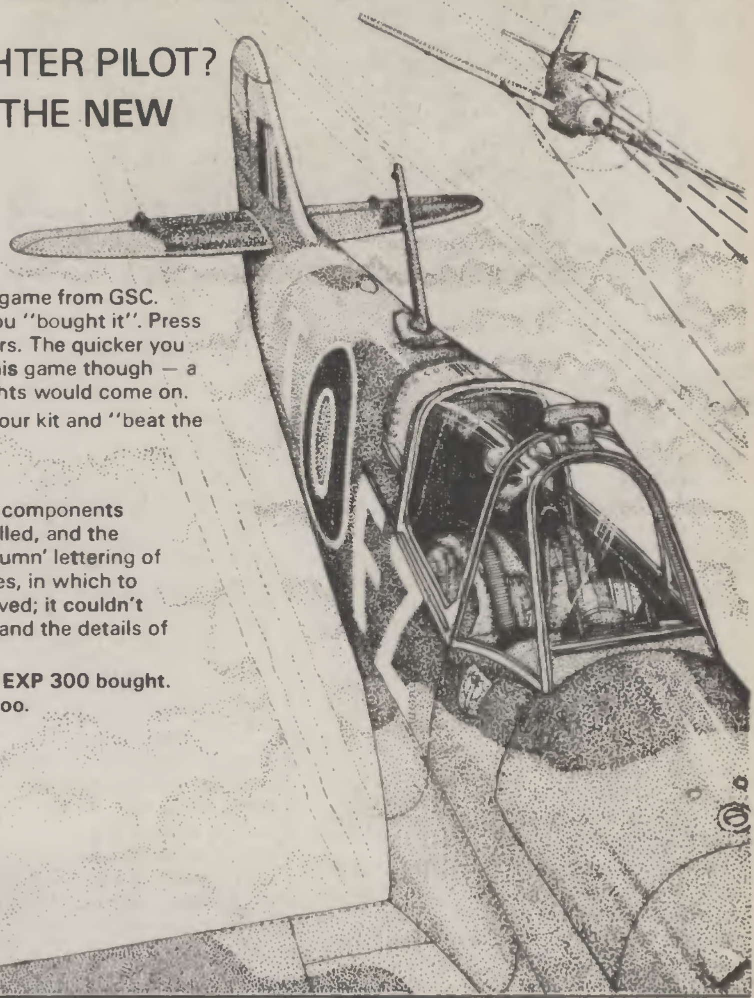

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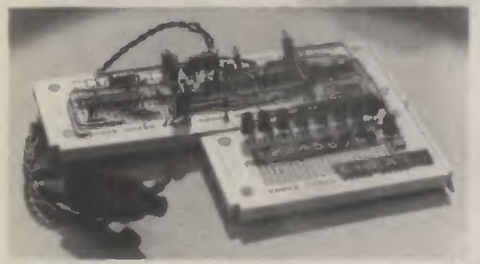

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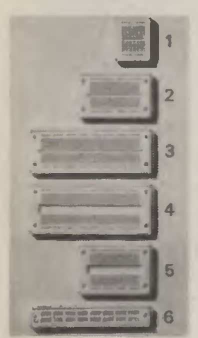

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TEACH-IN 84

8

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By GEORGE HYLTON

POWER IN GENERAL

Electric power, as we saw last time, is the rate at which electrical energy is being transformed into some other form. This can be heat, sound, light, mechanical energy, and other kinds.

The electronic engineer is often also concerned with the transformation of one form of electrical energy into another. In audio amplifiers, for instance, d.c. power from the battery is transformed into a.c. power to drive a loudspeaker. In mains power supply units, a.c. power is turned into d.c.

In d.c.–d.c. converters, d.c. at one voltage is turned into d.c. at another voltage.

VOLTAGE CHANGING

A.c. power supply circuits are sometimes called a.c.–d.c. converters. Here, a.c. mains power (at 240V, 50Hz in the UK) is turned into d.c., usually at a much lower voltage.

If the mains is 240V a.c. and we need 12V d.c. what do we do about the excess voltage? One possibility would be to "drop" it in a series resistance (Rs in Fig. 8.2). This would be grossly inefficient: 228V out of the 240V would be thrown away. At a current of 1A, the resistor would burn up 228W and the equipment being powered only 12W.

Power in Watts = Volts × Amps. In electronics we are often concerned with volts and milliamps rather than amps. The Power Alignment Chart or *nomograph* (Fig. 8.1) covers a range of common values.

If a rule is placed across Fig. 8.1 so that its edge intersects two known quantities the unknown third quantity is then read directly from where the rule intersects that column.

To return to Fig. 8.2, even if the waste were tolerable there is another snag. The d.c. output voltage varies. In real life the "load", RL is not a resistor but a piece of equipment such as an amplifier. If the power demanded by the amplifier varies,

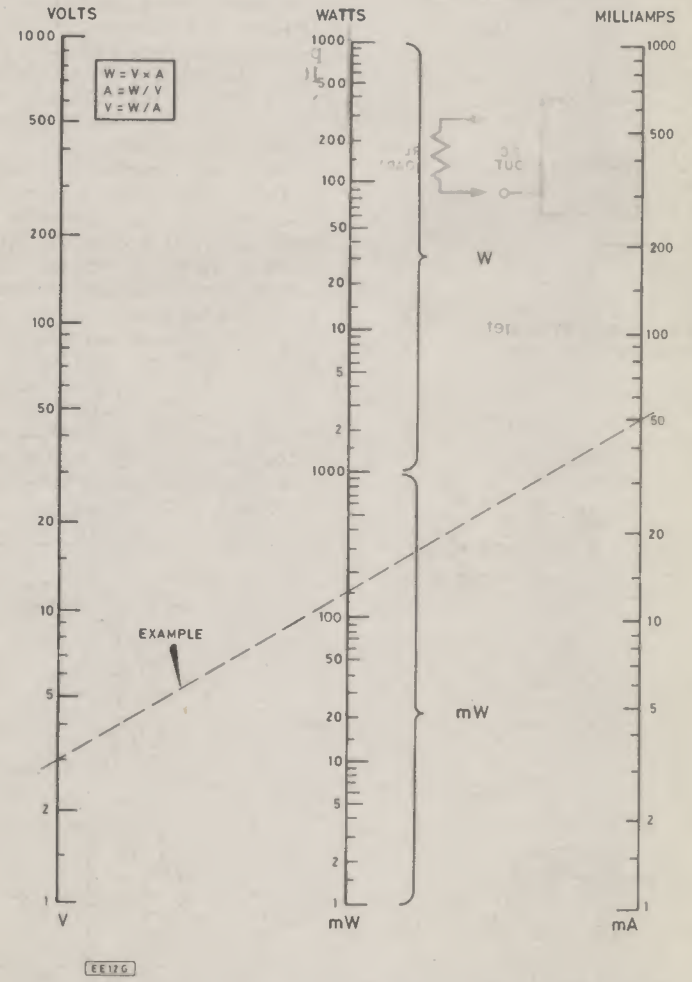


Fig. 8.1. Nomograph for Watts, Volts and Milliamps. The example line shows that at 3V a current of 50mA consumes a power of 0·15W.

then the value of RL varies. An amplifier which requires 12V at 1A looks like 12Ω. But if its current demand falls to 0·5A it looks like 24Ω.

In the Fig. 8.2 type of circuit, Rs is so much larger than RL that the current is forced to keep nearly constant despite such variations. The result is that the amplifier voltage nearly doubles if its effective resistance is halved.

To avoid this (which may be dangerous) we need a magic box (Fig. 8.3) which always gives out 12V, whatever the load. In other words, we need something which automatically adjusts the current drawn from the mains to suit the needs of the load, keeping the voltage supplied to the load constant.

TRANSFORMERS

Something like this can be done, for a.c. only, with the aid of an electrical transformer. The first transformer (invented by Michael Faraday in the course of experiments on electro-magnetism) looked like Fig. 8.4. An iron ring is provided with two "windings" of insulated wire. When an a.c. voltage is applied to the primary winding another a.c. voltage appears at the secondary winding.

The relationship between the two voltages is the same as the relationship between the numbers of "turns" on the windings. If the secondary has only one-tenth of the turns on the primary then the secondary gives out only one-tenth of the voltage.

What about the currents? Well, the secondary current is determined by the load. If the secondary voltage is 10V and the load connected to the secondary is 10Ω, then the secondary gives out 1A. The primary current is the load current divided by the ratio of primary to secondary turns. In our example, this turns ratio is 10, so when the load draws 1A the primary supplies 0·1A.

LOSSES

If the voltage applied to the primary is 100V, then a current of 0·1A implies a power at the primary of 100V × 0·1A = 10W. The power at the secondary is 10V × 1A, which is also 10W. So a transformer changes the voltage without itself consuming any energy.

Or rather, it would, if it were perfect. Real-life transformers are imperfect. Their windings have resistance so heat is produced (and voltage dropped) when currents flow. A certain amount of current also circulates uselessly round and round the iron core.

There is also a magnetic loss. Transformers work by creating a changing magnetic field in the core. The core's job is to conduct the whole of this field to the secondary, where it operates in reverse, inducing a voltage in the secondary winding. But in real life some of this field escapes. This is waste.

Despite these losses, a well-designed transformer can be very efficient. The small, low-power transformers often used in electronics are not specially efficient, but can still be quite good. The best type (toroidal transformers) use the same shape of core as Fig. 8.4, a "doughnut".

Most mains transformers, however, have rectangular cores made of thin sheets of silicon steel called laminations, stacked to provide the required thickness. (Much less waste current circulates in a laminated core than a solid core.) In a toroidal transformer the core is wound from a long strip of silicon steel tape which has the same loss-reducing effect.

A.C.–D.C. CONVERSION

We still have to convert the a.c. from the secondary into the d.c. for our equipment. For this we use rectifiers and reservoir capacitors.

A rectifier is an assembly of diodes. A diode is a device which allows current to flow in one direction (anode to cathode) but not in the reverse direction.

The kind of diode used as a power rectifier is able to pass large currents in the easy (or forward) direction and is able to withstand large reverse voltages which try to make it conduct "backwards". (In most rectifier circuits the peak reverse voltage, also called the peak inverse voltage or p.i.v., is twice the peak a.c. voltage at the transformer secondary.)

HALF-WAVE RECTIFIER

A single diode (Fig. 8.5a) makes a half-wave rectifier. It lets only half of the mains-derived sinewave through to the load. During the alternate half-cycles it is reverse biased and blocks current. So the load receives "humps" of current. This is useless for powering most sorts of electronic equipment. So the humps are smoothed out by adding a reservoir

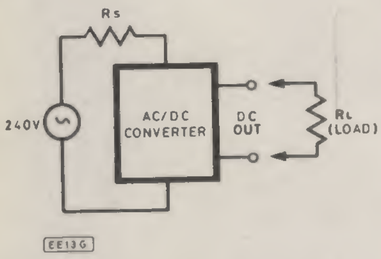


Fig. 8.2. A bad way to get rid of unwanted voltage.

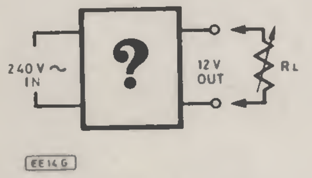


Fig. 8.3. "Magic Box" for voltage changing. The output is always 10V, whatever the size of RL.

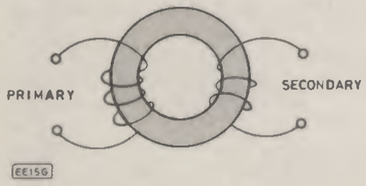


Fig. 8.4. One form of transformer.

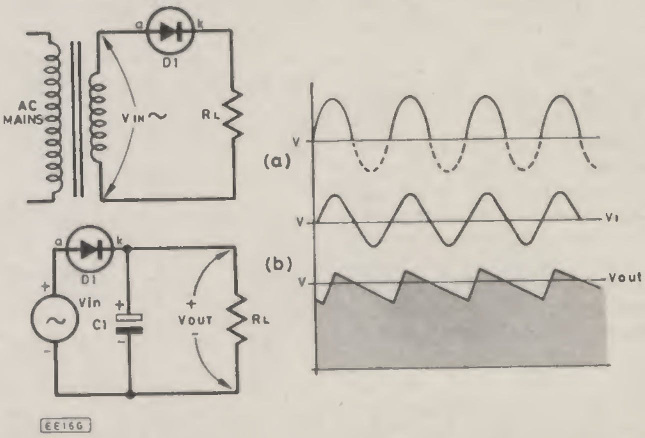


Fig. 8.5(a). Half-wave rectifier circuit, with waveforms. (b) Half-wave rectifier with reservoir capacitor.

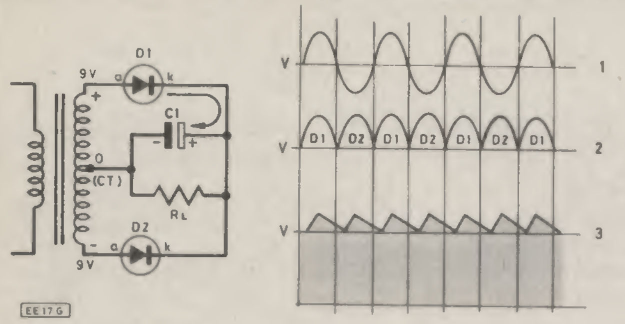


Fig. 8.6. Full-wave "push-pull" rectifier with waveforms.

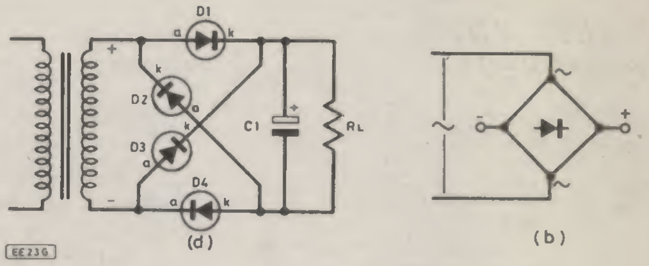


Fig. 8.7(a). Full-wave "bridge" rectifier with (b) an alternative symbol.

capacitor C1. This charges up rapidly when the a.c. input V_{IN} is near its peak, and gives out its charge when D1 is non-conducting.

If C1 is large enough, the fall in voltage which occurs between the times when D1 conducts and tops it up is small. This up and down wobble on the d.c. output is called the ripple voltage. Since it is an a.c. effect and is applied to a capacitor it follows that a.c. must flow through C1. This is the ripple current.

In the circuits commonly used the ripple current is about one-third of the a.c. input current to the rectifier. (For design purposes, call it half and use a reservoir capacitor with at least that ripple current rating.)

The larger the capacitance of C1 the smoother the d.c.; that is, the less the ripple voltage. Reservoir capacitors (sometimes called smoothing capacitors) are usually high-value electrolytics.

FULL-WAVE

Half-wave rectification is hardly ever used in the sort of power supply units (p.s.u.s) incorporated in mains radios and amplifiers. Full-wave rectification is the norm. Here both half-cycles of the mains are persuaded to produce d.c. of the same polarity.

One way of performing this trick is to use a mains transformer with a centre-tapped secondary (Fig. 8.6). The centre tap (c.t.) is a voltage zero or reference point.

During one mains half-cycle the voltage polarities are as shown. D1 conducts. During the next, the polarities reverse and D2 conducts. And so on. In the absence of C1 the voltage across R_L would be as in curve 2. With C1 it is as curve 3. C1 gets topped up every half-cycle. Current flows into C1 in short sharp pulses near the peak of each half-cycle.

The need for a centre-tapped winding is avoided if a bridge rectifier is used (Fig. 8.7a). This has four diodes. Only two conduct at any one time. When the mains polarity is as shown, D1 and D4 conduct, topping up C1. On the next half-cycle D3 and D2 conduct, and so on.

RECTIFIER VOLTAGE DROP

Rectifiers are cheap, so bridge circuits (often drawn in other ways, including the "shorthand" form illustrated in Fig. 8.7b) are common. But for very low voltage outputs they are not so attractive as the Fig. 8.6 arrangement ("push-pull" rectification).

The reason is that some voltage (usually about 1V) is dropped across each diode. In a bridge circuit, where two diodes conduct together, 2V is lost and the d.c. output voltage is 2V less than the peak a.c. input. With the push-pull circuit, only 1V is lost.

On the other hand, in Fig. 8.6 each half of the secondary is idle half the time, while in Fig. 8.7 the whole secondary is used on every half-cycle.

D.C. OUTPUT VOLTAGE

Since C1 gets topped up to nearly the peak a.c. voltage the d.c. output voltage is higher than you might expect. Transformer secondary voltages are often quoted as "r.m.s. voltage output at full load". Let's look at this.

For starters the peak of a sinewave like the mains voltage is 1·414 times the r.m.s. value. So 10V r.m.s. would yield 14·14V d.c. if there were no drop in the rectifiers. In a push-pull circuit this would fall to about 13V.

Next, the full-load output voltage means what the transformer delivers when it's working flat out, delivering as much current as it can safely do. But then the losses in the winding resistances and the core are greatest and the voltage suffers. The voltage loss can easily be 20 per cent more in the flat-out condition than when "idling". With no load, the d.c. voltage might be 16V instead of the 10V you might expect from the transformer specification.

In practice, much greater differences between full-load and no-load voltages are found in miniature transformers. The variation is called the regulation of the transformer and expressed in specifications ("specs") as a percentage:

$$\text{Regulation} = \left(\frac{\text{No-load V} - \text{Full-load V}}{\text{Full-load V}}\right) \times 100 \text{ per cent}$$

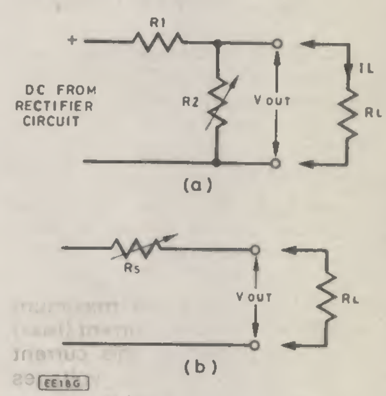


Fig. 8.8(a). Elements of a "shunt" or parallel voltage stabiliser. (b) Elements of a series stabiliser.

In complete power units the regulation is worse than the figure for the transformer alone.

VOLTAGE STABILISERS

In many applications this variation in voltage can be tolerated. But some equipment, notably computers and most other digital equipment, the voltage must be kept at a constant level (such as 5V d.c.) even when the current demanded by the equipment is varying, and also the mains voltage.

In such cases a voltage stabilising circuit is needed. There are two basic "traditional" ways of stabilising the voltage (Fig. 8.8). In the first (a) a higher than needed voltage is applied to a voltage divider (R1, R2). If the current demanded by R_L changes, R2 is automatically adjusted to compensate.

To make this sort of circuit work it must be operated at full current all the time. If R_L doesn't need it, the surplus current is absorbed by R2. Suppose the current demanded by R_L varies from 10mA to 100mA. Then when it is 10mA the unwanted 90mA must flow in R2. As the load current I_L rises, R2 adjusts itself to absorb less and less until, when I_L = 100mA no current at all flows in R2.

The required automatically varying R2 is obtained by using, not a resistor, but a Zener diode. A "Zener" behaves like an

CHECK YOUR PROGRESS

Questions on *Teach-In 84 Part 8*
Answers next month

Q8.1 A Zener diode is rated at 10V, 400mW:

(a) What is the maximum current it can safely pass?

(b) When used as R2 in Fig. 8.8a, if the d.c. input is 14V what is the lowest safe value for R1?

(c) If the tolerance on the Zener voltage is 10% and your Zener is on the lower limit what power does the Zener then dissipate when no load is connected across it?

(d) If R1 is 10% low how much current flows? (Other conditions as in c).

Q8.2 In Fig. 8.9, if the maximum permissible l.e.d. current (I_{MAX}) is 30mA and at this current the combined l.e.d. voltages come to 3·3V, what is:

(a) The value of R1 which allows I_{MAX} to flow?

(b) The power dissipated in the l.e.d.s when no load is across them?

(c) The power in the l.e.d.s when a load across them draws 20mA?

Q8.3 In a half-wave rectifier circuit like Fig. 8.5b, V_{IN} = 10V r.m.s. What is:

(a) The output voltage d.c. when R_L is infinite?

(b) The peak reverse voltage then experienced by D1?

Q8.4 A mains transformer has a secondary winding rated to deliver 12–0–12V r.m.s. at 100mA maximum.

(a) What type of rectifier circuit is it intended for?

(b) If the regulation of the transformer is 20% what is the likely d.c. output off-load?

(c) What would be a suitable minimum ripple current rating for the reservoir capacitor?

(d) If the 100mA rating is "r.m.s." what is the maximum safe d.c. output current when a reservoir capacitor is used?

(e) If the centre-tap is left unconnected and a bridge rectifier connected across the whole secondary, with a reservoir capacitor, what is:

(1) The likely d.c. output voltage, off-load?

(2) The maximum permissible output current?

Q8.5 When a reservoir capacitor is used, the rectifier diodes conduct for only a portion of a half-cycle. During this period they must provide enough current to charge the capacitor sufficiently to keep up the d.c. output. In Fig. 8.5, if the d.c. output is 100mA and D1 conducts for 10% of its "on" half-cycle, roughly how much current does it pass when conducting?

ANSWERS TO PART 7

Q7.1 (a) 100mA (0·1A). If all Vcc is dropped across the load (leaving nothing across the transistor) the current is 10V/100Ω = 0·1A.
(b) 1W (10V x 0·1A).
(c) Zero (0V x 0·1A = 0W). In practice there is always a small voltage across the transistor but it can be neglected in this kind of calculation.
(d) Vcc shared equally between load and transistor.
(e) V_{CE} = 5V, I_C = 50mA. (Dissipation is then 250mW.)
(f) 0·5mA (500μA).

Q7.2 (a) 10W. If the case is at 50°C and the junction at 150°C the temperature drop inside the transistor is 100°C. This drop appears across the thermal resistance (10°C/W). For every 10°C the transistor is dissipating 1W, so in our example the dissipation (called "collector dissipation" in data sheets) is 10W.
(b) 2·5°C/W. The thermal power supplied by the transistor to the heatsink is 10W and the temperature difference between sink and ambient air is 25°C.

Q7.3 (a) 25W. Peak load current = 10V/4Ω = 2·5A. Note that peak current = (Vcc/2)/R_L, which is the same as Vcc/2R_L. Peak power is this times the peak voltage Vcc/2. So peak power is Vcc/2R_L times Vcc/2 which comes to $Vcc^2/4R_L$. This formula is a handy rule of thumb for estimating the power obtainable from this type of circuit. In practice it is always an over-estimate because of inadequacies in the transistors and drive circuit.
(b) 100W. Note that doubling the voltage quadruples the power. (See Part 8).
(c) If the peak power is $Vcc^2/4R_L$, half this is $Vcc^2/8R_L$. This is the rule-of-thumb formula for estimating the r.m.s. sinewave power. In real-life mains-powered amplifiers, however, it may not be possible to obtain a sustained sinewave power output of half the peak power. This is because with sustained sinewave signals of large amplitude the supply voltage Vcc often falls and this limits the output power.

ordinary silicon diode in the "easy" direction, but it is in the reverse-biased state that it is used. Once the reverse voltage reaches a certain breakdown value the Zener conducts very freely.

If the voltage is to be stabilised at say 10V then a "10V Zener" is substituted for R2. If the voltage tries to rise above 10V the Zener conducts and the "surplus" is absorbed by R1.

By the way, all silicon diodes breakdown at some reverse voltage, but for rectifier diodes this is kept as high as possible. Zeners are made with breakdown voltages down to a few volts.

Circuit Fig. 8.8 (b) is less wasteful than (a). With no-load Rs becomes infinite so it absorbs all the surplus voltage without drawing current. At full-load, Rs is small and then also wastes little power even though it is passing all the current.

There is no simple component like a Zener which will do the work required of Rs. Quite complex combinations of transistors, Zeners and other components are required to make efficient voltage stabilisers. Fortunately they can be obtained in the form of integrated circuits, which you can use without bothering about their inner workings.

8.1—SHUNT STABILISER

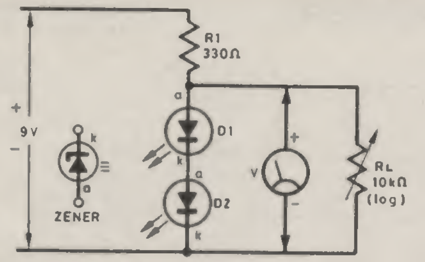


Fig. 8.9. Shunt stabiliser experiment. The two l.e.d.s are equivalent to a Zener diode giving 3V approximate.

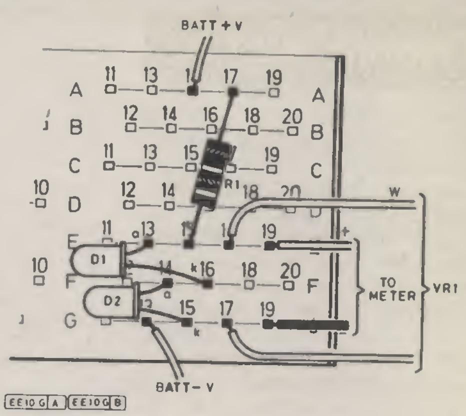


Fig. 8.10. EBBO board layout for Fig. 8.9. The lead to potentiometer VR1 marked "W" should connect to the centre or wiper terminal.

8.2—INPUT VARIATIONS

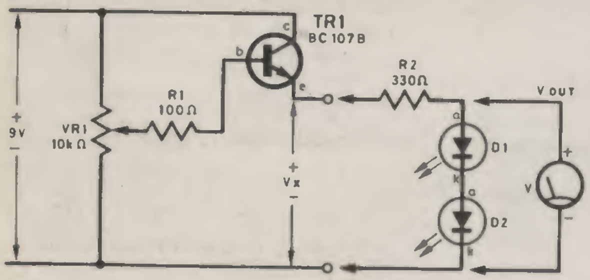


Fig. 8.11. Checking the effect of input-voltage changes.

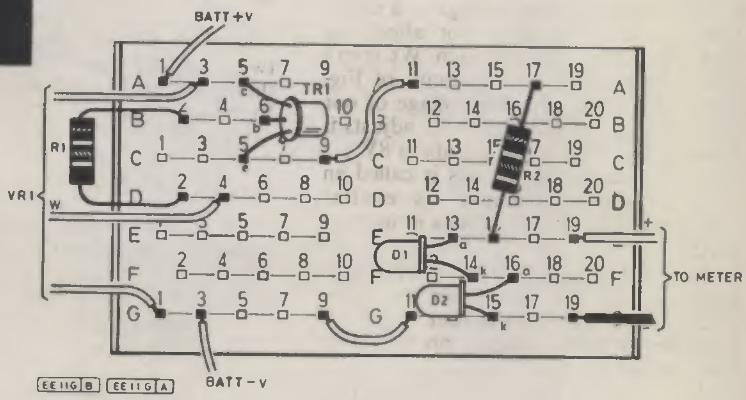


Fig. 8.12. EBBO board layout for Fig. 8.11. The lead marked "W" should connect to the wiper terminal of VR1.

8.3—SERIES STABILISER

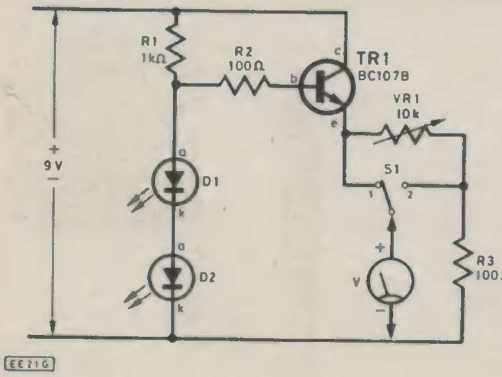


Fig. 8.13. Simple series stabiliser.

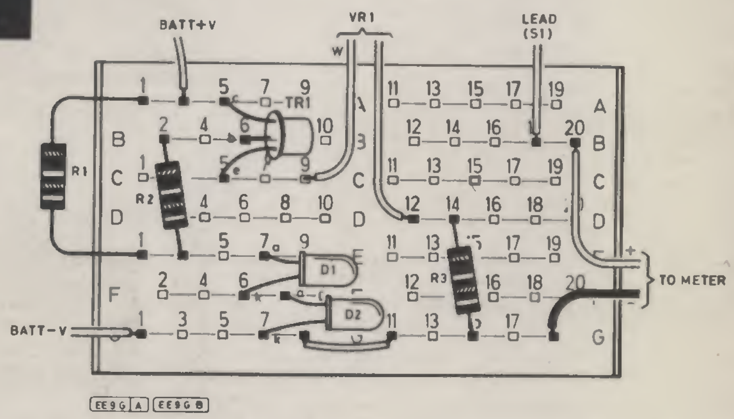


Fig. 8.14. EBBO board layout for Fig. 8.13. The lead marked "W" should connect to the wiper tag of potentiometer VR1.

EXPERIMENTS 8.1,2,3

A simple test circuit (Fig. 8.9) will demonstrate the working of the first sort of voltage stabiliser.

You haven't got a Zener? Never mind. It so happens that a l.e.d. used in the normal, "easy" direction acts like a low-voltage Zener. We'll use two in series (D1 and D2) to get a higher voltage. Variations in current show as brightness changes.

The "pot" (used here as a two-terminal variable resistance) simulates load variations (R_L). At very low settings of R_L the diodes are not turned on and have no effect. But at around 3V they start to take current. Increasing R_L then has little effect on the output voltage.

The set-up for this experiment is shown in Fig. 8.10.

INPUT VARIATIONS

In real life the input voltage of a mains p.s.u. varies. This must not affect the stabilised output voltage much. We aren't using the mains, but the circuit of Fig. 8.11 enables the effective voltage of our 9V battery to be reduced. VR1 adjusts it to anything between 0V and about 8V.

A transistor used like this is called an emitter follower because its emitter voltage follows any variations in its base voltage.

You should find that once the l.e.d.s light, turning R1 up further has little effect on the stabilised output. Thus the stabiliser protects against input voltage variations.

The set-up for Fig. 8.11 is given in Fig. 8.12.

SERIES STABILISER

Your transistor and l.e.d.s can also be used to demonstrate the Fig. 8.8b type of circuit. This is called a series stabiliser because the control element (Rs) is in series with the load R_L.

In Fig. 8.13, R1 and the l.e.d.s provide a stable voltage (about 3V). This is applied to the base of TR1 as a reference voltage. The load R_L is R3 and VR1, and can be varied between 100Ω and 10kΩ approx. With S1 in position 1 the meter measures the output voltage V_{OUT}. In position 2 it measures the drop (V_I) across R3; this indicates the load current since every 10mA drops 1V.

Plot a rough graph V_{OUT} against V_I. The output voltage is stabilised reasonably well at low and medium currents.

VARIABLE VOLTAGE

For many purposes a variable-voltage stabilised supply is needed. The essential elements of a variable series stabiliser are shown in Fig. 8.15. The differential (operational) amplifier is used to compare a tapped-off portion (V_F) of the output voltage with a reference voltage (V_{REF}) derived from the Zener, D1.

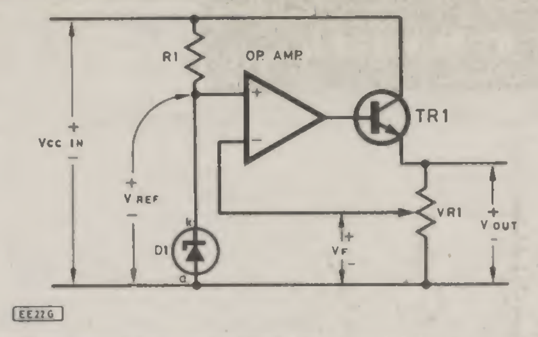


Fig. 8.15. Elements of an adjustable series stabiliser.

