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JUNE 1988

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The Magazine for Electronic & Computer Projects

VOL 17 No 6 JUNE '88

EVERYDAY ELECTRONICS

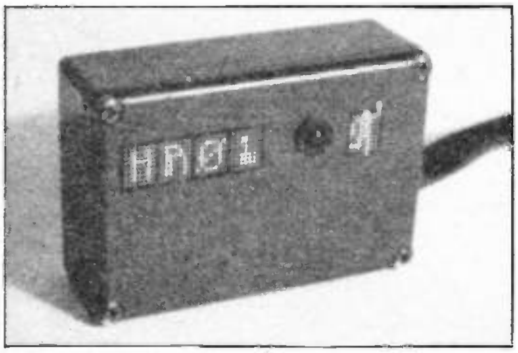
INCORPORATING ELECTRONICS MONTHLY

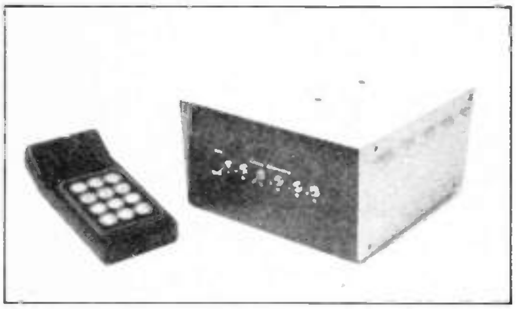
ABC

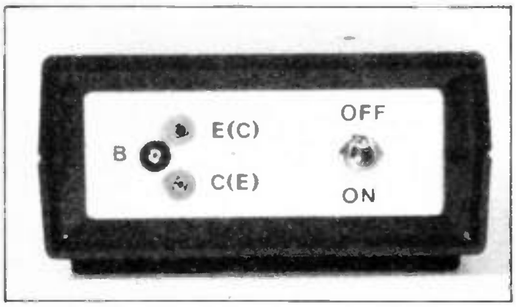
The Magazine for Electronic & Computer Projects

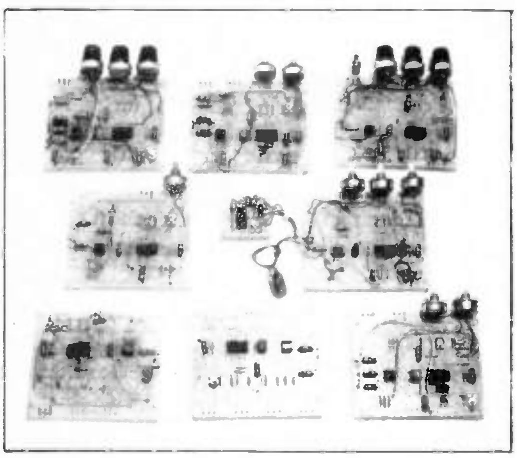
ISSN 0262-3617

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









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EE PROJECT KITS MAGENTA

Full Kits inc. PCBs, or veroboard, hardware, electronics, cases (unless stated). Less batteries.

If you do not have the issue of EE which includes the project—you will need to order the instruction reprint as an extra—80p each. Reprints available separately 80p each plus p&p £1.

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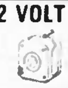

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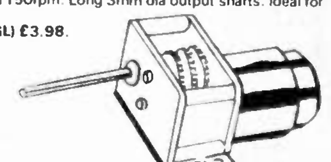

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EE CROSSWORD 5

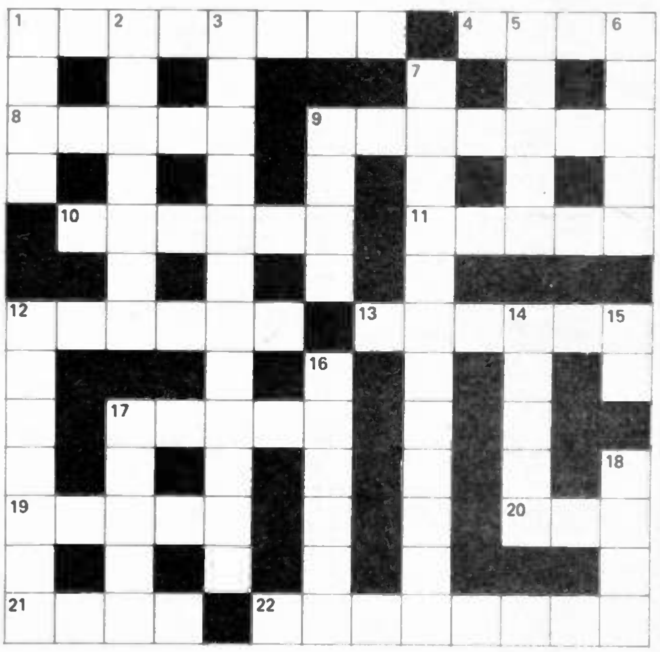
CLUES ACROSS

1 An additional secondary winding. (8)
4 Video heads found on this musical instrument? (4)
8 This steer will clear. (5)
9 and **11** In TV this component will increase the voltage. (7, 5)
10 Wavelength is measured in these units. (6)
11 See 9.
12 He knew Mr. Seeley. (6)
13 A type of coil that makes an utterance. (6)
17 Unwanted transient. (5)
19 This often occurs when warming up. (5)
20 Replaced by the Siemen. (3)
21 An array of elements. (4)
22 Release of electrons due to thermal agitation. (8)

DOWN

1 Prefix denoting 10^{12}. (4)
2 Luminous patterns produced by scanning. (7)
3 In a superhet all signals are converted to this frequency. (12)
5 Form of f.m. demodulator. (5)
6 Interrupted c.w. as a code. (5)
7 To be found in a corner of Hyde Park, raising their voices. (12)
9 Low audio frequencies. (4)
12 This scientist had a unit of measurement named after him. (7)
14 In the promenade there is a memory. (5)
15 Initially high frequencies. (2)
16 A million times the basic unit of resistance. (6)
17 In c.t.v. the burst does this. (5)
18 This form of loading increases the volume of sound radiated. (4)

For fun only—answers on page 370.



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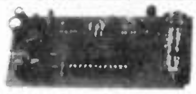
XK125 Complete kit of parts £24.00

VERSATILE REMOTE CONTROL KIT



This kit includes all components (+ transformer) to make a sensitive IR receiver with 16 logic outputs (0-15V) which with suitable interface circuitry (relays, triacs, etc – details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits. Supply: 240V AC or 15–24V DC at 10mA. Size (excluding transformer) 9 x 4 x 2 cms. The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available—MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

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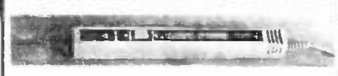

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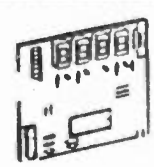

This kit contains a Single Chip Microprocessor, PCB, displays and all electronics to produce a digital readout of weight in Kgs. or Sts. and Lbs. in normal use a toothed wheel (pattern provided) is made to rotate when a weight is placed onto the scales, interrupting two infra-red beams. The processor counts the number of teeth passing the sensor (up or down, depending on which beam is broken first), and shows the reading on the LED display in Sts. and Lbs., Lbs or Kgms. A PCB link selects the scale for bathroom or two types of Kitchen Scales. A linear version of the toothed wheel could also be used. Other uses include up/down counters. A low cost digital ruler could be made by using a wheel with the correct tooth to diameter ratio. ESI **£6.50**

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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL. 17 No. 6 **June '88**

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THANKS

EVERYDAY Electronics—No. 1 again! I would like to thank all our readers for making EE the No. 1 U.K. electronics hobbyist magazine again this year (based on ABC figures for 1987). For three years running *Everyday Electronics* has sold more copies in the U.K. than any of its rivals. During 1987 our U.K. circulation rose by nine per cent and for the first four months of 1988 the figures have continued to rise.

Interest in our hobby is growing and, with your help, *Everyday Electronics* will continue to grow with it—thanks!

GROWTH

While the first ever U.K. magazine series leading to a formal electronics qualification (our *Introducing Microprocessors* series which leads successful readers to a City and Guilds qualification) comes to an end next month, the success of the series has led to further developments. For a start we will re-publish *Introducing Microprocessors* in book form—see the note on page 341 about this. Secondly, due to demand, we will start another City and Guilds linked series in our October issue.

The new course will be *Introducing Digital Electronics* and will lead the successful reader to a City and Guilds certificate in Introductory Digital Electronics (726/301). Aimed at readers with little or no previous knowledge of electronics we expect this new course to be even more popular than *Introducing Microprocessors*.

AVAILABILITY

One of the problems an increasing circulation creates is that of availability of issues. We have now completely sold out of the April 1988 issue and have been unable to provide copies to many readers who missed it. Please help us to make sure you get your copy by placing an order with your newsagent or by taking out a subscription. You will find a card in this issue which can be used for either of the above.

Mike Kenward

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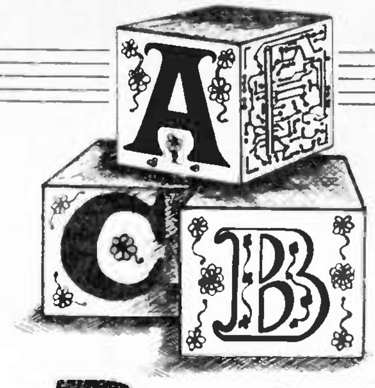
Constructional Project

AUDIO MINI-BRICKS



Part 1,

JOHN BECKER

A planned series of ten audio building "bricks" that can be connected together in numerous different ways to produce all kinds of sound effects. These basic building modules are examined in detail and, with one exception, all the circuits use identical i.c.s and a master printed circuit board.

The circuits are all self-contained and you can select whichever circuits you want to build. All projects are suited to assembly by novice and experienced constructor alike.

Amongst the 19 basic building blocks are a VCO, Mock Stereo, Noise Generator, Phasing, Fuzz, Voice Operated Fader and many more. If all building bricks are completed, a powerful "Sound Studio" will be created.

WHEN the circuit diagrams of many audio effects are examined in detail, it is apparent that many use similar functions. Although the actual components may differ, the block diagram representations of the circuit sections are often identical. From this observation, it will be clear that by creating a number of different mini-circuit building bricks, these can be connected together in numerous different ways to produce all kinds of sound effects and audio functions.

Over the next few issues, some of these basic building bricks will be examined in detail and practical examples of their use will be discussed. With one exception, all of the circuits use indentical i.c.s. and a multipurpose master printed circuit board.

The "bricks" will vary considerably in their circuit diagrams and functions, but their implementation depends only on component values, and positioning on the p.c.b. It is not necessary to build all modules in order to obtain specific effects. You can select whichever circuits you want to build.

All projects are suited to assembly by novice and experienced constructors alike. If they are all built, a powerful sound effects synthesising system can be achieved. Interested readers will also find inspiration to create other combinations.

Several graphs will be published showing the parameter ranges of some of the basic circuits. These will enable constructors to produce effects tailored to their own needs by amending specific component values.

CIRCUIT BLOCKS

There are 19 basic building blocks. These include a Voltage Controlled Oscillator (VCO) with four waveforms, and another VCO with a single output. Two Voltage Controlled Filters (VCF), one low pass, the other with four filtering options.

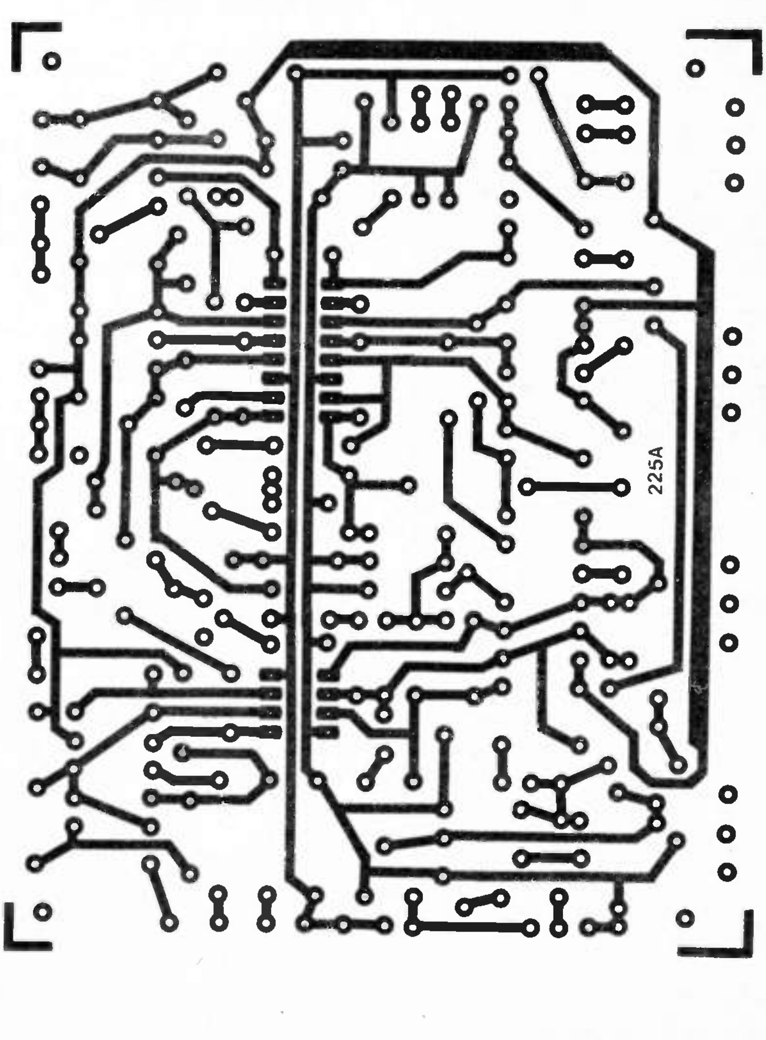
A Three-Input Active Mixer. Automatic Level Control. Signal Compressor. Noise gate. A Ring Modulator. Two frequency doublers. A Voltage Controlled Amplifier and a VC Pre-Amp. An Envelope Shaper, a Level Triggered Pulse Generator, a Sample and Hold circuit.

Three converters—Frequency to Voltage, Frequency Changing, Linear to Logarithmic. A White Noise source. Some modules are suitable for computer control, and a simple trigger interface circuit will also be given.

The circuits are self contained and can be used on their own. They can also be coupled together in a variety of ways to produce more complex circuits.

Amongst those to be shown are a VCO, with six different waveforms. A Tone Control and Equaliser. A Mock Stereo Simulator. Effects for Phasing, Fuzz and Tremolo. A Wobble-Wah unit. Two Siren

Fig. 1.1. Master Printed Circuit Board.

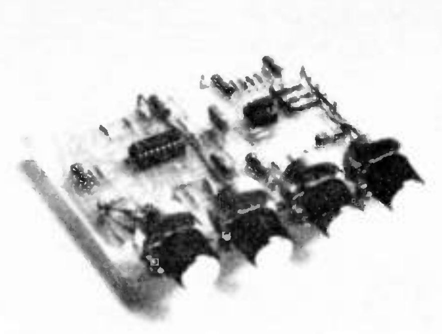


Generators, one simple, the other with triggering and modulation.

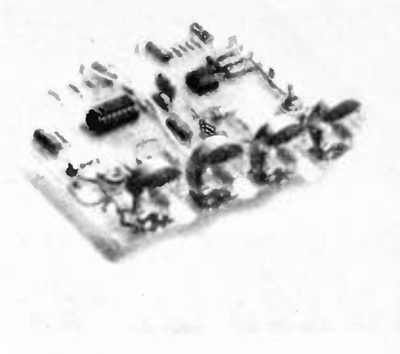
A Wind, Rain and Surf Generator. A Drum Effects Synthesiser and Gun Shot Generator. A Voice Operated Fader. Two note triggered circuits—Envelope Shaper, and Wah-Wah. A simple Frequency Meter. ***All of these and more can be assembled using the general purpose printed circuit board.***

A second printed circuit will also be shown. This is designed specifically as an Audio Delay Module. Using it in conjunction with some of the building blocks numerous other effects can be readily produced.

These include Echo, Reverb, Phasing, Flanging, Double Tracking and Vibrato. The final article in the series will describe a unit that can achieve all of these essential sound effects.



Prototype audio "brick" for a VCF and Mixer (Plan-B)—Next Month



Prototype audio "brick" for a Hex-Waveform VCO (Plan-A)—This Month

MAIN PRINTED CIRCUIT BOARD

The main or "master" printed circuit board is common to all building blocks, except for the Audio Delay Module. The full-size copper foil master pattern for the Main Board (255A) is shown in Fig. 1.1. (The delay board foil pattern will be given in a later part.). If it is intended to produce one of each of the blocks, 10 copies of the board will be needed. Some blocks need a board entirely to themselves. In other instances though, several can go on the same one. Some of the simple circuits can be constructed on Veroboard or similar instead of using the p.c.b.

For those who are interested in general experimentation it is possible to use just one p.c.b. in the manner of a tag board. In this case, solder in i.c. sockets, and 1mm terminal pins in the remaining holes. To these, components can be directly soldered for what ever circuit is needed.

Once curiosity in that circuit has been satisfied, the components can be exchanged for others to create another one. This is a preferable method to repeatedly soldering components in and out of the board which can eventually damage p.c.b. copper tracking. Those intent on assembling the board as a permanent unit should, of course, solder components on the board in the normal way.

Throughout the series the numbering of components follows a consistent pattern and order. A particular part number, irrespective of its function, will always go into the same p.c.b. holes.

Along one edge of the p.c.b. are 12 individual holes apparently unconnected. These are spaced so that rotary potentiometers can be soldered to the board at 3cm intervals.

Some circuits may need more than four potentiometers. In this case some can be mounted onto other boards that do not need them. This will be of assistance when a complex synthesising set of modules is being housed in the same box.

POWER SUPPLY

All modules run from a 9V power supply, but will accept at least 12V, and in most cases, probably up to 15V. For voltages higher than 9V, specifications quoted in graphs may need adjusting accordingly.

The circuit diagram Fig. 1.2 shows the basic PSU lines. These are common to all boards. Switch S1 though need only be used once. Resistors R28, R29, capacitors C10, C11, and C23 are used on each board constructed.

The voltage at the junction of resistors R28 and R29 will be 4.5V for a 9V power supply. It is notated as V_{ref}, and it is to this point that all other points marked V_{ref} in the circuit diagrams for any one board are terminated.

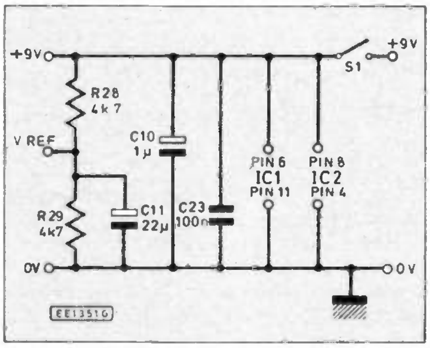


Fig. 1.2. Circuit diagram for the basic power supply lines.

CONTROL NODE VARIATION

The design of all the primary modules is based upon the attributes of one i.c. in particular, a transconductance amplifier (TCA) type LM13600. The current flow into the TCA control node can be varied in several different ways depending upon the application.

There is a maximum current permitted, and so a minimum resistance of at least 4k7 must always be in series with it. The current seen at the node will depend on the total series resistance.