If there is any difference the amplifier output drives the "series" transistor, TR1, the right way to reduce the difference. (Negative feedback rides again!) In other words, the circuit forces V_F to equal V_{REF}. The output voltage is then greater than V_{REF} by the voltage attenuation factor of the voltage divider VR1.

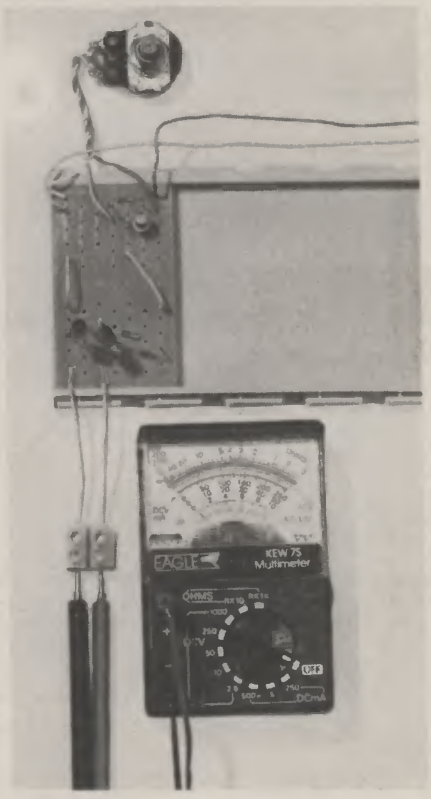
If $V_F = 5V$ and the factor is 3 then $V_{OUT} = 15V$. The circuit works only between certain limits. V_{OUT} can't be less than V_{REF}, and it can't be quite as high as V_{CC} because a certain voltage is needed to operate TR1.

SWITCHING STABILISERS

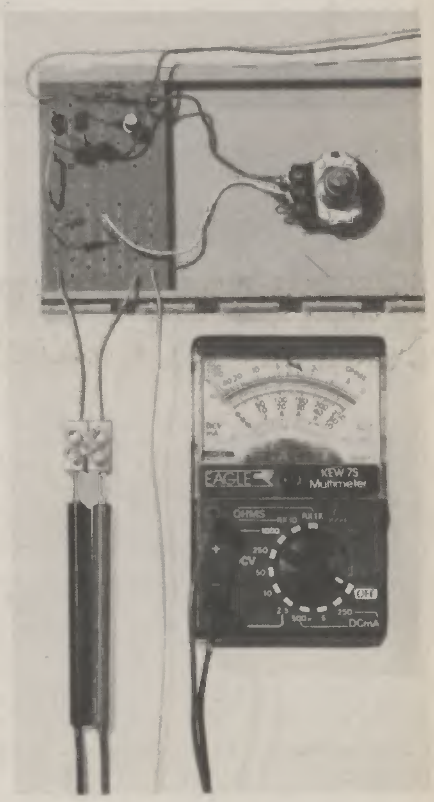
In recent years another kind of stabiliser has come into fashion. The essence of the switching stabiliser, as it is called, is to keep a capacitor across the load charged to the required voltage. To do this the capacitor is "topped up" from time to time by short pulses of current. These pulses come from the unstabilised supply via a series transistor. If the load demands more current the series transistor is turned on for longer periods at a time.

In practice switching regulators are rather complex. The capacitor topping-up is usually done indirectly, via an inductance, because this enables the efficiency to be increased. Integrated circuits for switching stabilisers are now available (as indeed they are for series stabilisers).

Next month: Radio Systems



The EBBO layout for input-voltage variations—Experiment 8.2.



Layout for Experiment 8.3. The "test" lead S1 is shown between meter and leads.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Holographic Call

Since British Telecom came under threat (now becoming reality) of privatisation, it has been loudly announcing or inaugurating something every day. The snag is that when BT has something really worthwhile to announce or inaugurate, it can pass unnoticed.

The fact that British Telecom's Phonecards use a holographic optical pattern, rather than a magnetic strip, to control a cashless call box, is a good example. The hot news on holography was buried in a rather boring press release which many people did not read the whole way through. So the clever use of holography was never reported.

Another good example, recently, was inauguration by BT of the world's first 140M bit/s commercial optical fibre link between Luton and Milton Keynes. Although an important achievement, it sounded like old news to many people.

At the British Association's annual meeting in Brighton last August, BT told scientists that it had transmitted light over 100km of optical fibre without amplification and predicted runs of 400km. In October 1983, BT announced "the first single mode optical fibre link", following a successful test of the 27km link between Luton and Milton Keynes.

Then, in November, BT announced the "go-ahead" for a submarine cable using single-mode fibres to carry phone-calls and data under the Atlantic. These will operate at a data rate of 280M bit/s. A month later BT announced that it had signed the contract for what had previously been announced.

Despite the inevitable feeling of *deja vu*, inauguration of the Milton Keynes link bears testimony to the fact that BT made the right decision in 1980. That was when engineers switched from graded index fibre, which carries a wide beam of light prone to undesirable dispersion, to mono-mode or single-mode fibre, which carries a single light ray with no dispersion.

The switch proved far easier than anyone expected. "The problems just tumbled as people put their minds to them," says Dr. John Midwinter, of BT Research Laboratories in Ipswich. "We were astounded when we put pulses in one end and they came out with identical shape after 50 kilometres".

Future Developments

They have, so far, kept quieter on their long-term research. They are now working on solid-state lasers with a longer wavelength, 1·5 micrometres instead of 1·3 micrometres, and with the laser tuned very tightly to a specific frequency. Longer wavelengths means less absorption by the fibre.

Tighter tuning makes it possible to send a large number of separate channels of information simultaneously down one mono-mode fibre, separated by only a slight shift in light carrier frequency. The use of tightly defined frequencies also makes it possible to use optical boosters instead of converting light into electricity and then back into light again.

Until now light amplifiers have operated on a broad frequency band and introduced too much unwanted noise. With tight frequency tuning the receiver at the far end of the cable can work on the heterodyne principle just like a radio receiver; the incoming light signal beats with a beam of locally generated laser light to produce an intermediate frequency (i.f.) of much longer wavelength.

BT believes it was the first body in the world to recognise the benefits of using lasers tuned to very narrow frequency. The system is still only a laboratory tool. But commercial development would mean that even existing mono-mode fibres, like those now laid under the ground between Milton Keynes and Luton, could carry more information channels than anyone has previously thought possible.

Also the theoretical distance for mono-mode transmission, without any boost along the route, rises to 500 kilometres. In contrast to all this, France is locked into the ten-year-old technology of "Graded Index Fibre" which is not upwards compatible in the same way as the mono-mode technology on which BT has successfully gambled.

The biggest problem in bringing mono-mode fibre technology out of the laboratory and into, quite literally, the field was the difficulty of joining the fibres, every kilometre, by a wet and windy roadside. The microprocessor controlled arc-fusion jointing machine built by BT, welds two fibres, each 125 micrometres in diameter, with a light carrying core of 8 micrometres, to an alignment accuracy of 0·25 micrometres!

Sociable Mic

Electronics shops often sell f.m. radio microphones, even though it is against the law to use them in Britain. An f.m. radio mic. is an ordinary microphone with a low power f.m. transmitter built into the handle which trails a wire aerial. A hidden tuning screw adjusts the transmission frequency over the v.h.f. f.m. band (usually 88MHz to 108MHz).

The idea is to transmit on a frequency which is unused in your area and pick it up on an f.m. receiver tuned to that frequency. It's an extension of the technique used in TV studios to let performers roam in front of the cameras unencumbered by trailing wires and without the need for a microphone slung on the end of a boom.

In Japan wireless mics are big business because they are ideal for "karaoke", the Far East craze for singing along with a pre-recorded musical backing track. In Japan you can also buy an f.m. wireless gramophone. A radio link, instead of wires, connects the gramophone turntable to the hi fi system.

In theory gadgetry of this type is of such low transmission power that it won't interfere with other domestic radio equipment. But there is no guarantee that there won't be some interference. This is one reason why f.m. radio mics, like all unauthorised transmission equipment, are illegal in the UK.

Obviously I'm not going to recommend that anyone uses an f.m. radio mic. in Britain. But there's no reason why you shouldn't use one abroad and their disadvantage (tendency to interfere with other people's radios) can be turned to your advantage. Here's how.

Imagine you are laying on a sunny beach, on holiday. Quite a few people on the beach are quietly listening to music on headphones from cassette tape. Then along comes an unsociable sunbather with an ordinary portable radio and sits down beside you. There are few worse sounds in the world than a portable radio turned up too loud so that it distorts music that you don't want to hear anyway.

To kill it, all you have to do is quietly switch on an f.m. radio mic. and tweak the tuning screw until its transmission frequency hits the same number as the rogue receiver. There is then either feedback or distortion. Before long the unsociable sunbather either changes stations, in which case you re-tune your mic., or gives up and switches off, in which case you've won.

War Games

The film *War Games* is now famous for its scarey suggestion that anyone with a home computer could gain access by telephone to one of the computers used by the military. Of course, *War Games* goes over the top, but it is true that any computer which is programmed for telephone access cannot be 100 per cent safer from unauthorised connection.

The more complicated the password procedure, the more difficult and time consuming it is for an authorised computer to gain access. So password procedure may not be too complicated. Also the basic idea of the film, that a defence computer will be accidentally triggered into playing war games for real, may not be as absurd as the military apologists have professed.

Take the case of the Thorn-EMI company, Simtec, who recently developed a war game simulator for the navy. The Simtec system is intended for training sonar and radar operators, and crews in charge of weapon systems. It can simulate a war in an area of over four million square miles, with up to 100 land vehicles, submarine or aeroplanes. Each of the vehicles can be assigned characteristics from a selection of 250 different classes, for instance: bomber, fighter, helicopter and so on.

There is nothing new in this, although the Simtec simulator obviously relies on a bigger and more powerful computer system than most. The sting is in Thorn-EMI's own description of the system. I quote verbatim:

"These trainers inject simulated responses into the actual sensor/weapon system. Operators and command teams are at their "real" battle stations and so train in a situation very close to realistic battle conditions."

In other words the Simtec war game computer actually tells the ship's missile crews how, when and where to fire. Let's hope that the system doesn't develop a fault, and doesn't have telephone inputs that can be accessed by a kid with a home computer.

SHOP TALK

BY DAVE BARRINGTON

Catalogues Received

This month only two catalogues, from **Marco Trading** and **Electrovalue**, have landed on the "Shoptalk" desk. Also news of the latest **Ambit** components catalogue was delivered, but alas no catalogue accompanied the release!

The TV service repair engineer will find a range of voltage-dependent resistors, TV replacement droppers or resistor networks and valves all included in the 109-page Marco Trading mail order components catalogue.

Also, there's an excellent range of plugs and sockets, including BNC and coaxial types. Aerial amplifiers and a u.h.f./v.h.f. colour bar generator are also listed.

The semiconductor section is spread over 35 pages and covers a comprehensive range of transistors, bridge rectifiers and integrated circuits, including CMOS devices.

Amongst the soldering equipment is an Antex 12V 25 watt soldering iron ideal for car owners. This iron comes with approximately 4 metres of cable terminated with heavy duty clips and is easily clamped on the battery normally fitted to any car, boat or caravan.

All prices of goods are contained on the page of entry but are exclusive of VAT, which must be added to the total order. A 30p credit note is included with each catalogue.

Copies of the Marco Trading catalogue cost 65p each and can be obtained from: **Marco Trading, Dept EE, The Maltings, High Street, Wem, Shropshire, SY4 5EN.**

Most of our readers will no doubt be familiar with the excellent component service offered by Electrovalue and will need no persuasion to obtain their latest A–Z product list.

If in doubt, we can only point out that this 36-page catalogue lists items ranging from cases and discrete components to meters and printed circuit materials. This is without listing the numerous computer equipment stocks.

Copies of the Electrovalue A–Z product list are available free of charge from: **Electrovalue Ltd., Dept EE, 28 St Judes Road, Englefield Green, Surrey, TW20 0HB.**

Ace Buy

Some good news for owners of the Jupiter Ace home computer who felt left out in the cold by the sudden demise of Jupiter Cantab Ltd.

It is now back on sale, by mail order only, from **Boldfield Limited Computing.** Existing owners will be pleased to note that the Jupiter 16K RAM packs and software are also available. Further titles will be added in the near future.

The best news is that the prices have been drastically cut! The Ace, with power supply, 182 page manual, demonstration cassette, leads, and a 12 month guarantee, is only £26. The 16K RAM pack costs £20 and all the software cassettes are £3 each. But add VAT and £3 towards postage and packing.

As a combined deal, you can purchase the Ace with a 16K RAM pack for £44 plus VAT. This would have set you back £124.90 previously.

For more information write to: **Boldfield Limited Computing, Dept EE, Sussex House, Hobson Street, Cambridge.**

CONSTRUCTIONAL PROJECTS

Simple Loop Burglar Alarm

The quad 2-input NAND gate i.c., type number 4011, used in the *Simple Loop Burglar Alarm,* carries the designation *B* after the numerals.

The use of this letter signifies that it has a buffered output and this type should be used in this circuit. Some devices may carry the letters *BE*, these types will work quite satisfactory in the circuit.

It is quite possible that an un-buffered type, designated *UBE*, will work, but they have not been tried in the prototype model.

The key switch or lock switch should not cause any buying problems, and is stocked by most component suppliers. However, if readers do experience difficulties in locating a source, it is currently listed by Maplin (code: FH40T), Greenweld, Rapid and Enfield Electronics.

Experimenter's Power Supply

The operational amplifier, type µA759, used in the *Experimenter's Power Supply* has similar characteristics to the 741 but features a power output stage capable of providing up to 325mA output current into a 50-ohm load. This advice appears to be only available from RS Components, Order code 303-258.

It should be noted that RS will not supply to the general public but must be ordered through a local stockist.

Microcomputer Interfacing Techniques

The motors and gearbox used in our model for the *Computer Controlled Vehicle* was obtained from Greenweld Electronics.

As the motors and gearbox come as one complete unit, this appears to be the "best buy" at £5.95, and to be recommended. They are also able to supply the wheels (two for £1.30).

These motorised gearboxes, originally used in a mobile model tank, have two 3-volt motors linked by a magnetic clutch. The gearing arrangement reduces the final drive speed to about 50 r.p.m.

Full details of these units can be obtained from: **Greenweld Electronics, Dept EE, 443D Millbrook Road, Southampton SO1 0HX.**

The mains transformer (code 207–199) and the infra-red slotted opto-switches (code 306–061) are available from RS Components. These items must be purchased through a bona fide dealer as RS will not supply components to the general public.

A similarly rated mains transformer could be used, but the printed circuit board layout would probably need to be changed to cater for the different pinning arrangements.

Most of our advertisers stock micro-switches and types with an operating lever should be specified when ordering.

Vari-cap A.M. Radio

The only component called-up in the *Vari-cap A.M. Radio* which could cause purchasing problems is the Vari-cap diode D2/3.

This is a dual-diode device in a single package and is stocked by Ambit International. The Vari-cap type KV1236 should be purchased and carries the stock number 12-12365.

Mastermind Timer

A suitable "earpiece" called for in this month's "Black Box" project—*Mastermind Timer,* is available from Magenta, Rapid and Enfield Electronics.

We do not expect any component purchasing problems for the *Extra 1K RAM for the Acorn Atom* or the *Extra Utility Prom.*

MICROCOMPUTER INTERFACING TECHNIQUES

INCLUDING MANY USEFUL CONSTRUCTIONAL PROJECTS

PART 11: COMPUTER CONTROL OF SMALL VEHICLES

BY J. ADAMS B.Sc, M.Sc. & G.M. FEATHER B.Sc.

THE intrinsic ability of the microcomputer—to execute a specific set of stored instructions—allied with its capability to interface with a wide range of peripheral devices has formed the basis of this series of articles.

In particular the reader will be aware that the microcomputer, in conjunction with external circuitry, is capable of accessing data, corresponding to both digital and analogue quantities. Such information may be used to modify or control the execution of output signals to additional electronic devices.

This month's article will deal with another application of this technique to control small motor driven vehicles.

Such vehicles are widely employed in "Technology" courses and several versions, differing both in general philosophy and mode of operation, are available. This article sets out to describe the underlying principles and construction of a simple "buggy" which will offer at least some of the facilities of its commercial counterparts.

TRACTION MOTOR CONTROL

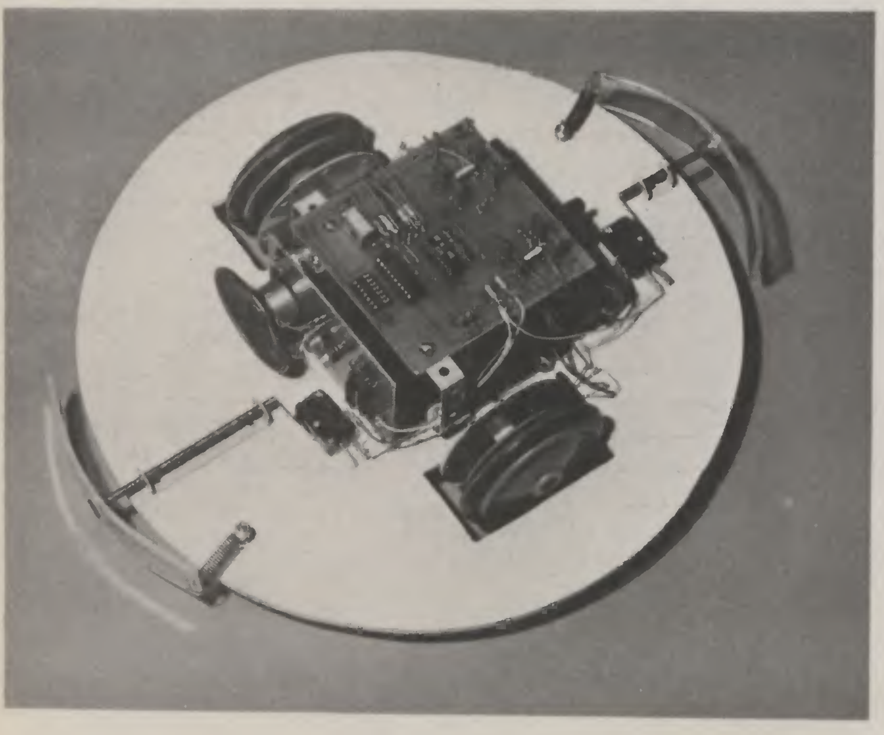
In order that reasonable precise positioning of the vehicle can be achieved it is of course essential that the operation of the traction motors is carefully controlled by the microcomputer.

Various techniques have been devised in order to achieve this end and an effective, albeit rather expensive, solution is the employment of stepper motors for this purpose. Readers interested in developing a system along these lines should refer to *M.I.T. Part 5* (November 1983) in which the control of such motors was described.

FEEDBACK

If it is intended to employ d.c. motors to provide traction for the vehicle, then some form of feedback is essential.

In the system to be described, such information is derived by opto-electronic sensing of the number of revolutions of the driving wheels. Assuming that slipping of the wheels does not occur, this arrangement is capable of providing reasonable precise information concerning the vehicle's operations. These include forwards, backwards and rotational motions.



COLLISION DETECTORS

Two other "sensors" are provided; these are collision detectors and will provide signals in the event of the vehicle encountering obstacles in its path whilst moving either forwards or in the reverse direction.

On receipt of such information, appropriate software can output control signals to the traction motors in order that the obstacle might be negotiated.

CIRCUIT DESCRIPTION

A complete circuit diagram of the Interface/Motor Control and associated circuitry is given in Fig. 11.1 and the reader should consult this.

Output signals from and input signals to the microcomputer user port are buffered by IC1, a 74LS244 octal non-inverting buffer. A pin-out diagram of this is shown in Fig. 11.2, which also shows the internal arrangement of the individual buffers.

Each employs Schmitt trigger circuits (which, insofar as signals from the sensors is concerned, is necessary) and all buffers offer tri-state outputs. Pins 1 and 19 provide control of the tri-state facility and are active low; in this application. The devices are permanently enabled by grounding these control inputs.

Inputs 1A1, 1A2, 1A3, 1A4 to IC1 are used for motor control information from the user port, corresponding respectively to starboard motor forward, starboard motor reverse, port motor reverse and port motor forward.

Associated outputs from IC1, 1Y1, 1Y2, 1Y3 and 1Y4 are routed directly to four of the inputs of IC2, a 7-stage Darlington driver i.c., the collectors of which drive the motor control transistors TR1 to TR8.

MOTOR OPERATION

Fig. 11.3 shows a simplified version of this section of the circuit for one of the motors, TR1 to TR4 having been represented as simple switches *S1, S2, S3, S4*.

S1 and S4 are closed, then the motor will run in one direction, whilst opening these and closing S2 and S3 will reverse the direction of the motor. If either S1 and S3, or S2 and S4 are open or closed, then the motor will stop. One motor can thus be controlled by a 2-bit binary number as shown in Table 1.

Table 1

Switch State		Result
S1/S3	S2/S4	
Ø	Ø	STOP
Ø	1	FWD
1	Ø	REV
1	1	STOP

Ø=open 1=closed

For control of both motors, a 4-bit number is required and this is derived from appropriate user port control lines configured for output. This is discussed later in the software section.

The drive motors are likely to produce some rather spurious pulse on their supply lines and, for this reason, a separate 7·5V supply for them is derived in the power supply section of the circuitry.

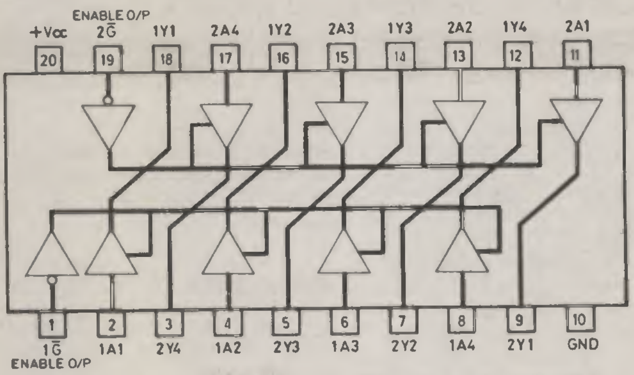


Fig. 11.2. Pin-out details of the 74LS244 tri-state octal buffer.

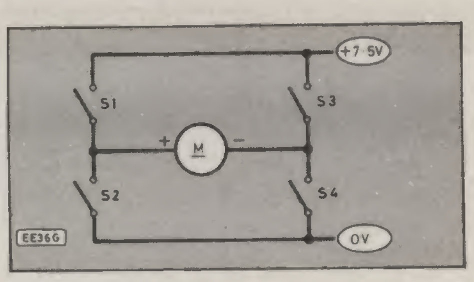
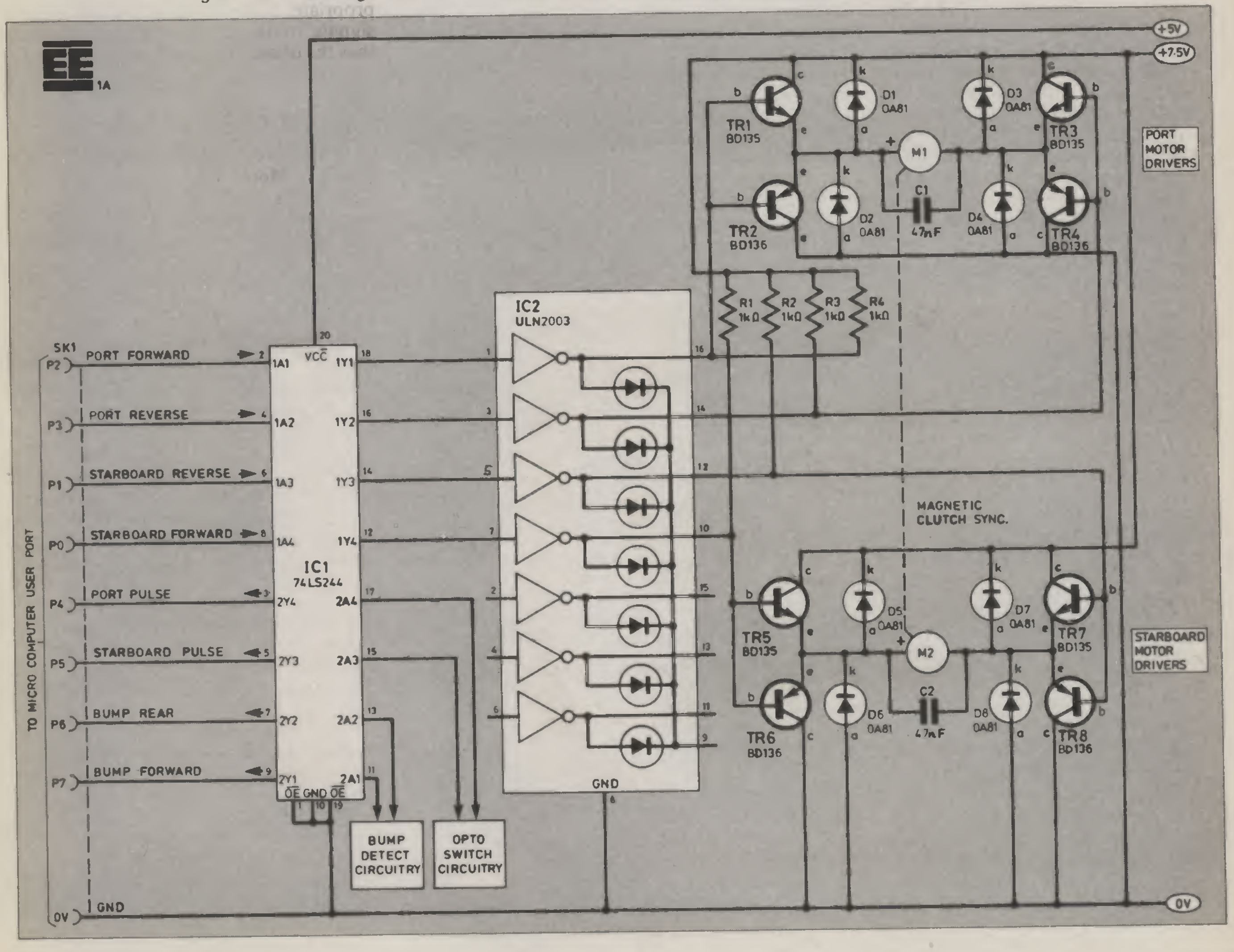


Fig. 11.3. Switch representation of the motor drive circuit.

Fig. 11.1. Circuit diagram of the Interface/Motor Drive section of the Computer Controlled Buggy.



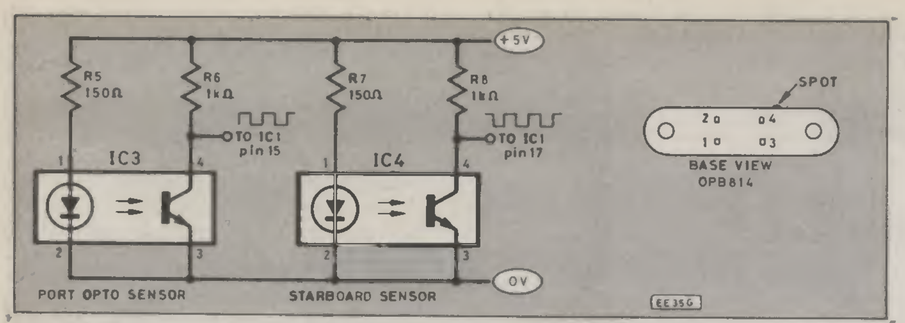


Fig. 11.4. Infra red opto-switch sensing circuit.

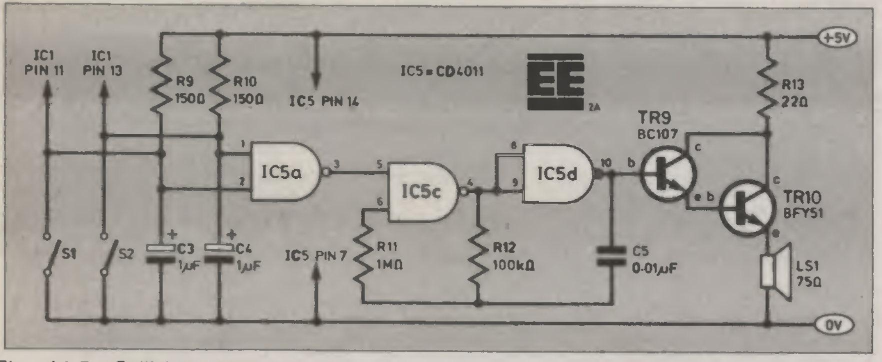


Fig. 11.5. Collision sensing/warning circuit diagram. The switches S1 and S2 are microswitches which form part of the "bumper" mechanism.

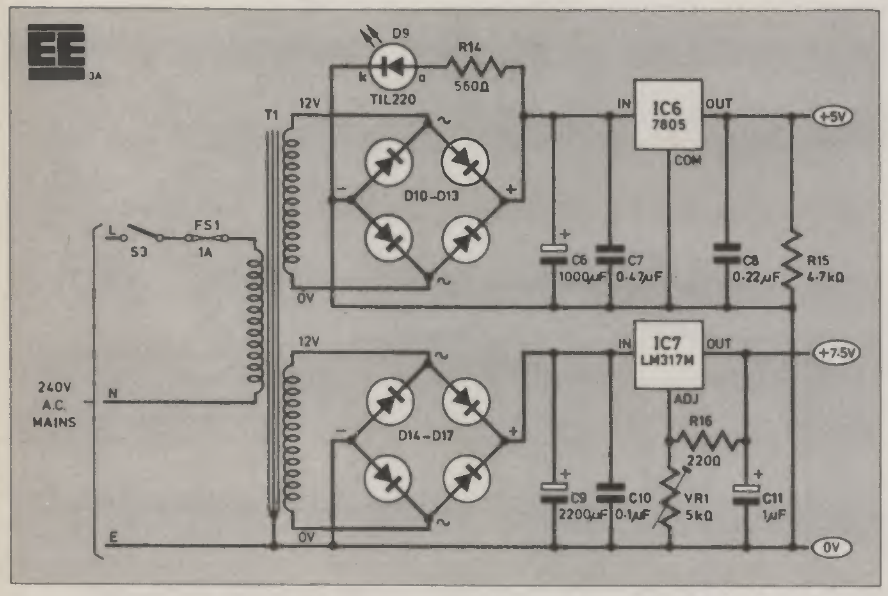
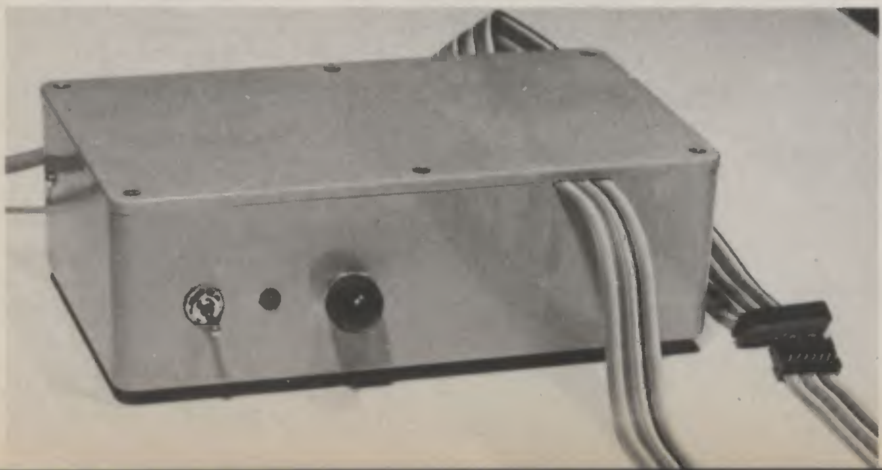


Fig. 11.6. Circuit diagram for a suitable power supply of the "buggy".