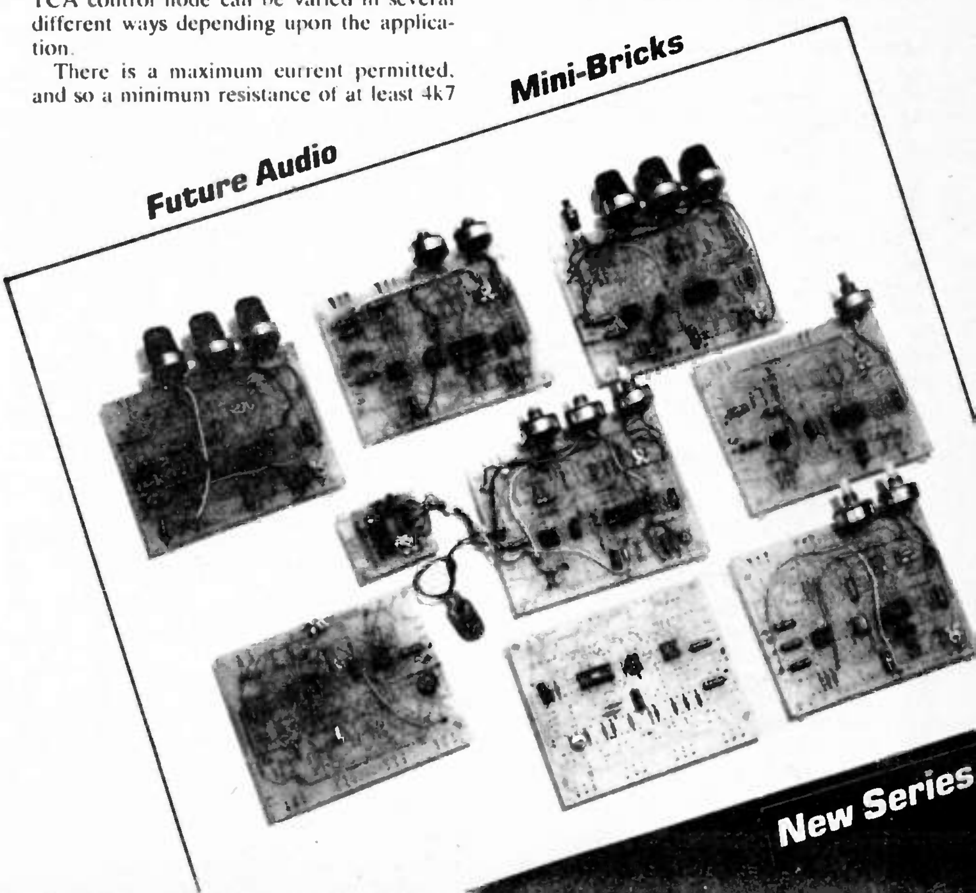
As in any circuit, the voltage across the resistor determines the current flow in relation to its value. Graph figures usually apply to a 9V level into the resistance. A voltage reduction will result in a lower current transfer level.

The voltage may come from other modules, or from external units, as for example from the voltage output of a synthesiser keyboard. It could also come from a computer via a digital-to-analogue converter.

Its effect may be further varied by changing the series resistance. In Fig. 1.3, VR7 shows a typical way in which a potentiometer can go between the node and the source. With the value shown a fairly wide variation of current can be achieved. The overall range may be changed by using a different potentiometer value.

Also in Fig. 1.3, VR6 shows another control method. One end of VR6 is connected to a fixed voltage level. The other is connected via resistor R8 to the ground line. When the wiper is turned, the voltage on it will be related to the total resistance to either side, in normal potential divider terms.

However, since the node itself draws current through the potentiometer via its own



resistor, the relationships become complicated. In practice, a value of 100k for VR6 will normally suit most eventualities.

The use of resistor R8 is not essential, and the bottom of VR6 could be taken directly to "ground". Its inclusion though is often preferable as the control node has a minimum input voltage requirement.

With a 9V power supply, this is around 1V. If the control voltage falls below this, current cannot flow into the node. Consequently, the TCA will fail to respond below this point.

This may be desirable in some cases, but in others a minimum response may be required, hence resistor R8. The value shown is typical for use with a 100k potentiometer. It may be varied to adjust TCA lower response levels.

Some control nodes have a variable preset potentiometer in series. This enables the maximum current flow to be restricted so limiting upper response levels.

A conversion chart plotting resistance against current in relation to different control voltages, is shown in Graph 1. This is of use whenever control response of any TCA function is being calculated.

Since the TCA is a high gain device, signal levels are normally first reduced by the input resistance networks. In most modules shown, the reduction is set to around one hundredth.

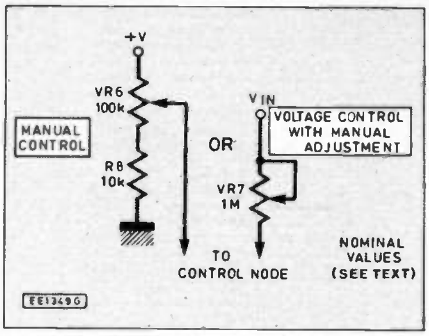


Fig. 1.3. Alternative voltage controllers.

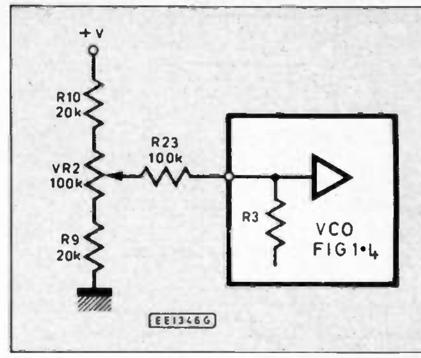


Fig. 1.4a. Adding a variable slope ramp control to Fig. 1.4.

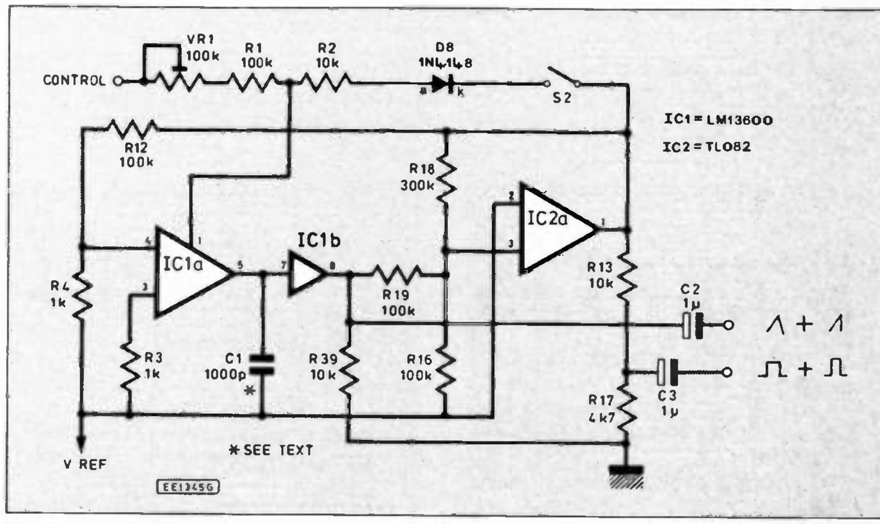


Fig. 1.4. Circuit diagram for a Quad-Waveform Voltage Controlled Oscillator (VCO). Typical output waveforms can be seen in photographs 1 and 2 opposite.

FIRST THREE CIRCUITS

We now turn to a practical use of the "master" printed circuit board. This will result in a Quad-Waveform VCO, a Low Pass Filter, and a 3-Input Mixer.

As shown this configuration results in a Hex-Waveform VCO. However, if the interlinking connections between the three are omitted, each circuit is self-contained, and can be used on its own, or connected to other modules yet to be described.

QUAD WAVEFORM VCO

In sound effects production, a fair number of circuits require modulation as the sound source itself. A multiple waveform VCO also forms the basis for signal generators.

The circuit diagram for a Quad-Waveform VCO shown in Fig. 1.4 can be used in any of these applications, and produces four waveforms of triangle, ramp, squarewave and pulse. Some typical output waveforms can be seen in photographs 1 and 2.

The circuit uses half of the TCA, IC1a and IC1b, and half of the op.amp, IC2a. When a current is put into the control node of IC1a, at pin 1, it passes an equivalent current to capacitor C1.

Since IC1b is a high impedance buffer, all of the current goes into C1 with very little leakage. As the charge on C1 changes so the output of IC1b follows suit. This is connected to IC2a which is configured as a comparator.

The trip point is set by the values of resistors R16, R18 and R19, and in relation to the voltage reference level. When the output of IC1b passes the trip point, the output of IC2a changes state. This is fed back to IC1a and the charge flow reverses until the trip point is passed in the opposite direction. This process continues indefinitely.

Because of the near-instantaneous changes in the state of IC2a, a squarewave is produced. The output of IC1b though is a constantly rising and falling ramp, which results in a triangle waveform.

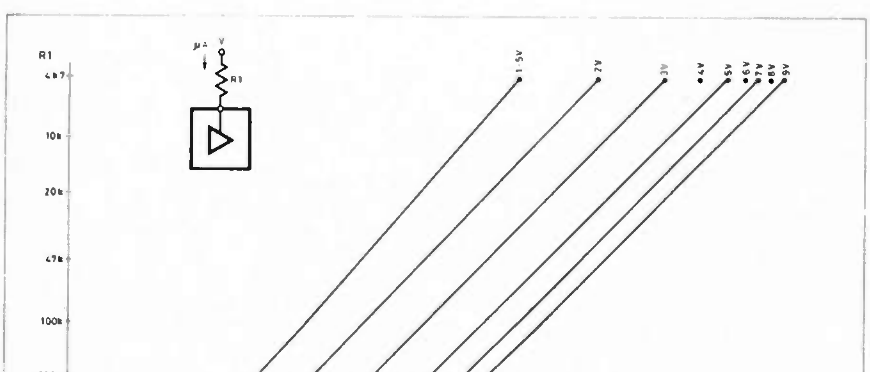
When S2 is switched on, the output of IC2a is also connected to the control node of IC1a, via diode D8. In this case when IC2a goes high, maximum current is delivered to the control node, and so the flow rate at capacitor C1 is rapid.

When IC2a goes low, the rate is unaffected since diode D8 only allows the current through in one direction. The output waveform thus becomes a ramp at IC1b, and a pulse at IC2a.

Mark-space ratios of the pulse will depend on the basic current going into the control node. The ramp direction may be changed by reversing the diode. It is also possible to vary the ramp slope by using the control shown in Fig. 1.4a. The variable ramped triangle waveform is shown in photograph 3.

Relative levels of the ramp and squarewave will of course differ. The maximum ramp height is limited by the threshold trigger level, whereas the output at IC2a will be a little under full line level swing. So that the

Graph 1. Conversion chart plotting resistance against current in relation to different control voltages.



levels at the two output points are at closer equivalence, resistors R13 and R17 are included to attenuate the squarewave level.

The oscillation frequency depends principally on the value of capacitor C1 and the current going into the control node. Graph. 2 shows various plots of frequency against both control node current and resistance, together with varying values of C1.

LOW PASS FILTER

The circuit diagram for a Low Pass Filter is shown in Fig. 1.5. As the name implies, it filters an a.c. signal so that only frequencies below a predetermined point are allowed to pass through.

Those above the basic pass level are progressively extracted until they cease to be transferred. In its simplest form it can be regarded as a "treble control". It is also useful in waveform shaping.

A sine wave is the simplest of all waveforms, and if it is truly sinusoidal it will contain no harmonics. However, they *are* contained in non-sinusoidal waveforms. The sharper the waveform edges, the more harmonics exist. These have frequencies that lie above the fundamental or basic frequency, and they can be filtered out.

As they are progressively reduced, so the waveform is softened and comes closer to a sine shape. By using the low pass filter in conjuction with the Quad VCO, the triangle wave and ramp can be modified to produce a sine wave and a semi-sinusoidal ramp. Typical examples of a sinewave and a ramped sine are shown in photos 4 and 5.

The functioning of the Low Pass Filter Circuit is quite simple and again relies on the rate of charge of a capacitor, C15. Since the rate will vary with the control current on IC1c pin 16, so upper frequencies of the input waveform will be smoothed out.

IC1d acts as a high impedance buffer so that the charge rate of C15 is relatively unaffected by other circuits that are connected. By feeding back part of the signal via resistor R37, the filter cut-off curve is tapered smoothly. The effect of various values of capacitor and control resistance on the response is shown in Graph 3 (shown next month).

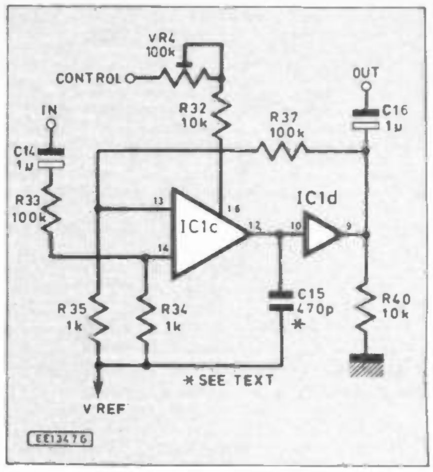


Fig. 1.5. Circuit diagram for a Low Pass Filter.

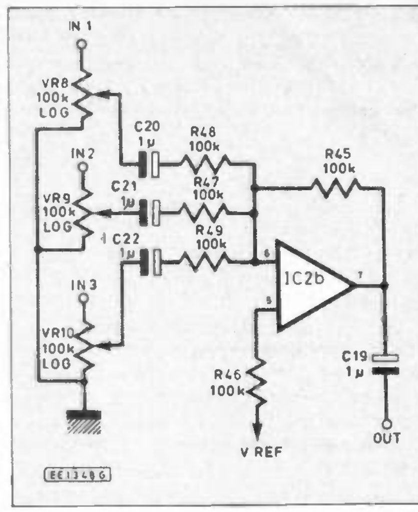
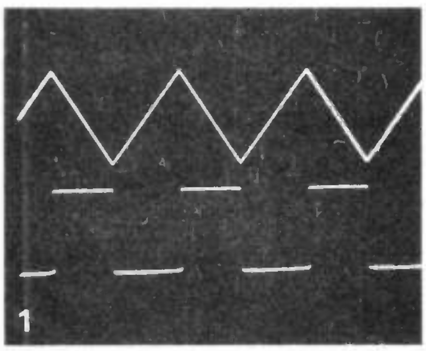
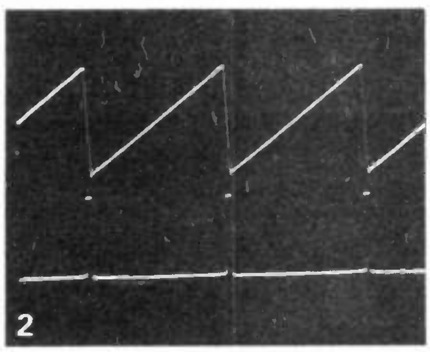
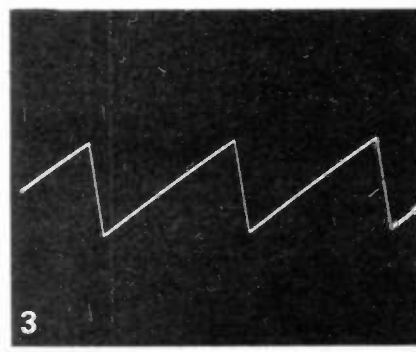
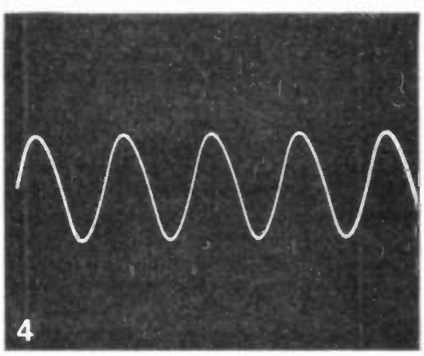


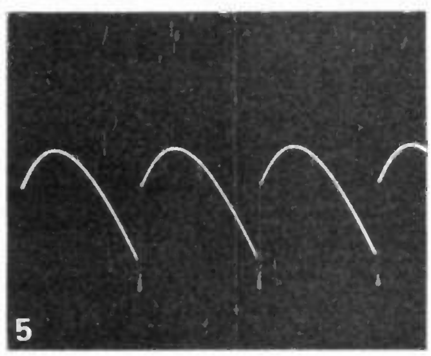
Fig. 1.6. Circuit diagram for a 3-Input Mixer.











1—Main VCO: triangle and square wave.

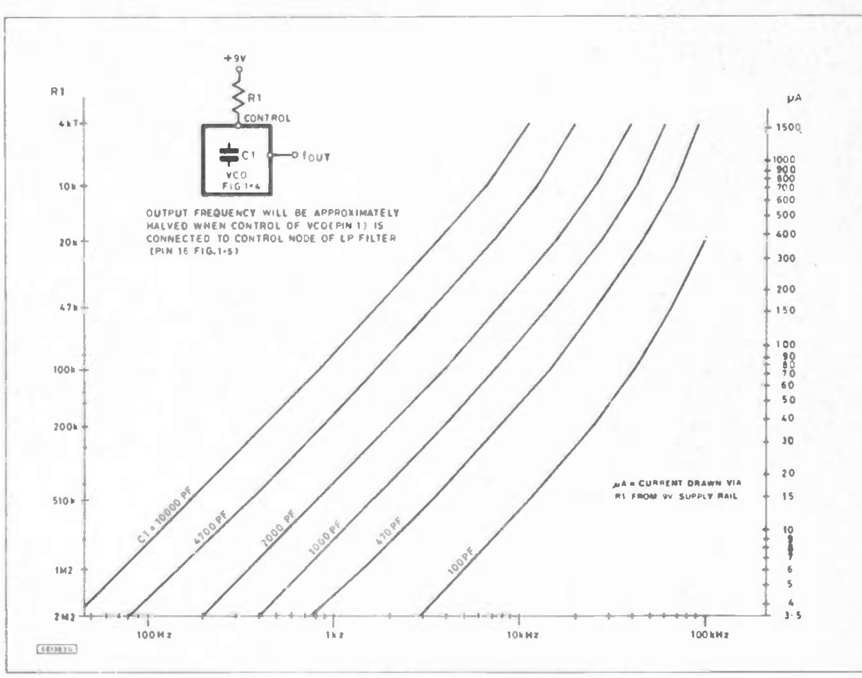
2—Main VCO: ramp and pulse.

3—Main VCO: variable ramped triangle.

4—Main VCO: sinewave.

5—Main VCO: ramped sinewave.

Graph 2 (below). Control resistance/capacitance against frequency, with varying values of C1 (Quad-VCO Fig. 1.4).



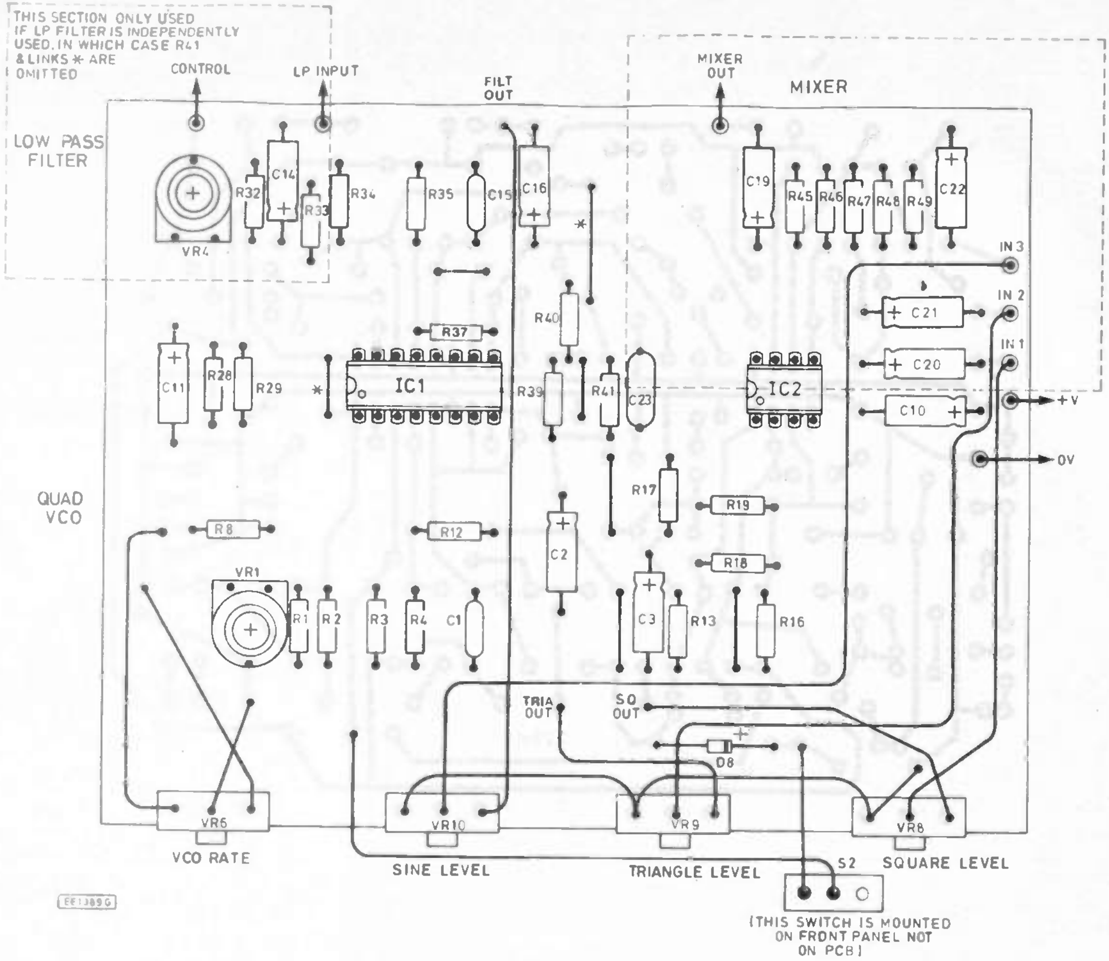


Fig. 1.7. Component layout for a Hex-Waveform VCO (Plan- A), including the Low Pass Filter, and 3-Input Mixer.

COMPONENTS

HEX VCO and MIXER

Resistors

R1, R12, R16, R19, R37, R45-R49	100k (10 off)
R2, R8, R13, R39, R40	10k (5off)
R3, R4, R34, R35	1k (4off)
R17, R28, R29	4k7 (3 off)
R18	330k
R41	33k

All 0.25W 5% carbon

Potentiometers

VR1	100k skeleton
VR6	100k mono rotary
VR8-VR10	100k log. mono rotary (3 off)

Capacitors

C1	1n polystyrene
C2, C3, C10, C16, C19-C22	1μ 63V elec. (8 off)
C11	22μ 16V elec.
C15	470p polystyrene
C23	100n polyester

Semiconductors

D8	1N4148
IC1	LM13600 Transconductance op. amp.
IC2	TL082 Dual BIFET op. amp.

Shop Talk

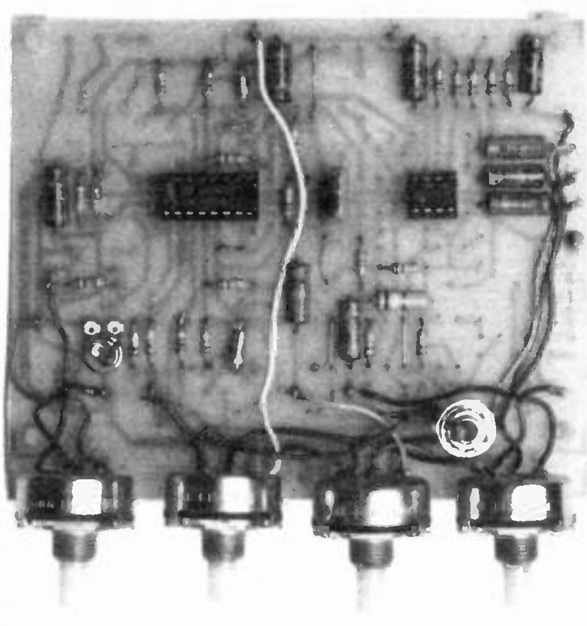
See page 360

Switches

S2	s.p.d.t. min.

Miscellaneous

Printed circuit board, 255A, p.c.b. clips (4 off); 8-pin i.c. socket; 16 pin i.c. socket; knobs (4 off); battery connector; connecting wire and solder.



Completed prototype circuit board for Plan-A (final boards may differ slightly from diagrams).

Additional Components Required If Building The LOW FILTER PASS (Fig. 1.5) Only

Resistors

R32, R40	10k (2 off)
R33, R37	100k (2 off)
R34, R35	1k (2 off)

Potentiometer

VR4	100k skeleton

Capacitors

C14, C16	1μ elec. 63V (2 off)
C15	470p

£15

Approx. cost Guidance only

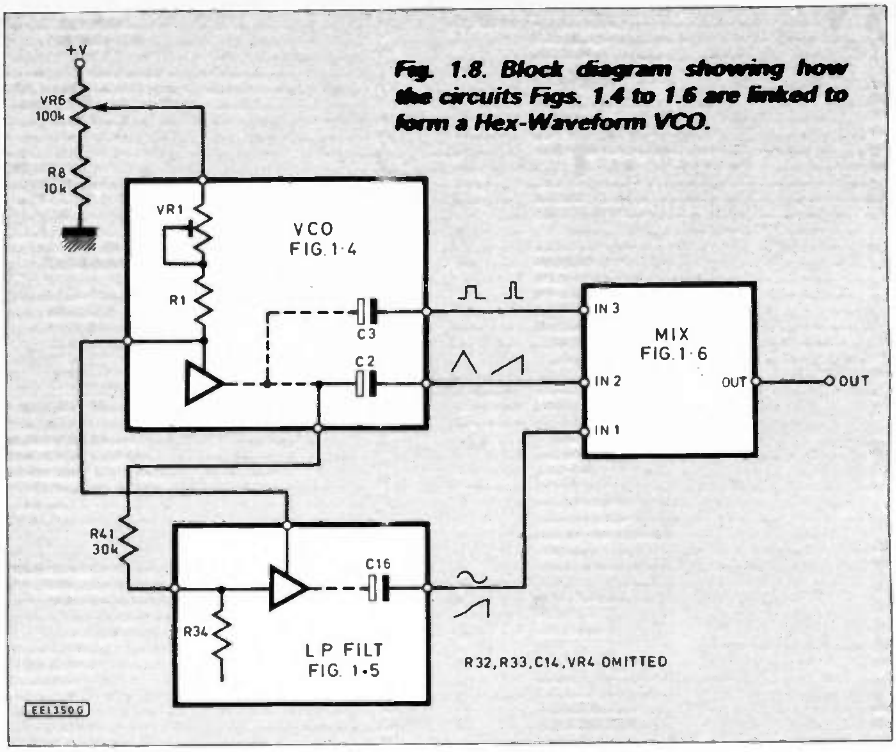


Fig. 1.8. Block diagram showing how the circuits Figs. 1.4 to 1.6 are linked to form a Hex-Waveform VCO.

THREE-INPUT MIXER

The circuit diagram for a 3-Input Mixer is shown in Fig. 1.6 and is suitable for using as a mixer in its own right for combining two or three audio signals into one channel. It consists of half an op. amp, IC2b.

The three inputs are shown preceeded by input level controls VR8 to VR10. They do not need to be included, and the signals can come in direct if preferred. Their inclusion though enables the levels to be varied between nil and maximum.

With the resistor values of R45, and R47 to R49, the maximum signal strength seen at the output for any one channel will be the same as that inserted. In other words, it only mixes and is not a pre-amplifier. Gain can be increased by either raising the value of resistor R45, or reducing the values of any of R47 to R49.

Amplification gain depends on the ratio of the input and feedback resistances. So on Channel-1, if resistor R48 is reduced to 10k, the gain will be R45 divided by R48, giving a gain of 10.

When other channels are simultaneously in use, the maximum output level will be the sum of all three signals, so could be three times the level of each on its own. The maximum input voltage should not exceed about 8V peak-to-peak otherwise clipping will occur. This will not harm the module, but it certainly will not sound too good!

CONSTRUCTION —PLAN A

The printed circuit board component layout for all three of the circuits just described is shown in Fig. 1.7 (Plan-A). The link wiring shown connects all circuits into one composite for use as a Hex-Waveform VCO—see Fig. 1.8.

The three basic waveforms are brought into the mixer, where the levels are varied by VR8 to VR10. The second range of waveforms is switched in by S2.

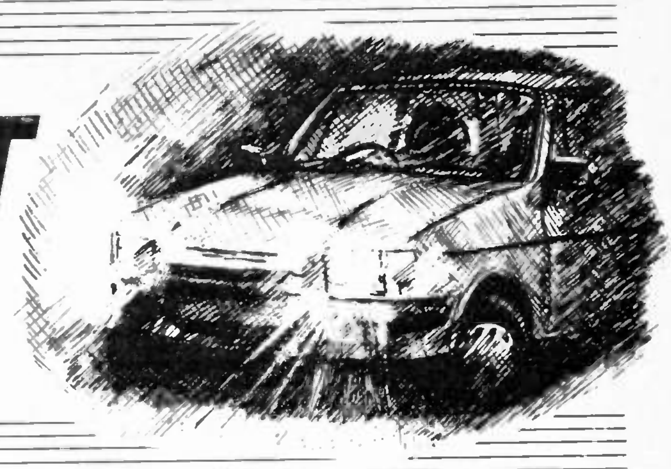
Any of the three modules may be repeated on other printed circuit boards. The changes required for using the Low Pass Filter as an individual circuit are also shown.

If the mixer is to be fed by signals from different sources, the right hand connections of VR8 to VR10 will be the signal input points routed to the alternative signals, and not to the VCO and filter points shown.

Next Month: Voltage Controlled Filter (VCF) and Ring Modulator.

Constructional Project

HEADLIGHT REMINDER



PAUL HARDING

This simple, easy to build unit will prevent the inconvenience and embarrassment of a flat battery. Fit it and forget it!

It is probably true that most motorists, at one time or another, have unwittingly left their car's headlights on, only to return to find the car's battery in a sad state of charge. The circuit presented here, then, is for almost all motorists, and the evening spent building and installing it could be time well spent.

The circuit sounds a buzzer and flashes a l.e.d. if one of the front car doors is opened whilst the headlights are on. In some instances, it may be required to leave the lights on with a door open: if this is the case, turning the ignition switch to phase 1 will cause the buzzer to sound only briefly as the car door is opened. The l.e.d, however, continues to flash for as long as the door is open.

CIRCUIT DESCRIPTION

Consider first the block diagram, Fig. 1. The output from the Control Logic element is active if suitable input conditions are present; i.e. CL low and SL high. The output from this element enables a slow oscillator and hence flashes the l.e.d. Simultaneously, the fast (audio) oscillator is enabled and this drives a piezo transducer.

The Control Logic element also triggers the Voltage Control Monostable element. The latter's output swings high, and only if IGN is high will it then return low. This action generates the other enable signal required by the fast oscillator, and hence the audio tone is gated on and off as required.

Since car wiring can exhibit large noise spikes, power supply decoupling and smoothing components are included in the circuit to give some protection to the semiconductors.

Moving on to the actual circuit diagram, Fig. 2, the Control Logic element consists of IC1a and IC1b and their associated components. The output from this element (pin 2 IC1b) is active low, and this condition arises only if both D1 and D4 are reversed biased. This occurs when SL is high and CL is low.

With IC1b's output low, D2 is reverse biased, and the slow oscillator around IC1c is "unclamped" (enabled). TR1 drives D10, the l.e.d., and receives base current from IC1c via R10.

The fast oscillator around IC1d is only enabled if D3, D6 and D8 are all reverse biased. D6 and D8 are driven from the voltage controlled monostable, IC1e and IC1f, whose operation is considered below. D3 is driven from the output of IC1c. IC1d's output directly drives WD1, a piezo ceramic

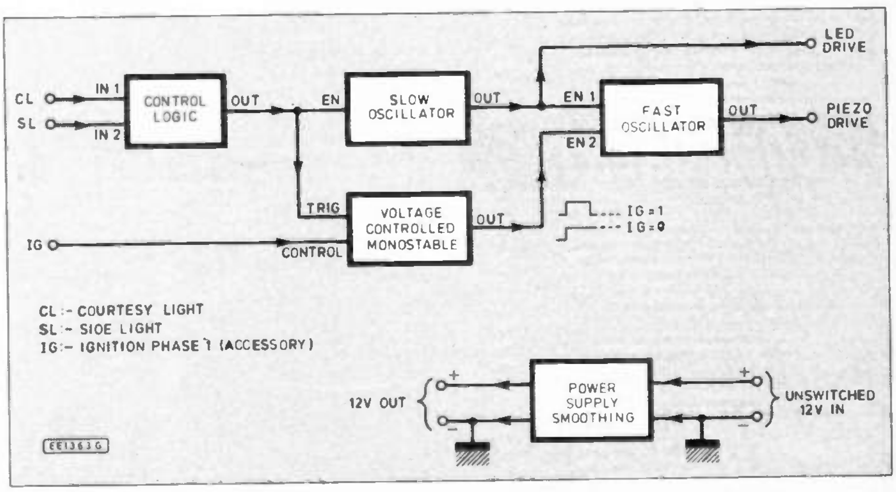
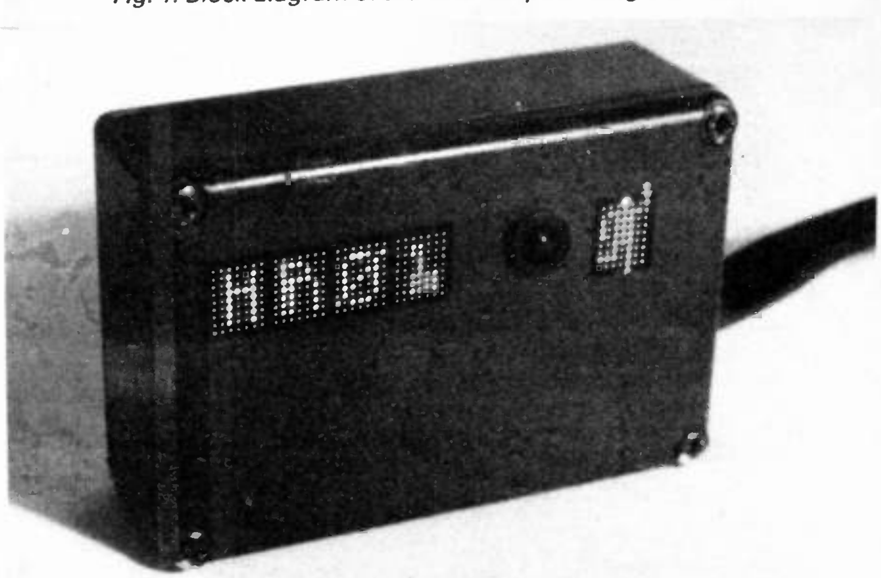


Fig. 1. Block diagram of the headlamp warning unit.



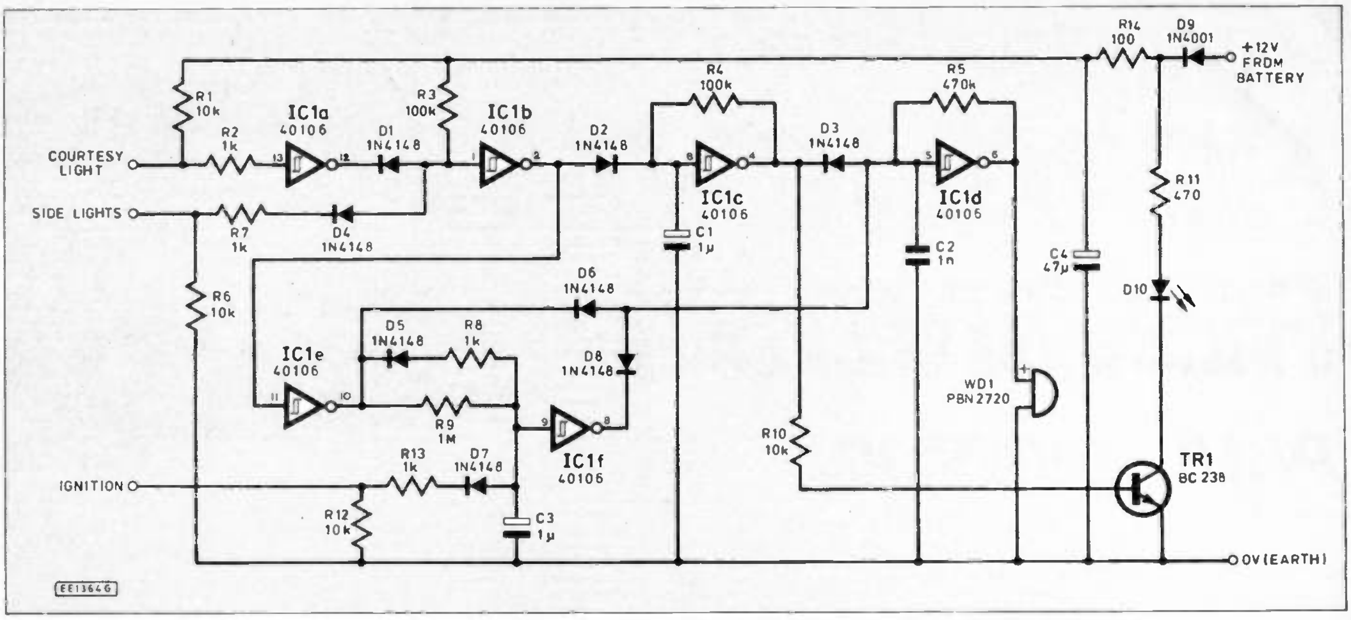


Fig. 2. Full circuit diagram of the unit.

transducer. Its circuit function here may be likened to that of a small loudspeaker.

The operation of the voltage controlled monostable is as follows: Consider initially that IGN is high, so D7 is reverse biased. The input to IC1e is also high, hence its output is low, and is holding C3 discharged via R8 and D5. The output of IC1f is high, and D8 is reverse biased. Consider now that the input to IC1e is taken low: its output swings high. D6 is reverse biased and the fast oscillator is unclamped during the high parts of the pulse train from IC1c. C3 starts to charge through R9, and at some point will cross the input threshold of IC1f. The latter's output will swing low, D8 will conduct, and the fast oscillator will be clamped off.

If IGN was initially low, as IC1e's output swung high D7 would conduct and so prevent the voltage across C3 from rising above about 800mV—the volt drop across D7 plus the voltage due to the potential divider R9 and R12+R13. This is well below IC1f's input threshold, and so its output would not change state. Hence D8 would remain reverse biased.

Capacitor C4, together with R14 and D9 smooth and decouple the supply voltage, and also guard against reverse polarity supply connections. While R1, R2, R6, R7, R12, and R13 protect the inputs to the circuit.

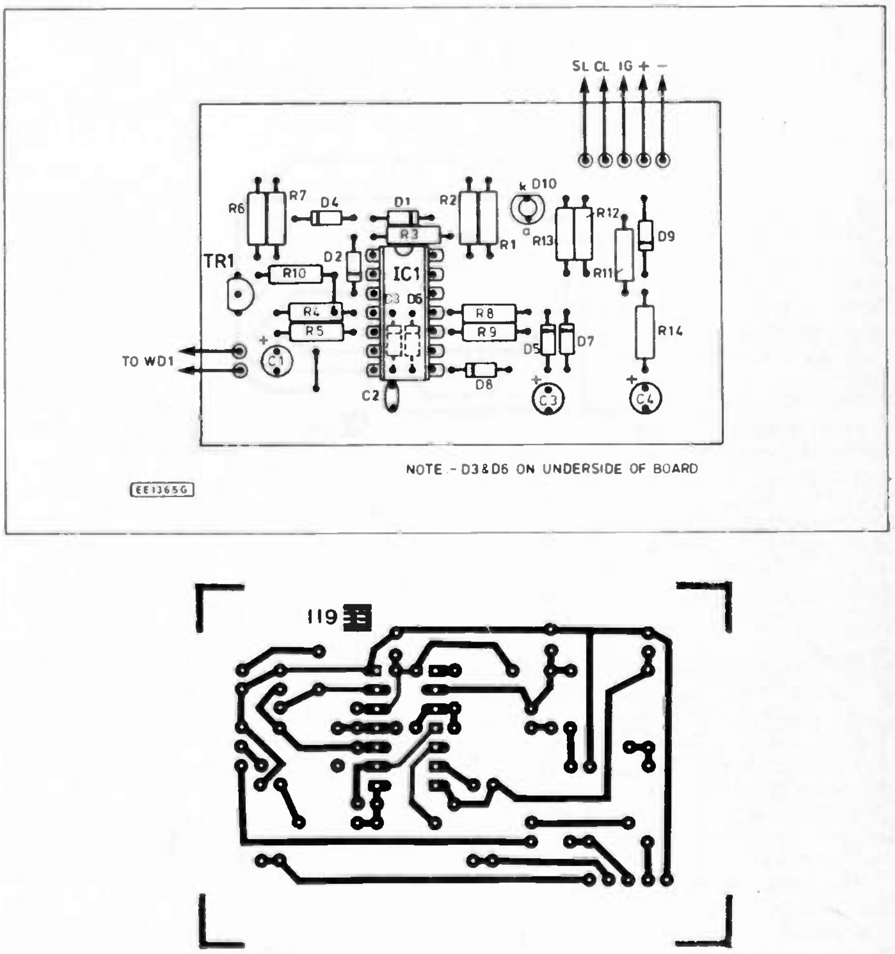


Fig. 3. Printed circuit layout and wiring.