Completed prototype power supply showing the "umbilical cord" which connects to the micro user port and the buggy (SK1). Note the slots in the case sides for the ribbon cable.



Diodes D1 to D8 provide protection against switching transients for the drive circuitry.

ROTATION SENSING

The final drive shafts from the motor/gearbox assembly are provided with rotational sensors. Each shaft carries a slotted disc which rotates in the gap of a slotted opto-switch. The pulse output from the phototransistor section of these devices is applied to two of the inputs of the 74LS244 buffer and the corresponding outputs are routed to the user port P4/P5 lines. Suitable software can provide positional information perhaps to be displayed on the VDU. The l.e.d. sections of the opto-switch derive their power from the +5V supply for the main board. Fig. 11.4 shows the circuitry of this section of the vehicle.

COLLISION DETECTION

Forward and rear mounted microswitches, S1 and S2, provide collision signals. The associated circuitry is shown in Fig. 11.5.

Under no collision conditions, these switches, S1 and S2, are open and the associated buffer inputs are pulled up to logic 1 by resistors R9 and R10. A collision pulse pulls either input down to logic 0 and the corresponding buffer output of IC1 also goes low. These signals are applied to user port lines P6 and P7 and IC1.

A subsidiary "on-board" circuit also provides an audible indication of a collision. This consists of IC5 and its associated circuitry. This i.c. is a CD4011 CMOS quad 2-input NAND gate.

One gate, IC5a, is used to detect a collision sensor output going low and reference to the NAND gate truth table given below will reveal that this condition results in the output of that gate going high. Two of the remaining three gates are wired as inverters in an astable circuit, oscillating at approximately 1kHz, the output of the first gate providing a logic 1 to initiate operation of the astable.

Transistors TR9 and TR10 form a conventional Darlington pair circuit to drive the small loudspeaker, LS1.

NAND gate truth table

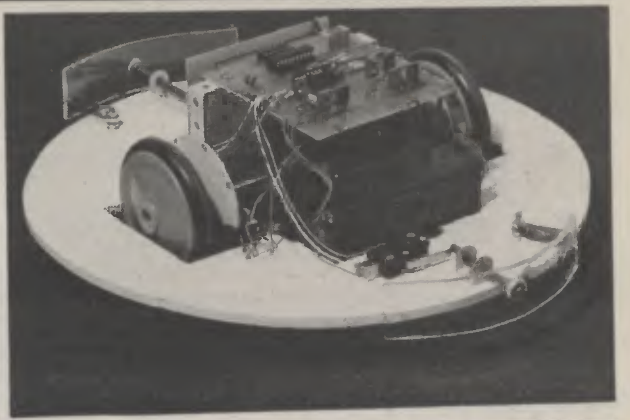
Inputs		Output
A	B	
Ø	Ø	1
Ø	1	1
1	Ø	1
1	1	Ø

POWER SUPPLIES

Fig. 11.6 shows the circuit diagram of the power supply section.

The power supply circuitry is fairly conventional; fixed and variable voltage regulators IC6 and IC7 providing respectively the +5V TTL and +7·5V motor drive supplies. Preset VR1 gives a measure of speed control for the vehicle and should be adjusted to provide the required voltage up to 7·5V.

COMPUTER CONTROLLED BUGGY CONSTRUCTION



INTERFACE DRIVER BOARD

The prototype employed three printed circuit boards in its assembly, two in the vehicle and the third in the case containing the power supply circuitry.

The actual-size master p.c.b. pattern for the board containing the interface and motor drive circuitry is shown in Fig. 11.7. This board is available from the ***EE PCB Service***, Order code 8405–02.

The layout of the components on the topside of this board is shown in Fig. 11.8. Begin by fixing the Veropins to the board to allow easy interconnection to other boards/components in the system. Next mount the i.c. sockets and link wires followed by the transistors and diodes. Pay special attention to the orientation of these devices when mounting to the board.

There are four resistors required in the circuit and all of these are contained in a single-in-line package (s.i.l.). This package may be mounted either way round.

COLLISION SENSING/ WARNING BOARD

Most of the components forming the collision sensing and warning circuitry of Fig. 11.5 are mounted on a printed circuit board, the actual-size master pattern of which is shown in Fig. 11.9. This board is available from the ***EE PCB Service***, Order code 8405–03.

The layout of the components on the topside of this board is shown in Fig. 11.10. Assemble the components as indicated making sure to use a d.i.l. socket to house IC5. Do not insert this device until all construction is complete. Once again use Veropins where indicated to facilitate easy wiring up later.

POWER SUPPLY

The power supply circuitry is housed in a plastics box measuring 215 × 130 × 85mm. Most of the components are fitted to a printed circuit board and the master pattern (actual-size) for this p.c.b. is

COMPONENTS

Approx. cost Guidance only **£35** excluding boards

See **Shop Talk** page 313

Resistors

R1–4	1kΩ 8-pin s.i.l. package
R5	150Ω
R6	1kΩ
R7	150Ω
R8	1kΩ
R9,10	150Ω
R11,12	100kΩ
R13	22Ω
R14	560Ω
R15	4·7kΩ
R16	220Ω

All $\frac{1}{4}$W carbon ±5% tolerance unless specified otherwise

Capacitors

C1,2	0·047μF
C3,4	1μF 10V elect.
C5	0·01μF
C6	1000μF 25V elect.
C7	0·47μF
C8	0·22μF
C9	2200μF 25V elect.
C10	0·1μF
C11	1μF 10V elect.
C12	100nF

Semiconductors

D1–8	OA81 small signal germanium diode (8 off)
D9	TIL220 5mm red l.e.d.
D10–13 D14–17	} 1A Bridge } (REC 70)
TR1,3,5,7	BD135 silicon *npn*
TR2,4,6,8	BD136 silicon *pnp*
TR9	BC107 silicon *npn*
TR10	BFY51 silicon *npn*
IC1	74LS244 low-power Schottky TTL octal non-inverting buffer with tri-state outputs
IC2	ULN2003 7-stage Darlington driver i.c.
IC3,4	Slotted Infra-red opto switch (2 off) (RS 306–061)
IC5	CD4011 CMOS quad 2-input NAND gates
IC6	7805 +5V 1A monolithic voltage regulator i.c.
IC7	LM317M adjustable positive 0·5A voltage regulator i.c.

Miscellaneous

S1,2	standard lever microswitch (2 off)
S3	miniature mains on-off toggle
VR1	5kΩ
T1	mains primary/ 0–12V, 0–12V 500mA secondaries (RS 207–699)
LS1	miniature moving coil speaker, 75 ohms impedance
M1/2	motorised gearbox assembly (Greenweld)
FS1	1A 20mm with panel mounting holder

Printed circuit boards: Interface/drive board, single-sided size 115 × 100mm, *EE PCB Service*, Order code 8405–02; Collision sensing/warning board, single-sided size 103 × 69mm, *EE PCB Service*, Order code 8405–03; power supply board, single-sided size 160 × 90mm, *EE PCB Service*, Order code 8405–04; plastics case type, size 215 × 130mm; 85mm diameter, 2mm thick Perspex discs (for position sensing) (2 off); brackets for board support; ribbon cable to connect to micro user port with appropriate SK1; 3-core lightweight mains cable to connect power supply unit to vehicle; 3-core mains cable; material for base of buggy; general-purpose hook-up wire, stranded, various insulation colours.

INTERFACE AND MOTOR DRIVE BOARD

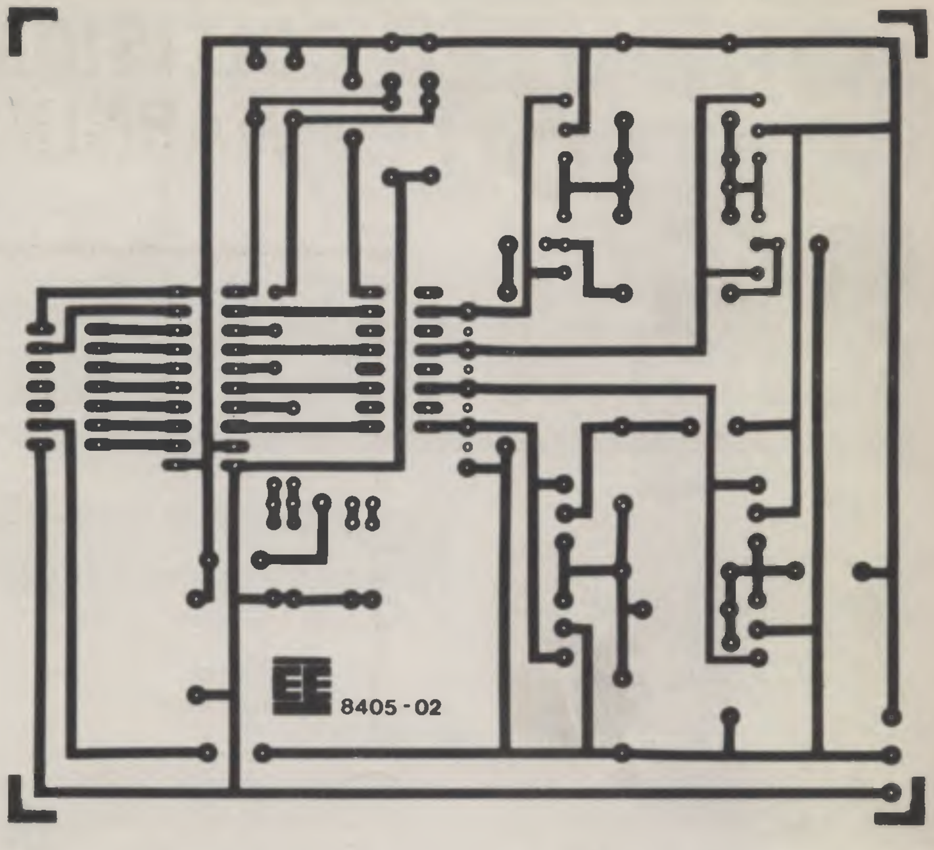


Fig. 11.7. Actual-size master pattern for the Interface/Motor Drive. This board is available from the *EE PCB Service*, Order code 8405–02.

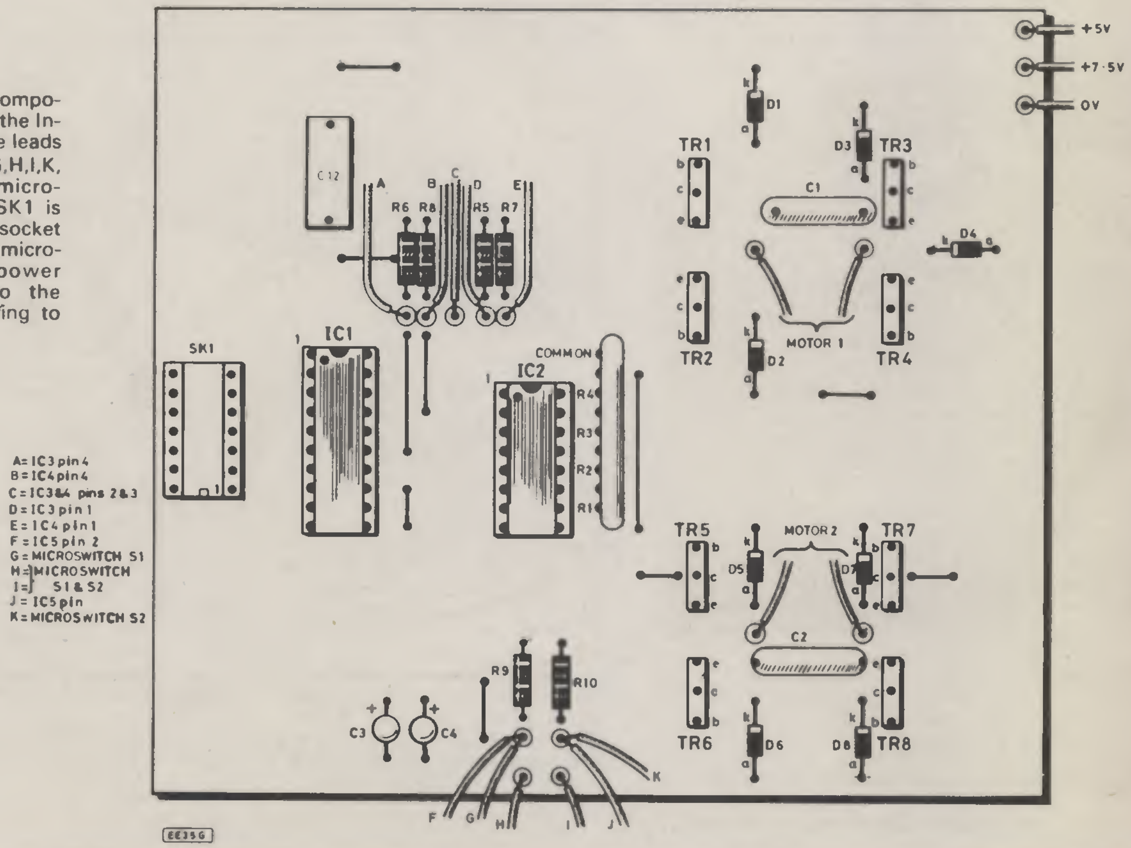
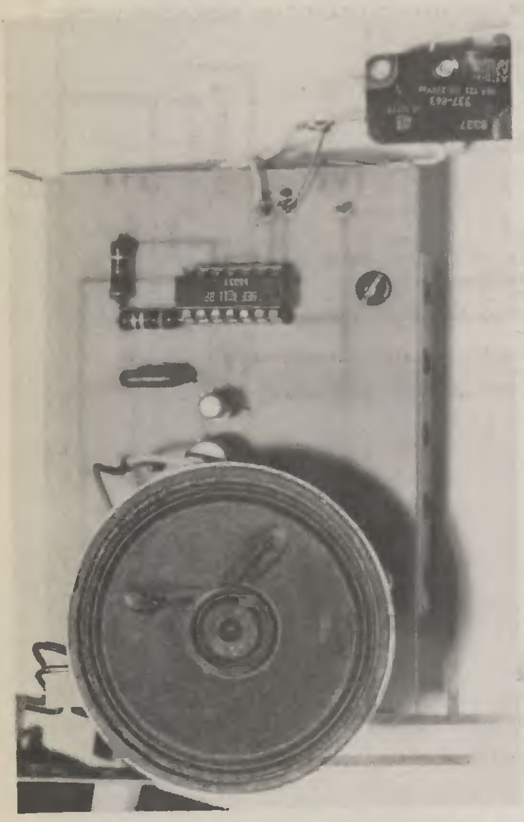


Fig. 11.8. Layout of components on the topside of the Interface/Drive board. The leads terminated in letters G,H,I,K, go to the bumper microswitches S1 and S2. SK1 is the inter-connecting socket for the buggy and microcomputer, via the power supply unit. Refer to the circuit diagram for wiring to the plug.

COLLISION SENSING WARNING BOARD



Completed prototype Collision Sensing/Warning board. One microswitch can be seen in the top right.

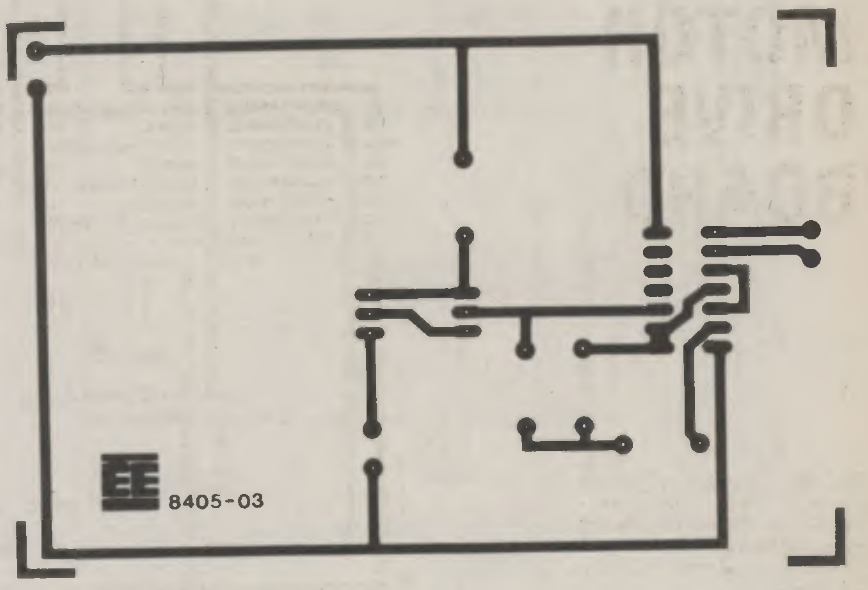
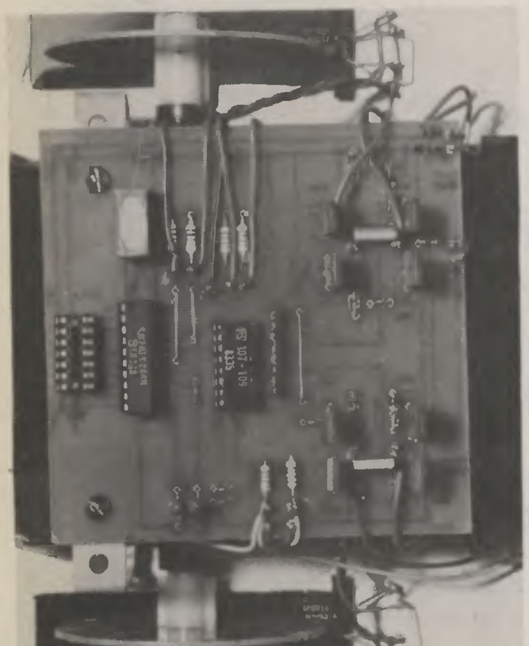


Fig. 11.9. Actual-size master pattern for the Collision/Warning board. This board is available from the *EE PCB Service*, Order code 8405–03.



Completed prototype Interface and Motor Drive board.

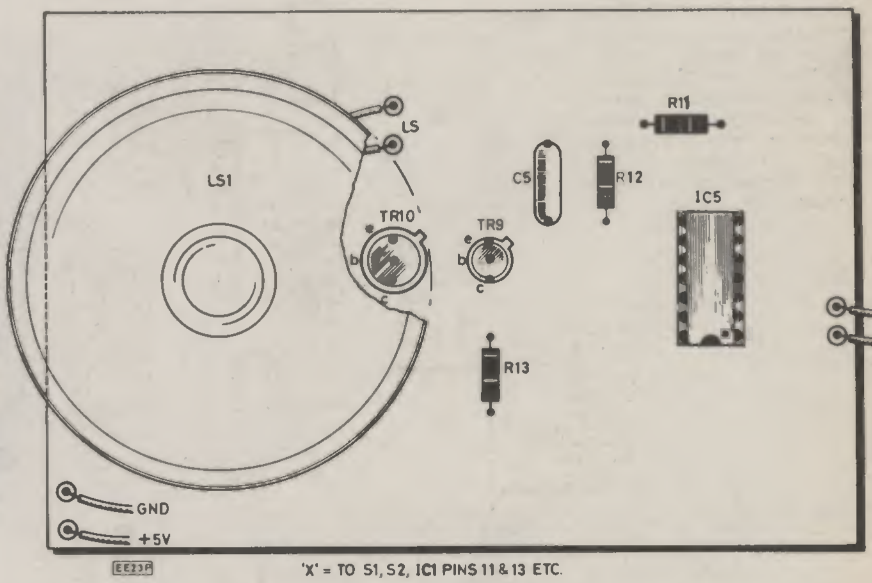


Fig. 11.10. Layout of components on the topside of the Collision/Warning board. The loudspeaker is held in position with impact adhesive.

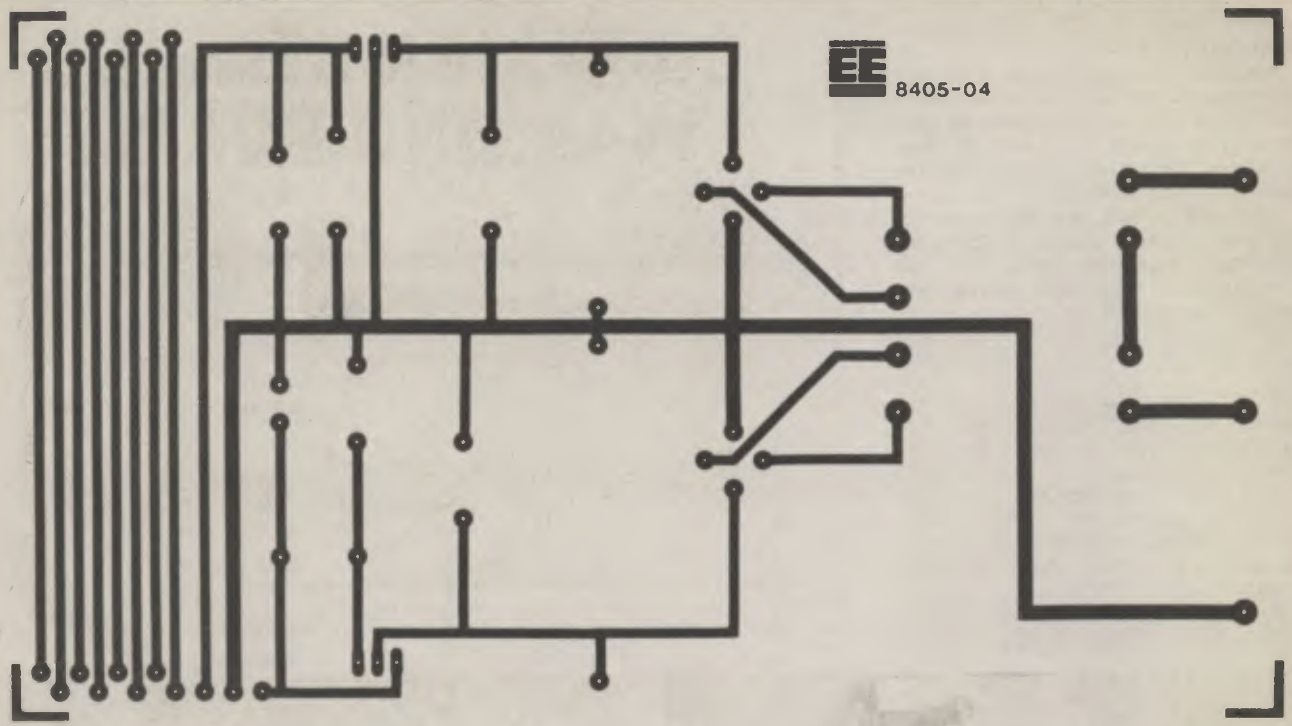


Fig. 11.11. Actual-size master pattern for the power supply board. This board is available from the *EE PCB Service,* Order code 8405–04.

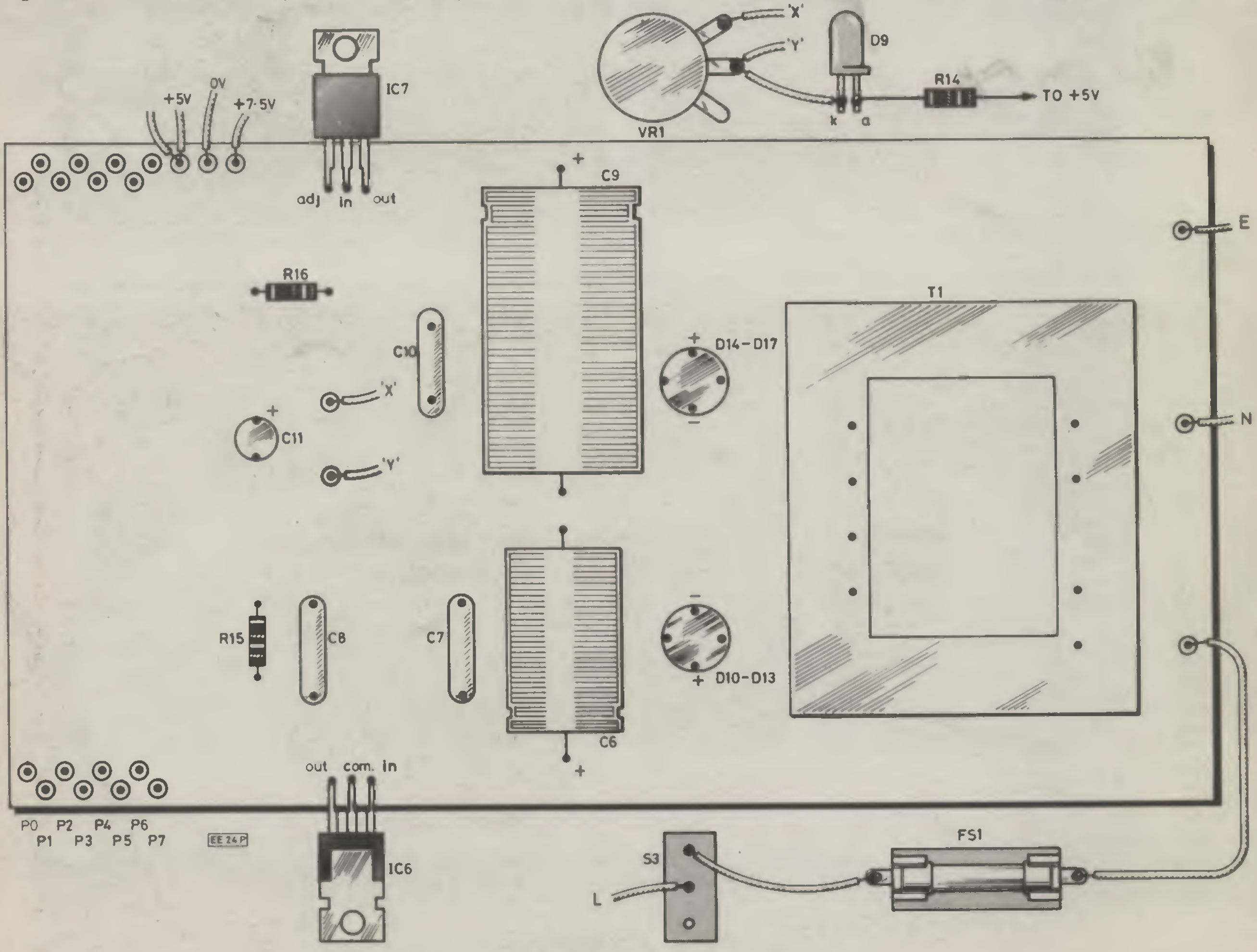


Fig. 11.12. Layout of components on the topside of the power supply board and interwiring to case mounted components.

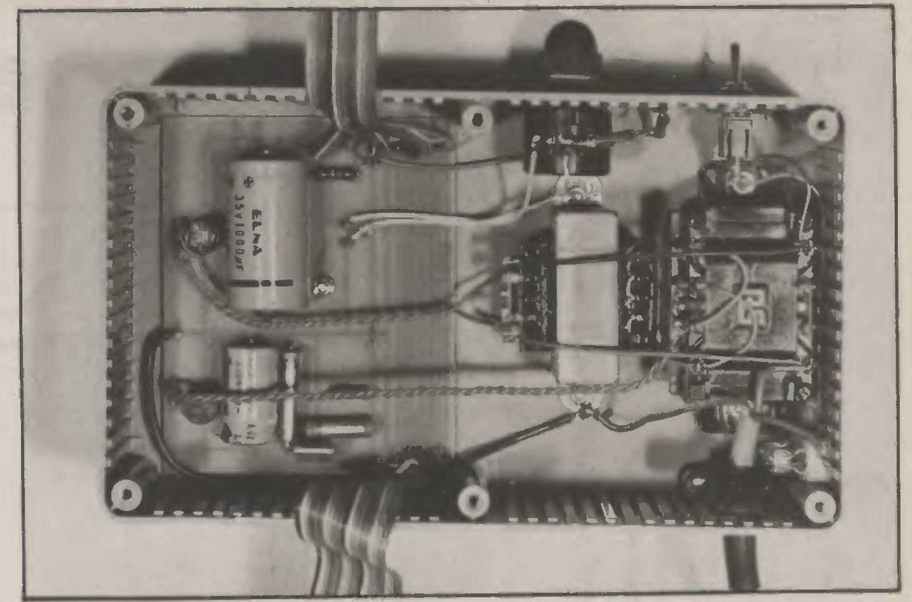
shown in Fig. 11.11. This board is available from the ***EE PCB Service***, Order code 8405–04.

Assemble the components according to the topside layout given in Fig. 11.12. Next prepare the case to accept the case mounted components and then fit these items. Fix the assemble board into the case and wire up as shown.

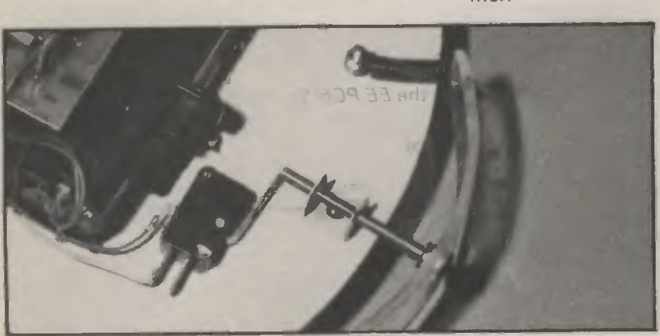
Thoroughly check over the assemblies and when satisfied secure these to the mechanical equipment detailed in the photographs or some other arrangement that may be required.

CABLES

Attach suitable lengths of cable to the vehicle to reach the power supply box and the micro user port outlet. The latter cable should be suitably terminated to mate with the micro user port. Constructors are referred to the pin assignment tables and diagrams for the user ports of the micros catered for in this series which appeared in *M.I.T. Part 1*.



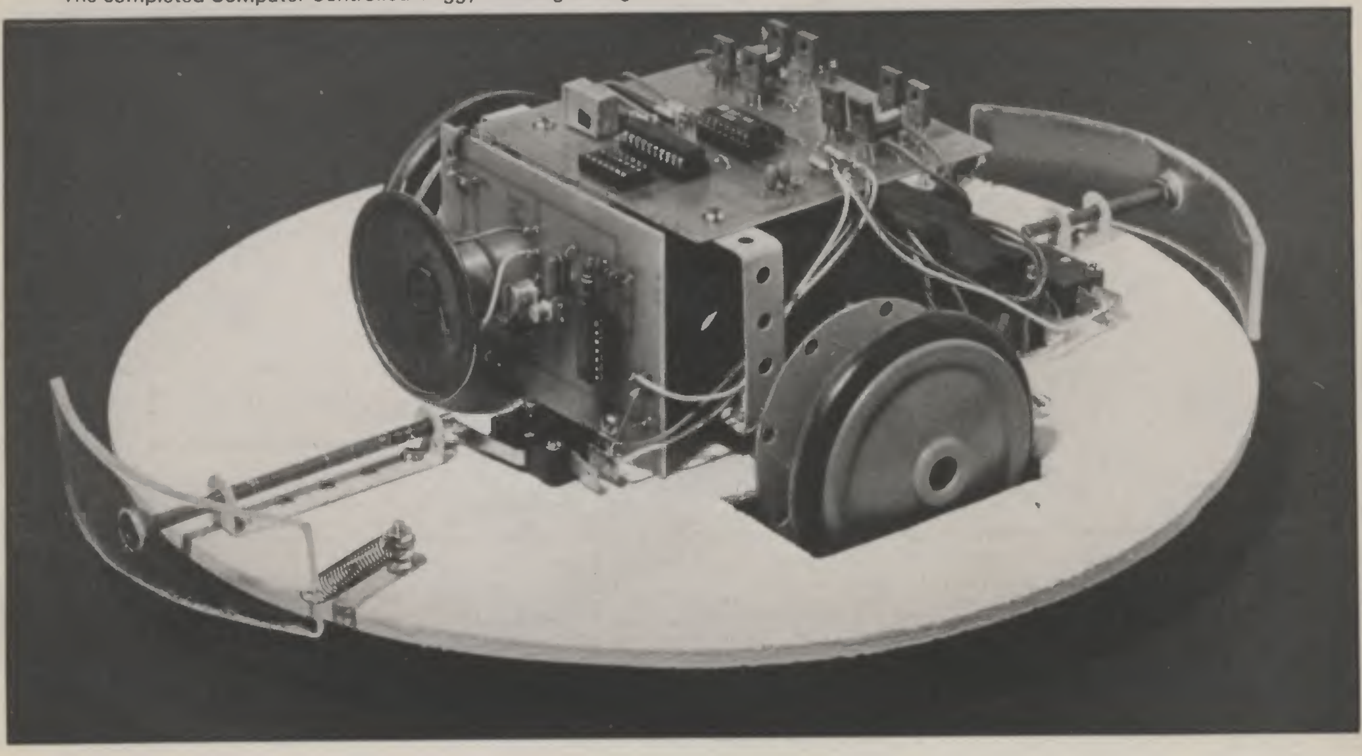
Early prototype of the power supply unit. This model shows two mains transformers which have been replaced by a single unit. The pcb has been extended to accept the new transformer.