COMPONENTS

Resistors

R1, R6, R10, R12	10k (4 off)
R2, R7, R8, R13	1k (4 off)
R3, R4	100k (2 off)
R5	470k
R9	1M
R11	470
R14	100

All ¼W ±10% carbon

Shop Talk
See page 360

Capacitors

C1, C3	1µ elect. 16V (2 off)
C2	1n Mylar
C4	47µ elect. 16V

Semiconductors

D1 to D8	1N4148 (8 off)
D9	1N4001
D10	5.0mm l.e.d.
TR1	BC238
IC1	40106B

Miscellaneous

WD1 PBN2720 piezo resonator; p.c.b. available from the *EE PCB Service*, order code EE611; Verobox PB301 i.c. socket; p.v.c. sleeving; grommet; wire; Scotchlock connectors.

Approx. cost Guidance only £9-50

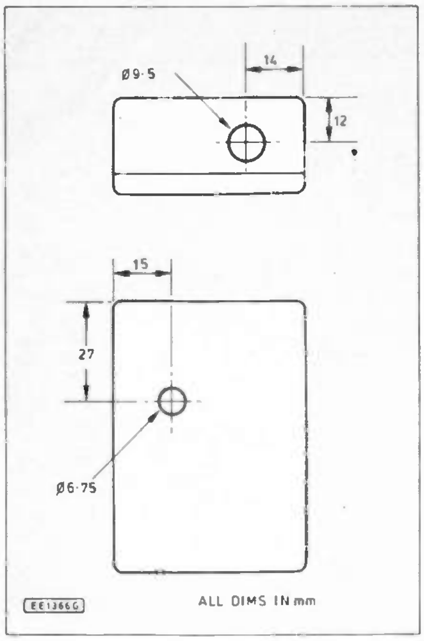


Fig. 4. Case drilling details.

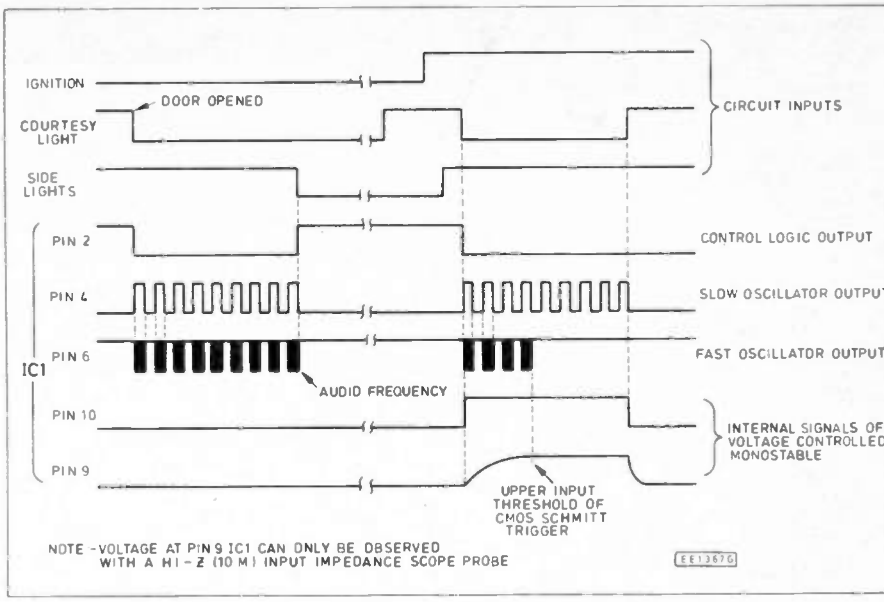
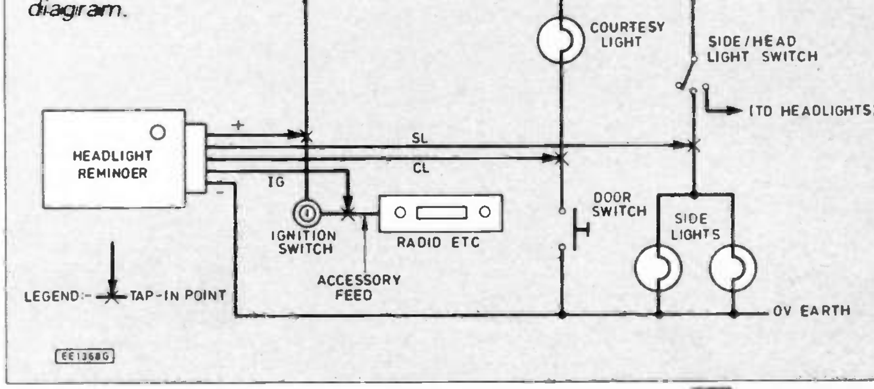


Fig. 5. Circuit waveforms.

Fig. 6. Car connection diagram.



CONSTRUCTION

Assemble the p.c.b. by inserting and soldering the components in the following order; wire links, resistors, diodes, i.c. socket, transistor, capacitors, and the l.e.d. Ensure that the electrolytic capacitors and semiconductors are orientated correctly. The p.c.b. diagram, Fig. 3 makes this clear. Note that D3 and D6 mount underneath the p.c.b. Consequently, their leads will be very short and care must be taken not to overheat them when soldering them in. Do not insert the actual i.c. until construction is complete.

The p.c.b has been designed so that the l.e.d. will protrude through a hole in the top of the case without the need for flying leads. The length of the l.e.d.'s pins is best determined by trial and error.

Solder two thin flexible wires to the piezo transducer; one to its brass plate and the other to the silvered ceramic face. It is important to keep the soldering iron in contact with the silver for as short a time as possible to prevent the latter's oxidation and ultimate destruction.

Drill the two holes in the case as per Fig. 4. The case can also be painted at this stage if desired. Glue the piezo's brass face to the case lid. It is not necessary for it to be mounted under a hole since the whole case acts as a sounding board anyway.

To make the off-board connections, solder a short length of tinned wire (e.g. a component lead offcut) or a terminal pin into the respective p.c.b. hole, solder the wire to it, and insulate the connection with a rubber sleeve. This also gives mechanical support.

The leads that connect to the car wiring are taken out through a grommet in the side of the case. To make a neater job, they can also be run through a short length of 6mm p.v.c. tubing.

COMPONENT MODIFICATIONS

It may be desired to change some of the circuit timings to account for component tolerances or personal preferences. Details are given below:

C1 and R4 control the slow oscillator frequency (l.e.d. flash rate, etc)

C2 and R5 control the fast oscillator frequency (audio tone)

C3 and R9 control the time before the tone is gated off when a door is opened with the ignition on.

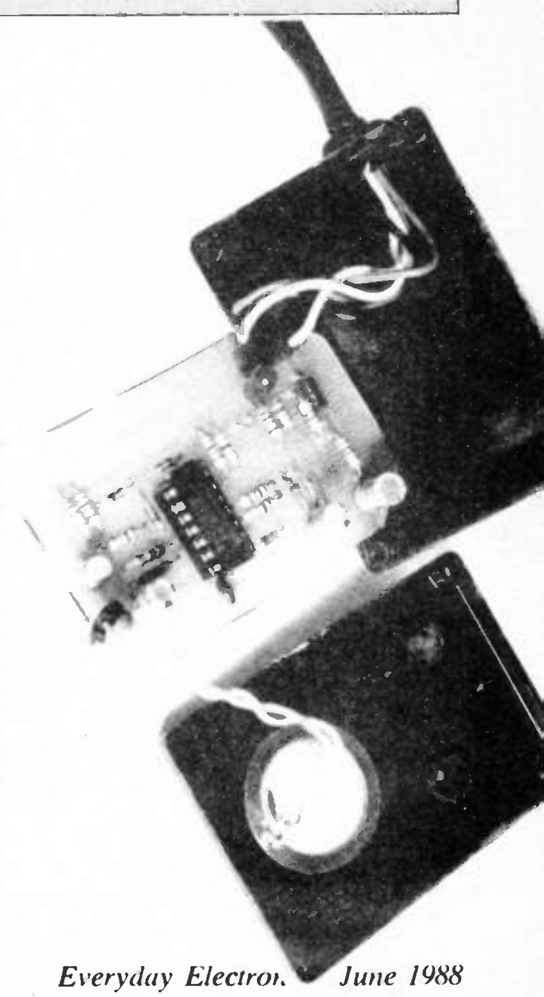
TESTING

It is probably better to test the circuit before installing it in the car. This can be easily done using a small 12V power supply, and by connecting the input wires to +12V or 0V as required. If the circuit does not work, reference to the waveform diagram, Fig. 5 and the Circuit Description section will help in tracing the fault.

Installation should not present too many problems if Fig. 6 is followed. If a wiring diagram for the car is available this will make the job considerably easier. The wires to which the circuit connects should all be found near the steering column or behind the fascia panel.

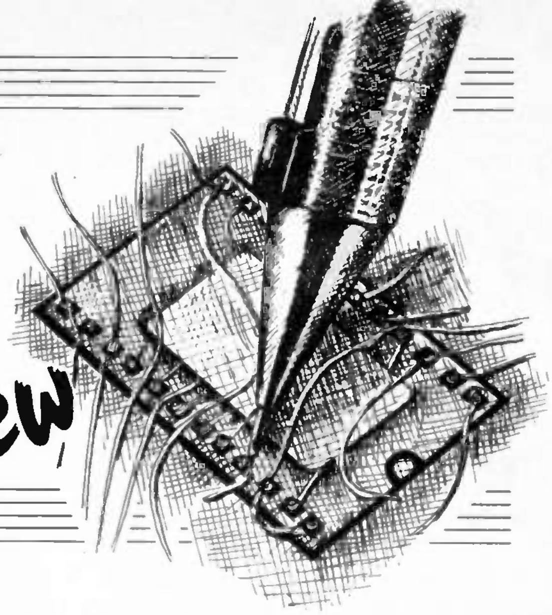
To make the connections to the required wires "Scotchlock" connectors will probably be found easiest to use. Alternatively, strip the insulation from the existing wire, solder the new wire to it, and insulate the joint with tape.

Stick three or four adhesive foam pads to the back of the circuit case and mount it in a convenient place on the fascia. The screen demister ducts can be used to route the circuit's wires to the required places. Drill a suitable sized hole in the duct behind the fascia to pass the wires through. □



VERO EASIWIRE Review

ROBERT PENFOLD



I HAVE long been of the opinion that there are systems for the permanent construction of circuits, and systems for building and testing prototypes, but no sensible system that properly covers both fields. There have been wiring boards in the past that offer some of the advantages of breadboards, but can also act as the finished product, but these have not been very successful. In general, they were less convenient than breadboards, and gave a finished product that tended to fall apart with the slightest provocation!

The "Easiwire" electronic circuit construction system takes a very different approach to any universal wiring system I have encountered in the past. It is somewhat slower and slightly more difficult to use than the familiar breadboards of the "Veroblock" type, but provides a stronger finished article that stands a better chance of standing up to the rigors of everyday use. It is also free from problems with large amounts of stray capacitance causing unwanted coupling from one part of a circuit to another. It seems much better than any previous product of this type that I have tried, but does it come up to scratch?

WIRE WRAP

In principle the Easiwire system is very simple, and is a variation on the well established wire-wrap system of construction. Easiwire does not involve any soldering. Circuits are built up on a board that looks rather like plain (i.e. no copper strips) stripboard, but it is white in colour and made from a semi-soft plastic. This is not purely of academic importance, and this fairly soft board with its slightly under-size component holes is an important part of the system.

Components are mounted on the board in the normal way, and the leadouts are trimmed to leave about three millimetres protruding on the underside of the board. The board grips the components quite well, and they do not fall out when the board is inverted to facilitate wiring-up. This greatly eases construction, and avoids the need for an expensive frame to hold everything in place. In fact I would have thought that this type of board could be applied equally well to custom printed circuit boards and stripboards.

For the benefit of those not familiar with normal wire-wrap construction in its basic form a pen-type tool is employed to strip insulation off the end of a thin wire and then wrap it tightly around a square pin. The corners of the pin bite into the wire to form a good joint.

The Easiwire system uses a pen-type tool with the wire mounted on a reel at the top of the "pen". The wire, which is just tinned copper wire with no insulation, passes down through the "pen" and out through the thin "nib".

Using the pen the wire is wrapped around leadout wires and pins, and it connects them together without having to solder the joints.

I suppose that the connections could be soldered if desired, and this might make the assembly somewhat tougher. However, one of the attractions of the system is its solderless nature. Also, as a by-product of this the materials are largely reusable. When you have finished experimenting with one circuit you can simply take it apart and reuse practically everything in future circuits. The only "disposable" part of the system is the wire used to connect everything together, and this is not particularly expensive.

THE KIT

The Easiwire kit comes in bubble-pack form, and contains everything you need to get started, apart from the electronic components of course. The main component is the wiring pen which comes ready fitted with a spool of wire, and there is one spare reel included with the kit. There should be sufficient wire here for at least a dozen small projects. The pen is fitted with a handy built-in cutting blade which can be used to cut the wire once a section of wiring has been completed. The blade is spring-loaded so that it automatically retracts after use.

A second tool is included in the kit, and this is a double-ended affair. One end has a simple spike which can be used to enlarge holes in boards if component leadouts or leads prove to be too large. The other end has a sort of forked "snake's tongue" which is the kit's equivalent of a desoldering tool. It can be placed under a joint and used to prise the spiral of connecting wire off the leadout wire. Plastic caps are provided for both ends of the tool.

The other main ingredient of the kit is the board which has holes on the usual 2.54 millimetre (0.1 inch) pitch, and measures 147 by 98 millimetres (slightly smaller than the standard Eurocard dimensions). It is quite flexible, but seems to be sufficiently rigid and tough enough for the job. The corners of the board are drilled with larger holes of about three millimetres in diameter which can be used for mounting purposes. The component holes are larger on one side of the board than on the other, and the components are inserted from this side.

There are a few more minor but important items included in the kit, and one of these is two sheets of double-sided self-adhesive material. If wires are only to be routed straight from one point to the next, this material is not needed. If wires must be taken around curves, then a sheet of this film must be placed on the appropriate side of the board before construction is commenced. It provides a tacky surface to which the wires can be fixed when they are taken through curves. Otherwise they just tend to become displaced, leading to short circuits and broken wires.

OFF BOARD CONNECTIONS

Off-board connections are potentially a problem with any solderless wiring system. The Easiwire kit includes what looks like half a dozen small springs, but these are the equivalent to printed circuit pins. They will accept two millimetre plugs, or there are three matching connectors supplied with the kit. These are simple brass connectors which have crimp style connections to the leads. Why there are six sockets but only three plugs included I am not quite sure. Neither ration seems very generous, but extra connectors (and other expendables) can be obtained.

Finally, the kit includes an instruction sheet, which largely duplicates the instructions printed on the reverse side of the pack. Whoever produced the instructions clearly believes in the old adage that "a picture is worth a thousand words", but the illustrations are very well done, and the lack of words does not really matter.

TRICKS

One obvious difference between using this system and a conventional wire-wrap one is that with this system it is not acceptable to take one wire over another. Remember that the wires are not insulated, and that running one over another simply short circuits them together. In this respect the Easiwire system is just like conventional printed circuit boards, and one solution is to take wires onto the top side of the board. This is easily achieved using a piece of wire or a double sided pin to act as each through-pin.

A simple alternative is to place a piece of insulation tape over the first wire so that a second wire can be taken over the top of it without producing a short circuit. In fact by using several pieces of tape it should be possible to have several layers of wires. The only drawback to this method is that it could be difficult to make changes if a mistake is made in the wiring, or a change in the circuit is required.

It is feasible to use this system with boards other than the plain matrix one supplied as part of the kit, and available separately. The only problem with most of the alternatives is that they will not hold the components in position, and will require some assistance in this respect. A novel idea is to have pieces of thick cardboard marked with the component layout on one side, and the "track" pattern on the other. These are not just layout cards—the circuits can be built up on them!

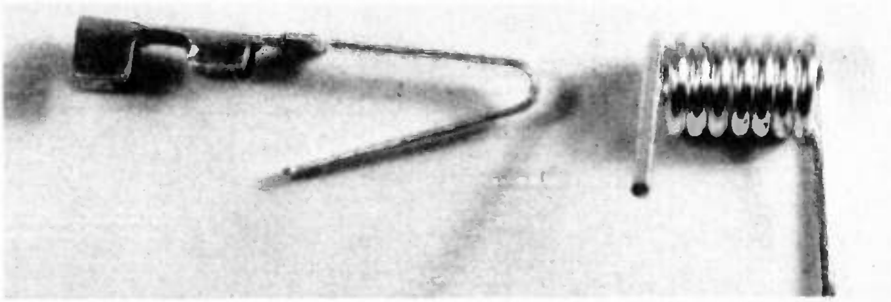
A range of cards for small projects may be produced, and there is the possibility of cards being made available for magazine projects. While plasticised cardboard and Easiwire is not going to give a standard of finish to rival a good fibreglass printed circuit board, it gives perfectly adequate results. The cost of the boards is very low, and with this method of construction it is very difficult to make mistakes. In particular, the wiring up process is about as fool-proof as it could be. This certainly represents an excellent method of construction for beginners.

IN USE

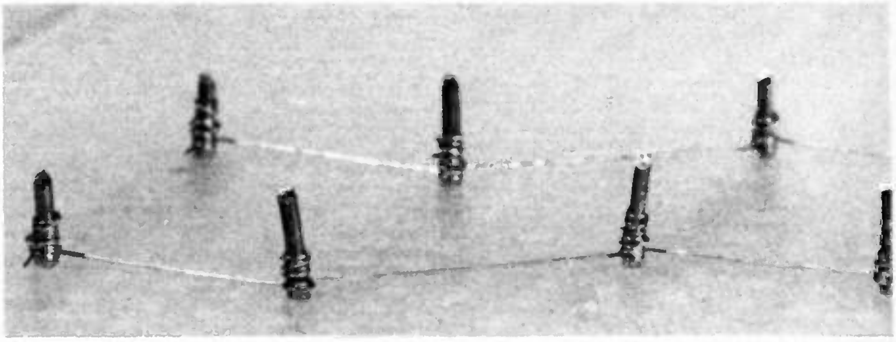
The Easiwire system seems fine in theory, but how does it fare in use? Most components fit onto the board without difficulty, but types which have heavier gauge leadout wires need their mounting holes enlarged slightly before they will fit. Not all components will actually fit onto a 2.54 millimetre matrix, but the vast majority will do so. It should not be difficult to drill additional holes in the board to accommodate awkward components. I expected to experience problems with components falling off the board, but this did not prove to be a problem.

Care needs to be taken when trimming the leadout wires, as it is very easy to leave too little protruding. It is better to err on the generous side when cropping the leads.

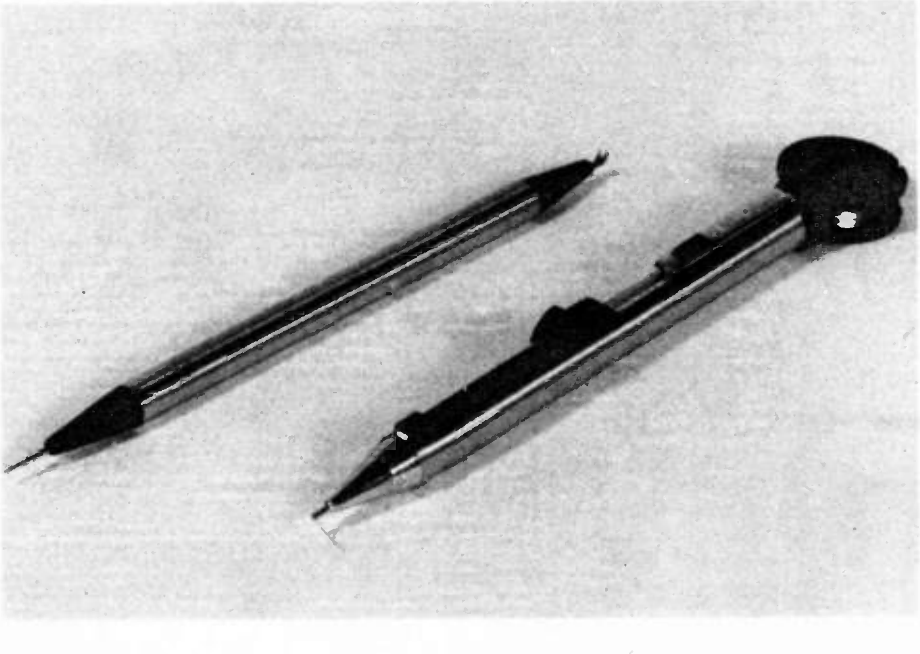
To start the wiring process a finger is used to hold the end of the wire in place, close to the first leadout wire. Using the wiring



The off-board connections are simple but effective.



Above: Wiring up components on the matrix board supplied. This is easy with practice.



Left: The two basic tools of the Easiwire system. They are both well made and should last a very long time in normal use. (You will also need a pair of pliers.)

"pen" the wire is then wrapped around the leadout about four or five times, working from the board upwards. A further four or five turns are then added, working downwards. It is difficult to get results anything like as neat as the illustrations in the instruction leaflet, but the joints seem quite good (electrically and physically) anyway. It is important to use this method of wrapping the wire, as it keeps the links from one leadout to the next close to the surface of the board. Remember, the wire is very fine, and if it stands clear of the board it would be vulnerable to being accidentally snapped.

Having completed the first connection, it is a a matter of moving on to the next one in the line and completing that one in the same way, then moving on to the next one, and so on, until a set of connections have been finished. The wire is then cut using the blade built into the wiring "pen", and this is a simple one-handed job. This process is repeated until the whole board has been wired up.

It sounds very easy, and in practice it seems to be a fairly straightforward task. There is inevitably a short piece of excess wire at the beginning of each run of connections, and it is a good idea to trim this off or bend it out of the way where it cannot produce any unwanted connections. You have to be careful not to let too much wire out of the pen, or when wire wrapping you find that you are wrapping the wire around two or three leadout wires.

The wire must be wrapped reasonably tightly in order to give good strong joints, but it is easily snapped if you over-do it slightly. One minor niggle is that I kept finding that I was left with no wire sticking out of the end of the "pen". This can easily be rectified by unscrewing the tip, pulling out some more wire, and replacing the tip, but I wasted quite a lot of time doing this. These are all relatively minor problems though, and no doubt they can be avoided once more expertise at "wire-wrapping" has been gained.

It would be unrealistic to expect any new form of construction to be entirely trouble-free until you have become used to the new tools and methods used.

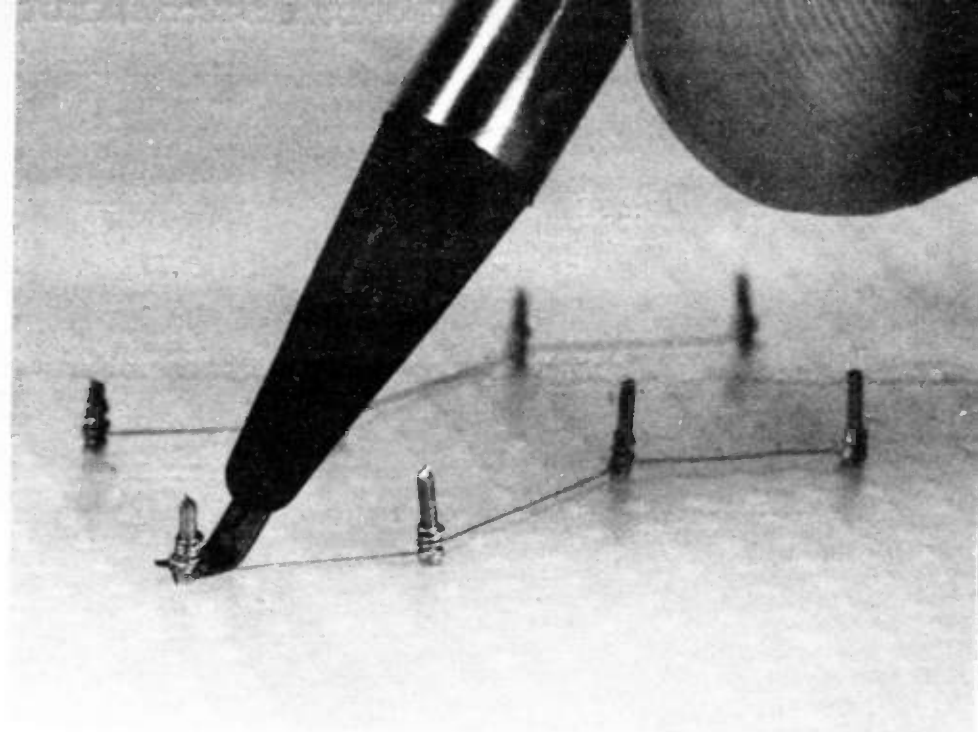
CURVED TRACKS

Using the self-adhesive material to produce curved "tracks" is a little more tricky, and I think that I would be inclined to avoid this method as far as possible. It can certainly be done, but laying down a number of closely spaced curved tracks is a skilled job, and one that really needs to be left until you have become reasonably expert at using the system. It would be much easier if the wire was sticky rather than the adhesive on the board (like producing printed circuit artwork using track tapes), but presumably this is not a feasible way of doing things. It is quite easy if there are only a few curves to negotiate.

CONCLUSIONS

I suppose that previous systems of this general type have failed to gain widespread acceptance for two main reasons. One is a lack of physical strength, making them of dubious value for finished projects. The other is a lack of compatibility with existing methods of construction. The Easiwire system overcomes both of these limitations.

Taking the question of physical strength first, on the face of it this is a very flimsy method of construction. I quite expected wrapped wires to unwrap themselves, but there seems to be no problem here. I also had doubts about components becoming detached from the board, but provided the wire is wrapped reasonably tightly, trying to pull components from the board is fruitless.



The "unwrap" tool in action. This simple method allows re-use of all the electronic components.

Clearly the finished board does not have the strength of a custom printed circuit board or stripboard. It is good enough for most purposes though. This system would probably not be suitable for car projects or similar applications where the finished product will be subject to a lot of vibration, but it is only a minority of applications where it to could be counted out on these grounds.

The Easiwire system is very similar to the one where components are mounted on a plain matrix board, and then the leadout wires are soldered together on the underside of the board. Any layout for this method of construction should be easily translated into an Easiwire layout. Similarly, a stripboard layout could easily be copied using the Easiwire system, with the component layout being left unaltered, and wires being used in place of the pieces of copper strip that actually carry connections.

Easiwire can also be used to copy printed circuit boards, although the more intricate designs might not be a practical proposition. Looking back through some past issues of *Everyday Electronics* there are plenty of simple projects with component layouts that could easily be copied using the Easiwire system.

Although this system has a lot in its favour, it is not without its limitations. It does not appear to be well suited to complex projects, or the intricate interconnections required for some digital projects. The wires used for the interconnections are quite thin, and are not suitable for high current applications.

There should be no real problems with stray coupling from one part of a circuit to another, or no more so than with printed circuit boards anyway. In this respect the system is well suited to high frequency applications, but the thinness of the connecting wires could again prove to be a slight problem.

Although the system is solderless, there are the connections to off-board components to be considered. Using the special plugs and sockets there is no difficulty in connecting leads to the board, but how are the other ends connected to potentiometers, switches, etc.? Miniature crocodile clips are one possibility, but it could be difficult to find a really good solution to this problem, other than opting for soldered connections.

Another point to bear in mind is the cost of using Easiwire. The running costs would seem to be quite reasonable, and roughly comparable to stripboard or printed circuit boards. There is the initial cost to consider though. This is comparable to the cost of basic soldering tools, but I suspect that most users would eventually obtain soldering equipment as well, or will already have them.

FINALLY

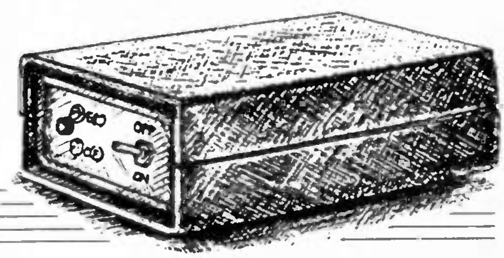
Easiwire is easy to use, and well suited to projects for beginners at electronic project construction. It probably succeeds better in this role than as a prototyping system, where modern breadboards are far quicker and can easily accommodate complex circuits. It is not without its limitations, but it is a good practical, down to earth method of construction, and is very usable.

Most forms of circuit board seem to be quite expensive these days, and Easiwire may seem to be no better in this respect than most others. However, do not overlook the fact that it is almost totally reusable. In the medium and long terms it could be a very inexpensive method of construction. It is also well suited to experimenting with a project, pulling it apart and trying a different one, pulling that one apart and building a new one, and so on. You can have a lot of fun in this way, as well as learning a lot about electronics.

I was quite impressed with Easiwire. Unlike some previous wiring systems it really does provide reasonably strong and compact boards that can be fitted in cases and realistically used as a permanent project. Alternatively, it can just be used for experimenting with circuits. It is primarily aimed at the hobbyist/student market, where it deserves to succeed. □

Constructional Project

EASI-TRANSISTOR TESTER



ROBERT PENFOLD

We bring you the first-ever published project using the Vero Easiwire system. A completely solderless transistor tester.

A TRANSISTOR tester is one of those items of test equipment that every electronics home constructor is likely to need quite regularly. Some multimeters now feature a built-in transistor check facility, but a simple tester is easily constructed if you do not have a multimeter of this type. This transistor checker is of the "go/no-go" variety rather than a proper gain measuring device. However, this is sufficient for most purposes where it is merely necessary to have an indication of whether or not the test components are functioning. Detailed and accurate information on their performance parameters is not normally required.

In this design a serviceable device is indicated by a l.e.d. flashing on and off at a low frequency (about twice per second). If the l.e.d. remains switched on, this indicates that the component under test has gone closed circuit. If the l.e.d. fails to light up at all, then the test device has gone open circuit. Flashing of the l.e.d., but at lower than normal intensity, indicates that the test transistor has only a low level of gain. This gain might be acceptable, and it obviously depends on whether the test component is a low gain type (such as an r.f. or switching transistor) or high gain device.

TRANSISTOR BASICS

The basic test circuit for an *npn* transistor is shown in Fig. 1(a). A variable voltage supply is used to set the collector voltage at which the device is to be checked, and potentiometer VR1 is used to apply an input current to the base of the device.

The base current causes a much larger current to flow in the collector circuit, and the current gain of the transistor is equal to the collector current divided by the base current. VR1 is adjusted to give the collector current at which the test is to be made, with the assistance of ME2 which measures the collector current. ME1 indicates the flow of current in the base circuit, and the current gain can be calculated from the reading obtained from ME1.

Testing *pnp* transistors is much the same, and requires the basic test circuit of Fig. 1 (b). The only difference here is that the polarity of the supply has been reversed, and this necessitates a reversal in the polarities of ME1 and ME2 as well.

We have ignored any leakage current that flows in the collector circuit even with no base current applied to a device. In the days of germanium transistors this current was often quite significant, and had to be deducted from the collector current before making the gain calculation. Germanium transistors are now largely obsolete. Modern silicon transistors normally have very low leakage levels of under one microamp. This does not normally have any significant affect on the current gain calculation, and can be disregarded.

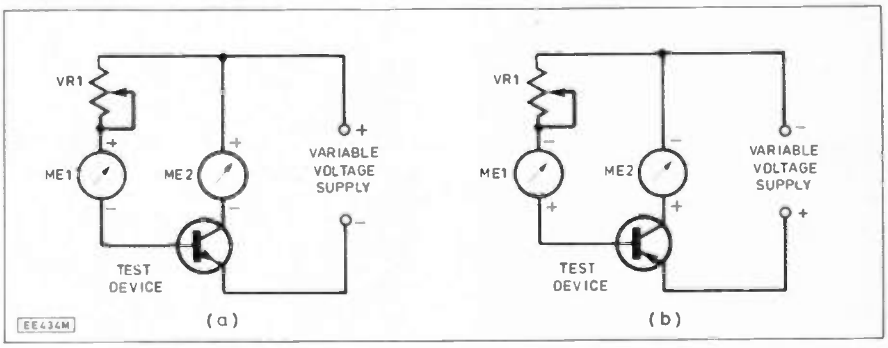
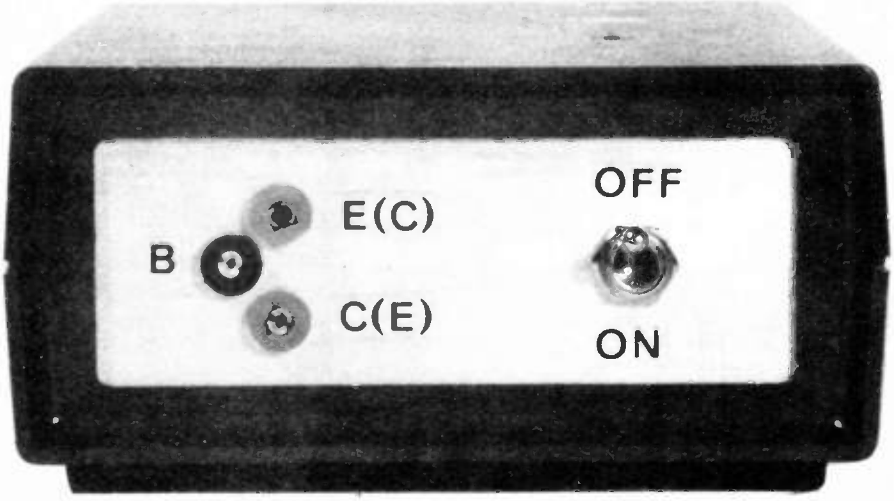


Fig. 1a. Basic test circuit for an npn *transistor. 1b. Basic circuit for a* pnp *transistor.*



SIMPLE ARRANGEMENT

In this tester the simple arrangement of Fig. 2 has been adopted. Taking the *npn* test setup (a) first, the output of the low fre-

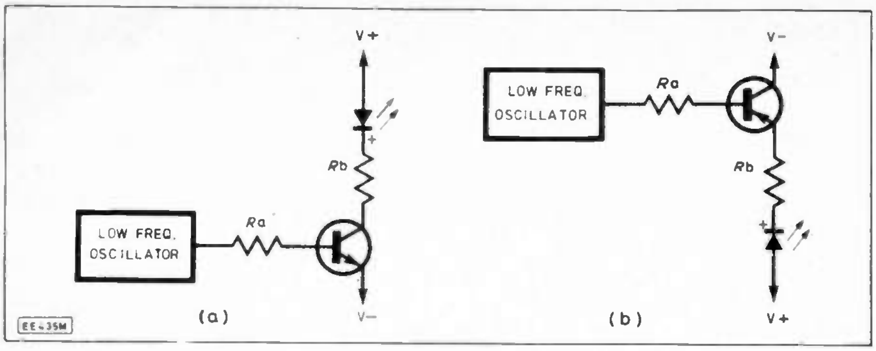


Fig. 2. The simple arrangement used in this tester.

quency oscillator drives the base of the test transistor. When the output of the oscillator goes high, the device under test is biased into conduction. The value of R_a is selected to give a fairly modest base current, but provided the transistor has a reasonable current gain, this will give a collector current of a few milliamps.

A l.e.d. indicator is connected in the collector circuit, and should switch on if the test component is serviceable. If the l.e.d. only lights dimly, this indicates that the test transistor has only a low level of gain. If the l.e.d. fails to light at all, then the transistor is a "dud" which has gone open circuit. R_b provides current limiting to protect the l.e.d. against a high current flow if the test transistor should be closed circuit, or if it is wrongly connected.

When the output of the oscillator is low, the transistor is cut off and only leakage currents flow in the collector circuit. These currents should not be large enough to cause the l.e.d. to visibly glow. If the l.e.d. glows dimly, this shows that it has a significant leakage level, and if the l.e.d. is left at full brightness, the test device has gone closed circuit.

Testing a *pnp* transistor (b) is similar, but the l.e.d. is in its emitter circuit. This is acceptable because the collector and emitter currents are not significantly different. One is only the output current while the other is the sum of the input and output currents. The input current is limited by R_a to a level where it cannot boost the output current to a significant amount and upset the correct operation of the circuit. Really, it is just a matter of using the test device in the emitter follower mode rather than as a common emitter amplifier.

The point of doing this is that it eliminates the need for any *npn/pnp* switching. If you examine the two test setups you will find that there is no difference in the circuits driving the test components, the only difference is in the way that the test devices are connected to the checker.

It is only of academic importance that when testing *pnp* transistors the l.e.d. switches on when the output of the oscillator is low (negative), and is turned off when it goes high (positive). The l.e.d. still flashes on and off about twice per second, and there is no apparent difference to the user.

THE CIRCUIT

The full circuit diagram for the transistor tester is shown in Fig. 3. The oscillator is a simple operational amplifier relaxation type having C2 and R4 as the timing components. R5 limits the base current to about 200 microamps. A transistor having a current gain of ten times will therefore give an output current of about two milliamps, which will drive the l.e.d. (D1) at fairly low brightness.

A gain of ten is about the minimum that would be expected from a low gain type. R6 limits the collector current to about 10 milliamps. Any device having a current gain of about fifty or more (10/0.2=50) should therefore cause D1 to flash at full brilliance, and most transistors have a gain of fifty or more these days.

Note that IC1 is a type that can provide output voltages virtually equal to the negative supply rail. This ensures that *npn* test components are fully switched off when IC1's output goes low, and that the unit functions correctly. Most operational amplifiers, such as the μA741C and LF351, have a minimum output voltage of about 2.5 volts. These will not work in the circuit as they will keep *npn* test components switched on continuously.

The current consumption of the circuit is approximately two milliamps under standby conditions, and seven milliamps (average) when the l.e.d. is flashing. This can be supplied economically by even a small (PP3 size) 9 volt battery.

CONSTRUCTION

A 0.1 inch pitch (2.54mm) Easiwire board forms the constructional basis for the unit. This has 38 by 13 holes, and can conveniently be a strip cut from a standard 38 hole wide board. This type of board is easily cut using a hacksaw, cutting along a row of holes, but only light pressure is needed. The fairly soft plastic can tend to fray slightly along the length of the cut, but can be carefully shaved using a modelling knife.

Details of the component layout and wiring of the board are shown in Figs. 4 and 5 respectively. Fit all the components onto the board before undertaking any of the wiring. This includes the five Easiwire sockets which are used to make connections to off-board components. IC1 is a MOS device, and it is therefore advisable to use a holder for this component. Do not plug IC1 into place until the unit is in all others respects finished, and handle it as little as possible. Until then, leave it in its anti-static packaging (conductive foam, plastic tube, or whatever).

All components should plug into place without having to enlarge any of the holes in the board. The leads of D1 should be left quite long so that this component stands some 20 to 25 millimetres above the surface of the board. The cathode ("k") leadout of D1 will probably be indicated by a shorter leadout wire. Ordinary wire cutters are used to trim the leadouts so that about 3 millimetres or so of each one is left protruding on the underside of the board. The leads of the

COMPONENTS

Shop Talk
See page 360

Resistors

R1, R2	10k (2 off)
R3	6k8
R4	1M
R5	39k
R6	680

All 0.25W 5% carbon

Capacitors

C1	10μ radial elect. 25V
C2	470n Polyester (C280)

Semiconductors

IC1	CA3140E
D1	5mm red l.e.d.

Miscellaneous

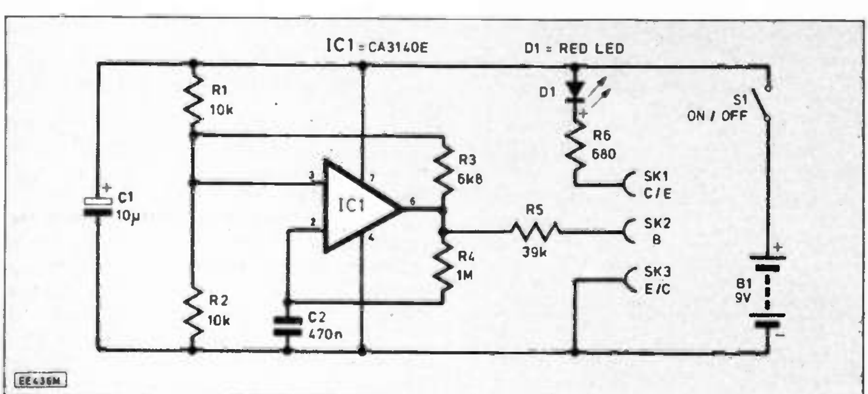
B1	9V battery (PP3 size)
S1	s.p.s.t. miniature toggle switch

SK1 to SK3 1mm sockets (3 off).