Close-up view of the bumper mechanism.

Close-up view of the sensor opto-switch and sensor disc.

The completed Computer Controlled Buggy showing arrangement and positioning of boards, motors and front and rear bumpers.



Insofar as the mechanical side of the construction is concerned the photos give the layout used in the prototype, but clearly much scope exists for the ingenuity of the reader in designing his own version of the vehicle.

MECHANICAL DESIGN OF THE VEHICLE

The prototype vehicle was designed around the motorised gearbox assembly currently available from Greenweld Ltd. and intending constructors are strongly urged to employ this unit. An interesting feature of the unit is its magnetic clutch arrangement; the purpose of this is to pull both motors into synchronisation with each other and the arrangement appears to be quite effective.

The use of entirely separate port and starboard motors without some arrangement for synchronising the speed of the two would almost certainly lead to problems.

SOFTWARE

The behaviour of the "buggy" is entirely under the control of the microcomputer. The following software modules should allow the flexibility necessary for the reader to write software appropriate for the particular application.

It should be stressed that in cases where the computer senses a collision, for example, PRINT "FRONT COLLISION", then remedial action should be taken. One obvious step would be to reverse both motors if a front collision is detected. This is particularly important if the vehicle is stationary even though the motors are active. Rotational sensing software would prove useful in this case.

Although this series has dealt exclusively with the use of BASIC for control it is worthwhile to note that machine code software can offer considerable advantages in many control applications.

For example, the rotational sensing software could be written as an interrupt service routine and the position of the vehicle displayed on the VDU. This approach is, unfortunately, beyond the scope of the article.

The BASIC software utilises the same principles that have been used throughout the series. Logical operators are used to test for individual bumper collisions.

In BBC BASIC an EXCLUSIVE-OR operation is first performed to confirm the states of lines P7 and P6 whilst lines P5 to PØ are masked by the AND operator.

This is accomplished in Commodore BASIC by the use of a WAIT statement as outlined in *M.I.T. Part 2*.

A NOT operation and then six shift rights ensures that the nature of the collision will result in an appropriate branching condition.

It should be noted that logical operators follow a strict order of priority with the NOT operator taking the highest precedence.

Next Month: Speech Synthesis

SOFTWARE MODULES

INITIALISATION

The least significant four lines (PØ to P3) need to be configured for output whereas the four most significant lines (P4 to P7) must be configured for input. This is achieved using the appropriate data direction register as follows:

BBC	?65122=15
PET	POKE 59459,15
COMMODORE 64	POKE 56579,15
VIC-20	POKE 37138,15

MOVE THE BUGGY FORWARDS

Linear forward motion can be achieved by rotating both port and starboard motors in the same direction at the same speed as follows:

BBC	?6512Ø=5
PET	POKE 59457,5
COMMODORE 64	POKE 56577,5
VIC-20	POKE 37136,5

MOVE THE BUGGY BACKWARDS

Linear reverse motion can be achieved by rotating both port and starboard motors both in the opposite direction to that required to move the buggy forwards:

BBC	?6512Ø=1Ø
PET	POKE 59547,1Ø
COMMODORE 64	POKE 56577,1Ø
VIC-20	POKE 37136,1Ø

TURN THE BUGGY TO THE LEFT

A left turn can be achieved by reversing the port motor whilst the starboard motor rotates in a forward direction:

BBC	?6512Ø=6
PET	POKE 59459,6
COMMODORE 64	POKE 56577,6
VIC-20	POKE 37136,6

TURN THE BUGGY TO THE RIGHT

A right turn can be achieved by reversing the starboard motor whilst the port motor rotates in a forward direction:

BBC	?6512Ø=9
PET	POKE 59457,9
COMMODORE 64	POKE 56577,9
VIC-20	POKE 37136,9

STOP THE BUGGY

This can be achieved by turning off both port and starboard motors:

BBC	?6512Ø=255
PET	POKE 59457,255
COMMODORE 64	POKE 56577,255
VIC-20	POKE 37136,255

TEST FOR BUMPER CONTACT

A front collision will be indicated by a negative transition on P7 whereas a rear collision will be indicated by a negative transition on P6:

BBC

```
 1Ø IF (?6512Ø EOR 192) AND 192
    THEN 2Ø ELSE 1Ø
 2Ø ON NOT (?6512Ø/64) AND 3 GOSUB
    1ØØ,2ØØ,3ØØ
 3Ø STOP
1ØØ PRINT "REAR COLLISION":RETURN
2ØØ PRINT "FRONT
    COLLISION":RETURN
3ØØ PRINT "BOTH FRONT AND REAR
    COLLISIONS!":RETURN
```

PET

```
 1Ø WAIT 59457,192,192
 2Ø ON NOT (PEEK(59457)/64) AND 3
    GOSUB 1ØØ,2ØØ,3ØØ
 3Ø STOP
1ØØ PRINT "REAR COLLISION":RETURN
2ØØ PRINT "FRONT
    COLLISION":RETURN
3ØØ PRINT "BOTH FRONT AND REAR
    COLLISIONS!":RETURN
```

COMMODORE 64

```
 1Ø WAIT 56577,192,192
 2Ø ON NOT (PEEK(56577)/64) AND 3
    GOSUB 1ØØ,2ØØ,3ØØ
 3Ø STOP
1ØØ PRINT "REAR COLLISION":RETURN
2ØØ PRINT "FRONT
    COLLISION":RETURN
3ØØ PRINT "BOTH FRONT AND REAR
    COLLISIONS!":RETURN
```

VIC-20

```
 1Ø WAIT 37136,192,192
 2Ø ON NOT (PEEK(37136)/64) AND 3
    GOSUB 1ØØ,2ØØ,3ØØ
 3Ø STOP
1ØØ PRINT "REAR COLLISION":RETURN
2ØØ PRINT "FRONT
    COLLISION":RETURN
3ØØ PRINT "BOTH FRONT AND REAR
    COLLISIONS!":RETURN
```

JUNE FEATURES...

Electronic SURVEILLANCE SYSTEMS

How can electronics effectively guard property? What are the various surveillance options? This series explains the advantages and disadvantages of relative systems and presents the following three alarm projects:

Passive Infrared, Ultrasonic, and ***Microwave.***

All these provide a secure envelope in which any movement is detected, and an alarm sounded.

SPECTRUM PSU

This digitally controlled bench PSU has been designed for use with the ZX Spectrum. It has a maximum output voltage of 24 volts which can be incremented in 0·1 volt steps and is current limited over four switched levels; 50mA, 100mA, 500mA and 1A.

TRAIN

WAIT

This is a must for model train enthusiasts, wanting more realism and automation. This circuit provides automatic wait facility for selected trains at stations and crossings.

EVERYDAY ELECTRONICS and computer PROJECTS

JUNE 1984 ISSUE ON SALE FRIDAY, MAY 18

EVERYDAY news ... from the world of

MATCHING UP TO THE FUTURE

REMOTE CONTROL of all the home entertainment facilities such as TV, hi fi, teletext and video are featured in the new Matchline System Television unveiled by Philips.

Made up of separate units, it can, for instance, integrate all the present video possibilities into one system under the command of a single remote "keypad".

Matchline is their answer to the changing role of the domestic television. Video recorders, teletext, home computers, TV games, "stereo" sound and video discs are already with us; satellite and cable broadcasts are just around the corner.

Initially, three TV models will be available, the 20in V6620, 22in V6720 and the 26in V6820. Each model incorporates a 15W stereo tuner/amplifier, with two speakers mounted at the rear of the cabinet behind adjustable, hinged flaps for sound direction. Alternatively, for a better "stereo impression", a pair of separate hi fi speakers are available, or the sound can be replayed through an existing home audio system.

Teletext is standard, along with Philips' "Supertext" facility. This allows 20 page numbers to be stored in the sets memory. Automatic tuning is capable of giving direct access to 99 channels, 50 on pre-selection. Channel selection is indicated by a fluorescent display.

Euroconnector

The secret to Matchline's flexibility lies in the use of the "Euroconnector", an internationally agreed new standard for connecting video and audio components. The TV receivers each have two Euroconnector sockets, allowing permanent connection of additional equipment. This can take the form of video recorder and computer.

Using the remote control, via the Euroconnector link, it is possible to control and operate the Philips Video 2000 video recorder. Also, it is claimed that in the future control of the LaserVision video disc player will be possible, even if it is in a different room.

One of the new Matchline sets with remote control and separate loudspeakers. New video features and services such as Satellite TV and Videotex may be added to the system by plugging in new modules as they become available.

NEWS . . . ROBOTICS NEWS . . . ROBOTICS NEWS . . . ROBOTICS NEWS . . .

TRAINING FOR ROBOTS

As more and more firms turn to robots in their drive for efficiency, so the need for experts who understand what these non-human workers can and cannot do increases.

Now a new project under the Open Tech Programme, sponsored by the Manpower Services Commission, aims to meet that need by making training readily available throughout the country.

It will be run by the Organisation for Rehabilitation through Training (ORT), whose Technical Department in London, under the direction of Dr. Dan Sharon, has developed a robot study programme.

This programme is split into 92 two-hour study units under seven "chapters": introductory topics, supporting subjects, electronics, computers, robotics, applications, and social and economic impacts.

The plan is to establish a network of up to 20 countrywide contact points, at which students will be able to receive instructions and access to robotics hardware, or even borrow equipment such as desk-top computers and educational robotic arms to use at home.

*You can, of course, start by constructing the **Computer Controlled Buggy** in this issue, see page 317.*

Training for the Microprocessor

One of the claims for the new Heathkit microprocessor training course being marketed in the UK by Maplin, is that it provides the most comprehensive educational and training programme covering 16/8-bit micros currently available.

The training course provides full-scale understanding of the principals and practice of 16-bit micro technology and the kit has been designed to meet the needs of both beginner and those who may already be familiar with 8-bit techniques.

The self-contained training course will meet the needs of the classroom student or provide individual self-instruction. Basic training units include programming, memory segmentation, data handling and hardware interfacing.

Doug Simmons of Maplin, believes that completion of the total course will take about 100 to 120 hours. Cost of the classroom course, together with experiment parts is approximately £99.

Micro-Robotics Fair

The *"London Computer Fair"* is being held at the Central Hall, Westminster over the Easter Bank Holiday weekend from 19 to 23 April. This is the fifth annual fair to be sponsored by the Association of London Computer Clubs.

The *"1984 ACC Micro-Robotics Conference"* is also to be held at Central Hall, Westminster, on 21 April. This venue is in conjunction with the Association of London Computer Clubs' Easter Fair, and many of the stands will have a Robotics flavour.

COMPUTER HOLIDAYS for the HANDICAPPED

Last year the first one-week Computer Holiday for the Handicapped was planned to accommodate only 25 persons, but the response was overwhelming with over 400 applicants wanting to take up residence.

This year, from July 23 onwards, it is planned to run three one-week computer holidays for the handicapped at Valence School, Westerham, Kent. Accommodation is limited to 60 persons at a time and will be on a "first come first served" basis.

The holiday will cost £145 for full-board, tuition and the use of the computers. For more information write to Dr. Lionel Wardle, c/o M.A.P.S. Ltd., Dept EE, 37 University Road, Southampton, SO2 1TL.

TRANS WORLD CALL

The Business Communications Service end of British Telecom has just secured a data transmission contract from Trans World Airlines (TWA) of Kansas City, Missouri, worth £1 million over five years.

Working in close harmony with TWA, they have designed and are to install dedicated equipment to give a 24-hour, year-round communications facility for the airline.

This deal from a major multinational company means that TWA will use London as the hub of all its computer data transmissions between Europe and the United States.

Locations in 12 European capitals and major cities will feed their computer data to London, over private leased circuits, and through equipment in London, to TWA's offices in Kansas City using undersea transatlantic cable links.

Exhibitionist

The 15th Annual Scottish Electronics Exhibition and Convention, SCOTELEX '84, organised by the Institution of Electronics, will be held during the period 5 to 7 June, inclusive, 1984, in the Royal Highland Exhibition Halls, Ingliston, Edinburgh, EH28 8NF. Admission will be free-of-charge to visitors, via tickets available from the exhibitors, and from the organisers.

• • •

The first International Computer Show for Venezuela, "Inforven 84", will be held from 8 to 11 May 1984, in the new Convention Centre at the recently opened Caracas Hilton Hotel in central Caracas.

The exhibition, and the associated conference, will be sponsored by the Minesterio de formento, Oficina Central de Estadistica (OCEI) and by Petroleos de Venezuela S.A. (PDVSA).

• • •

The Offshore Computer's Conference and Exhibition, to be held from 5 to 7 June in Skean Dhu, Altens, Aberdeen, has to date attracted 35 confirmed exhibitors from The Netherlands, Norway and the UK.

Vote of Confidence

The Organisers of "The All-Electronics/ECIF Show" announced that over four hundred members of the electronics industry voted "yes" to the proposal that "The Show" should move to the new Olympia 2 in 1985.

After detailed discussions with Hudson Soft Co., of Tokyo, Kuma Computers have announced that an agreement has been reached for them to market certain Sharp MZ700 and Spectrum software packages in the UK. The most important of which is Hu-Basic and Hu-Cal.

GEC Computers has been selected to supply hardware for the second phase of British Telecom's Prestel Service.

Avon Direct Mail Services, is to install a Rediffusion R2800 Telecentre system.

RAIL LINK

Following successful trials of a Westinghouse "Westronic System Two" data link installed between East Finchley station and Cobourg Street control centre, London Transport has ordered a further nine links for installation on the Northern Line between High Barnet and Kennington.

BIASED REPORT

Recording-tape manufacturers throughout the Common Market are taking a lead from Britain. A UK call for immediate action to stop the European Parliament imposing levies on sales of blank audio and video recording tape has been fully accepted by manufacturers in member states.

At an international conference in Brussels, staged by the UK "Tape Manufacturers' Group" (TMG) last month, delegates from France, Germany, Italy, Belgium, Denmark and the Netherlands all agreed to campaign in their own countries and on a united basis amongst European parliamentarians . . . just as British manufacturers have been campaigning since May 1981.

Their first task is to expose the "total bias and inadequacy" of a report, requested by the EEC, which could force consumers to pay more than double the present retail costs for recording tape.

Entitled, "The Private Copying of Sound and Audio-Visual Recordings", the report calls for levies of one EEC currency unit (61p Sterling) per playing hour on sales of blank audio tape and three currency units per playing hour on blank video tape. In addition, Value Added Tax would be payable on the costs of the levies as well as on the costs of the recording tape. That would mean that a one-and-a-half-hour C90 audio cassette, at present retailing for 90p, would have an over-the-counter cost of about £1.80. And a three-hour E180 video cassette, currently retailing at around £5.30, would sell for upwards of £10.60.

The report was prepared by the International Federation of Phonogram and Videogram Producers (IFPI)—the very people who would receive the money raised by levies.

Leader of the British initiative, TMG Chairman, Mr. Bill Fulton (MD of Sony UK) said after the conference: "I'm delighted. We came here to make the case for immediate, united action and response has been magnificent. The degree of co-operation here is remarkable. Our mission has been a complete success."

Condemning the controversial report requested by the EEC, Mr. Fulton stressed: *"It is a totally biased document, compiled without consulting consumer protection groups or, indeed, anyone except the people who would benefit from the imposition of levies; in other words the music and film industries.*

"What is needed is a genuinely impartial analysis of the situation by a totally independent body, experienced in preparing such documents."

As this is a subject of very controversial opinions, our *Readers' Letters* page is open to all interested parties to record their own personal "soundings".

EXTRA 1K RAM FOR THE ACORN ATOM

BY A. J. PRESNAIL

THE basic Acorn Atom RAM is made up from 2114 static memory devices. These are 1024 × 4-bit chips and are arranged in pairs in the Atom to yield 1024 × 8-bit blocks.

An extra 1K of RAM can easily be added to the Acorn Atom without a great deal of difficulty. All that is needed is experience with a soldering iron.

This extra 1K of RAM will be located between the maximum on-board memory (at hex 3BFF) and the start of off-board memory (at hex 4000).

This is accomplished by soldering two extra 2114s directly on top of two existing 2114s, IC10 and IC11 of the Atom circuitry; the pins are soldered in parallel with those of the existing chips except for pin 8 of each which connects to other parts of the Atom circuitry.

CIRCUIT DIAGRAM

The circuit diagram of the expansion is shown in Fig. 1. Pin 8 of IC1 and IC2 (the "chip select" pins, $\overline{CS}$) are connected together and also to IC5 pin 1 and IC6 pin 7. The remainder of the lead-outs are in parallel with the on-board RAM chips.

IC5 pin 1 and IC6 pin 7 must be disconnected from the Atom p.c.b. This is easily achieved by bending up the i.c. pin so that it sits out of its socket.

IC6 selects these new memory chips between locations hex 3C00 and hex 3FFF. Pin 1 of IC5 connects to pin 7 of IC6 to disable the locations from being accessed by the off-card buffers.

CONSTRUCTION PROCEDURE

(1) Carefully remove IC6 from its socket and bend out pin 7.

(2) Remove IC5 and bend out pin 1.

(3) Remove IC10 and IC11.

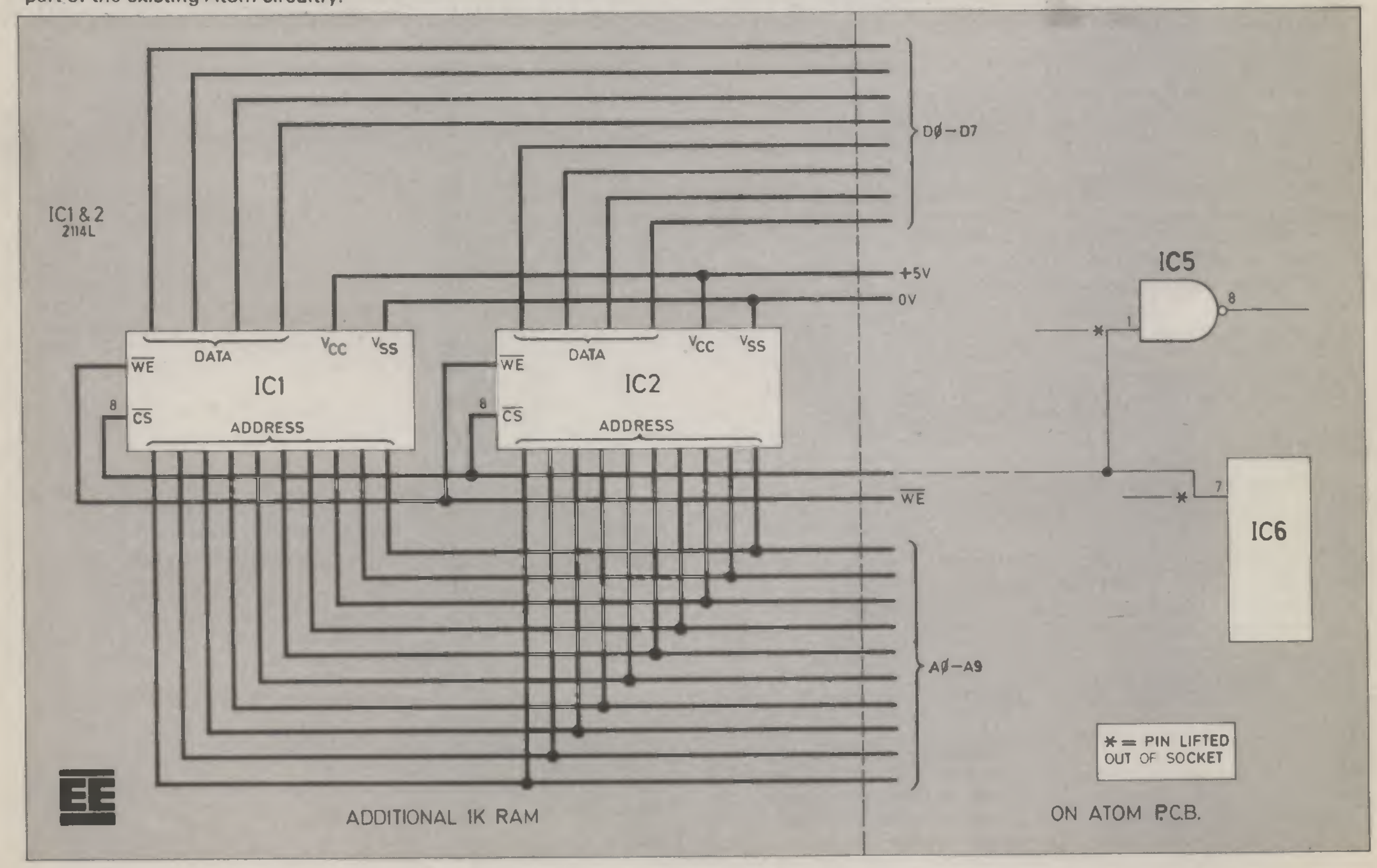
(4) Bend out pin 8 on both of the new memory chips and then place these new chips over the two removed 2114s, IC10 and IC11, and carefully, with a small soldering iron, solder the two chips together.

(5) Connect a wire to pin 7 of IC6, another to pin 1 of IC5 and one to each pin 8 of the new memory chips. Cut the wires to a convenient length, strip their ends, twist together and solder. Slide a short length of sleeving over the connection to prevent it shorting on any other part of the circuitry.

(6) Re-insert all the chips into their respective sockets.

(7) Run the Memory Test given below.

Fig. 1. Circuit diagram of the 1K RAM expansion for the Acorn Atom. IC1 and IC2 are the additional 2114 static memories; IC5 and IC6 are part of the existing Atom circuitry.

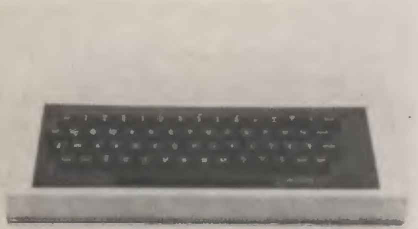


MEMORY TEST

```
10  F.A=0 TO 255;F.X=#3C00 TO #3FFF
20  ?X=A;N.
30  F.X=#3C00 TO #3FFF
40  IF?X<>A P.&?X,"AT
    "&X,"SHOULD BE",&A'
50  N.;N.;E.
```

If all is well the program should run and end without any errors.

If however errors are printed out, by examining the printout you should be able to tell where the problem is. □



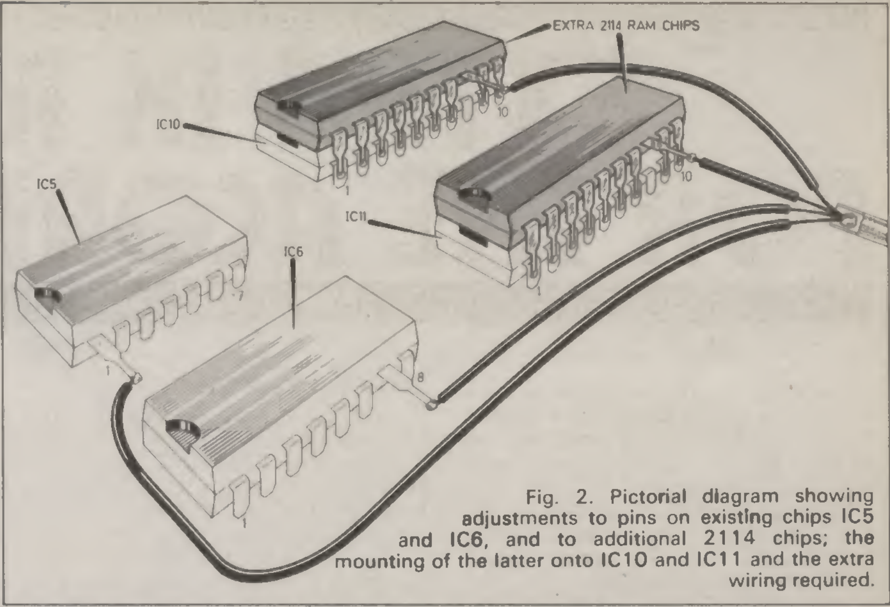


Fig. 2. Pictorial diagram showing adjustments to pins on existing chips IC5 and IC6, and to additional 2114 chips; the mounting of the latter onto IC10 and IC11 and the extra wiring required.

EXTRA UTILITY PROM FOR THE ACORN ATOM

BY A. J. PRESNAIL

THE Atom only has one EPROM socket for utility PROMS which can be a disadvantage if you have more than one EPROM to go into it, for example, Wordpac, Toolkit, etc., since you have to power off and open the Atom's case to change the EPROM.

A simple solution to this would be to parallel two sockets from the Acorns with a switch on the select lines, but a better way would be to select the PROMS by software or from the keyboard.

The following circuit allows up to eight EPROMS to be selected, or with an additional i.c. it can select 16.

DESCRIPTION

IC1 pin 14 goes low if an address in the range hex 9000 to 9FFF is written to, or read from.

IC2 pin 8 goes low if an address in the range hex XFF0 to XFFF is selected.

These two lines are NORed together by IC4 which when ANDed with clock 2 (ø2) by IC3 enables the latch IC5. This means that IC5 is enabled in the range 9FF0 to 9FFF, which is not normally used in the Atom.

When IC5 is enabled the address lines A0 to A3 are latched into IC5 to become LA0 to LA3, these outputs will stay at their latched levels until IC5 is again enabled or the power is turned off.

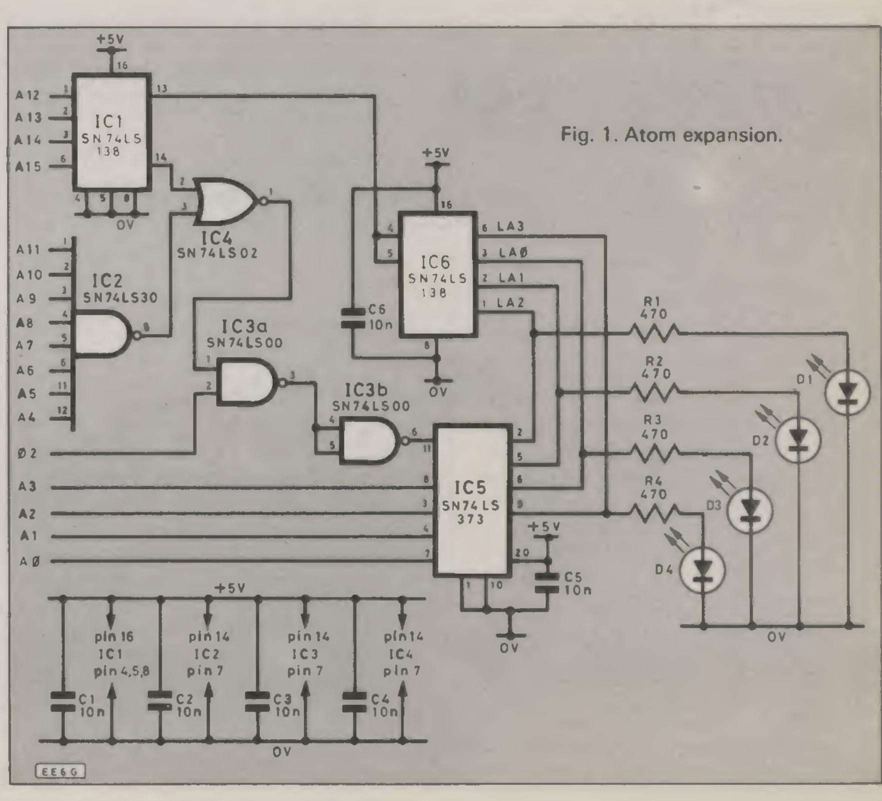


Fig. 1. Atom expansion.

Table 1. EPROM Socket Pin 20 to IC6 or IC7

Prom Address	IC6 Pin	Prom Address	IC7 Pin
9FF8	15	9FF0	15
9FF9	14	9FF1	14
9FFA	13	9FF2	13
9FFB	12	9FF3	12
9FFC	11	9FF4	11
9FFD	10	9FF5	10
9FFE	9	9FF6	9
9FFF	7	9FF7	7

Table 2. Atom Output Bus Connector Pins

+5V	a1
0V	a32
A0	a15
A1	a14
A2	a13
A3	a12
A4	a11
A5	a10
A6	a9
A7	a8
A8	a7
A9	a28
A10	a27
A11	a26
A12	a25
A13	a24
A14	a3
A15	a2
D0	a23
D1	a22
D2	a21
D3	a20
D4	a19
D5	a18
D6	a17
D7	a16
clock 2(ø2)	a29

COMPONENTS

Resistors
R1–4 470Ω (4 off)

Capacitors
C1–7 10nF (7 off)

Semiconductors
IC1,6,7* SN74LS138 (3 off)
IC2 SN74LS30
IC3 SN74LS00
IC4 SN74LS02
IC5 SN74LS373
D1–4 Any l.e.d.s (4 off)

Miscellaneous
i.c. or socket
24-pin i.c. socket
SN74LS08 i.c. for Atom mod.

*IC7 only necessary if greater than eight EPROMs required.

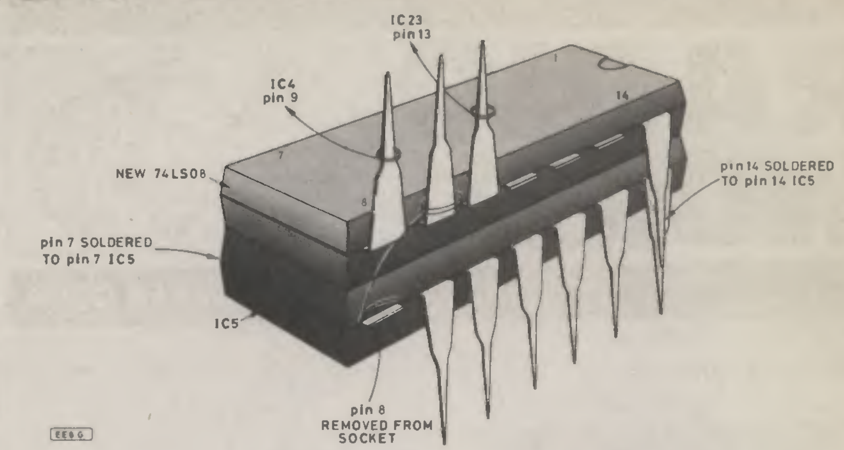


Fig. 2. Pins 1 to 6 and pins 11 to 13 of the new 74LS08 must be bent away from IC5's pins.

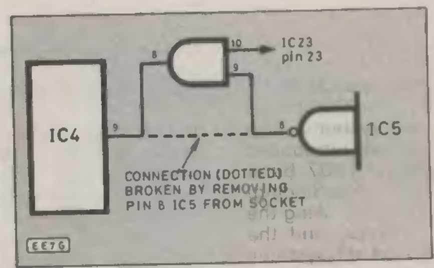


Fig. 3. Modification to allow Utility PROM (address AXXX) to appear on the output bus (i.c. numbers refer to the Atom's main p.c.b. i.c.s).

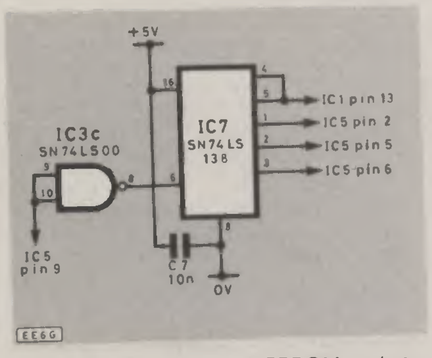
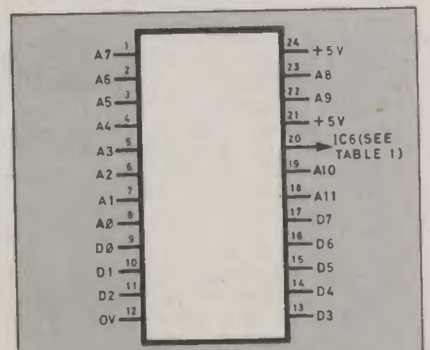


Fig. 4. Modification for 16 EPROM sockets.



Duplicated for each socket required.

When an address in the range A000 to AFFF is read from, or written to, pin 13 of IC1 goes low and in turn selects one of the outputs of IC6. Which output is selected depends on the binary code on latched lines LA0 to LA3, which must be between 8 and hex F. The l.e.d.s will display the binary code that is latched.

MODIFICATION FOR 16 EPROMS

By inverting LA3 with one of the spare NAND gates (for example, pins 8, 9, 10 of IC4) and then repeating the wiring as for IC6 an extra eight EPROMS can be selected, their address would be 9FF0 to 9FF7.

MODIFICATION REQUIRED TO THE ATOM MAIN PCB

Because Addresses A000 to AFFF are normally only present on the main p.c.b. a small modification has to be undertaken. This requires that IC5 of the Atom has to be removed from its holder and pin 8 bent out, a 74LS08 then has to be placed over this chip so that pins 7 and 14 can be soldered. Pin 8 of IC5 has to be connected to pin 9 of the 74LS00 and pin 10 of the 74LS08 has to be connected to pin 13 of IC23. Pin 8 of the new 74LS08 now has to be connected to pin 9 of IC4. Replace IC5 into its socket. □

RADIO WORLD

BY PAT HAWKER G3VA

Finding Directions

Radio navigational techniques have come a long way since their early use, now dating back more than 70 years, of the simple loop aerial. This, when combined with triangulation on two or more transmitters, was already in use before the first World War.

One of the first scientists to become interested in the directional properties of radio was Professor Frederick Braun, inventor in 1897 of the "cathode-ray indicator tube", that was later to become such an important component not only for TV but also for many radio-navigational systems. Two Italians, E. Bellini and A. Tosi, introduced the idea of using fixed aerials in 1907, but it was the wide use of d/f (direction finding) techniques, in World War I, for tracking the movement of warships, airships, and the like, that raised the status of d/f systems and resulted in reliable equipments.

Similarly World War II gave a further impetus to d/f and also saw the development of the pulsed hyperbolic systems such as Gee, Loran and Decca for accurate radio-navigation.

Bird Sense

But radio navigators have always looked with interest and puzzlement at the natural navigational abilities and compass sense of birds and animals.

Over the past decades many attempts have been made to determine just how some birds are able to navigate so accurately over enormous distances. There is now good evidence that the compass sense of birds is based on a combination of celestrial and geomagnetic cues.

The celestrial cues are provided by the Sun, sunset, skylight polarisation pattern and stars much as in classic astro-navigation. More puzzling, and for a long time more controversial, are the natural "magnetic compasses", yet there is good and convincing evidence that young birds, particularly before the full development of their celestrial compass, do possess a magnetic sense that they use, if only to "calibrate" their Sun compasses.

Further evidence of the role of the geomagnetic field has come from experiments carried out at the University of Lund in Sweden. Scientists deliberately "shifted" the magnetic field at the nesting boxes of Pied Flycatchers and have been able to show that a corresponding shift was still occurring two months later.

This was done using large Helmholtz coils energised from 12-volt batteries throughout the incubation period of the eggs and the subsequent nestling periods (about one month in all). Control birds had no coils attached to their nesting boxes and showed no sign of any anomalies in their navigation. Fully-grown birds seem to depend much more on their "Sun compass" than on magnetic fields.

Auto-route

Engineers for several decades have sought to develop navigational systems that would provide guidance to car drivers in urban or rural areas or for cross-country journeys, seeking to replace map-reading or stopping to ask the way.

While various systems of vehicle position location and guidance have been developed most of these have postulated the use of buried inductive loops or radio transmitters, and would be expensive to install. The latest system, "Autoscout" has been developed by Siemens and Volkswagenwerk in West Germany, and is currently undergoing field trials in Wolfsburg.

This uses low-cost infra-red transmitters, basically similar to those used in many TV remote-control units, installed on traffic-lights. They act as beacons providing to the vehicles a stream of data on main roads in the area.

The vehicle has a microprocessor-controlled, dashboard-mounted, control unit with display and keypad, and also a magnetic field sensor mounted under the car roof which acts as a "compass", with circuitry that is claimed to correct errors due to surrounding metal and similar objects. Distance pulses are fed into the control unit from the vehicle's speedometer, providing direction and line-of-sight distance data.

The control unit can operate independently of the infra-red beacons to display distance and direction; however, in conjunction with the local information provided by the beacons it can guide a driver to the destination programmed by the keypad into the control unit, including detours or other local routeing information. Autoscout can even direct the driver to a specific building, garage, or parking space using information from the local beacons.

The vehicle unit, in volume production, would cost about the same as a good car radio. All traffic lights at a major intersection could be equipped at under £1500.

Sounds good, but how far is it away from a completely "guided" vehicle in which the "driver" becomes merely a passenger?

Shoot Out

Some people regard particular TV and radio presenters less than enthusiastically but usually express their dislike by means of a channel switch. But Jerry Dunphy, a 62-year-old TV "news anchor" in Los Angeles for more than 20 years, together with a woman make-up artist, were victims of a shooting incident last Autumn.

Both were shot, Jerry Dunphy seriously, while returning to the studios of KABC-TV, Hollywood, after a meal. The police, however, believe it to have been a random act of violence rather than the action of a TV critic.

However, in nearby Monterey a man first fired several shots over the head of a radio disc jockey and then scattered some 58 shotgun rounds into the equipment, including the record that was being played. When arrested, the suspect claimed that KWAV-FM was "poisoning his mind".

Voice from Space

The success of the long-awaited operation of a 144MHz amateur-radio hand-held transceiver by Dr. Garriott, W5LFL, aboard the "Columbia" Space Shuttle early December, focused much media publicity on the hobby.

Whether it added much to anybody's technical knowledge of space communications is more doubtful, though it certainly showed that a low-power v.h.f. rig can easily span over 250km when the curvature of the Earth or the local topography does not get in the way. Dr. Garriott taped the incoming calls from amateurs to sort out on the ground, all a bit like the airborne "Jean-Eleanor" v.h.f. equipment used by the Americans during the closing stages of World War II when they were able to wire-record messages from their agents in Germany.

Chatter Box

The silicon revolution in the form of ultra large-scale integrated circuits means that it is already possible to put nearly one-million components on a single silicon chip for such purposes as providing large electronic memories. Over the past two decades this represents an increase of some 100,000 times on the first integrated circuits—and equally important a corresponding decrease in terms of "cost per transistor" to the level where this amounts to only about one-thousandth of a penny.

But at a recent Mountbatten lecture of the National Electronics Council, Dr. Ian Ross, president of the famous Bell Laboratories, confidently predicted that we still have a long way to go before we reach the end of this road. After carefully analysing all the ultimate limiting factors, he foresaw development over the next two decades of devices with 1000-million (an American billion) components on a single 1-inch chip, operating from a 1-volt supply, and suitable, because of the miniscule dimensions of the components, of acting at speeds of about 10 picoseconds.

"Micro-electronics is merely at the half-way point," he said, though he seemed a little less certain of what will be done with such complexity. He mentioned computers for language translation, for weather forecasting, for the prediction of the land-fall of hurricanes—and computers that can be programmed just by talking to them. Indeed, he feels there is a need to make computers more "user-friendly" so that ultimately it should be possible to hold a fluent discourse with a computer.

It sounds to me a bit like having a chat with your accountant, wondering all the time what he is really thinking. With individual computer-designed dolls sweeping America I wish I could be as enthusiastic as Dr. Ross about a world in which one is liable to be nagged by a computer!

A Black Box Project

MASTERMIND TIMER

As the title suggests, this is a timer which can be used to give the similar conditions to a contestant as in the BBC's Mastermind quiz. After switching on the unit and pressing the reset button, a delay is in effect (variable from one to two minutes), after this time the familiar bleep-bleep will sound signifying the end of the required time. It can also be used for other games such as chess or draughts to give a time limit for each move.

CIRCUIT DESCRIPTION

The circuit diagram of the Timer is shown in Fig. 1. The first time period is based around IC1, a 555 timer. This is wired up as a resettable monostable multivibrator; this can be stopped in the middle of a cycle and re-started again by pressing S1.

This connects the trigger input and reset pins to ground, creating a negative-going pulse (positive to ground transition) as the pins were previously held high by R1. If a negative-going pulse appears at this input then the timing capacitor C2 will be discharged, resetting the cycle.

The output from this i.c. (pin 3) is connected to pin 12 and pin 13 on IC2a and is inverted by the Schmitt trigger action of this NAND gate. The output pin 11 is connected to input pin 9 on IC2b. The other two gates are made up as two oscillators; one being controlled by the other. The oscillator based around R3, C4 (IC2d) is approximately 0·5Hz; this switches on and off the oscillator based around R4, C3 (IC2c); this has a frequency of about 3kHz approximately.

The output of IC2c goes to the other input of gate IC2b. When the condition arises that IC1 output (pin 3) goes low then IC2a goes high; this makes input pin 9 high and so whatever appears at the input (pin 8), will appear at the output (pin 10); in this case half second bursts of a high frequency squarewave (see Fig. 2). This is then fed to the output speaker via C1. The sound level is quite adequate for this circuit as long as the earpiece is used. The current drain on the battery is approximately 4·5mA on standby and 18mA to 20mA when bleeping.

CONSTRUCTION

All the components should be mounted on the Veroboard as shown in Fig. 3. It was found best to solder in the i.c. sockets first as this provides a location to base all the other components and links. IC1 can be soldered in directly if the constructor feels confident enough, otherwise an 8-pin socket should be used.

Note that C1 is fitted lying flat against the board to allow room for all the components and the board to fit into the case.

ALL DESIGNS FEATURED IN THE BLACK BOX SERIES WILL USE THE SAME BLACK PLASTICS CASE AND SAME SIZE PIECE OF STRIPBOARD

Fig. 1. Circuit diagram of the Mastermind Timer.

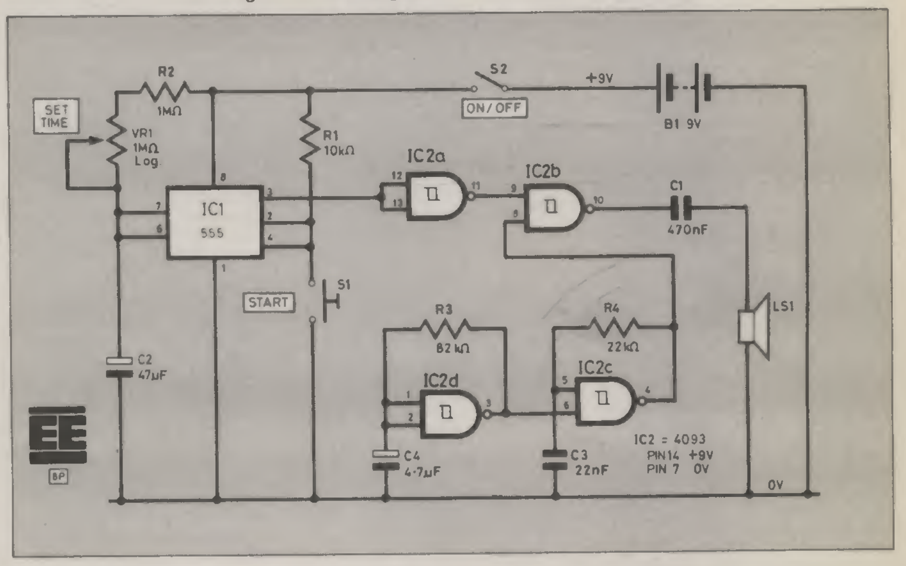
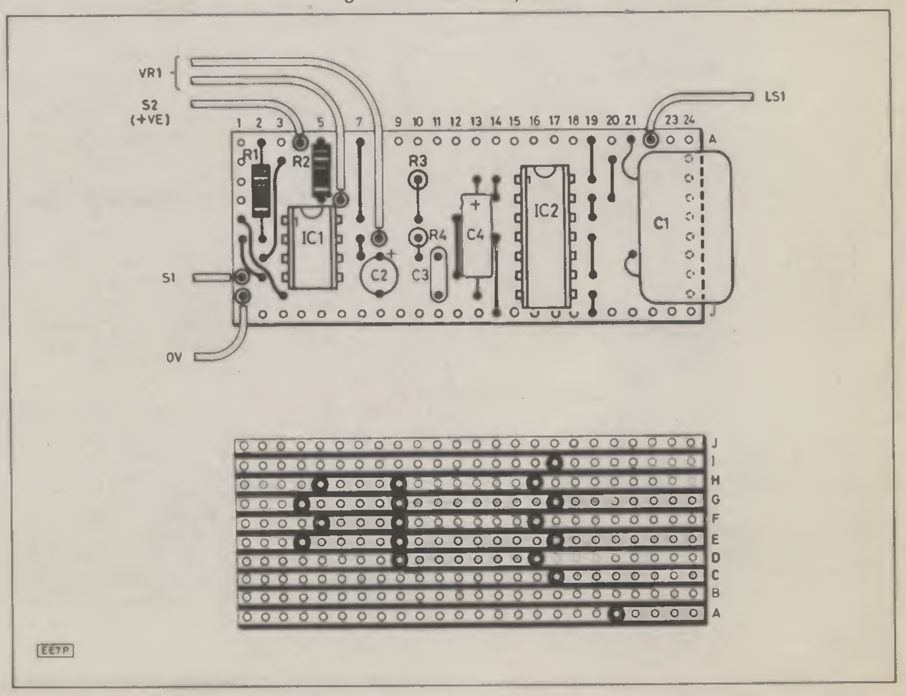


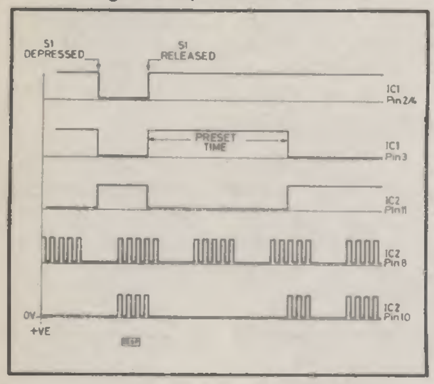
Fig. 3. Veroboard layout.



ER

BY L. A. PRIVETT

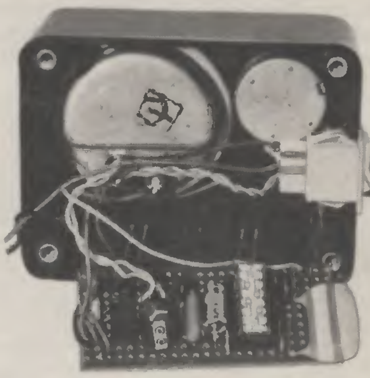
Fig. 2. Output waveforms.



Both switches were fixed to the top of the box (Fig. 4) while the speaker was glued to the front after drilling suitable holes; VR1 is also mounted on the front panel and is held by its own fixing nut. Cardboard can be used to insulate the battery from the rest of the circuit. When placing IC2 into its socket normal CMOS precautions should be taken.

TESTING

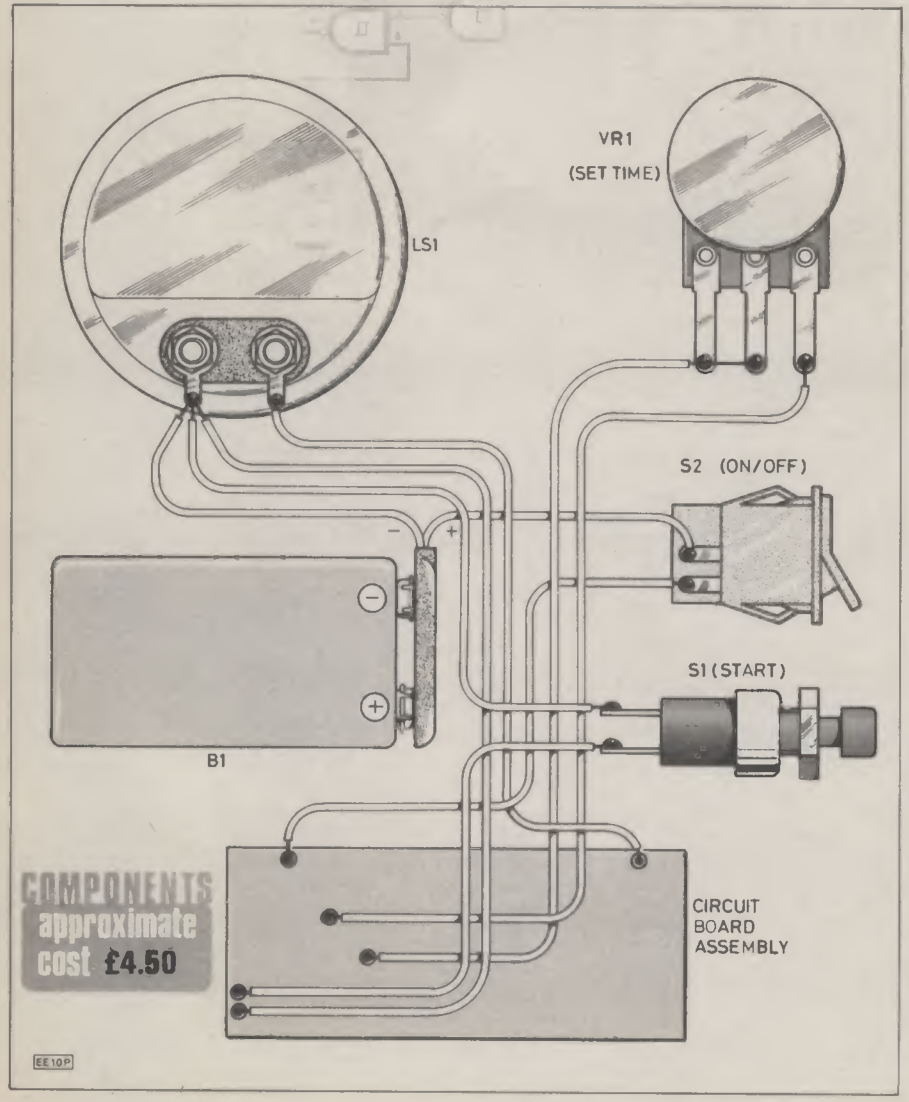
Insert battery; switch on; the bleep may sound depending on the condition of C2. Pressing S1 will sound the bleep-bleep and upon releasing, the sound will be extinguished for the time period set by VR1 (between one and two minutes).



Internal view of the Timer.

After the preset time the familiar sound should be heard and will continue until switched off by S2. For games such as chess then each player has a set time to make his move; after which he then presses S1 and so resetting the time for his or her opponent. As to whether the move has to be made before any sound is heard or within so many bleeps is up to the players making the rules. □

Fig. 4. Wiring diagram.



COMPONENTS

Resistors

R1	10kΩ
R2	1MΩ
R3	82kΩ
R4	22kΩ
VR1	1MΩ log. carbon pot.

All resistors $\frac{1}{4}$W carbon ±5%

Capacitors

C1	470nF
C2	47μF 16V electrolytic radial
C3	22nF polyester
C4	4·7μF 25V electrolytic

Semiconductors

IC1	555 timer
IC2	4093 quad 2-input NAND

Miscellaneous

S1	push-to-make single pole
S2	on/off toggle

Veroboard; case 80 x 61 x 41mm; PP3 battery connector; 14-pin i.c. socket; knob for VR1; wire and cable for on and off board links; (LS1) telephone ear-piece; (B1) PP3 battery.

LETTERS

Clearing the Air

Sir—It is to be regretted that your contributor A. Flind was not better informed on the question of ozone generation from ionisers. As a direct consequence he has caused considerable concern to a number of our clients who have purchased ionisers for the treatment of asthma (see *Negative Ion Generator,* February issue.)

We trust that you will make space available to offer the reassurance afforded by the following:

1) Whilst a number of early ionisers (particularly American models) generated considerable quantities of ozone, techniques to overcome this were developed and patented in the UK by Medion some 15 years ago.

2) Since then all Medion Ionisers and many other models utilising these design features have been free of ozone. Independent or government tests in the UK, USA, Canada and Australia have all confirmed that, at distances of four or more inches from the ion-emitters, ozone densities do not exceed 1 part in 2000 million. This is less than the natural background level which exists in clean air and is, in fact, less than can be detected by the most sophisticated equipment currently available.

3) Ozone is not produced purely as a function of the voltage applied to a needle tip, but by the employment of too high a field intensity. This would almost certainly be the case with the published design where an earthed lead is positioned only 5mm from needles with voltages of 7kV to 8kV.

4) It should be appreciated that any ioniser can be induced to produce ozone if an earthy object comes close to the needles, and *this includes the human nose.* Sniffing close to an ioniser gives no indication whatever of ozone emission under normal usage. Perhaps the simplest way to confirm this is to sniff the air when first entering a room with an ioniser. The "electric motor" smell of ozone will be quite apparent if it is present.

5) The author suggests that ozone is linked to output voltage and that it seems to be higher at about 3·5kV and above 8kV. We can assure readers that this simply is not so and wonder how this conclusion was reached.

6) It should be appreciated that research into various therapeutic effects of negative ions has been conducted in many parts of the world since before the last war. Many of the results of controlled trials have been outstanding, particularly with all kinds of respiratory disorders and tension conditions.

Julian P. Laws,
Manager—Environmental Division,
Medion Limited,
Old Oxted,
Surrey.

Firstly, the disparaging remarks about some commercially made ionisers were not intended to apply to the products of Medion, a reputable firm specialising in them. Indeed this company's name is not mentioned anywhere in my article. Nevertheless, I hope Medion will accept my apologies for any inconvenience that may have been caused unintentionally.

The fact is that for some years it was possible to assemble a transformer with half a dozen diodes and capacitors into a box and sell the result for £80 or more, and this not unnaturally attracted a few "cowboys". This led to sub-standard ionisers being sold.

Field intensity, and thus ion and ozone production, seems to be related to voltage, area and the proximity of earthy conductive objects. If the voltage is high enough it must exceed a point where ozone is emitted directly into the atmosphere, regardless of the other factors.

The earthed wire in my design is some distance from the needle tips where the field intensity is supposed to be at its highest. Over a long period of use I have never encountered any smells of ozone except, as Medion suggest, when taking a good sniff very close to the needles.

I hope this will set the minds of both Medion's customers and constructors at rest.

A. Flind.

Vanishing Tardis

Sir—As an ardent viewer of the BBC TV series *Dr. Who,* I am pleased to see that the instrumentation used by so many planets' civilisations rely on meters, lamps and switches of European manufacture.

Obviously our electronic and electrical industries advertising and sales teams have achieved results "out of this world". But why haven't we heard about this from the firms themselves?

Is there a straightforward answer or are my suspicions likely to be proved correct. Have the aliens been secretly stealing our best designs from inside the Tardis!!! Would they dare steal from a British Police Box!

Mind you, rumour has it that the Tardis will "change" in the underwater series. The police box is retiring because "children no longer understand what a police box is!" Viewers in other countries have lived with this problem since the first series in 1963 . . . and have accepted this rare British customised police "vehicle" with the blue flashing light on top warning of its imminent disappearance.

How true. Very few are now visible in the UK. Although a very slim Dr. Who might be able to make use of London's Metropolitan Police call boxes: the door does seem very small though.

Doesn't Dr. Who understand that parents and grandparents remember with pride the old "Tardis" in their village or town and enjoy telling the children what they were for, or is the doctor happy in the knowledge that the generation gap will widen?

Derek Gooding,
London.

Help the Handicapped

Sir—I am compiling a catalogue of programs and hardware available to help the handicapped make use of a Micro and would be very glad to hear from anyone who has developed or knows of such "aids".

In particular programs or devices to help the severely handicapped to communicate or to control their environment, for instance, controlling domestic appliances, opening doors, turning book pages and so on.

Dr. Lionel Wardle,
c/o M.A.P.S. Ltd.,
37 University Road,
Southampton, SO2 1TL.

Mini-Roulette

Sir—I wish to draw readers' attention to my circuit for a "Mini-Roulette" published on the *Circuit Exchange* page in the February 1984 issue.

The wire from pin 13 of IC2 (4017) should run to the cathode of D1 *not* to battery negative.

The wire from TR1 collector should run to battery negative *not* to the cathode of D1.

J. Wood,
West Lothian,
Scotland.

The BBC assures us that there are no immediate plans to retire the "Tardis" and it will appear throughout 1984–5. Apparently the speculation was sparked off by a comment made by the programme's producer when he suggested the Dr. Who team might need to consider the relevance of the police box style in an age when few children see them.—Ed.

"Tardis" photo courtesy of BBC

ENFIELD ELECTRONICS

208 Baker Street, Enfield, Middlesex. EN1 3JY. Tel: 01-366 1873

Access — BARCLAYCARD VISA

TRANSISTORS

				BF198	14p	TIP29C	45p	2N1304	80p
				BF199	14p	TIP30A	40p	2N1305	80p
				BF200	35p	TIP30B	50p	2N1307	70p
AC125	30p	BC183C	12p	BF224B	20p	TIP30C	45p	2N1308	80p
AC126	30p	BC183L	12p	BF244B	35p	TIP31	38p	2N1613	36p
AC127	30p	BC183LB	12p	BF256	35p	TIP31A	40p	2N2222A	30p
AC128	30p	BC184	12p	BF257	35p	TIP31B	40p	2N2369A	28p
AC132	90p	BC184B	12p	BF258	35p	TIP31C	45p	2N2646	68p
AC141	30p	BC184L	12p	BF259	35p	TIP32A	40p	2N2904A/5A	30p
AC142	30p	BC186	30p	BF594	40p	TIP32C	40p	2N2906A	60p
AC176	30p	BC187	30p	BF595	30p	TIP36C	140p	2N2907A	30p
AC187	30p	BC212A	14p	BFR39	20p	TIP41A	50p	2N2926G	12p
AC188	30p	BC212L	12p	BFR79	30p	TIP41B	50p	2N2926R	12p
AD149	80p	BC213	12p	BFR80	30p	TIP42A	60p	2N2926Y	12p
AD161	45p	BC213B	12p	BFX29	30p	TIP42B	65p	2N3053	30p
AD162	45p	BC213L	12p	BFX84	30p	TIP120	80p	2N3054	75p
BC107	12p	BC214	12p	BFX85	30p	TIP121	80p	2N3055E	60p
BC107A	14p	BC214B	14p	BFX87	30p	TIP142	120p	2N3442	150p
BC107B	14p	BC214L	12p	BFX88	30p	TIP2955	70p	2N3615	200p
BC108	12p	BC237	18p	BFY50	28p	TIS43	36p	2N3702	12p
BC108A	14p	BC238B	18p	BFY51	25p	TIS44	40p	2N3703	12p
BC108B	14p	BC307	18p	BFY52	25p	TIS90	30p	2N3704	12p
BC108C	14p	BC308	16p	BFY90	80p	TIS91	30p	2N3705	12p
BC109	12p	BC327	16p	BRY39	40p	VN10KMA	75p	2N3706	12p
BC109B	14p	BC328	16p	BSX20	30p	VN66AF	95p	2N3707	12p
BC109C	14p	BC337	16p	BSX29	35p	VN88AF	110p	2N3708	12p
BC140	35p	BC338	16p	BU105	170p	ZTX107	12p	2N3710	12p
BC141	35p	BC441	36p	BU205	200p	ZTX108	12p	2N3711	12p
BC142	35p	BC461	36p	BU208A	220p	ZTX109	12p	2N3771	200p
BC143	35p	BC477	40p	MJ2955	90p	ZTX300	15p	2N3772	200p
BC147	12p	BC478	40p	MJE340	50p	ZTX301	18p	2N3773	200p
BC148	12p	BC517	45p	MJE371	90p	ZTX302	20p	2N3819	25p
BC157	12p	BC547	15p	MJE2955	110p	ZTX303	20p	2N3820	45p
BC158	12p	BC548	15p	MJE3055T	80p	ZTX304	20p	2N3823	50p
BC159	12p	BC549	16p	MPSA06	25p	ZTX330	35p	2N3866	100p
BC160	50p	BC556	20p	MPSA56	30p	ZTX500	18p	2N3903	15p
BC161	45p	BC557	16p	MPSU05	65p	ZTX501	18p	2N3904	15p
BC167	15p	BC558	16p	MPSU56	60p	ZTX502	18p	2N3905	15p
BC168	12p	BC559	16p	OC22	150p	ZTX503	18p	2N3906	15p
BC169	12p	BCY70	20p	OC23	150p	ZTX504	30p	2N5172	30p
BC170	20p	BCY71	20p	OC26	100p	ZTX531	30p	2N5194	80p
BC171	13p	BCY72	23p	OC28	200p	ZTX550	35p	2N5457	42p
BC172A	12p	BD131	50p	OC36	220p	2N696	35p	2N5458	48p
BC173	13p	BD132	50p	OC41	75p	2N698	40p	3N128	85p
BC177	20p	BD133	60p	OC42	75p	2N699	40p	3N140	85p
BC178	20p	BD135	40p	OC70	60p	2N706A	20p	3N141	85p
BC179	25p	BD136	40p	OC76	60p	2N708	30p	3N163	110p
BC181	23p	BD137	40p	OC81	60p	2N914	36p	3N201	110p
BC182	12p	BD138	40p	OC82	60p	2N918	30p	3N202	125p
BC182B	14p	BD139	45p	OC84	50p	2N930	30p	40406	80p
BC182L	12p	BD140	45p	TIP29	30p	2N1131	30p	40407	80p
BC183	12p	BF194	14p	TIP29A	35p	2N1132	30p		
BC183B	12p	BF195	14p	TIP29B	50p	2N1303	80p		