Plastic/metal box about 88×40×143mm; Easiwire board, etc.; 6BA fixings; battery connector; 8 pin d.i.l. holder; connecting wire.

Approx. cost Guidance only £5

Fig. 3. Complete circuit diagram of the Easi-Transistor Tester.



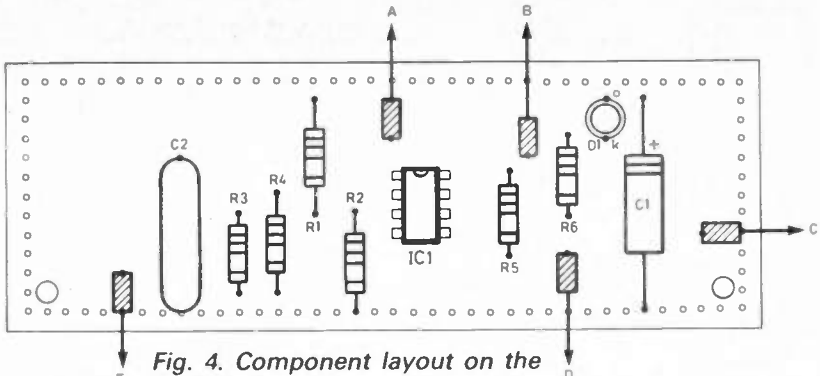


Fig. 4. Component layout on the Easiwire board.

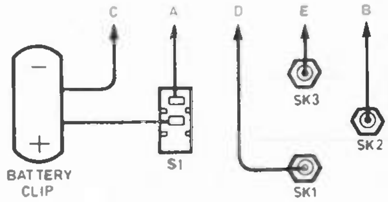


Fig. 6. Interwiring details.

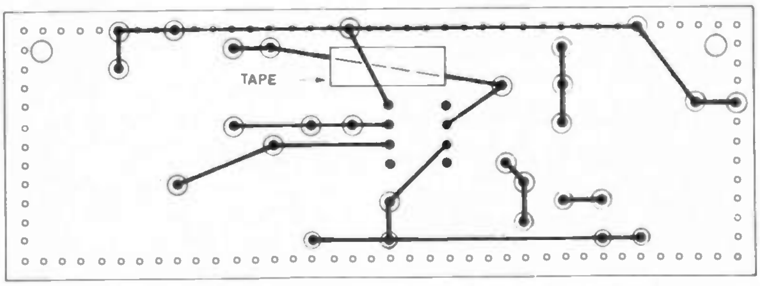
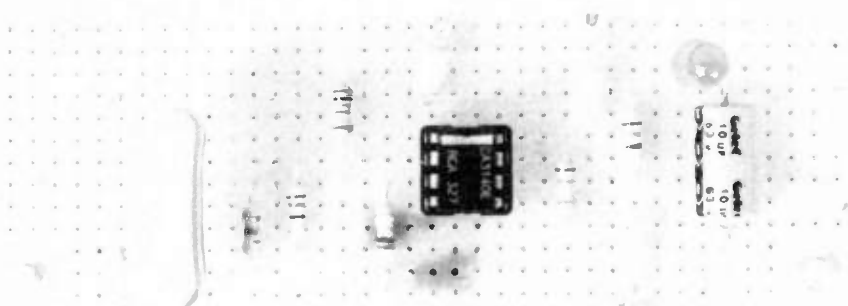
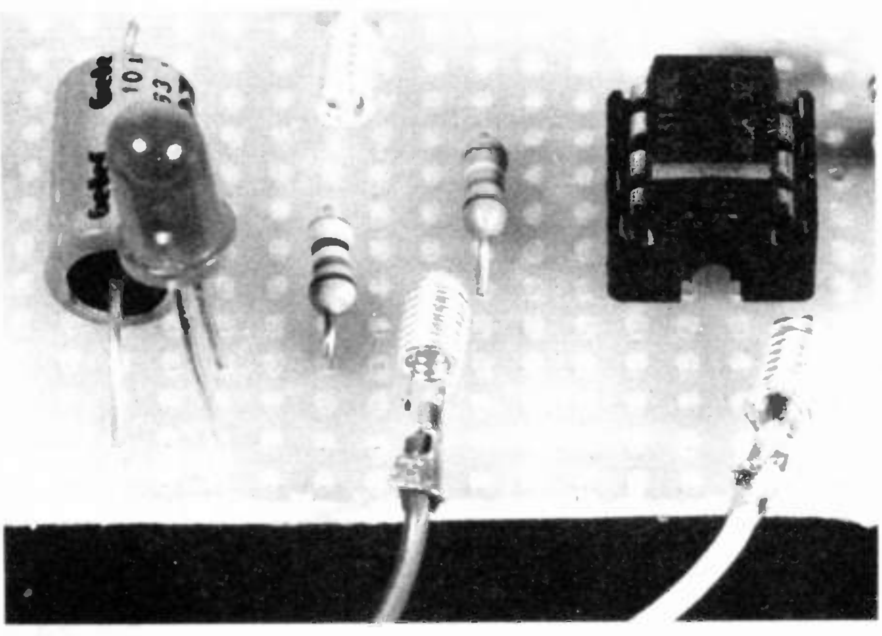


Fig. 5. Wiring on the underside of the board.





sockets are ready-trimmed, and serve as a good guide to the optimum lead length when trimming the leadout wires.

Most of the wiring is quite straightforward, but if you are new to wire- wrapping it might take a little practice before you become really accomplished at it. Try to keep the connecting wires taut so that they cannot accidentally come into contact with one another and cause short circuits.

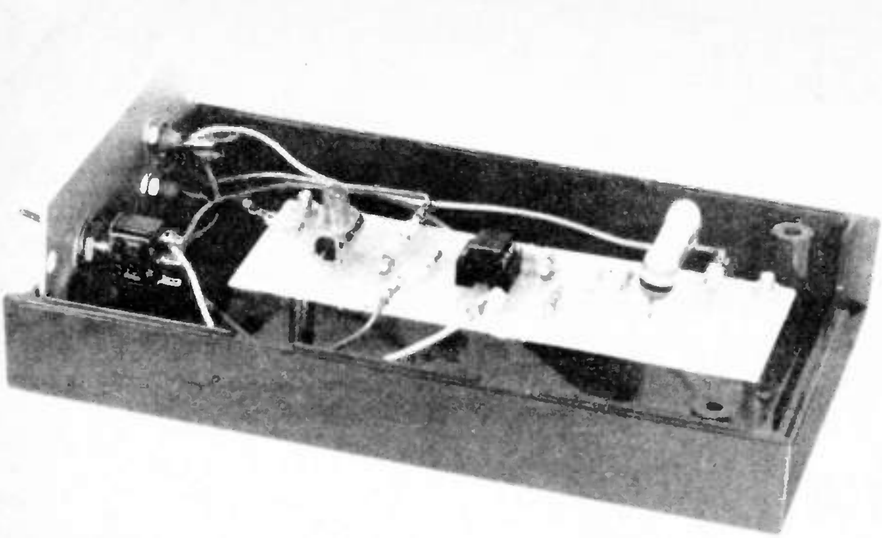
Do not use separate lengths of wire to connect a series of points. The board will be much neater and stronger if you use a single length of wire to connect each series of points, and this method is much quicker and easier anyway. It is advisable to push each component down onto the board to make sure it is fully pushed home before wire wrapping one of its leadout wires.

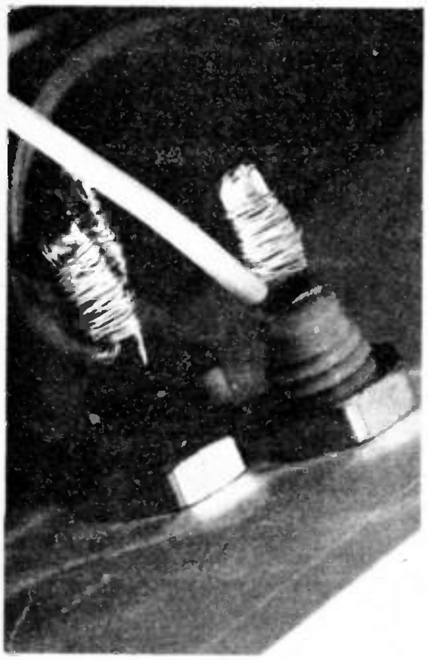
Do not leave the ends of wires sticking out all over the place. They are the Easiwire equivalent of solder splashes, and are likely to cause unwanted short circuits. Any wire ends that protrude significantly from joints should be carefully trimmed off using a sharp modelling knife. It is important that each connection should start and finish as close to the surface of the board as possible. The board then protects the wires and greatly reduces the risk of them being accidentally snapped. If a set of connections do not look up to standard, simply remove them using the unwrap tool and try again.

CROSSOVER

There is one slight complication in that there are a pair of crossed wires just below IC1 (see Fig. 5). Initially, leave out the wire that takes the negative supply to pin four of IC1. When all the other wiring has been completed, add a small piece of insulation tape at the position indicated in Fig. 5, and then add the missing connecting wire. One end of the wire goes to a point where there is already a connection. However, there is no difficulty in adding one connection on top of another, and this gives two good quality connections.

The finished board is mounted in the case using 6BA or M3 fixings, including spacers to hold the board about 18 millimetres clear of the base panel. With Easiwire boards the use of spacers is essential. Without them the components on the board would be forced upwards and out of place as the board was bolted into position. In this case there is a need to raise the board anyway. The top of the l.e.d. must be brought to about the same height as the top of the case. It can then "look" through a five millimetre diameter





hole drilled at the appropriate point in the top of the panel of the case.

The on/off switch and three sockets are mounted on the front panel. If the three sockets are closely grouped in a triangular configuration rather than a straight line, it should be possible to plug most transistors directly into the sockets. A set of three short test leads terminated in crocodile clips are needed for unco-operative devices, which will include all power types. It is advisable to use leads of different colours to aid correct identification, and help avoid getting test devices connected incorrectly.

OFF-BOARD CONNECTIONS

At the board end, leads are fitted to the sockets by way of the matching plugs. These can be crimped onto the bare ends of leads with the aid of pliers, and will give very strong joints. Connecting the leads to the sockets and on/off switch is a little more tricky. One answer is to solder them, or these connections could be made using miniature crocodile clips. A simple but effective method, and the one I used, was to wire-wrap them!

This is just a matter of holding the bare end of the leadout wire alongside the tag to which it is to be connected, and then wrapping about fifteen turns of wire tightly around the two. Like soldering, this is really a three handed job! You need one hand to hold the lead in place, one to hold the end of the wire, and one to hold the "pen". You might be able to hold the lead and the end of the wire-wrap wire with one hand, but I found it was much easier to use some Bostik Blue-Tack to hold the lead in place. This then leaves both hands free to carry out the wire-wrapping, which is then very easy.

Normally connections are made with the lead coming straight back from the tag to which it is connected. This does not work too well with this method where the lead tends to severely hamper the wire-wrapping process. It is much easier if the lead runs forwards towards the front panel, and is then curved through 180 degrees to take it back towards the component panel. Apart from making the wire-wrapping much easier, this probably reduces the risk of the lead being pulled away from the tag and gives what is effectively a stronger joint (see photo left).

Details of the off-board connections are provided in Fig. 6, in conjunction with Fig. 4 (e.g. "A" in Fig. 4 connects to "A" in Fig. 6).

TESTING

Before trying out the transistor checker, give all the wiring a thorough search for errors. As an initial check try short circuiting SK1 and SK3 using a short piece of tinned copper wire (a trimming from a resistor leadout should suffice). With the unit switched on this should result in D1 lighting up brightly. If it does not, switch off immediately and recheck all the wiring.

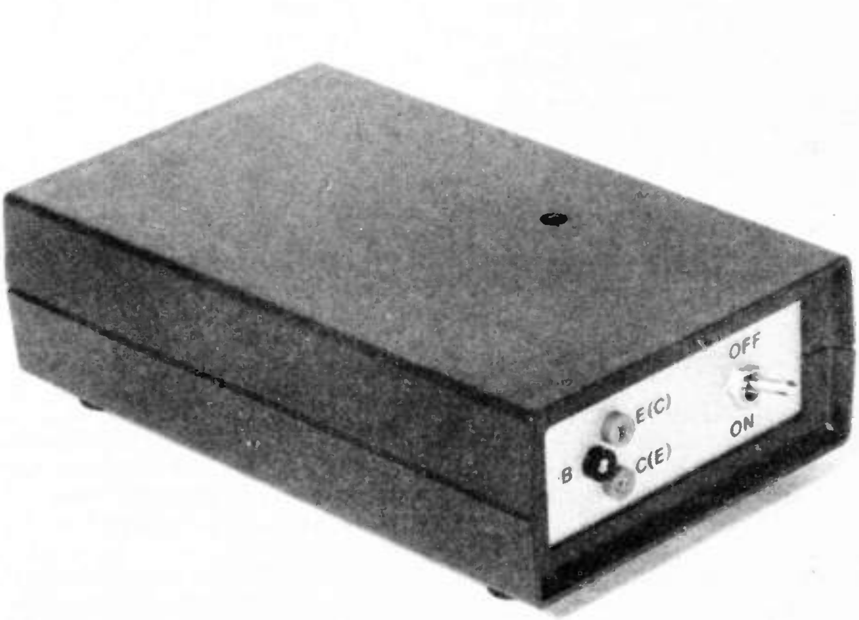
If all is well, try connecting a transistor to the unit, but make sure that you use the correct method of connection, as detailed below—

SOCKET	*NPN LEAD*	*PNP LEAD*
SK1	COLLECTOR	EMITTER
SK2	BASE	BASE
SK3	EMITTER	COLLECTOR

It is a good idea to use front panel legends to mark the three sockets with their functions. You must be equally careful to correctly identify the leadouts of any transistors that are tested. With plastic cased transistors in particular, identical looking devices can have different leadout configurations. Always check the leadout configuration before testing a component, and recheck it if the device is indicated as being faulty. With any transistor of moderate to high gain the l.e.d. should flash quite brightly. With lower gain devices it will be somewhat dimmer, but if it barely glows, the test component is a "dud".

With silicon transistors the l.e.d. should fully extinguish during the off periods. With germanium types it might glow dimly, but there should still be plenty of contrast between the on and off states. There is little risk of damaging silicon transistors if they are connected incorrectly, but germanium types are a little less tolerant of this type of thing. In particular, they can be damaged by a supply voltage of the wrong polarity. Take extra care if you need to test any germanium devices. □

CONSTRUCTORS NOTE
Full details on and supplies the Vero Easiwire system used to construct this project are available from: BICC Vero Electronics Ltd., Flanders Road, Hedge End, Southampton, SO3 3AG. Tel. 04892 88774.



City and Guilds

C+G

INTRODUCING MICROPROCESSORS

MIKE TOOLEY B.A.

Part 8

PROGRAMMING

In the last part we explained how such commonplace items as l.e.d.s and relays can be interfaced to the parallel I/O port of a microprocessor based system. In this part we shall be dealing with programming of microprocessor systems and will introduce flow charts and languages. We also provide details of the third Practical Assignment.

LEARNING OBJECTIVES

The general learning objective for Part Eight of Introducing Microprocessors is that readers should understand simple assembly language programs used to control external devices connected to the parallel port of a microprocessor-based system.

The specific objectives for Part Eight are as follows:

6.1 LANGUAGES

6.1.1 Explain the need for programming languages and distinguish between high level and low level languages.

6.1.2 State the desirable characteristics of programming languages for each of the following applications:
real-time control systems
data processing
systems and application software.

6.2 ASSEMBLY LANGUAGE PROGRAMMING

6.2.1 Describe the logical procedure which must be adopted in order to create a satisfactory program.

6.2.2 Describe algorithms and draw flowcharts relating to simple problems.

6.2.3 Identify and use common flowchart symbols.

6.2.4 Explain what is meant by assembly language.

6.2.5 Describe, with typical examples, the use of mnemonics in assembly language programs.

6.2.6 Write, hand-assemble, enter, test and debug simple programs using a subset of the instruction set of any common 8-bit c.p.u. to:
a) add two eight-bit data values from RAM and place the result in a third RAM location
b) operate an external relay or l.e.d. in a pre-defined on/off sequence.

PROGRAMMING LANGUAGES

In order to simplify the process of producing working programs, the software developer may use one (or more) of a number of programming languages to simplify the task of producing a working program. The choice of language depends essentially upon several factors including the application concerned, the degree of familiarity which the programmer has with the language concerned, and the availability of the necessary development software for the microprocessor system to be used.

Languages which are well suited to producing software in fields such as data processing are generally not well suited to producing software for such applications as real-time control. Furthermore, a programmer who is competent in a language such as Pascal may be very much out of his or her depth with Forth.

Happily, a range of languages is available to most modern microcomputers and the final choice of language will take into account such factors as compactness (i.e. size of program code generated), speed of execution, ease of use, portability (i.e. ability to transfer code easily from one system to another), and ease of maintenance.

The desirable characteristics of languages for three typical applications (real-time control, data processing and applications software) are listed in Table 8.1.

HIGH AND LOW-LEVEL LANGUAGES

Programming languages are often classified as "high level" or "low level". High level languages are generally those which are "procedure oriented" and are written in structured English such that programs are easily readable. Each program statement in a high level language will normally have a recognisable function and, furthermore, will be equivalent to several assembly language instructions.

Low level languages are those which are "machine oriented" and are thus close to the binary "machine code" which is executable

	Real-time control	Data processing	Applications software
Speed of execution?	MUST be very fast	not generally critical	as fast as possible
Size of code	MUST be very compact	not generally critical	should be reasonably compact
Portability	not generally critical	should be reasonably portable	MUST be highly portable
Availablity of data structures	not generally critical	MUST offer a range of powerful data structures	should offer a range of data structures
Example language	Assembly language	Pascal	C

Table 8.1 Characteristics of programming languages for three typical applications areas

by the microprocessor. Assembly language is an example of a low level language which uses mnemonic operational codes (opcodes) and symbolic addresses (instead of actual memory locations). The individual program statements in a program written in a low level language may not in themselves, be particularly meaningful and therefore comments are generally added to clarify the action of the statements.

ASSEMBLY LANGUAGE PROGRAMMING

In Part Three we briefly mentioned that assembly language was a low-level language in which the instructions are presented in mnemonic code for later translation into the binary code acceptable to the microprocessor. Readers will doubtless recall that this process is normally carried out by means of an assembler program.

The assembler acts upon a text file written in mnemonic assembly language code (known as "source code") and generates a binary code (known as "object code") within the microcomputer's memory. Thereafter, the object code constitutes a directly executable program i.e. we simply load the Instruction Pointer or Program Counter with the entry (start) address of the code and execution commences.

Some assemblers produce intermediate programs in hexadecimal format such that the mnemonic source code is first translated into a hexadecimal file. This file may be subsequently stored on disk (as a "hex. file") or loaded into the microcomputer's memory ready for execution.

Alternatively, where programs are extremely short, it is possible to dispense completely with the services of an assembler and resort to "hand assembly". This, somewhat tedious process, involves first writing the program in assembly language mnemonics and then translating each instruction (operation code and operand) into hexadecimal code which is then loaded into an appropriate region of memory prior to excution. Hand assembly requires the services of a machine code "monitor" or "debugger". Alternatively a rather more specialised "hexadecimal code loader" may be used.

At this point, it is worthwhile reminding readers of the simple example which we used in Part Three. We wished to add together two bytes of immediate data (stored in RAM as part of the program) using our hypothetical microprocessor (IMP). This task involved three instructions. The first loaded the first operand (in this case a byte of immediate data) into the accumulator (A). The second loaded the second byte of data into the B register. Finally, the third instruction added together the contents of the A and B registers and placed the result back into the accumulator.