TTL

		7417	28p	7447	75p	7486	35p	74119	70p	74160	65p	74190	58p
		7420	20p	7448	55p	7489	140p	74121	35p	74161	55p	74191	55p
		7422	28p	7450	21p	7490	37p	74122	41p	74162	46p	74192	55p
7400	18p	7425	28p	7451	20p	7491	45p	74123	41p	74163	46p	74193	55p
7401	18p	7426	28p	4753	21p	7492	40p	74126	70p	74164	46p	74194	52p
7402	18p	7427	30p	7454	21p	7493	41p	74132	65p	74165	60p	74195	52p
7403	18p	7428	30p	7460	21p	7494	41p	74135	50p	74166	60p	74196	55p
7404	18p	7430	26p	7470	25p	7495	41p	74141	51p	74167	185p	74197	55p
7405	18p	7432	26p	7472	25p	7496	41p	74144	250p	74170	195p	74198	95p
7406	32p	7433	35p	7473	30p	7497	60p	74145	575p	74173	120p	74199	95p
7407	32p	7437	30p	7474	35p	74100	95p	74147	125p	74174	65p	74221	60p
7408	25p	7438	30p	7475	40p	74104	58p	74148	65p	74175	65p	74279	60p
7409	25p	7440	23p	7476	35p	74105	58p	74150	70p	74176	46p	74284	95p
7410	18p	7441	51p	7480	30p	74107	30p	74151	46p	74177	55p	74285	95p
7411	25p	7442	40p	7481	110p	74109	30p	74153	46p	74180	50p	74366	64p
7412	26p	7443	71p	7482	70p	74110	41p	74154	81p	74181	121p	74390	325p
7413	26p	7444	95p	7483	58p	74111	70p	74155	46p	74182	70p	74393	100p
7414	37p	7445	71p	7484	81p	74116	70p	74156	46p	74184	105p		
7416	28p	7446	71p	7485	71p	74118	65p	74157	35p	74185	105p		

LS TTL

		74LS27	21p	74LS83	51p	74LS138	40p	74LS169	98p	74LS243	81p	74LS293	46p
		74LS28	21p	74LS85	52p	74LS139	39p	74LS170	86p	74LS244	65p	74LS353	71p
74LS00	17p	74LS30	21p	74LS86	23p	74LS147	121p	74LS173	63p	74LS245	86p	74LS362	110p
74LS01	17p	74LS32	21p	74LS90	39p	74LS148	86p	74LS174	58p	74LS247	65p	74LS365	35p
74LS02	17p	74LS33	21p	74LS93	35p	74LS151	46p	74LS175	52p	74LS248	66p	74LS366	35p
74LS04	17p	74LS37	21p	74LS95	46p	74LS153	52p	74LS181	115p	74LS249	66p	74LS367	35p
74LS05	17p	74LS38	21p	74LS96	109p	74LS154	120p	74LS183	201p	74LS251	40p	74LS368	35p
74LS08	18p	74LS40	21p	74LS107	46p	74LS155	46p	74LS190	58p	74LS253	46p	74LS373	70p
74LS09	20p	74LS42	37p	74LS109	35p	74LS156	46p	74LS191	55p	74LS257	40p	74LS374	70p
74LS10	20p	74LS49	63p	74LS112	32p	74LS157	40p	74LS192	55p	74LS258	43p	74LS375	52p
74LS11	20p	74LS51	21p	74LS113		74LS158	40p	74LS193	55p	74LS259	67p	74LS386	130p
74LS12	23p	74LS54	21p	74LS114	32p	74LS160	40p	74LS194	52p	74LS260	30p	74LS390	55p
74LS13	28p	74LS55	21p	74LS122	46p	74LS161	40p	74LS195	52p	74LS266	32p	74LS393	55p
74LS14	32p	74LS63	138p	74LS123	46p	74LS162	40p	74LS196	52p	74LS273	63p	74LS395	98p
74LS15	21p	74LS73	25p	74LS124	166p	74LS163	43p	74LS197	52p	74LS275	145p	74LS398	310p
74LS20	21p	74LS74	25p	74LS125	37p	74LS164	48p	74LS221	63p	74LS279	40p	74LS541	130p
74LS21	21p	74LS75	28p	74LS126	35p	74LS165	60p	74LS240	81p	74LS280	110p	74LS629	200p
74LS22	21p	74LS76	25p	74LS132	41p	74LS166	81p	74LS241	75p	74LS283	46p	74LS669	160p
74LS26	21p	74LS78	25p	74LS136	28p	74LS168	97p	74LS242	80p	74LS290	60p	74LS670	120p

CMOS

		CD4015	46p	CD4035	55p	CD4054	100p	CD4093	40p	CD4503	46p	CD4569	80p
		CD4016	30p	CD4038	125p	CD4060	80p	CD4099	140p	CD4511	52p	CD4572	80p
		CD4017	40p	CD4040	50p	CD4066	30p	CD4160	75p	CD4512	60p	CD4581	80p
CD4000	15p	CD4018	52p	CD4041	50p	CD4068	20p	CD4161	75p	CD4514	140p	CD4582	80p
CD4001	15p	CD4019	30p	CD4042	45p	CD4069	20p	CD4162	75p	CD4515	200p	CD4583	60p
CD4002	15p	CD4020	52p	CD4043	46p	CD4070	16p	CD4163	75p	CD4516	65p	CD4584	60p
CD4006	60p	CD4021	46p	CD4044	46p	CD4071	18p	CD4175	75p	CD4518	52p	CD4585	110p
CD4007	16p	CD4022	46p	CD4045	120p	CD4072	18p	CD4402	75p	CD4520	60p	CD40100	200p
CD4008	45p	CD4023	20p	CD4046	55p	CD4075	25p	CD4412	75p	CD4528	81p	CD40106	80p
CD4009	30p	CD4024	40p	CD4047	46p	CD4076	60p	CD4419	75p	CD4538	100p	CD40109	100p
CD4010	35p	CD4025	18p	CD4048	45p	CD4077	30p	CD4445	75p	CD4539	78p	CD40114	200p
CD4011	15p	CD4026	100p	CD4049	30p	CD4078	25p	CD4446	75p	CD4541	100p	CD40174	80p
CD4012	20p	CD4027	25p	CD4050	30p	CD4081	25p	CD4449	75p	CD4555	60p		
CD4013	25p	CD4028	45p	CD4052	70p	CD4082	25p	CD4501	35p	CD4561	110p		
CD4014	55p	CD4029	55p	CD4053	60p	CD4085	72p	CD4502	70p	CD4568	80p		

LINEAR

		CA3090	415p	LM339	80p	LM3911	140p	SAA5020		TDA1008	347p	TL074	117p
		CA3130	105p	LM348	90p	LM3914	285p	SN76013N	295p	TDA1022	570p	TL081	40p
CA1310E	185p	CA3140	52p	LM358	62p	LM3915	285p	TAA621A	290p	TDA1024	120p	TL082	65p
CA1350E	90p	CA3240	125p	LM380	85p	LM3916	285p	TAA661B	175p	TDA2002	150p	TL083	92p
CA3020	230p	ICM7555	105p	LM381	170p	MC1458	70p	TBA120B	70p	TDA2003	345p	TL084	65p
CA3028	110p	ICM7556	200p	LM382	130p	MC1488	80p	TBA120S	68p	TDA2020	350p	UA748	40p
CA3035	270p	LF347	200p	LM384	160p	MC1489	90p	TBA120U	98p	TDA2030	340p	ZN414	95p
CA3043	305p	LF351N	55p	LM386	100p	NE555	20p	TBA540Q	161p	TDA2102		ZN424	150p
CA3055	85p	LF353N	100p	LM387	140p	NE556	55p	TBA651		TDA2522		ZN425	400p
CA3065	150p	LM224	150p	LM389	110p	NE564	405p	TBA800	95p	TDA9400		ZN426	345p
CA3080	80p	LM301	30p	LM732	55p	NE566	173p	TBA810S	110p	TL061	50p	ZN427	715p
CA3081	225p	LM308	100p	LM747	75p	NE567	161p	TBA820	81p	TL062	75p	ZN1034	230p
CA3085	145p	LM311N	81p	LM1458	45p	NE570	391p	TBA920Q	175p	TL064	150p	ZN1040	750p
CA3086	65p	LM318N		LM3900	70p	NE571	387p	TCA270S	171p	TL071	50p		
CA3089	230p	LM324	50p	LM3909	92p	SAA5010		TDA1004	345p	TL072	60p		

RIBBON CABLE

(Priced per ft)

WAYS	COLOUR
10	26p
20	53p
26	76p
34	100p

DIODES

AA119	15p	OA200	9p	1N5060	18p
AA215	16p	OA202	9p	1N5062	20p
BAX13	10p	1N823	5p	1N5400	11p
BY100	30p	1N914	5p	1N5401	12p
BY127	18p	1N916	6p	1N5402	14p
BY133	20p	1N4000	5p	1N5403	15p
BY206	30p	1N4001	5p	1N5404	16p
BY207	30p	1N4002	5p	1N5405	17p
BY299	40p	1N4003	6p	1N5406	18p
BYX10	18p	1N4004	6p	1N5407	22p
OA47	10p	1N4005	7p	1N5408	25p
OA90	8p	1N4006	7p	1S44	5p
OA91	8p	1N4007	8p	1S921	7p
OA95	8p	1N4148	5p	1S922	7p
		1N4448	6p	1S923	7p

D' CONNECTORS

	MALE	FEMALE
9 way	75p	100p
15 way	100p	1140
25 way	140p	195p

D-CONNECTOR COVERS

9 way	110
15 way	110
25 way	125

I.C. SOCKETS

LOW PROFILE D.I.L Type	Price	TURNED PIN D.I.L. Type	Price
8 pin	10p	8 pin	35p
14 pin	12p	14 pin	50p
16 pin	14p	16 pin	60p
18 pin	18p	18 pin	65p
20 pin	24p	22 pin	75p
22 pin	25p	24 pin	80p
24 pin	30p	28 pin	100p
28 pin	32p	40 pin	150p
40 pin	35p		

ZENER DIODES

BZX61C/1.4 watt: 3V3, 3V6, 3V9, 4V7, 5V6, 6V2, 7V5, 8V2, 10V, 11V, 12V, 13V, 15V, 18V, 20V, 22V, 24V, 27V, 30V, 33V, 36V, 39V, 43V, 47V, 56V, 68V, 75V, 82V, 100V, 180V, 200V — 16p each

BZY88C/0.4 watt: 1V3, 2V7, 3V, 3V3, 3V6, 3V9, 4V3, 4V7, 5V1, 5V6, 6V2, 7V5, 8V2, 9V1, 10V, 11V, 12V, 13V, 15V, 16V, 18V, 22V, 24V, 27V, 30V, 33V, 36V — 10p each

LEDs

5mm:	Red	10p	113:	Red	
	Green	13p		Red	20p
	Yellow	13p		Green	25p
3mm:	Red	10p		Yellow	25p
	Green	13p	323:	Tri.	
	Yellow	13p		Red	20p
CQX21:	Red flashing	65p		Green	25p
				Yellow	25p
251:	Rect/stack		503:	Square	
	Red	20p		Red	20p
	Green	25p		Green	25p
	Yellow	25p		Yellow	25p

REGULATORS

LM304H	180p	UA723C	77p	78H12 (3A/5V)	460p
LM309H	80p	7805A	50p		
LM309K	130p	7812A	50p	78L05	35p
LM317K	350p	7812Kc	121p	78L12	35p
LM317T	130p	7815A	50p	78L15	35p
LM320/5	65p	7818A	50p	78L18	35p
LM320/12	65p	7824A	50p	78L24	35p
LM320/15	65p	7905A	55p	78L62	35p
LM320/24	65p	7912A	55p	79L05	45p
LM337T	180p	7915A	55p	79L12	45p
LM1469	324p	7918A	55p	79L15	45p
UA78P (8A/5V)	450p	7924A	55p	79L18	45p
				79L24	45p

RECHARGEABLE BATTERIES

HP2, 1.2v, 4.0AH	£3.95
HP2, 1.2v, 1.2AH	£2.60
HP11, 1.2v, 1.2AH	£2.40
HP7, 1.25v, 500mAH	£1.00
AAA, 1.2v, 180mAH	30p
PP3, 8.4v, 110mAH	£4.50

ALUMINIUM BOXES

31⅞" × 19⅞" × 9⅞"

80 × 50 × 25	80p
100 × 65 × 50	1.20
100 × 70 × 40	1.20
100 × 100 × 40	1.20
135 × 70 × 40	1.20
135 × 105 × 40	1.40
180 × 125 × 65	1.95
205 × 155 × 75	2.50

VERO PLASTIC BOXES

White 71 × 49 × 25	60p
Blk 71 × 49 × 25	60p
Blk 120 × 80 × 35	1.10
Blk 180 × 110 × 55	1.75

VERO BOARDS

127 × 63	1.10
95 × 63	95p
431 × 63	3.17
127 × 95	1.20
95 × 95	1.15
431 × 95	4.20
454 × 119	5.50
63 × 25 pk of 5	1.30

THYRISTORS

				600mA/200V	45p	5A/400V	60p
				1A/50V	40p	5A/600V	70p
BT101	104p	T05 1A/400V	104p	1A/100V	45p	5A/800V	80p
BT102	104p	2N1599	40p	1A/200V	50p	7A/100V	55p
BT106	104p	2N4441	170p	1A/400V	60p	7A/200V	60p
BT107	132p	2N4444	150p	1A/600V	75p	7A/400V	70p
BT108	143p	2N5060	36p	1A/800V	90p	7A/600V	80p
TIC44	20p	2N5061	33p	3A/50V	46p	7A/800V	90p
TIC106D	40p	2N5062	42p	3A/100V	53p	10A/50V	55p
TIC106M	77p	2N5063	47p	3A/200V	58p	10A/100V	60p
TIC126D	99p	2N5064	47p	3A/400V	71p	10A/200V	65p
TIC206D	80p	600mA/20V	21p	3A/600V	79p	10A/400V	70p
TIC226D	90p	600mA/30V	24p	3A/800V	99p	10A/600V	88p
TIC246D	130p	600mA/100V	30p	5A/50V	43p	10A/800V	115p

TRIACS

2A/200V	50p
2A/400V	60p
2A/600V	60p
4A/400V	60p
6A/100V	80p
6A/200V	80p
6A/400V	90p
8A/400V	80p
10A/100V	80p
10A/200V	100p
10A/400V	110p
10A/400P	100p

BRIDGE RECTIFIERS

1A/50V	30p	6A/50V	75p
1A100V	30p	6A/100V	75p
1A/200V	35p	6A/200V	80p
1A/400V	40p	6A/400V	100p
2A/50V	35p	10A/200V	200p
2A/100V	45p	10A/400V	200p
2A/200V	50p	25A/200V	250p
2A/400V	55p	25A/400V	300p

Dalo Etch resist £1.10

SOLDER

20 swg. 3 core

500g — 495p

POTENTIOMETERS

Carbon track, ¼ watt log & linear values:

Range	Price
470R-2.2MR (single track)	40p
4.7K-2.2MR (dual gang)	100p
4.7K-2.2MR (single gang D/P switch)	90p

SLIDER POTS

60mm track, log & linear values:

Range	Price
5K-500K	80p

PRESETS

Pre-set pots ¼ watt

Range	Price
50R-4.7MR (mini vert. & horiz.)	10p

RESISTORS

High stability, ¼ watt, 5%

Range	Price (1-99)	(100+)
1R-10MR	2p	1p

High stability, ½ watt, 5%

Range	Price (1-99)	(100+)
1R-10MR	3p	1.5p

CAPACITORS

CERAMIC 1pF, 2p2, 2p7, 3p3, 3p9, 4p7, 5p6, 6p8, 8p2, 10pF, 12pF, 15pF, 18pF, 22pF, 27pF, 33pF, 39pF, 47pF, 56pF, 68pF, 82pF, 100pF, 120pF, 150pF, 180pF, 220pF, 270pF, 330pF, 470pF, 560pF, 680pF, 820pF, 1000pF, 1n5, 1n8, 2n2, 3n3, 3n9, 4n7, 5n6, 6n8, 8n2, 10nF, 22nF, 47nF, 100nF 6p each

MYLAR 100V 1nF, 2n2, 3n3, 4n7, 6n8, 10nF 7p each. 15nF, 22nF, 33nF, 47nF 9p each. 68nF, 100nF 11p each. 220nF 15p. 330nF 18p. 470nF, 20p.

POLYSTYRENE 22pF, 47pF, 68pF, 82pF, 100pF, 120pF, 150pF, 220pF, 270pF, 330pF, 390pF, 470pF, 680pF, 820pF, 1000pF, 1200pF, 1500pF, 1800pF, 2000pF, 2200pF, 3300pF, 4700pF, 5600pF, 10nF 8p each

TANTALUM BEAD 3V: 100uF, 150uF, 220uF, 330uF 64p each. 470uF 110p. 680uF 160p. 6V3: 6u8. 12p. 10uF 13p. 33uF 33p. 47uF 25p. 100uF, 220uF 77p each. 470uF 160p. 10V: 15uF, 22uF 20p each. 33uF 33p. 47uF 40p. 68uF 63p. 220uF 110p.
16V: 2u2, 3u3 20p each. 4u7, 6u8 25p each. 10uF 32p. 22uF 35p. 16V: 33uF 40p. 47uF 60p. 100uF 95p. 220uF 105p. 25V: 15uF, 22uF 40p each. 47uF, 68uF 60p. 35V: 0.1uF, 0.22uF, 0.47uF 16p each. 1uF, 1u5 18p each. 2u2 25p. 3u3, 4u7 20p each. 6u8 30p. 10uF 40p. 47uF 60p.

ELECTROLYTIC Axial or Radial 16V: 10uF, 22uF, 33uF 10p each. 47uF, 68uF, 100uF 12p each. 125uF, 220uF 14p each. 330uF 18p. 470uF 24p. 680uF 36p. 1000uF 30p. 1500uF 40p. 2200uF 50p. 25V: 1uF, 10uF, 22uF, 47uF 10p each. 100uF 12p. 220uF 20p. 470uF 30p. 1000uF 40p. 2200uF 55p. 4700uF 115p. 35V: 120uF, 250uF 20p each. 40V: 6u8 10p. 470uF 30p. 1000uF 45p. 50V: 0.47uF, 1uF 8p each. 1uF (small) 12p. 220uF 35p. 63V: 1uF, 2u2, 4u7 7p each. 10uF, 22uF 10 each. 47uF 12p. 100uF 20p. 220uF 30p. 100V: 4.7F 48p. 160V: 10MF 32p. 250V: 0.01uF, 0.047uF, 0.1uF 10p each. 0.22uF 11p. 0.47uF 12p. 1uF 18p. 2u2 26p. 10uF 23p. 100uF 35p. 400V: 0.47uF 35p. 600V: 0.022uF, 0.047uF 30p each. 0.22uF, 67p. 1000V: 0.0022uF 27p. 0.022uF, 0.1uF 39p each.

POLYESTER C280 250V .01, .022, .033, .068, .1 8p. .15, .22, .33 10p. .47 12p. .68 20p. 1uF 26p. 2.2 50p.

SILVERED MICA 2p2, 3p3, 5pF, 10pF, 18pF, 20pF, 22pF, 25pF, 27pF 13p each. 30pF, 33pF, 39pF, 47pF, 50pF, 56pF, 68pF, 75pF, 82pF, 100pF, 120pF, 150pF, 180pF, 200pF, 220pF, 250pF, 270pF, 300pF 15p each. 330pF, 390pF, 470pF 19p each. 500pF, 560pF, 680pF 22p each. 820pF 24p. 1000pF 27p. 1500pF 32p. 1800pF 42p. 2200pF 45p. 2700pF 48p. 3600pF 55p. 3900pF 68p. 4700pF 83p. 5000pF 98p. 6800pF 115p. 8200pF 120p. 10000pF 125p.

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WHY NARROW BAND F.M.?

Part 2

BY E.A.RULE

In the first part of this article we considered the main differences between the f.m. and a.m. systems. We shall now take a closer look at some of these differences.

Taking the receiver first, Fig. 8 shows a typical a.m. detector circuit and Fig. 9, an f.m. discriminator; however these are only two examples of the different types used in each system.

SIMPLE A.M. DETECTOR

In Fig. 8 we have a simple a.m. detector circuit where T1 is the last i.f. transformer (normally around 455kHz), this feeds D1 (the actual diode detector) and R1, the diode load resistor. Capacitors C1, C2 and R2 form a low-pass filter which removes any residual i.f., and C3 is a d.c. blocking capacitor which passes the recovered audio on to the next stage but prevents any d.c. being passed on. The diode detector D1 acts like any half-wave rectifier and a voltage will develop across R1. The amplitude of this voltage will depend on the amplitude of the signal feeding into D1 from T1.

As the signal increases more voltage will be produced across R1 and this can be fed via R3 back to the earlier stages to control their gain and prevent overloading on strong signals. (Remember that in Part 1 we explained that the amplitude modulation on the signal must be passed on without distortion and that some means of preventing stages from overload must be provided.)

The audio is recovered from the signal by D1 acting as a half-wave rectifier which removes one half of the modulated carrier leaving the other half with the audio signal on it. The low-pass filter removes the remaining carrier and the audio passes via C3 to the next stage. This action is shown in the waveform diagrams in Fig. 8.

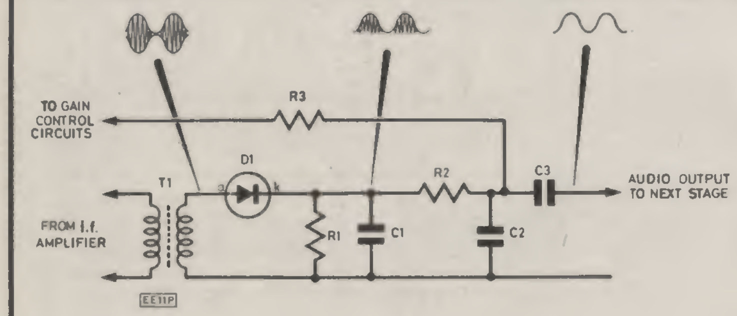
RATIO DETECTOR

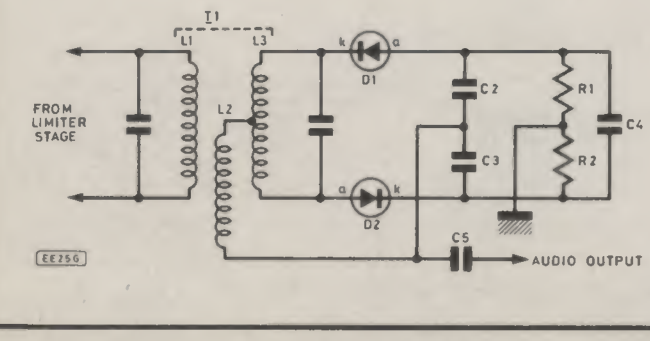
Fig. 9 shows an f.m. discriminator circuit and this type is called a "ratio detector". The phasing of the coils which make up T1 are arranged so that at the centre frequency (normally 455kHz or 10·7MHz) the voltage across the two diodes D1 and D2 is equal and the resultant voltage at the end of L2 is zero.

Now when the incoming frequency shifts due to deviation, the circuit will no longer be balanced, and because of the phase differences between L2 relative to the two halves of L3 there will be unequal voltages applied to the diodes and the difference between these two voltages will appear at the end of L2. As this voltage will be varying at an audio rate due to the modulation of the carrier it will be passed on to the next stage via C5 as the recovered audio signal.

The explanation of how these detectors work has been simplified, as a full description would require considerable space and there are many technical books available for those who wish to pursue the matter in more detail.

Fig. 10 shows the response of the f.m. discriminator regarding its output voltage plotted against input frequency. As the output voltage swings plus and minus in polarity depending on the deviation of the incoming signal it can be used to control an automatic frequency correction circuit





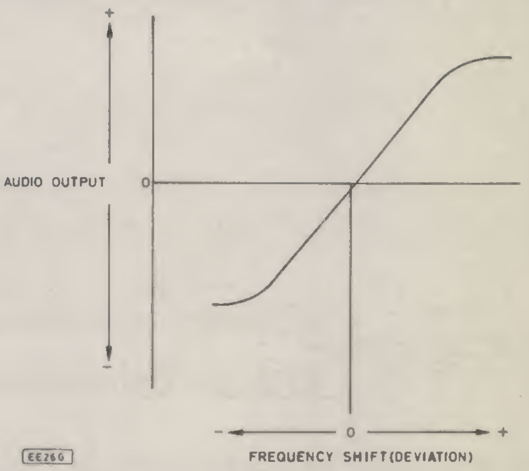


Fig. 10 (above). F.M. detector response characteristic.

Fig. 8 (above left). A typical a.m. detector circuit.

Fig. 9 (left). A typical f.m. discriminator (Ratio Detector).

to maintain the receiver on tune. However with the modern crystal controlled oscillators used today this feature may not be used.

Although amplitude pulses will already have been removed by the limiter stage (to be described later) the f.m. discriminator will also reject any amplitude pulses remaining on the signal, because such pulses will be presented to the diodes in equal amounts, and cancel out in the same way as a carrier at the centre frequency. Many of today's transceivers use a "quadrature" detector. This is normally included into an integrated circuit which also contains the i.f. amplifiers, limiters and meter drive circuits. Such a circuit is shown in Fig. 11.

THE I.F. AMPLIFIER

The i.f. amplifier stage is different for the two systems because in the case of the a.m. signal we want to amplify it and pass it on with the minimum of amplitude distortion, and in the f.m. case we want to remove any amplitude variations and only pass on changes in frequency.

Fig. 12 shows a typical a.m. i.f. stage and Fig. 13 one used for f.m. These are simple versions as the modern circuit would almost certainly use integrated circuits for these. In the case of the a.m. circuit, automatic gain control is applied via R5 so that as the signal gets stronger the gain is reduced to prevent the next stage overloading. The f.m. circuit is allowed to operate at maximum gain all the time so that the next stage is fully saturated. This next stage is the "limiter" and has no counterpart in the a.m. receiver.

Fig. 14 shows a simple limiter. The main difference between this and the i.f. amplifier is that the collector voltage is held down to a low level so that the output is prevented from increasing once a certain level has been reached. The graph in Fig. 15 shows what happens.

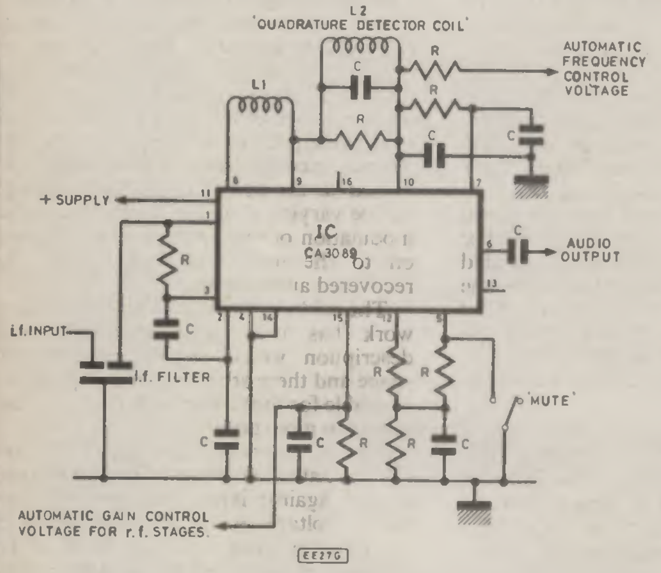


Fig. 11. Typical quadrature detector circuit using the CA3089 i.c. The use of integrated circuits makes for fewer overall components and greater reliability. The i.c. contains the i.f. amplifiers, limiter stage, a.g.c. amplifiers, quadrature detector, muting circuits, and an audio output stage. In fact, a complete receiver except for the r.f. and mixer.

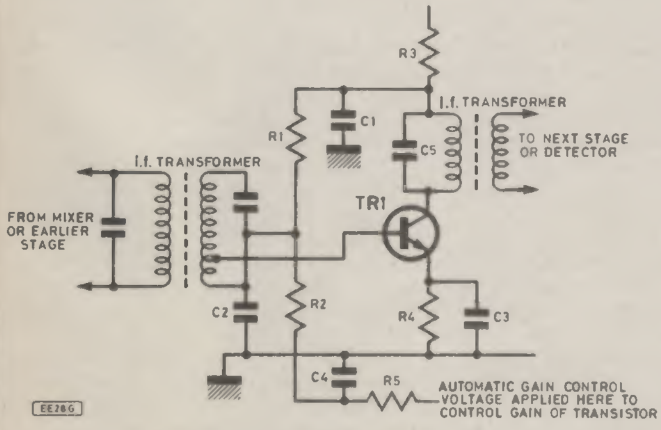


Fig. 12. Simple a.m. i.f. amplifier stage.

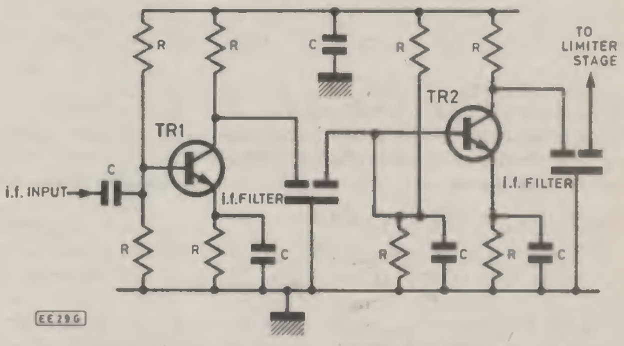


Fig. 13. Basic i.f. amplifier circuit used on f.m. Note that each stage is designed to operate at maximum gain so that the maximum possible signal is applied to the limiter stage to ensure saturation (limiting).

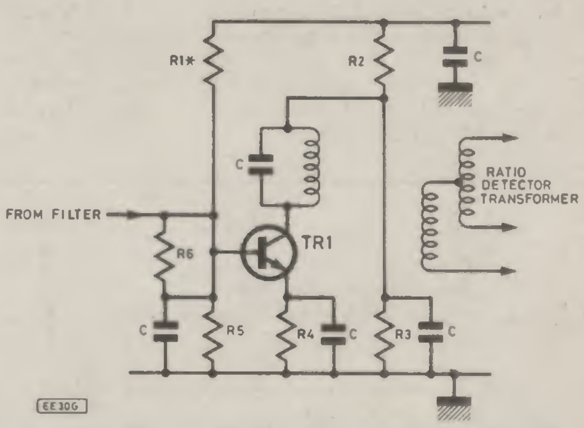


Fig. 14. Simple f.m. limiter stage. Resistors R2 and R3 make up a potential divider which limits the voltage on the collector of TR1 and ensures that the output obtained "saturates".

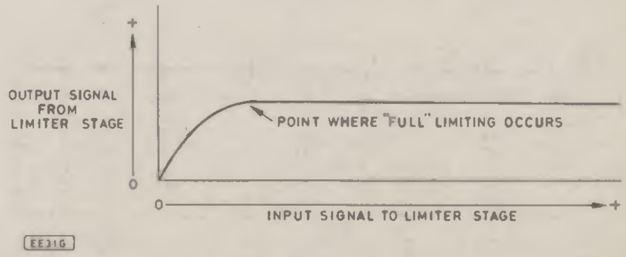


Fig. 15. Showing how once a certain input level has been reached the output remains constant.

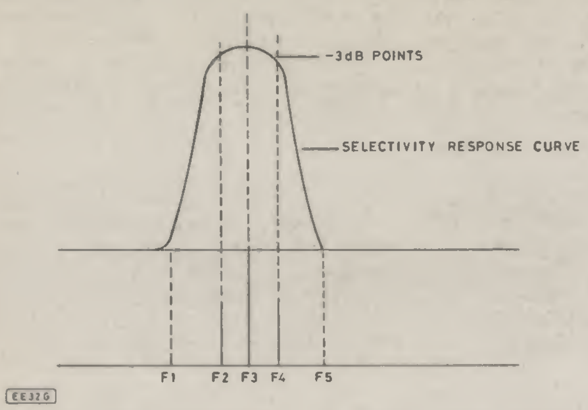


Fig. 16. Points F1 and F5 are the absolute limits of the selectivity curve. F2 and F4 represent the point where the selectivity curve would be about −3dB down on its maximum response. These also represent the two sidebands, one above the carrier, F3, and one below. Any sidebands spaced further out than these would be attenuated by the selectivity curve until at points F1 and F5 there would not be any output at all. From this it can be seen that the higher the selectivity (narrower) the greater the loss of the higher audio frequencies.

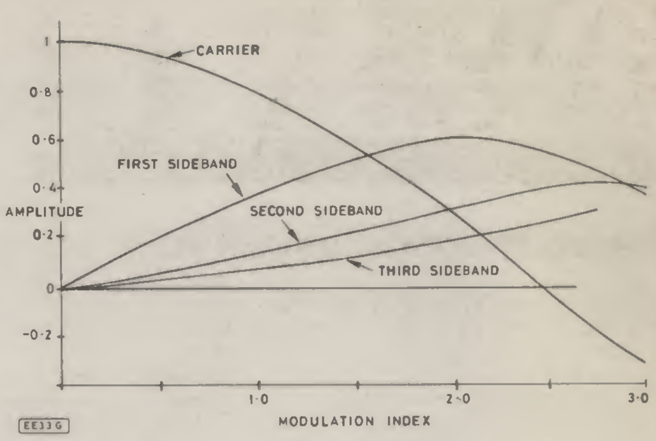


Fig. 17. Showing how the various sidebands vary in amplitude with the modulation index. The carrier would go through zero at a number of points at higher values of modulation index. This also applies to the sidebands.

Once the maximum output has been reached any further increase in input will not cause a corresponding increase in output. Thus any interference pulses on the signal are effectively removed, it also means that all signals irrespective of their strength are passed to the discriminator at the same signal level, effectively removing any need for an r.f. gain control on an f.m. receiver. Some f.m. receivers have a.g.c. applied to their r.f. amplifier stages before the mixer, to prevent overload and cross-modulation, but that is another story and also applies to a.m. Here we are only concerned with the main differences between the two.

GENERATING THE A.M. OR F.M. SIGNALS

The main difference between the a.m. and f.m. transmitter is in the way the signal is produced. Looking first at the a.m. system, we find that the modulation is mixed with the carrier wave and this results in the amplitude of the carrier varying at the same rate as the modulating signal.

This modulation process also produces "sidebands" adjacent to the main carrier frequency. For example, if the modulation signal was at 1kHz and the main carrier frequency was at 1MHz then the modulation process would also produce frequencies at 1MHz plus 1kHz and 1MHz minus 1kHz, that is, three separate radio frequency signals.

When speech is used to modulate the carrier the sidebands can extend to plus and minus 3kHz, a total bandwidth of 6kHz. The a.m. receiver must be able to accept these in order to reproduce the original audio without distortion. In other words the receiver bandwidth (selectivity) would be a minimum of 6kHz. Fig. 16 shows a typical a.m. receiver selectivity curve and the type of signal it will accept.

With the f.m. transmitter the modulating signal is used to shift either the carrier frequency or the phase; in practice the end result is the same and most so called f.m. transmitters are in fact phase modulated. This modulation process also sets up sidebands but the number of sidebands that occur on f.m. depend on the relationship between the modulating frequency and the amount of deviation used. The relationship between these two is called the "modulating index".

$$\text{Modulation index} = \frac{\text{Carrier frequency deviation}}{\text{Modulating frequency}}$$

for example, if our modulation frequency is 3kHz (same as our a.m. example) and our maximum deviation is 5kHz (the maximum for the UK CB service), we get

$$\frac{5000}{3000} = 1{\cdot}666$$

For the same deviation the modulation index at 300Hz would be 16·666 and so on. The deviation figure is for a frequency shift on one direction, so a 5kHz deviation means plus and minus 5kHz, that is a total of 10kHz.

A full technical explanation would take up far too much space but a given modulating frequency will produce a number of sidebands whose individual amplitude will depend on the modulation index for the particular system. A rough rule of thumb calculation for f.m. overall bandwidth is: 2Fd + Fmod, where Fd is the maximum deviation and Fmod is the highest modulating frequency used.

In our example, of maximum deviation 5kHz and 3kHz maximum modulating frequency we get, $2 \times 5 + 3 = 13$kHz. In other words our bandwidth is 13kHz compared with 6kHz of the a.m. system for the same modulating frequency.

So clearly, the maximum deviation and modulating frequency must be restricted if a larger number of stations are to operate in a given band of frequencies (channels). Just for interest the BBC stereo system requires a bandwidth of 250kHz and is known as "wide-band f.m." whereas the CB specification calls for a maximum bandwidth of 13kHz and is known as "narrow-band f.m."

SHIFT OUTSIDE PASSBAND

From the above it can be seen that if the f.m. transmitter is over-deviated or if higher than permitted audio frequencies are used, the signal can shift completely outside the receiver passband, with resulting distortion or even loss of signal.

Fig. 17 shows how the amplitudes of the carrier and sidebands vary with the modulation index. The chart is for a single tone modulation. These sidebands will occur on each side of the carrier. For example, if our modulating frequency is 2kHz and our carrier frequency is 28MHz the first sideband pair will be at 28·002MHz and 27·998MHz, the second pair at 28·004MHz and 27·996MHz, the third pair at 28·006MHz and 27·994MHz, and so on. The amplitude of these sidebands will depend on the modulation index, not the amount of frequency deviation present.

Note also that in Fig. 17 the carrier strength varies with the modulation index, compared to a.m. where the carrier amplitude is constant and only the sideband amplitudes vary. In the f.m. system the energy that appears in the sidebands comes from the carrier, the *total power* is the same regardless of the modulation index (on a.m. the total power varies with the modulation).

Since the amplitude is constant with an f.m. signal any amplification can be carried out with class "C" biased stages for maximum efficiency (or as mentioned earlier a receiver can use amplitude limiter stages). □

BOOK REVIEWS

MACHINE CODE FOR BEGINNERS

Author	L. Watts & M. Wharton
Price	£1.99 limp
Size	240 × 168mm. 48 pages
Publisher	Usborne
ISBN	0-86020-735-8

ONE of the most difficult areas of computing is machine code programming, not only is it more difficult to write, but it is less easy to understand than a program in BASIC.

Machine Code For Beginners is a book designed to introduce fun into learning machine code and with the aid of easy text and cartoon drawings it manages to succeed. The book has 48 pages and starts with a basic description of machine code and its advantages and disadvantages. Although the contents of this book are aimed at a fairly low level of computing knowledge, the subject matter becomes progressively more difficult as you delve further.

A particularly useful section are the Decimal/Hex conversion charts, because in machine code programs, numbers and addresses are always written in hexadecimal. Plenty of conversion examples are given, so no difficulties should be encountered.

Mnemonics are short words which represent an instruction to the computer and are much easier to understand than hex. A program in mnemonics is called an assembly language program and is fully explained and example programs are provided.

On the whole the book provides a reasonable introduction to machine code programming and does not try to baffle the reader.

R.A.H.

ROBOTICS

Author	T. Potter & I. Guild
Price	£1.99 limp
Size	240 × 168mm. 48 pages
Publisher	Usborne
ISBN	0-86020-724-2

ROBOTICS is classed as a complete science all on its own, although computing does play an important part in the control of the robot. There are many robots in existence today which are mainly used for industrial processes and doing jobs that would be impossible for people to do.

The text gives the reader a sufficient insight into the uses of robots and the basic technical format that is required to operate one. The book also provides constructional details for a computer-controller micro-robot with step by step instructions on how to make an electronic interface circuit to connect the robot to a computer.

In the Usborne tradition the book is full of colour illustrations which enhance the overall appearance of the pages and help support the text. There are 48 pages contained within and the text touches briefly on the most important areas of robotics. Cybernetics, the science of control and communication in both machines and living organisms is also briefly explained, which is just as well, because this is a highly specialised area. R.A.H.

Simple LOOP BURGLAR ALARM

Chris Lare

MOST designs for alarm units are very flexible and quite expensive. The unit described here is a simple loop alarm which was originally designed to be connected to a wire loop of the sort used in shops to protect small and easily stolen articles such as radios. The design does, however, have many applications since the principle is that the alarm sounds for a preset length of time once the loop is broken. It would be possible to connect the loop to a magnetic reed switch or even foil strips as often used on large windows.

The circuit is designed around CMOS logic components and consumes less than 10μA in its standby condition and so it is well suited to being battery powered. Naturally, the supply current rises dramatically once the alarm sounds. The alarm tone itself is pulsed at half second intervals which not only makes it much more noticeable but cuts down battery consumption by some 50 per cent.

OSCILLATIONS

It has already been mentioned that the circuit is designed around CMOS logic i.c.s to minimise power consumption. It is important to note that this type of logic will not work reliably when fed with slow moving analogue signals, and therefore the levels supplied to each gate at any time should be close to the supply voltage.

Other voltages, particularly those around the half supply area, are likely to cause the gate to oscillate at a high frequency which will cause the i.c. to overheat and eventually destroy itself, not to mention the apparent spurious action of the circuit involved. It may be of interest to note that TTL logic is much more sensitive to this type of abuse than CMOS parts, and half supply input voltages will almost certainly quickly destroy the gate; although for a different reason.

Consider a typical CMOS gate as shown in Fig. 1. This is an inverting gate so that when the input voltage is close to 0 volts the output is high. As the input voltage is increased the output will eventually go low, but at some time in between the gate may become unstable and several samples measured oscillated at 2MHz as well as consuming large amounts of current. This oscillation becomes worse with increasing input series resistance but may be reduced by the addition of a 100pF capacitor between the gate input and 0 volts which effectively reduces the source impedance presented to the gate.

SCHMITT TRIGGERS

The most popular way to clean up a slow moving edge such as this is to employ a Schmitt Trigger which operates by applying feedback across the logic gates. Some logic gates are actually manufactured for this purpose including the CMOS 4093 (quad 2-input NAND). These require no further treatment of the input signals but do tend to be much more expensive than the equivalent standard gate. Fig. 2 illustrates a Schmitt Trigger designed around standard CMOS gates and serves as a suitable example to explain the Schmitt action.

With 0 volts applied to the 330kΩ input resistor (V_{in}) the output of the first gate will be high and naturally the output of the second gate will be low. This means that until the output from the second gate starts to go high the 1MΩ resistor will act as a potential divider to any input voltage applied, such that the input gate voltage (V_{gate}) will be only about two-thirds V_{in}. Obviously therefore, an input voltage of some 3 volts will be required before the gate starts to change its output state.

Immediately this happens however, the output of the second gate will rise and the 1MΩ resistor will no longer act as a potential divider to ground, but to the +ve supply since the gate output will pull it high. Immediately therefore the starting voltage on the gate of some 2 volts becomes 4 volts without any increase in V_{in}.

This action is very fast and so the final output is a good edge. Once the gate has changed state the 1MΩ will tend to source current holding V_{gate} slightly high and so the input voltage has to be reduced considerably to return the system to its original state. This is the most important feature of a Schmitt Trigger: The input voltage at which switching occurs is different depending on whether the input voltage is rising or falling. This action is called hysterisis and is denoted by a symbol which combines the graphs of rising input and falling output into a box with two tag ends. Hysterisis was originally noticed in magnetic circuits when iron cores tended to retain some magnetisation.

CIRCUIT DESCRIPTION

The full circuit diagram of the alarm is shown in Fig. 3. In normal non-active conditions the "loop" pins will be joined

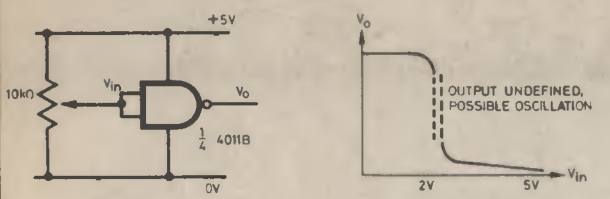


Fig. 1. Output waveform of a CMOS gate with a variable input.

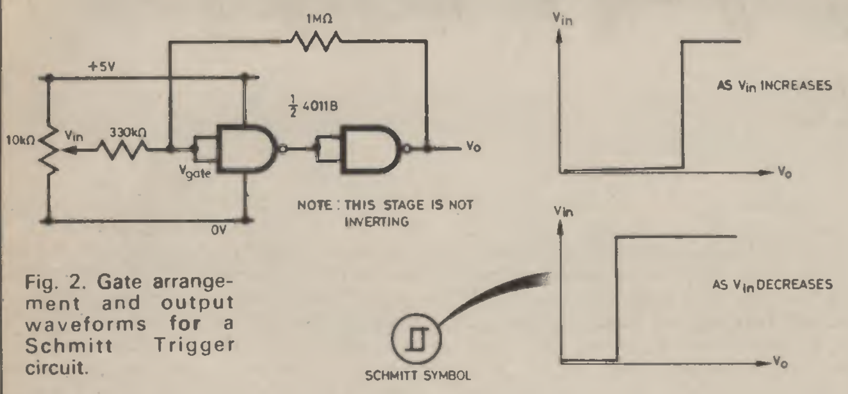


Fig. 2. Gate arrangement and output waveforms for a Schmitt Trigger circuit.

together which means that the inputs to gate IC1a are held high by R1.

When the loop is broken R2 pulls these inputs low, but it must be a fairly high value resistor to minimise current flow when the loop is joined. R3 is present to protect the gate inputs from static and mains pick-up when the loop is open.

As soon as the loop is broken the gate output goes high which rapidly charges up C1 by means of R4 and D1. The voltage across C1 then triggers the Schmitt Trigger formed by the two gates of IC1b and IC1c. When the loop is joined again pin 3 of IC1 will go low which will discharge C1 through R5, R4 having no effect because of the series diode.

The relative high value of R5 ensures that C1 takes a long time to discharge sufficiently to alter the output state of the Schmitt Trigger and so allows the alarm to go on ringing some time after the loop has been rejoined.

It must be noted that R5 is not solely responsible for this reset delay and that in its high state the Schmitt Trigger sources some current through R6 and R7 helping to increase the reset time.

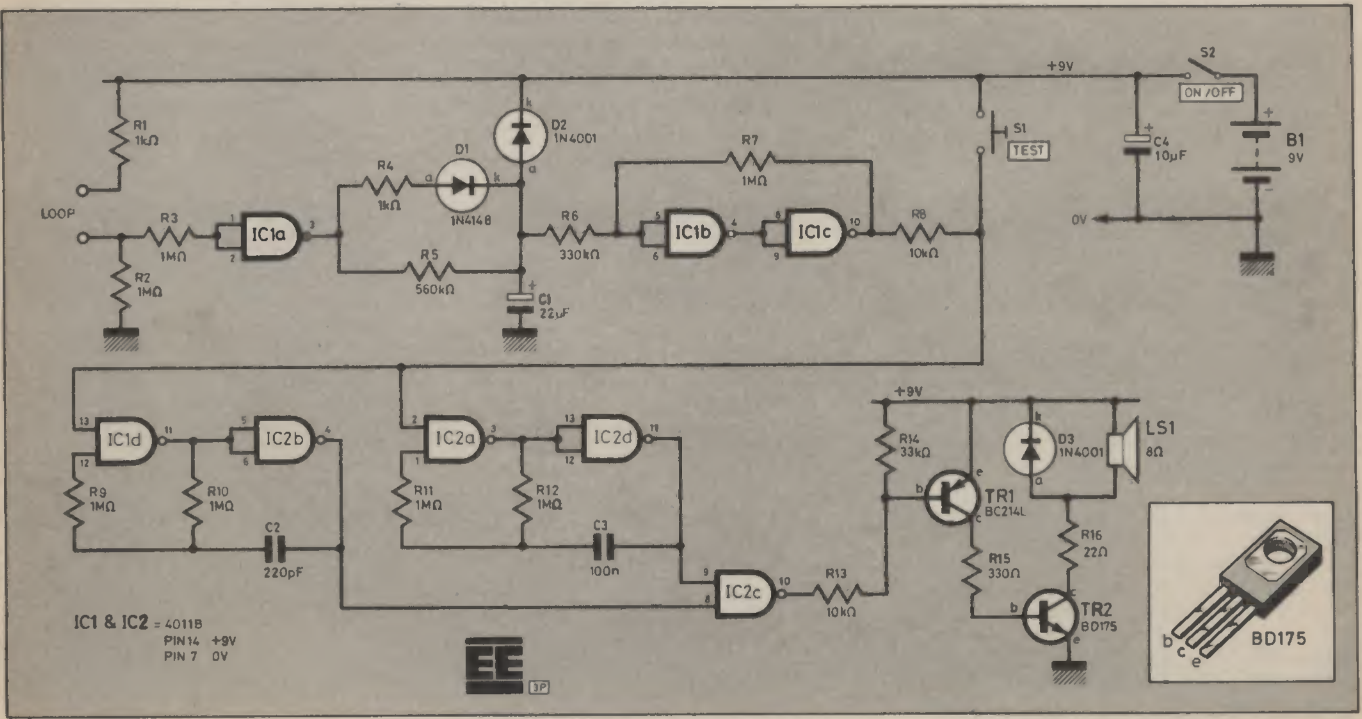
Obviously some form of manual reset is required since the alarm is not required once someone has been alerted and total reset is obtained by simply removing the power for a brief period. This allows C1 to discharge via D2 and hence resets the circuit.

OSCILLATORS

The output from the Schmitt is used to gate two oscillators, also built around standard CMOS parts. The first formed by IC1d and IC2b uses a 220pF capacitor and operates at about 700Hz, whilst the second formed by IC2a and IC2d operates at 1·3Hz. Only when the output of the slow oscillator is high will the tone be allowed on the output by virtue of gate IC2c. S1 serves as a test switch and may be omitted if desired, the main advantage of this is the alarm only sounds when the switch is pressed. R8 protects gate IC1c when the switch is pressed.

The tone output on pin 10 of IC2 is buffered by two transistors arranged such that when the alarm is inactive pin 10 is high and no current is consumed. In this state TR1 will be off (since it is *pnp*) and so no current will be available to switch TR2 on. When pin 10 does fall TR1 turns on and sources current to TR2 which drives the speaker at some 700Hz in 0·6 second bursts. Diode D3 blocks any back e.m.f. from the speaker which might damage other parts of the circuit. A 22-

Fig. 3. Circuit diagram of the Loop Alarm.



ohm resistor was inserted in series with the prototype speaker to limit the volume slightly since the shop display was always staffed but this may be linked instead if required.

The complete circuit was decoupled with a 10µF electrolytic capacitor.

CONSTRUCTION

PRINTED CIRCUIT BOARD

The prototype unit was assembled on a p.c.b. which gives a much neater and more reliable result than circuits built on stripboard. Fig. 4 shows the design of the p.c.b. and the component layout is shown in Fig. 5. The components should be placed into the board in a logical way, i.e., the smallest first, although the 4011s should be left until last. The i.c.s used in the prototype were directly soldered in but sockets may be used if preferred. Pay

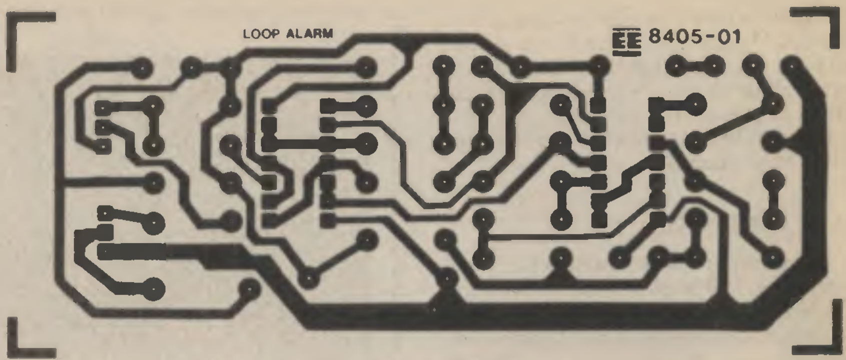


Fig. 4. P.c.b. design.

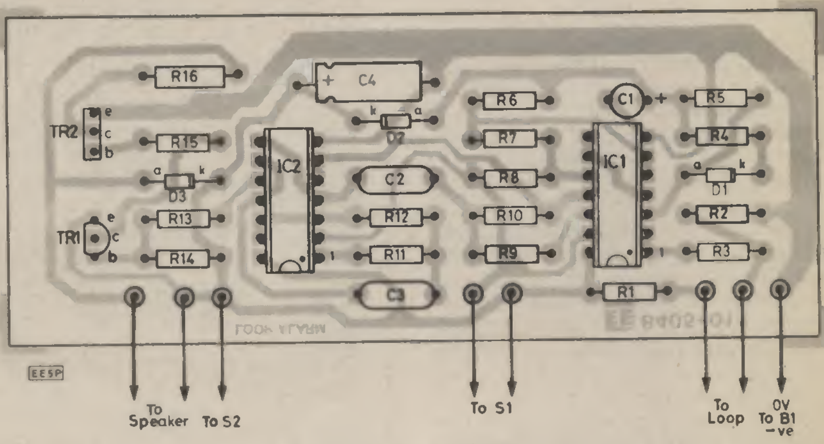
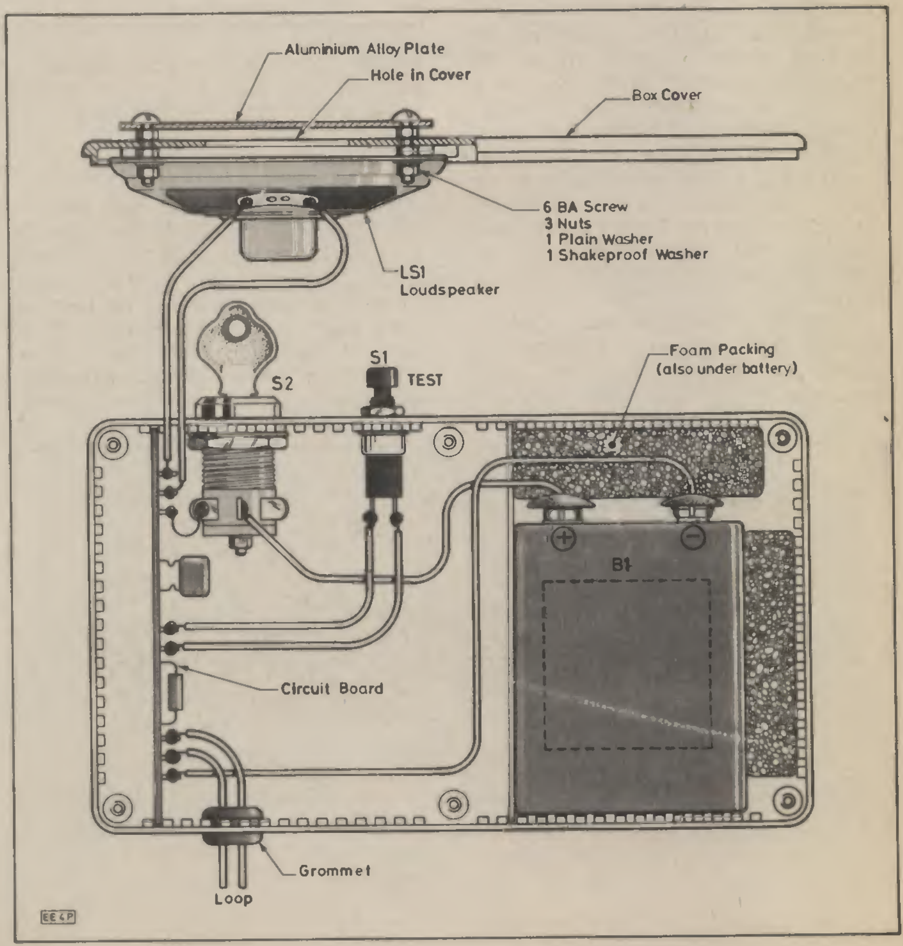


Fig. 5. Component layout.



COMPONENTS

See Shop Talk page 313

Resistors

R1,4	1kΩ (2 off)
R2,3,7,9, 10,11, 12	1MΩ (7 off)
R5	560kΩ
R6	330kΩ
R8,13	10kΩ (2 off)
R14	33kΩ
R15	330Ω
R16	22Ω ½W carbon

All resistors ¼W carbon except where otherwise stated

Capacitors

C1	22µF 10V tantalum
C2	220pF polystyrene
C3	100n polyester C280
C4	10µF 16V electrolytic

Semiconductor

D1	1N4148
D2,3	1N4001 (2 off)
TR1	BC214L
TR2	BD175
IC1,2	4011B quad 2-input NAND gate (2 off)

Miscellaneous

Printed circuit board: single-sided, size 105 x 42mm; *EE PCB Service*, Order code 8405–01; terminal pins (8 off); plastic case 190 x 60 x 110mm; S1 press-to-make switch; S2 keyswitch; battery PP9; battery clips for PP9; 8-ohm speaker 85mm square; polystyrene foam; aluminium sheet; loop plugs and sockets (if required); connecting wire; 6BA bolts 25mm (4 off); 6BA nuts (12 off); grommet.

Approx. cost Guidance only £16

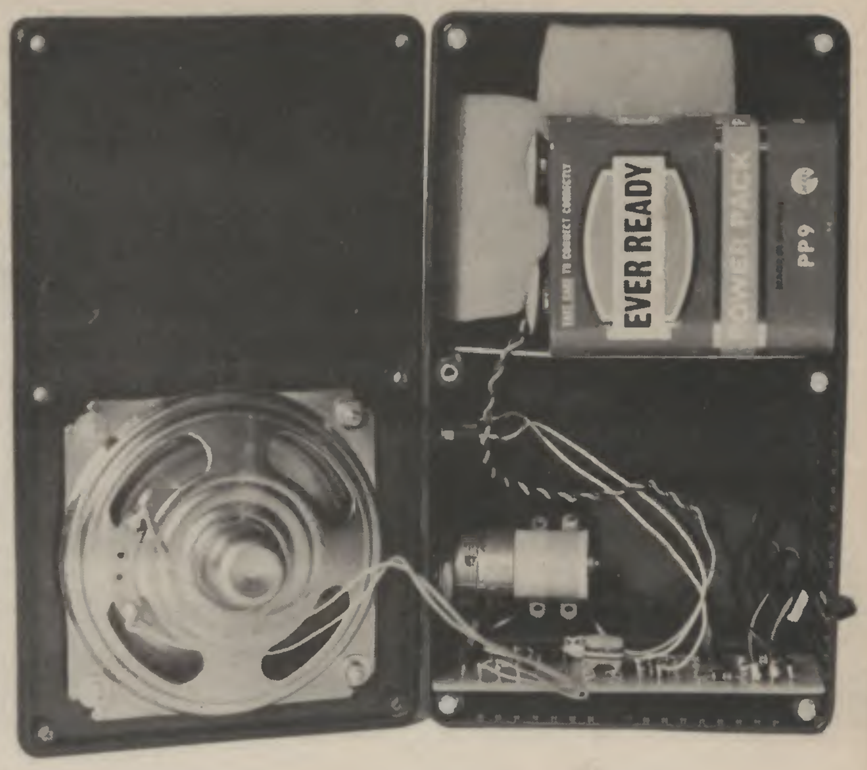
particular attention to the orientation of the BD175 transistor which is not always obvious; the side of the transistor with the metal plate should face the rest of the circuit board (see Fig. 2).

It is best to bench test the circuit board before final assembly.

CASE ASSEMBLY

The prototype was housed in a black plastic box 190 × 60 × 110mm. The circuit board is exactly the right size to slip into the slots provided in this type of box. It is suggested that the speaker be mounted first into the lid of the box to ensure that suitable clearance is left for all the other major components. Fig. 5 shows the general assembly and the method of mounting the speaker.

A 50mm hole should be cut in the middle of one end of the box lid, and the speaker mounting hole positions marked and drilled. The hole may be covered with an aluminium plate cut slightly larger than the hole with four corner holes corresponding to the speaker mounting holes. This plate was painted matt black for the prototypes. Assemble the speaker as shown in Fig. 5. Note that three nuts are used on each bolt, one to space off the metal plate, one to space the speaker and one to hold the speaker in place. Additional washers may be required if the speaker has unusual mounting holes or none at all, in which case the rim must be clamped.



Internal view of the Alarm Unit.

Position the circuit board at one end and then choose the positions for the other components. Note that if a keyswitch is used care must be taken before assembly to ensure that it does not foul the speaker. Wire up the unit as shown in Fig. 6. Cut a piece of aluminium 105 × 35mm to act as a battery retainer and place it and the battery in the box. Two pieces of polystyrene foam were glued in place to hold the battery secure.

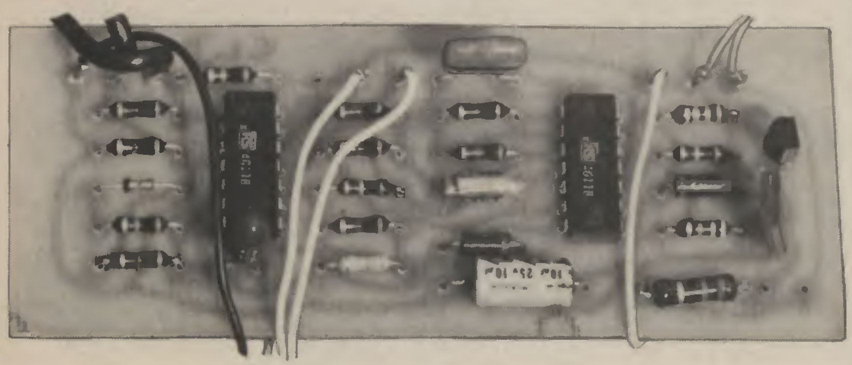
Since the prototypes were used as security loops the loop consisted of lengths of black 24/0·2in wire each terminated in a 3·5mm jack plug and socket. Two lengths were connected to the box itself, again one end terminated with a plug, the other with a socket.

TESTING

Connect the complete unit with the loop closed to a battery and speaker. Testing may be accomplished by simply opening the loop when the alarm should sound. If it does, reconnect the loop and check that the alarm keeps on for 30–40 seconds. Finally break the loop quickly and remake it which should again sound the alarm but only for the 30–40 seconds.

If these checks are correct measure the current consumption of the board. Firstly connect an ammeter in series with the supply line set to the highest range, switch on and wait for a minute. This is to allow the circuit to settle. Progressively increase the range until the current can be measured; this should be less than 20µA. If it is much greater than this ensure that all the CMOS pins that should be connected together actually are, and that the transistors are fully off.

If the unit does not fully work check each stage in turn, starting at the output of IC1 pin 3, through the voltage on C1, the Schmitt operation, and finally the oscillator and output stages.


Photograph showing prototype p.c.b.

IN USE

The prototype units were connected to a 10-metre loop split into eight sections and two one-metre lengths attached directly to the alarm unit itself. This loop was then threaded through the handles of the goods to be protected. Other uses where the loop is connected to window foil or even pressure pads under a carpet are not hard to imagine.

Again in a shop situation it would be far nicer to have a pressure mat in front of the counter instead of a bell push marked "press for attention". In this sort of application it would be better to replace the keyswitch with a simple press-to-break switch since it does not really matter who resets it. □

NEW · NEW · NEW · NEW

PRODUCTS

NEW · NEW · NEW · NEW

IN THE PICTURE

THE Bradford-based manufacturer of colour computer monitors, **Microvitec**, has just announced that it is making available its Cub range of 14in and 20in monitors to home users.

The Cubs are already familiar to schools as they are the only colour monitor to be approved under the Government's "Micros in Schools" programme and over 20,000 primary and secondary schools, not to mention colleges of further education, are claimed to be users.

They claim that the monitors are better than conventional television sets in two ways. First of all, the screens have up to four times as many "dots" as ordinary colour television tubes and so can reproduce much finer detail. Secondly, because they are "RGB" monitors, the Cubs can accept signals straight from the computer without the necessity for those signals to be encoded on a carrier by the computer and then decoded by the conventional TV circuitry.

Because the coding and decoding have been eliminated, the clarity of the picture or display is claimed to be much sharper. The greater resolution offered by the Cub range is seen by Microvitec as an important feature, particularly as a text-width of 80 characters is becoming an industry standard for the microcomputer.

Microvitec Ltd.,
Dept EE, Futures Way,
Bolling Road, Bradford,
West Yorkshire BD4 7TU.