Assuming that the data bytes have hexadecimal values of 01 and 02 respectively the program takes the following form:

LD A,01
LD B,02
ADD B

Its hexadecimal representation may be found by referring to the instruction set as follows:

LD A,01 is represented by 3E (the opcode) followed by the byte of immediate data (in this case 01)
LD B,02 is represented by 06 (the opcode) followed by the byte of immediate data (in this case 02)
ADD B is represented by 80 (the opcode) and there is no operand

The hexadecimal representation of the program is thus:

3E 01
06 02
80

Assuming that the program is to commence at an address of 1800H, the contents of IMP's memory would be as shown in the table below:

Address (hex)	Contents (hex)	(binary)
1800	3E	00111110
1801	01	00000001
1802	06	00000110
1803	02	00000010
1804	80	10000000

After execution of the program, the Instruction Pointer (Program Counter) will have reached 1805H and the A and B registers will contain 03 and 02 respectively. Note that, if we wished to test the program it would be necessary to halt the microprocessor at address 1805 otherwise it would continue to execute whatever code it came across. This is a potentially dangerous situation as the microprocessor cannot distinguish between random data and program code (the former may cause the system to lock-up in an endless loop or even over-write the program with spurious data).

Now let's consider a more complex example. Suppose that we wish to add together two eight-bit data values stored in RAM (not as part of the program) and place the result into a third RAM location. We will assume that, in both cases, the bytes of data are stored in memory locations 1900H and 1901H and that the result is to be deposited at address location 1902H. To make life easier, we will ignore the possibility of an overflow occurring (as would be the case if the sum of the two bytes were to exceed 255 decimal or FFH).

The assembly language program, and corresponding hexadecimal machine code, will be different for different microprocessors. Indeed, the programmer may have to adopt slightly different techniques due to the constraints imposed by the instructions and addressing modes (i.e. methods of locating the data used by an instruction) available with the microprocessor concerned.

The following routines for the Z80 and 6502 illustrate this point:

Z80 CODE

LD A, (1900H) ; get first byte

```
LD B,A          ; transfer to B
LD A, (1901H)   ; then get the
                  second byte
ADD B           ; find their sum
LD (1902H),A    ; and store the
                  result
```

6502 CODE

```
CLC             ; first clear carry
                  flag
LDA $1901       ; get second byte
ADC $1900       ; and add to first
STA $1902       ; then store the
                  result
```

Problem 8.1

Use implied addressing (with register pair HL acting as a pointer) to produce an alternative Z80 program which will have the same effect. (NB: A subset of the Z80 Instruction Set appeared on Data Card 4.)

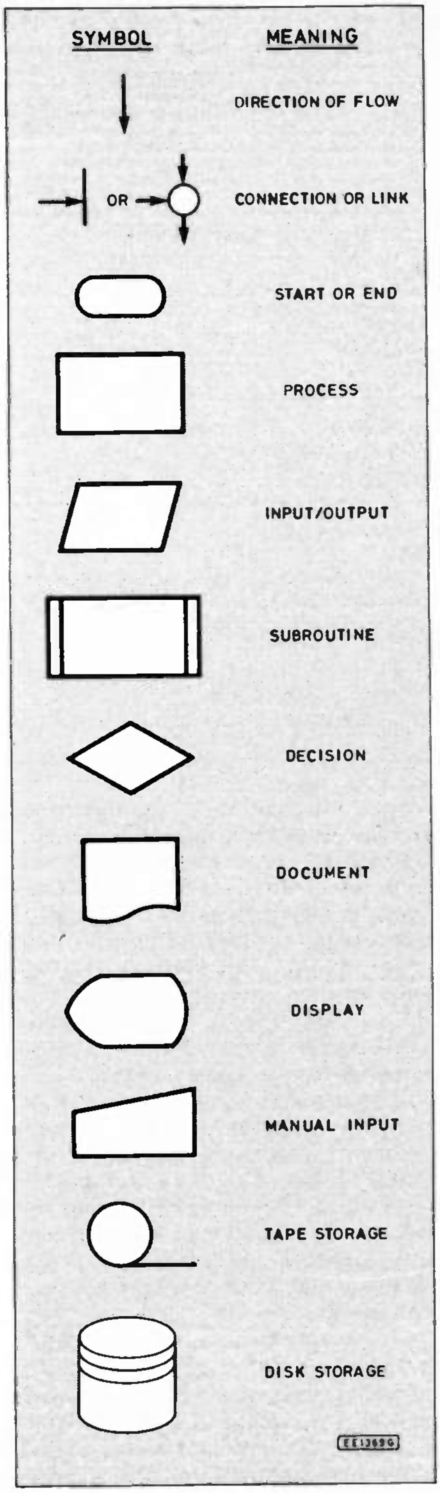


Fig. 8.1 Flowchart symbols

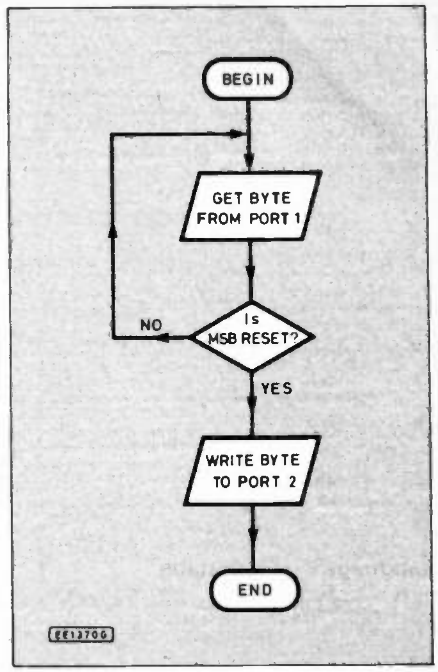


Fig. 8.2 Flowchart for a simple I/O process

ASSEMBLY LANGUAGE PROGRAMMING TECHNIQUE

Regardless of the processor involved, a number of techniques can be used to improve the overall efficiency of a program and also make it easier to maintain. Many of these techniques are easy to implement and merely require a little forethought and self-discipline on the part of the programmer.

Programs will invariably comprise a number of smaller modules each having an identifiable function. The overall structure of the program should be defined at a very early stage and no attempt should be made at coding any of the modules required by the program until the overall program structure has been finalised.

An algorithm is a method of describing the sequence of operations which should be followed in order to solve a problem. An algorithm is often expressed using a diagram to show the sequence of events. This diagram is known as a flowchart and a standard set of symbols (Fig. 8.1). These symbols indicate the type of process involved and the flowchart is annotated with brief explanatory comments which are inserted within the symbols to which they refer.

The overall structure and flow of a program should be defined using one, or more, flowcharts at an early stage. Alternatively (or in addition to a flowchart representation) the sequence of the program may be described by a series of statements written in a form of structured English. In any event, the overall flow of the program should be sequential, there should be only one entry and one exit point, and all transfers of control (i.e. jumps and calls) should be explicit.

As an example of using flowcharts and structured English statements, consider the case of a simple routine which reads a set of switches connected to an input port, loops until the switch connected to most significant bit (MSB) is closed and then transfers the byte read from the switches to an output port.

A flowchart for the process is shown in Fig. 8.2. Alternatively, we could express the problem in terms of the following structured English statements:

```
Begin
Repeat
   Get byte from PORT 1
Until MSB of byte is reset
Output byte to PORT 2
End
```

Armed with one or other of the foregoing algorithms, it is a relatively simple matter to develop the code. A particular solution based on the Z80 microprocessor, is shown in Fig. 8.3

Problem 8.2

Sketch a flowchart to describe the steps in finding the sum of two data

Fig. 8.3 Simple Z80 I/O subroutine

```
; READ BYTE FROM PORT1, LOOP UNTIL MSB RESET,
; THEN TRANSFER BYTE TO PORT2
;
; EXIT: A = (PORT1), BC = PORT2, ZF = reset
;
; REGISTERS AFFECTED: A, B, C, F
;
GETBYTE:    LD    BC,PORT1        ; Get byte from
            IN    A,(C)           ; PORT1
            BIT   7,A             ; Is MSB reset?
            JR    Z,GETBYTE       ; No, keep trying
            LD    BC,PORT2        ; Yes, send byte
            OUT   (C),A           ; to PORT2
            RET
```

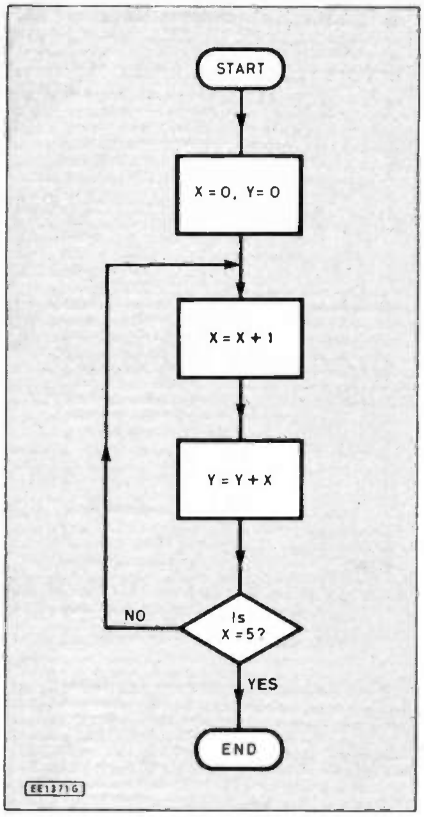


Fig. 8.4 See Problem 8.3

values (taken from memory) and place the result back into memory.

Problem 8.3

The flowchart in Fig. 8.4 indicates a process. Determine the values of the variables X and Y upon exit.

SUBROUTINES

The fragment of code shown in Fig. 8.3 constitutes a subroutine. This is a section of code which may be called from various points in the main program (using the CALL instruction) and returned to (by means of a corresponding RETurn) instruction. If desired, both the CALL and RETurn instructions can be made conditional on the contents of the flag register. Furthermore, a subroutine may have several conditional RETurn statements.

The CALL instruction saves the old value of the Instruction Pointer (or Program Counter) in the stack before replacing it with the value of the subroutine start address. On returning from the subroutine, the Instruction Pointer (or Program Counter) is loaded with the value saved on the stack so that the main program can be resumed at the point at which it was left.

Parameters can be easily passed to and from subroutines by simply placing them in one or more of the CPU registers. Alternatively, parameters may be passed using the stack or by reserving an area of memory in which parameters can be deposited before making the call and recovered after the call has been made. These techniques allow the passing of a much greater number of parameters than would be possible using just the CPU registers.

Care must be taken to preserve the contents of any CPU registers that may be modified as a result of executing a subroutine call and that are required in subsequent processing. It is thus essential to have a knowledge of the effect of a subroutine on the CPU registers (in any event, this should be clearly indicated in the source code). Furthermore, subroutines should be designed so that they minimise usage of the CPU registers, thus keeping things simple for the programmer and reducing any potential overhead associated with storing and retrieving register contents.

The use of subroutines makes programs easy to maintain and allows modules to be easily transferred into other programs without having to rewrite an entire program. This is an important point and one which can save the programmer a great deal of time!

PROGRAMMING I/O DEVICES

Readers may recall that we concluded last month's instalment by describing a representative output driver arrangement based on a programmable parallel I/O device. We also stated that the external devices could be easily operated by simply writing an appropriate data byte to the port in question. As an example, a binary value of 11000111 (hex. C7) written to Port A will illuminate the three l.e.d.s connected to PA0, PA1 and PA2 and operate the relays connected to PA6 and PA7. To turn the l.e.d.s and relays off, a binary value of 00000000 (hex. 00) should be sent to Port A.

Readers may recall from Part Six that a microprocessor employing memory mapped I/O (such as the 6502) can simply write data to an output port using an instruction of the form: STA address (the accumulator must first be loaded with the requisite byte of immediate data). In the case of a microprocessor which uses port I/O (such as the Z80), the accumulator is again first loaded with the requisite byte of data and then an output instruction of the form OUT (port), A is used.

In either case, it will usually be necessary to configure the programmable I/O device (this will often be a 6520 PIA or 6522 VIA in the case of 6502 CPU or a Z80-PIO or 8255 PPI in the case of a Z80 CPU) before I/O can commence. The configuration routine will be very much dependant upon the hardware configuration and type of I/O device fitted. Such specific routines are beyond the scope of Introductory Microprocessors but, where readers require further details they should refer to the documentation provided by centres for use in Practical Assignments Three and Four.

Problem 8.4

A microprocessor based system is fitted with one input and one output port. The input port is connected to eight switches and the output port is connected to eight l.e.d.s. Devise a simple assembly language program which will continuously read the switches and operate the respective l.e.d.s in each of the following cases:

(a) Using a 6502 CPU memory mapped with the following port addresses: Input, 8002H Output, 8005H
(b) Using a Z80 CPU employing port I/O with the following port addresses: Input, FBH Output, FDH

THIRD PRACTICAL ASSIGNMENT

Readers should now be ready to undertake the third Introductory Microprocessors Practical Assignment. This assignment involves Programmable Input/Output Devices and Peripheral Control and the module objective references are 4.2.4 and 5.1.4

As before, the Practical Assignment must be undertaken at an approved local centre where candidates will be provided with supervision and appropriate working conditions. Candidates should, however, provide their own A4 note paper, pens and pencils. For its part, the Centre will supply candidates with any hardware, data sheets, books or handbooks required (including full documentation for the microprocessor-based system, a full instruction set for the microprocessor and details of port connections and addresses). During the Practical Assignment, candidates will normally be required to undertake the following tasks:

(a) Draw a pin-out diagram of the programmable parallel input/output device provided on the system, clearly labelling the supply pins, address, data, input/output and control bus lines. Readers may wish to refer to Data Card 6 (April 1988 E.E.) which contains details of five of the most popular programmable I/O devices.
(b) Using the data sheets provided for the programmable parallel I/O device on the system being used, name the internal registers and briefly explain their function.
(c) With power off, connect an l.e.d. relay driver unit to the

microprocessor-based system.

(d) Connect a 12V d.c. motor to the normally-open contacts of the relay in (c).

(e) Write an assembly language program which will operate the l.e.d. and motor (via the relay driver). Include an algorithm or flowchart to show how the program works and include the configuration routine (supplied by the tutor/assessor).

(f) Hand assemble the program, enter, test and debug the program using the facilities offered by the microprocessor-based system.

Note that this assignment should be completed in two hours 30 minutes. Extra time may prejudice your chances of success.

Marking

Candidates will have satisfactorily completed this first Practical Assignment if they can demonstrate success in all items marked with a square and at least TWO out of FOUR items marked with a circle in the list below:

Completed within two hours 30 minutes ○
Pin-out diagram of programmable I/O device □
Internal registers identified and functions explained ○
I/O addresses stated and/or memory map included ○
Flowchart or algorithm ○
Program machine code and assembly language listing □
Program functions correctly with l.e.d. relay driver □

Where candidates are deemed unsuccessful, a period of at least seven days must elapse before a retake is permitted. This should give candidates an opportunity to prepare themselves. Note also that most centres will expect candidates to use a different microprocessor-based system and programmable I/O device for their second, and any subsequent, attempts.

NEXT MONTH

Next month we shall bring our series to a conclusion by preparing readers for the second Written Assessment and the fourth Practical Assignment. We shall also include replies to a number of queries raised by readers in our second, and final, Readers' Forum.

ANSWERS TO PROBLEMS

8.1. Either of the following programs would prove satisfactory:

(a)
```
LD HL, 1900H
LD, B, (HL)
INC HL
LD A, (HL)
INC HL
ADD B
LD (HL), A
```
(b)
```
LD HL,1900H
LD A, (HL)
INC HL
ADD (HL)
INC HL
LD (HL),A
```
Note that the program in (b) is one byte shorter than that in (a)

8.2. See Fig. 8.5

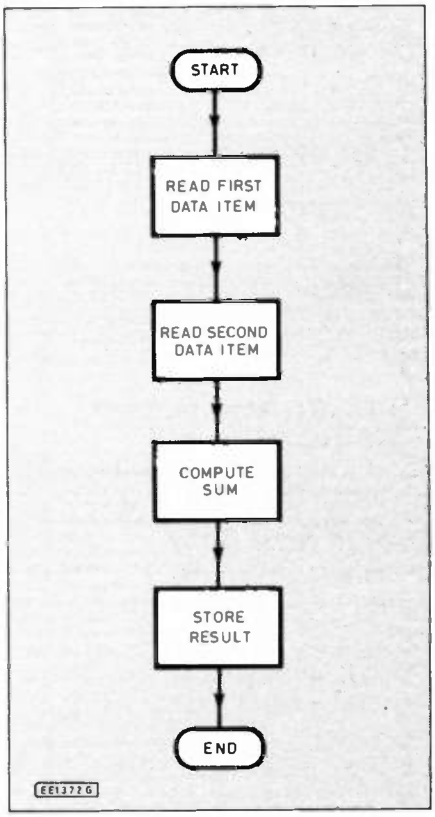


Fig. 8.5 Answer to problem 8.2

8.3. X=5, Y=15

8.4. (a) **LDA $8002 ; get byte from switch bank**
STA $8005 ; and send it to the LED

(b) **IN A, (FBH) ; get byte from switch bank**
OUT (FDH),A ; and send it to the LED

BACKGROUND READING

The following background reading is recommended for Part Eight:

(a) Chapter 3 (Software and Programming) of *Beginner's Guide to Microprocessors* by E. A. Parr (a Newnes Technical Book published by Heinemann-Newnes) ISBN 0 408 00579 3. **Available from Direct Book Service—see page 362.**

(b) Chapter 4 (Program Creation at Machine Code Level) of *Microelectronic Systems 2* by R. Vears (published by William Heinemann Ltd.) ISBN 0 434 92194 7. **Available from Direct Book Service—see page 362.**

CORRESPONDENCE

Comments and queries from readers are welcome and should be sent directly to the author at the following address: Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

Readers' queries will be dealt with in our final "Readers' Forum" which will appear next month.

GLOSSARY FOR PART EIGHT

Algorithm
The sequence of steps (presented in a clearly understandable form) which describe the procedure used to solve a problem.

Call
An instruction to jump to a subroutine. A jump to the specified address is performed, but the contents of the Instruction Pointer (or Program Counter) is saved so that the (calling) program can be resumed when the subroutine has been completed.

Flowchart
A graphical representation of program logic. Flowcharts enable the software developer to visualize the steps and logical flow within the program.

Hand assemble
The process of translating a program presented in assembly language mnemonics into machine code without the aid of an assembler program.

High level language
A problem oriented programming language (as distinguished from a machine oriented language). The syntax of a high level language is usually similar to English.

Program
A procedure for solving a problem coded into a form suitable for execution by a computer. Often referred to simply as "software".

Subroutine
A routine or sub-program which is separated from the main body of the program and which is executed by means of a CALL instruction (or its equivalent in a high level language). At the conclusion of the subroutine, control reverts to the main (calling) program at the point at which it was left.

PLEASE NOTE

The *Introducing Microprocessors* series has proved to be very popular with both readers and lecturers/teaching establishments etc.

To meet this on-going demand for the series we will be republishing it in book form. The book will be available from newsagents and from the Direct Book Service during October—watch out for full details.

Constructional Project

MULTI-CHANNEL REMOTE LIGHT DIMMER

PART TWO

B. ROBINSON

Create just the right "ambience" from the comfort of your armchair.

Last month we presented details for building the Infra-red Transmitter and Receiver. The setting-up procedure for these two units called for the use of an oscilloscope, so before moving on to describe the Relay, Dimmer, PSU and Mother boards we should like to offer some guide lines on setting-up without an oscilloscope.

SETTING-UP WITHOUT AN OSCILLOSCOPE

To set up the receiver without the use of an oscilloscope is slightly more difficult, but providing the circuit is functioning correctly, it can be done. The variable resistor on the transmitter, VR1 should be set somewhere near its mid point and pin 5 of the transmitter i.c. should be connected to pin 15 to give the code "0001". The l.e.d., D1, should light showing that the i.c. at least is operating.

The receiver should be mounted within a metre or so of the transmitter and a voltmeter should be connected to the "A" output of the receiver board, or pin 5 of the ML926. The receiver should then be powered up. The meter will probably read 0V at this stage, if it does, *slowly* rotate the variable resistor VR1 on the receiver and observe the meter carefully.

If the current tuning point is found, then the "A" output of the ML926 will rise almost to supply volts, and this can be observed on the meter. If no point can be found where the output changes, then re-adjust the transmitter variable resistor (VR1) to a setting slightly off centre and try again. By repeating this operation and by making careful notes about the positions of the transmitter variable resistor which have been tried, an operating position will eventually be found.