ACT ONE

A COMPLETE analogue training instrument containing all the functions required for studying and experimenting with active filters, operational amplifiers and other analogue circuitry is being marketed by **E & L Instruments.**

Called the ACT-1 it contains four regulated, short-circuit proof, d.c. power supplies. Two are fixed at ±12V d.c., the third is variable from 0 to +7·5V d.c. and the fourth is variable from 0 to −7·5V d.c.

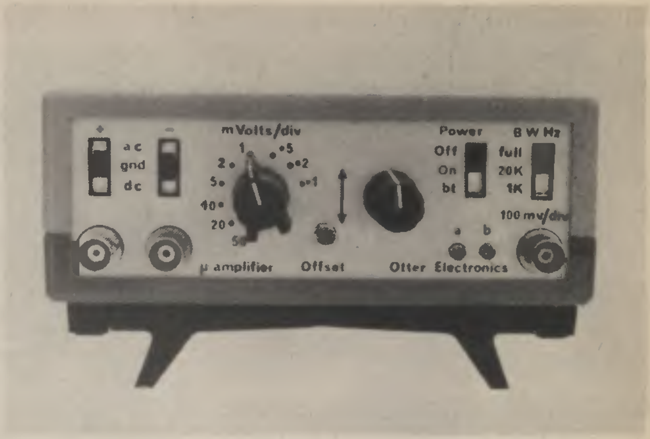
Integral to the front panel is a function generator circuit providing waveform outputs for amplifier experiments. It has outputs of sine, triangle, square and TTL as well as a.m. and f.m. modulation control lines.

The front panel also contains a number of uncommitted devices, including a 10kΩ slide potentiometer, 100kΩ slide potentiometer, two slide switches, two BNC connectors and one uncommitted solderless breadboard.

To support the "trainer" a series of manuals are being produced.

For more details of price and addresses of local stockists contact:

E & L Instruments Ltd.,
Dept EE, Whitegate Industrial
Estate, Whitegate Road,
Wrexham, Clwyd LL13 8UG.



OSCILLOSCOPE AMPLIFIER ADD-ON

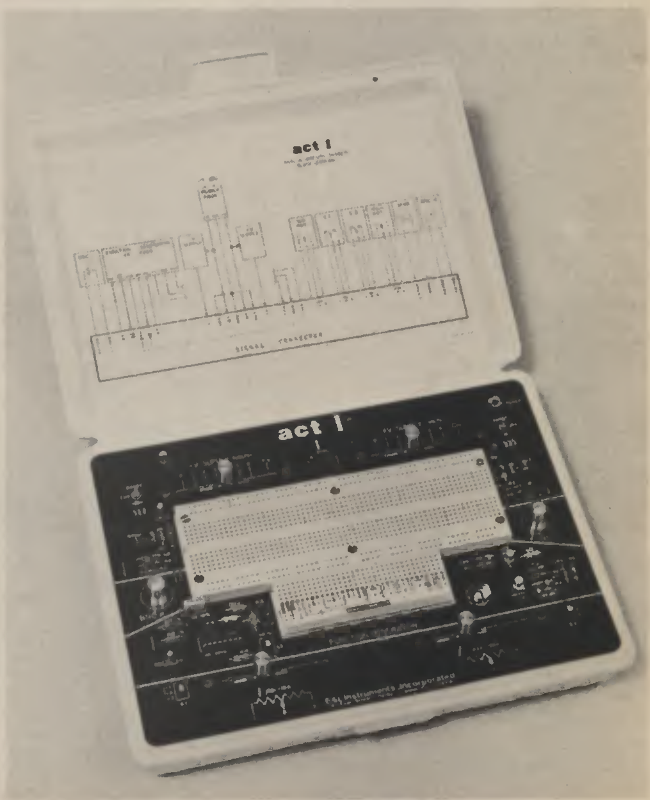
THE µAmplifier from **Otter Electronics** allows signals as minute as 100µV from d.c. to 2MHz to be viewed and measured on most oscilloscopes. The amplifier offers sensitivities from 100µV/division to 50mV/division with a.c. or d.c. input coupling, and maintains a constant output of 100mV/division.

To make full use of the high sensitivity a differential input is provided so that common mode signals can be minimised. Also to improve the display, a bandwidth limiting switch is provided to reduce the upper frequency limit to 20kHz or 1kHz.

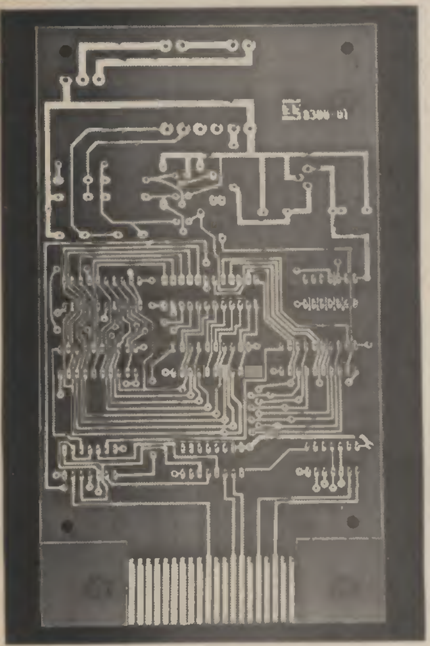
This amplifier will find many uses in audio and video work enabling monitoring of signals direct from playback heads and measuring ripple. Even physiological signals come within the amplifier's wide performance.

The amplifier is powered from **PP3** batteries and further details and addresses are obtainable from:

Otter Electronics Ltd.,
Dept EE, Otter House,
West Underwood,
Olney, Bucks MK46 5JS.



EVERYDAY ELECTRONICS PRINTED CIRCUIT BOARD SERVICE



Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

We regret that the ordering codes for the August projects have been incorrectly quoted in the Sept-Oct issues. Correct codes are given here.

Please note that when ordering it is important to give project title as well as order code. Please print name and address in Block Caps.

Readers ordering both p.c.b.s *and* software cassettes may send a single cheque/PO for the combined amounts listed.

*Set of four boards.

**Calibrated with C1, VR1 and IC3 fitted.

M.I.T.—Microcomputer Interfacing Techniques, 12-Part Series.

Readers are advised to check with prices appearing in current issue before ordering.

PROJECT TITLE	Order Code	Cost
Eprom Programmer, TRS-80 (June 83)	8306-01	£9.31
Eprom Programmer, Genie (June 83)	8306-02	£9.31
Eprom Programmer, TRS-80 & Genie (June 83)	8306-03	£1.98
User Port Input/Output *M.I.T. Part 1* (July 83)	8307-01	£4.82
User Port Control *M.I.T. Part 1* (July 83)	8307-02	£5.17
Storage 'Scope Interface, BBC Micro (Aug 83)	8308-01	£3.20
Car Intruder Alarm (Aug 83)	8308-02	£5.15
High Power Interface *M.I.T. Part 2* (Aug 83)	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Part 2* (Aug 83)	8308-04	£3.56
Electronic Die (Aug 83)	8308-05	£4.56
High Speed A-to-D Converter *M.I.T. Part 3* (Sept 83)	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Part 3* (Sept 83)	8309-02	£4.48
Stylus Organ (Sept 83)	8309-03	£6.84
Distress Beacon (Sept 83)	*8309-04	£5.36
Distress Beacon Pocket Version (Sept 83)	8309-05	£3.98
D-to-A Converter *M.I.T. Part 4* (Oct 83)	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4* (Oct 83)	8310-02	£5.13
Electronic Pendulum (Oct 83)	8310-03	£5.43
TTL/Power Interface for Stepper Motor *M.I.T. Part 5* (Nov 83)	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5* (Nov 83)	8311-02	£5.70
Digital Gauss Meter (Nov 83)	8311-03	£4.45
Speech Synthesiser for BBC Micro (Nov 83)	8311-04	£3.93
Car On/Off Touch Switch (Nov 83)	8311-05	£3.11
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6* (Dec 83)	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6* (Dec 83)	8312-02	£5.29
TRS-80 Twin Cassette Interface (Dec 83)	8312-03/09	£7.43
Environmental Data Recorder (Dec 83)	8312-04	£7.24
Touch Operated Die (Dot matrix) (Dec 83)	8312-05/06	£4.34
Touch Operated Die (7-segment) (Dec 83)	8312-05/07	£4.34
Continuity Tester (Dec 83)	8312-08	£3.41
Central Heating Pump Delay (Jan 84)	8401-01	£3.33
Biological Amplifier *M.I.T. Part 7* (Jan 84)	8401-02	£6.27
Temp. Measurement & Control System for ZX Computers (Jan 84)		
Analogue Thermometer Unit	8401-03	£2.35
Analogue-to-Digital Unit	8401-04	£2.56
Games Scoreboard (Jan 84)	8401-06/07	£9.60
Eprom Programmer/ROM Card for ZX81 (Feb 84)	**8402-01	£7.84
Oric Port Board *M.I.T. Part 8* (Feb 84)	8402-02	£9.56
Negative Ion Generator (Feb 84)	*8402-03	£8.95
Temp. Measurement & Control System for ZX Computers (Feb 84)		
Relay Driver Unit	8402-04	£3.52
Latched Output Port *M.I.T. Part 9* (Mar 84)	8403-01	£5.30
Buffered Input Port *M.I.T. Part 9* (Mar 84)	8403-02	£4.80
VIC-20 Extension Port Connector *M.I.T. Part 9* (Mar 84)	8403-03	£4.42
Commodore 64 Extension Port Connector *M.I.T. Part 9* (Mar 84)	8403-04	£4.71
Digital Multimeter Add-On for BBC Micro (Mar 84)	8403-05	£4.63
Multipurpose Interface for Computers	8404-01	£5.72
Data Acquisition "Input" *M.I.T. Part 10* (Apr 84)	8404-02	£5.20
Data Acquisition "Output" *M.I.T. Part 10* (Apr 84)	8404-03	£5.20
Data Acquisition "PSU" *M.I.T. Part 10* (Apr 84)	8404-04	£3.09
Timer Module (Apr 84)	8404-05	£3.58
A.F. Sweep Generator (Apr 84)	8404-06	£3.55
Quasi Stereo Adaptor (Apr 84)	8404-07	£3.56
Simple Loop Burglar Alarm (May 84)	8405-01	£2.92
Computer Controlled Buggy *M.I.T. Part 11* (May 84)		
Interface/Motor Drive	8405-02	£4.75
Collision Sensing	8405-03	£3.04
Power Supply	8405-04	£4.53

SQUARE one FOR BEGINNERS

LOGIC gates are used in many electronic applications to perform a variety of specific functions. The idea of logic is to have only two distinct states known as high or low, on or off, or simply 1 or 0. In electronic circuits these states are determined by voltage levels present at the input or output of the gates. Each gate has two or more inputs, and one output whose logical state can be manipulated by its input condition.

There are several "Logic Families" available, the most common being Transistor-Transistor Logic (TTL) and Complementary Metal-Oxide Semiconductor (CMOS). Their characteristics are quite different but the same logic rules apply to both. These gates are usually contained in dual-in-line (d.i.l.) i.c. packages, a typical example being a quad 2-input NAND gate (TTL-7400), which has 14 pins.

LOGIC SYMBOLS

The logic symbols used in circuit diagrams are shown in Figs. 1 to 4, and input/output functions are shown in the truth tables. A 0 and 1 represent low and high voltage levels, respectively.

Fig. 1

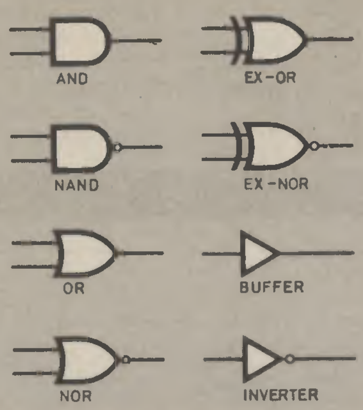


Fig. 2

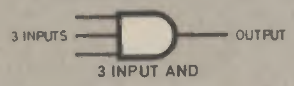


Fig. 3

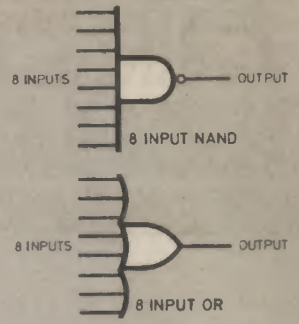
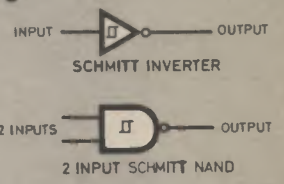


Fig. 4



The three basic logic functions can be explained as follows:

The AND function will always give a low output unless all its inputs are high, for example, any 0 in will give a 0 out.

The OR gate will give a low output unless any of its inputs are high, for example, any 1 in will give a 1 out.

The EX-OR gate will give a high output if only one input is high (not both).

Each of the above gates is available with inverted outputs, thus giving: NAND, NOR and EX-NOR functions. An inverted logic level is one that is changed from a high to low, or low to high. For example, any 1 into a NOR gate will give a 0 out. Logic gates are available with up to eight inputs with exception of the EX-OR and EX-NOR which can have only two inputs.

Other gates which are commonly used are the Buffer, Inverter and "Schmitt" triggered gates. Buffers and Inverters are single input devices used to buffer previous outputs. The buffer will give the same logic level at its output, as applied to its input, whereas the inverter will give the inverse. "Schmitt" triggered devices are fast switching inverting gates used in high speed circuits.

There are limitations to the use of these chips which vary from one type of i.c. to another. However, they are all clearly defined in manufacturers' data sheets. Examples of limits are supply voltages, load currents and fan-out capability. Fan-out capability, being the number of gates which can be connected to any one output.

TRUTH TABLES

AND

Inputs		Output
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

OR

Inputs		Output
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

EX-OR

Inputs		Output
A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

NAND

Inputs		Output
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

NOR

Inputs		Output
A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

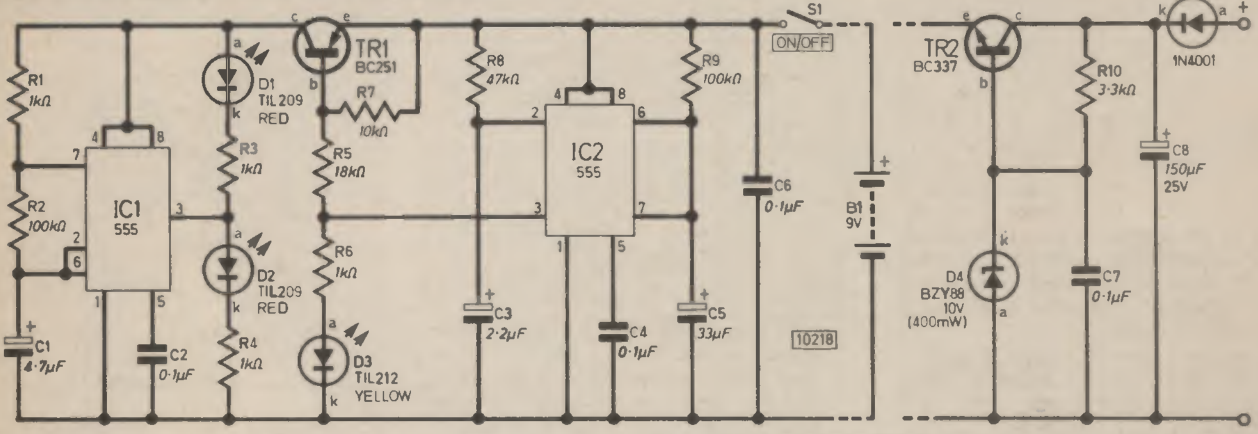
EX-NOR

Inputs		Output
A	B	C
0	0	1
0	1	0
1	0	0
1	1	1

CIRCUIT EXCHANGE

This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.

LEVEL CROSSING LIGHTS FLASHER



THIS circuit is used to simulate level crossing lights on a model railway. R8 and C3 trigger IC2 as soon as S1 is closed. The yellow l.e.d., D3, lights for about five seconds, after which the output of IC2 goes low. The yellow l.e.d. goes out and TR1 is biased into conduction which starts the red l.e.d.s flashing.

The circuit operates from a 9V battery, but if the railway power controller has a separate fixed voltage d.c. output, then this can be used, although the smoothing and regulator circuit shown above may be required. On an "00" scale layout, 3mm diameter l.e.d.s should be used.

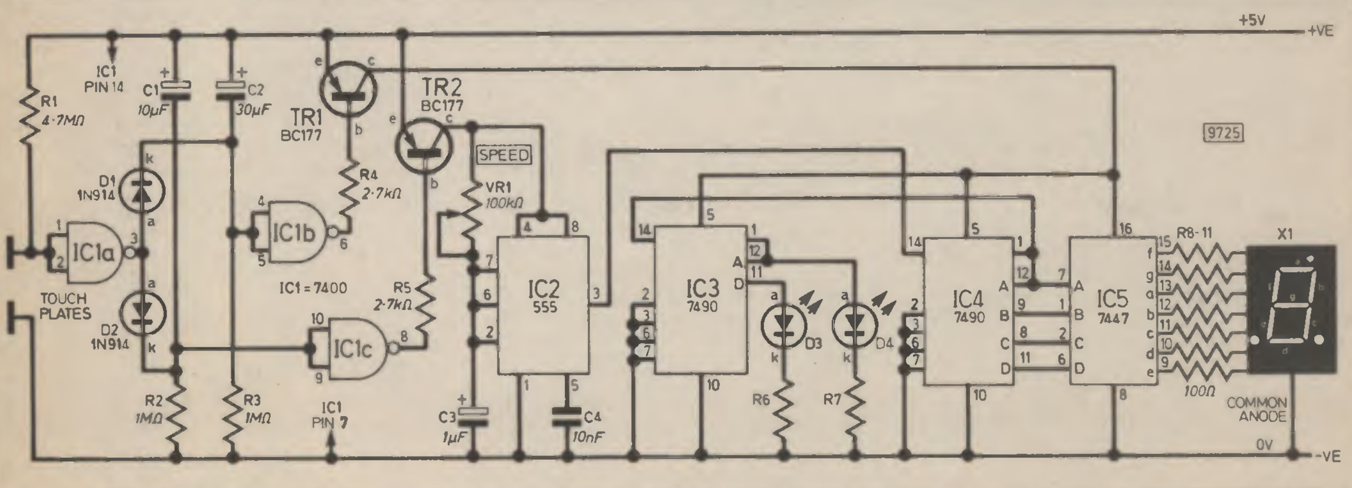
R. Ormston,
Hythe,
Hants.

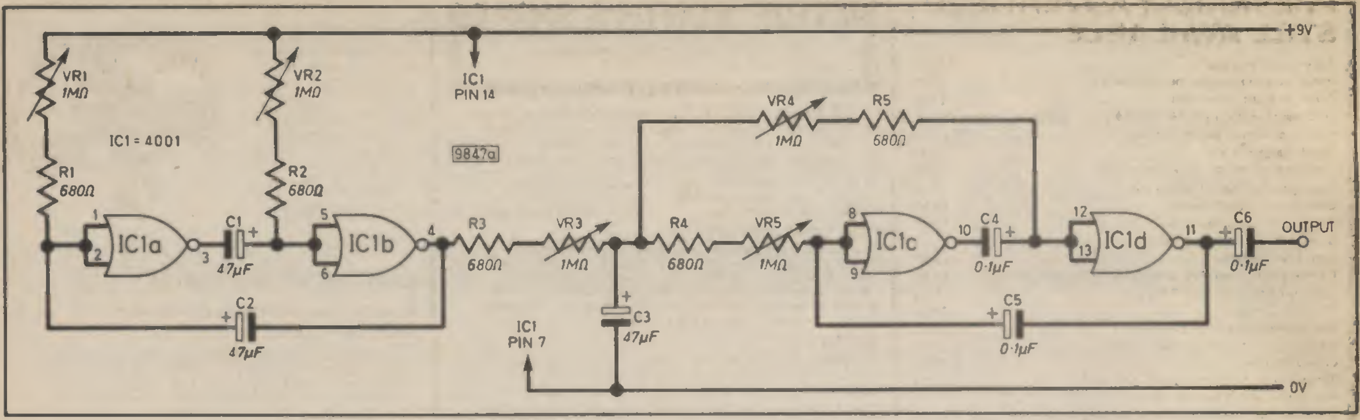
DIGITAL GAME

THE circuit presented here is a game which uses two l.e.d.s and a large 7-segment display for playing and one of its features is touch operation. To start the game, the player must touch the two touch plates. As soon as these are bridged C1 and C2 will be charged up via D1 and D2. The time constant for these networks will be determined by C1, R2 and C2, R3 respectively, and will change the logical states of two NAND gates from high to low (1 to 0). TR1 and TR2 will switch on for a predetermined time, and thus supply current to the rest of the circuit. Since C1 is smaller than C2, TR1 will switch off, first causing the oscillator to switch off before the display. The frequency of the oscillator may be adjusted by VR1.

After a certain time, the display will turn off and the power consumption of the whole circuit will be around 1µA or less (because of CMOS i.c.s). Because of the low current drain an on/off switch is not needed. For D3 and D4 a Tri-colour l.e.d. could be used but this device will increase the price of the unit.

Hamid Reza Tajzadeh,
Tehran,
Iran.





ELECTRONIC SIREN

THE heart of the electronic siren is a quad two-input NOR gate MC717 integrated circuit or equivalent. The four gates are used in pairs to make two oscillators. One oscillator varies the frequency of the other.

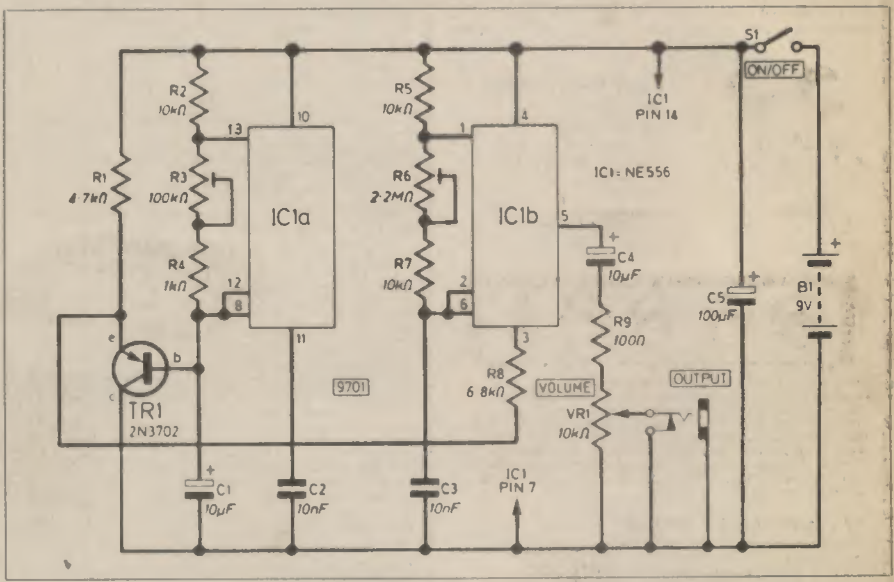
After completing the circuit, setting all pots to mid position should yield a sound much like that of an air-raid siren.

Hamid Reza Nameri, Tehran, Iran.

ELECTRONIC CANARY

THE Electronic Canary was designed for play sound effects. The circuit is quite simple and is based around an NE 556 timer i.c. Pin 3 is connected to the emitter of TR1 which follows the voltage on C1 to produce a "ramp" waveform. That is the charge/discharge curve of C1. Thus a roughly triangular wave is fed to the audio oscillator causing it to glide between tones.

Shaun Gander, Lewes, Sussex.



COUNTER INTELLIGENCE

BY PAUL YOUNG

Ubiquitous Electronics

A cartoon in the "Nationals" the other day, depicted a little boy being asked by the King what he wanted to be, and he answered, "A jeweller and an electrical engineer". "Why both?" asked the King. "So I can repair watches".

I think I might have used the word, "Electronic" instead of "Electrical" but what impressed me was, that the cartoonist was stating a truth that goes far beyond watches. If the boy in question wanted to be any number of things, Automobile Engineer, Washing Machine Mechanic, Typewriter Repairer, Refrigeration Engineer, the list could be extended almost indefinitely, today, he would still need to have a thorough grounding in electronics.

This can only be good news for the technical schools and the electronics magazines, for what better start can any youngster have in this field, than reading "Everyday Electronics" and our sister publication, "Practical Electronics".

Solutions Good and Bad

One thing that pleases all of us is a neat solution to a problem, especially if electronics are involved. Here is a case in point.

High up in the very isolated Ibardin Pass, between France and Spain, telephone engineers wanted to install a coin-operated phone box. Laying cables would have presented a major problem so this is what they did.

The power supply was solved by using solar panels to charge up batteries. It can function up to 15 days without any sunlight and instead of wires carrying the sound, a short-wave radio link connects it to the nearest exchange.

If this earns a bouquet, then a brick bat should go to whoever installed the lighting at Fenchurch Street Station. The lights are arranged to come on automatically when the natural daylight falls below a certain level.

Nothing new in that of course, but here is the rub. The sensors have been placed so that the artificial light falls directly on them. The result being, that they immediately switch all the lights off again.

Sound Sense

I recently had the misfortune to burst an ear drum, a legacy of my flying days. About a week later I was wandering disconsolately down Middlesex Street, better known as Petticoat Lane, and speculating on whether it would eventually heal, or whether I should need a hearing aid, when I heard a costermonger calling out, "Don't bother with the National Health, Deaf Aids only 10p".

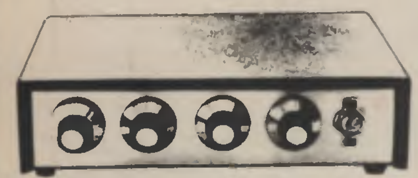
Deciding that I could hardly go wrong, I purchased one. I was given a small cardboard box and inside was a yard (sorry metre) of white tea string with a knot in one end.

"How does it work?" I asked the vendor. "Simple, Guv, put the knot in your ear and the other end in your breast pocket, and people will shout at you like mad!!"

PREVIOUSLY ADVERTISED STILL AVAILABLE

Tape punch and reader	£22.50
Bench isolating transformer 250 watt	£7.75
BOAC in-flight stereo unit	£1.50
Drill assortment 4 each 25 sizes between .25mm & 2.5mm	£11.50
Battery condition tester, less box	£1.75
Nicad chargers, mains	£0.75
Flourescent inventor 13 watt from 12v	£3.50
Ten digit stitch pad-pb phone etc.	£1.95
Uniselector 2 pole 25 way	£4.60
Water valve mains operated	£2.50
Counter 6 digit mains operated	£1.15
ditto 12v resettable	£3.45
Double glazing clear PVC sheet, 23½" wide per running ft.	£0.15
Locking mechanism with 2 keys	£1.15
Magnetic Clutch	£4.50
Mouth operated suck or blow switch	£2.30
Solenoid with slug 8 - 12v battery op.	£1.82
ditto 230v mains	£2.30
Timer Omron STP NH 110v AC Coil	£6.90
Key switch with 2 keys dp mains	£1.75
Air valve mains operated	£3.75
Latching relay mains operated	£3.50
Dry film lubricant aerosol can	£0.65
Coin op switch, cased with coin tray	£4.60

8 POWERFUL MODEL MOTORS (all different)
for robots, meccanos, drills, remote control planes, boats, etc. £2.95.



Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form or £25.00 assembled and tested.

12 volt MOTOR BY SMITHS
Made for use in cars, etc. these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. They have a good length of ¼" spindle — Price £3.45.
Ditto, but double ended £4.25.
Ditto, but permanent magnet £3.75.

EXTRA POWERFUL 12v MOTOR
Probably develops up to ¼ h.p. so it could be used to power a go-kart or to drive a compressor, etc. £7.95 + £1.50 post.

THERMOSTAT ASSORTMENT
10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses; appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 — 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 - however, you can have the parcel for £2.50.

MINI MONO AMP on p.c.b., size 4"x 2" (app.)
Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 10 for £10.00.

— BARGAIN OF THE YEAR —

The AMSTRAD Stereo Tuner.

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio — easy to carry about and which will give you superb reception.

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THIS MONTH'S SNIP

Hi Fi sound from your Spectrum 1 watt amp — pm speaker & instructions £2.45

REVERSIBLE MOTOR with control gear Made by the famous Framco Company this robust motor is approx 7½" long, 3½" dia. 3/8" shaft. Very powerful, almost impossible to stop. Ideal for operating stage curtains, doors, ventilators, etc. Even garage doors if properly balanced. Offered complete with control gear as follows:
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1 circuit diag. of connections — ONLY £19.50 + postage £2.50.

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Why not make your greeting card play a tune? It could play 'Happy Birthday', 'Merry Christmas', 'Wedding March', etc, or 'Home Sweet Home', etc. Wafer thin 3 part assemblies, for making cards musical. Mini microchip speaker and battery with switch that operates as the card is opened. Please state tune when ordering. Complete, ready to work £1.25.

JOYSTICK
WHY PAY £10 OR MORE — Make yourself a Joystick — full details were given in Dec/Jan 'Sinclair Projects'. We will supply complete kit for £2.30. Although designed for the Spectrum or ZX81 it is equally suitable for any home computer.

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Plugs only 4 pin or 5 pin	£1.15
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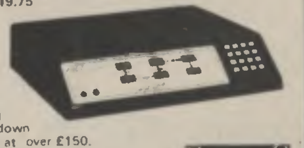
Note: British Telecom may not connect this equipment as there is no manufacturer to guarantee it, however it is well worth buying for its immense breakdown value — sold originally at over £150.



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Hi-Fi	Woofer	12in	80	8	£25.00
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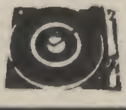

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2.	(3)	Modem	LW99H	£44.95	5 XA05F
		Case also available: YK62S Price £9.95.			
3.	(5)	ZX81 I/O Port	LW76H	£9.25	4 XA04E
4.	(4)	Car Burglar Alarm	LW78K	£6.95	4 XA04E
5.	(8)	Partylite	LW93B	£9.45	Best of E&MM
6.	(2)	Keyboard for ZX81	LW72P	£23.95	3 XA03D
		Case also available: XG17T £4.95. Complete ready-built: XG22Y £32.50			
7.	(10)	8W Amp Module	LW36P	£4.45	Catalogue
8.	(14)	VIC20/64 RS232 Interface	LK11M	£9.45	7 XA07H
9.	(7)	Syntom Drum Synthesiser	LW86T	£11.95	Best of E&MM
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11.	(17)	Spectrum RS232 Interface	LK21X	£17.95	8 XA08J
12.	(6)	VIC20 Speech Synthesiser	LK00A	£22.95	6 XA06G
13.	(13)	ZX81 Sounds Generator	LW96E	£10.95	5 XA05F
14.	(11)	Ultrasonic Intruder Detctor	LW83E	£10.95	4 XA04E
15.	(15)	Logic Probe	LK13P	£9.95	8 XA08J
16.	(26)	Car Battery Monitor	LK42V	£6.25	Best of E&MM
17.	(18)	Hexadrum	LW85G	£19.95	Best of E&MM
18.	(21)	Synwave Sounds Synth	LW87U	£10.95	Best of E&MM
19.	(25)	Spectrum Keyboard	LK29G	£28.50	9 XA09K
		Also required: LK30H £6.50; Case: XG35Q £4.95 — Total £39.95. Also available complete ready-built: XG36P £44.95.			
20.	(9)	ZX81 Speech Synthesiser	LK01B	£16.95	6 XA06G

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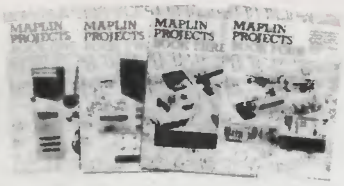

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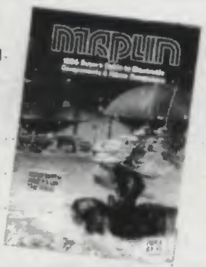

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