When this happens, the receiver control should be rotated gradually one way and then the other to ascertain the range of the resistor over which the circuit operates, then the control can be set to the middle of this range. This is important, because the receiver could be at the edge of the correct operating frequency and any drift in the transmitter frequency could cause the receiver to lose the signal. Of course, it is possible that when the receiver is first switched on it will happen to be correctly tuned. If this happens ensure that the receiver is in the middle of its range as before and be sure to do the football pools.

IT IS VERY IMPORTANT TO SWITCH THE MAINS OFF BEFORE HANDLING ANY OF THE BOARDS, MAINS LAMP DIMMERS ARE POTENTIALLY LETHAL

DECODER AND RELAY DRIVERS

The decoder and relay driver circuit diagram is shown in Fig. 7. The 4-bit binary output from IC3 of the receiver circuit is applied to the input of the 4514 CMOS 4 to 16-line decoder. This device outputs a "1" on one of its sixteen output lines according to the binary code being received. Again only six of the possible sixteen codes are being used.

The 4514 (IC4) has an input latch which is enabled by pin 1, but because this pin is tied to Vcc (0V line), the latch is transparent that is the output changes when the input changes. Pin 23 is the output enable pin and because it is a negative true input, it is held low by tying to the 0V line, thus enabling the outputs.

Each output has a transistor amplifier TR1 to TR6 to provide the necessary drive to operate one of the relays RLA to RLF which in turn operate one of the six lamp dimmers. Relays are used to provide good electrical isolation from the mains voltages present on the dimmers.

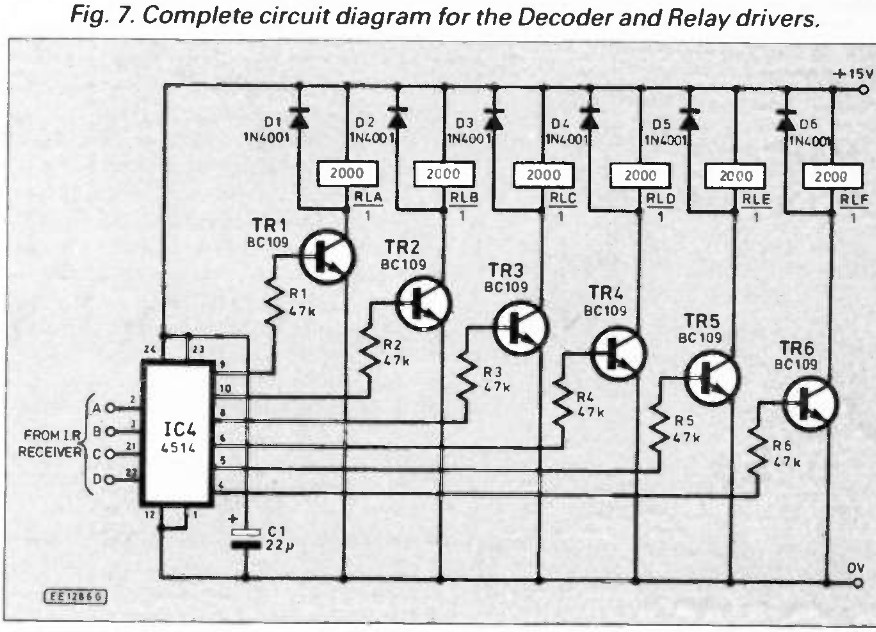
The diodes D1-D6 across the relay coils protect the transistors by clipping the back e.m.f. generated by the coils when the transistors switch off. The capacitor C1 decouples the supply and removes any relay switching noise from the supply.

CONSTRUCTION AND TESTING

The decoder and relay drivers are built on a printed circuit board, the component layout of which is shown in Fig. 8. Although IC4 can be soldered into the board, it is a 24-pin device and would be extremely difficult to unsolder, so it is better to use an i.c. socket so that it can be changed if a fault should occur.

Ensure that there are no tracks being bridged by solder especially around the relay contact pins and all transistors and diodes are connected the correct way round. Also en-

Fig. 7. Complete circuit diagram for the Decoder and Relay drivers.



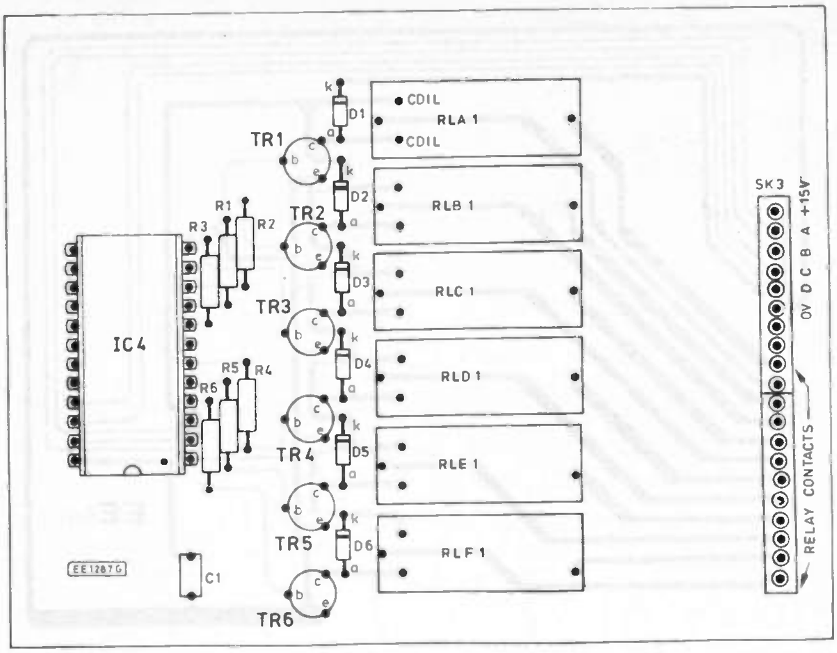


Fig. 8 (above). Decoder/Relay Driver board component layout and(right) full size p.c.b. copper foil master pattern.

sure that IC4 is correctly orientated before applying power to the board. Because IC4 is a CMOS device, it is safest to leave it off the board until the rest of the components are installed and so minimise the risk of static damage.

The board can be tested after construction by the following method. Connect a short piece of wire to each of the four input pins A, B, C and D and tie them *all* to ground (0V). Connect an ohmmeter (multimeter set to "ohms") across the contacts of RLA and apply power to the board, the meter should show an *open* circuit.

Now remove the wire going to input pin A of the board from the 0V line and connect it to the 15V supply pin and the meter sould show a *short* circuit. Assuming it does, replace the "A" wire on the 0V line and do the same test with the "B" wire and the meter across RLB contacts. Repeat this test with the pins shown in the table below:

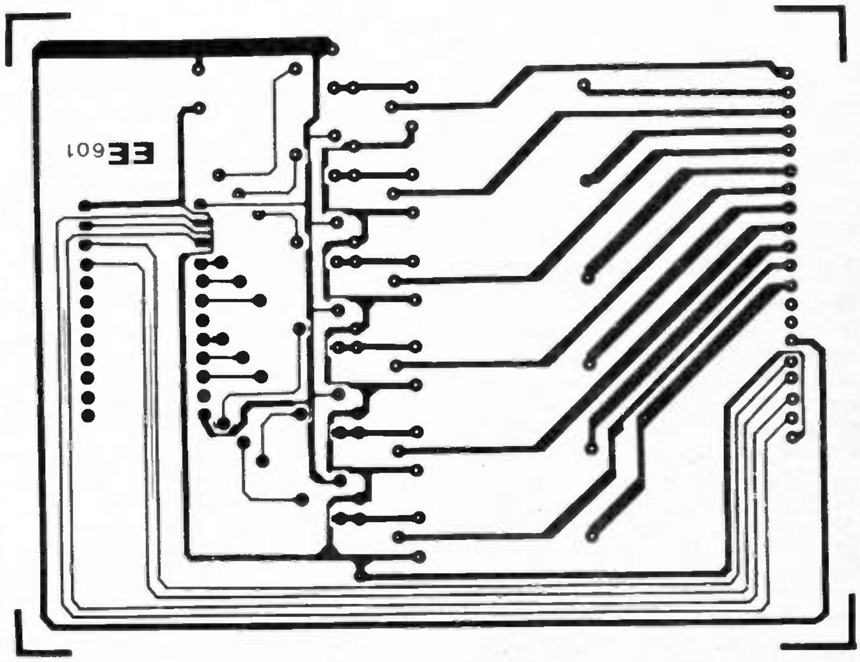
LOW	HIGH	RELAY
B,C,D	A	RLA
A,C,D	B	RLB
C,D	A,B	RLC
B,D	A,C	RLD
A,D	B,C	RLE
D	A,B,C	RLF

If all the outputs are correct then the board is functioning properly, but if any one is incorrect, check the layout for faults and check that the appropriate transistor is not faulty. If nothing works, suspect the supply is missing or wired to the wrong pins, the latch enable (pin 1) or the output enable (pin 23) is not connected, or the integrated circuit is the wrong way round or faulty.

LAMP DIMMERS

The circuit diagram for a single lamp dimmer is shown in Fig. 9. This circuit is repeated for the required number of dimmers.

The S576 touch switch i.c. is normally used in touch sensitive lamp dimmers by providing the components shown boxed in Fig. 9.



COMPONENTS

RELAY BOARD

Resistors
R1–R6 47k (6 off)

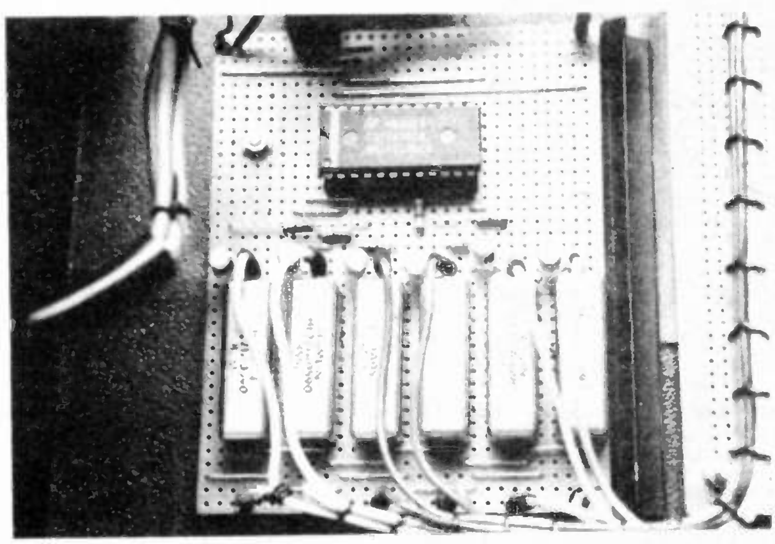
Capacitors
C1 22μ elec. 25V

Semiconductors
D1–D6 1N4001 (6 off)
TR1-TR6 BC109 *npn* silicon (6 off)
IC1 CD4514 4 to 16-line decoder

Shop Talk
See page 360

Miscellaneous
SK3 10-way p.c.b. connector (female)
RLA–RLF 2000 ohm, 12–18V relay, s.p.s.t. contacts (6 off)
Printed circuit board, available from *EE PCB Service*, code EE601; solder pins; 24 pin i.c. socket.

Approx. cost Guidance only **£15**



Completed prototype relay board built on stripboard.

Touching the sensor plate or closing the relay for a period between 50 and 400mS causes the lamp to toggle between on and off depending on its previous state.

Touching for longer than this causes the lamp to cycle between maximum and minumum brightness as long as the touch is applied, taking about seven seconds to go from one extreme to the other. This operation is shown diagrammatically in Fig. 10. The 50mS lower time limit before the circuit responds is provided to eliminate spurious switching caused by interference picked up on the input.

The mains voltage is dropped through resistor R2 and capacitor C2 and is clamped to 15V by Zener diode D1, the diode D2 rectifies the voltage and it is smoothed by capacitor C3 to provide a 15V supply for IC1. The components R3 and C4 synchronize the circuit to the mains frequency to ensure that the triac CS1 fires at the correct point in the mains cycle. Resistors R5 and R6 are used to limit the current into IC1 in the event of a signal of incorrect polarity appearing and being aplied to the extension input.

GATE TRIGGER

The trigger signal is fed to the gate of CSR1 through diode D3 at the required point in the mains cycle, and R1 and C1 form a snubber circuit which slows down the rate of rise of voltage across CSR1 at switch off and hence limits the amount of interference radiated by the circuit. The resistors R7 and R8 inside the box may be used if the dimmer is to be used as a "touch dimmer" as well as a remote control dimmer, but are not necessary otherwise.

CONSTRUCTION

The dimmer circuits are built on printed circuit boards which are slotted into a mother board, thus providing the facility to replace a

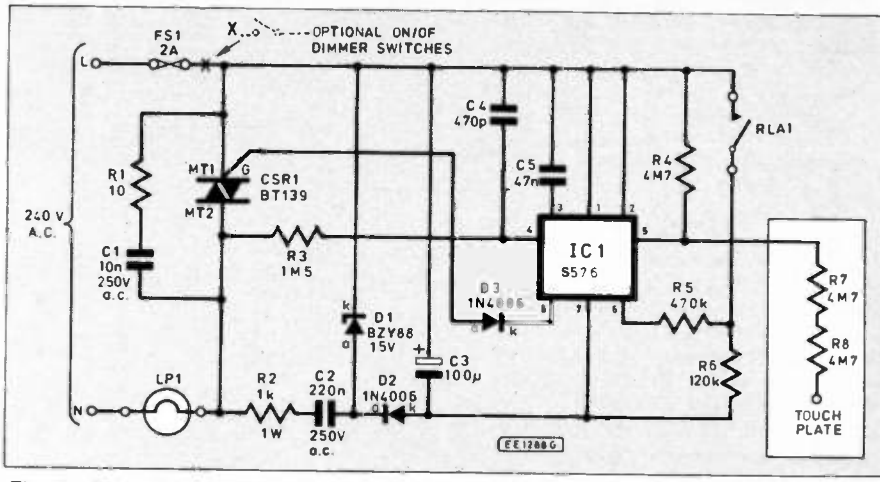


Fig. 9. Complete circuit diagram for a single Lamp Dimmer. The resistors R7 and R8 are optional for "touch" operation.

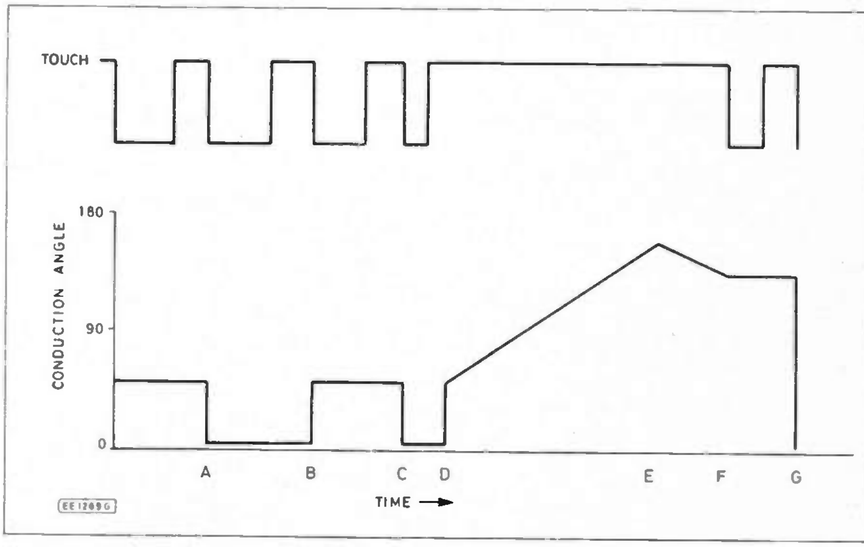


Fig. 10. Lamp dimmer operation or cycle.

COMPONENTS

DIMMERS
(Parts for one dimmer)

Resistors

R1	10
R2	1k, 1W
R3	1M5
R4	4M7
R5	470k
R6	120k
R7, R8	4M7 (2 off – optional)

All 0.25W 5% carbon, except where stated

Shop Talk
See page 360

Capacitors

C1	10n disc ceramic, 300V a.c.
C2	220n polycar. 300V a.c.
C3	100µ elec 25V
C4	470p polysty.
C5	47n polyester

Semiconductors

D1	BZY88 15V Zener
D2, D3	1N4006 (2 off)
CSR1	BT139 triac
IC1	S576 dimmer i.c.

Miscellaneous

SK1 4-way P.C.B. connector (female)

Printed circuit board, available from *EE PCB Service*, code EE602.

Approx. cost Guidance only **£9**

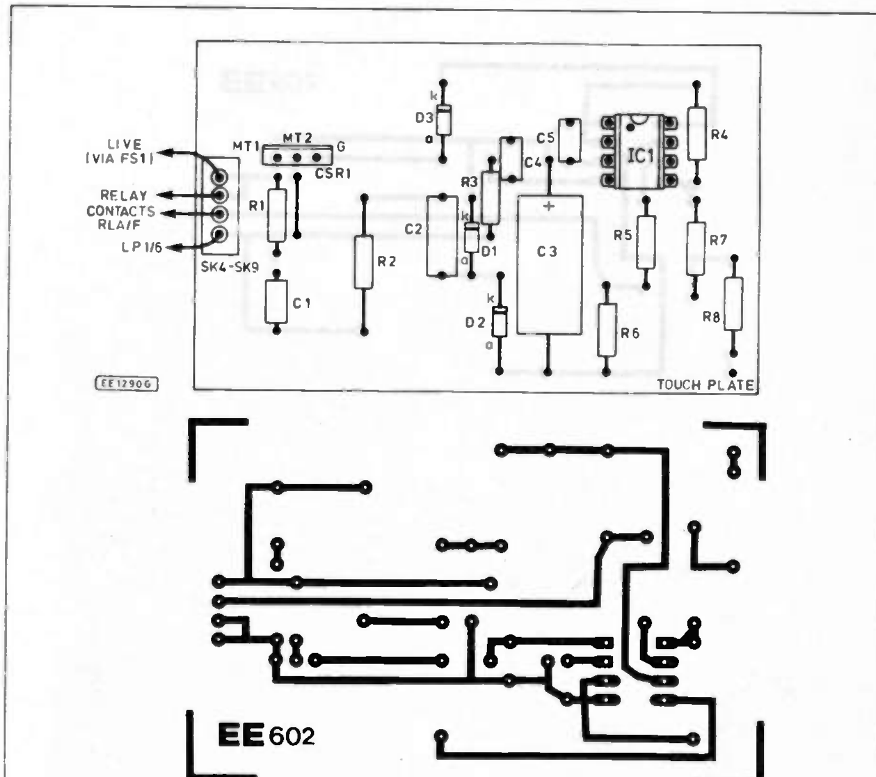


Fig. 11. Lamp Dimmer component layout and full size printed circuit board copper foil master pattern.

dimmer very quickly should a fault occur. This seemed a worthwhile system as the dimmers are the most likely part of the circuit to fail. The fuse FS1 in the dimmer circuit should protect the triac in the event of a lamp failure, but it is not unknown for a lamp failure to destroy the triac before the fuse has time to blow.

The component layout and full size foil master pattern of the printed circuit is shown in Fig. 11. This board is available from the *EE PCB Service*, code EE602.

Care should be taken when assembling the dimmer boards, because a short between tracks or an incorrect component could spell disaster for the circuit. After construction the dimmers can be tested by making a temporary test set-up consisting of a mains lead with fuse and a mains lamp. A switch across the relay inputs (contacts) can simulate the relay, ***but be very careful, the lamp dimmer board is potentially lethal.***

The completed receiver can be mounted in a box along with the lamp dimmers as was the case with the prototype, or the dimmers can be mounted remotely from the receiver. This allows the possibility of replacing the conventional room light switches with "touch dimmers" while still retaining the remote control facility. The first method will be described in detail, with suggestions for those wishing to use the second method.

POWER SUPPLY

The circuit diagram for the power supply is shown in Fig. 12. The various parts of the circuit all run from a 15V supply, and the total current required is only a few milliamps.

The mains transformer T1 is rated at 15V 6VA and its output is rectified by the bridge rectifier (D1-D4) to provide the raw d.c. voltage which is smoothed by capacitors C1 and C2 and applied to the 15V regulator IC1. The capacitors C3 and C4 are required to prevent any high frequency noise being generated by the regulator.

The power supply is built on a single p.c.b. (EE code 603) and the full size master pattern and component layout is shown in Fig.13. This board is also available through the *EE PCB Service*, see page 373.

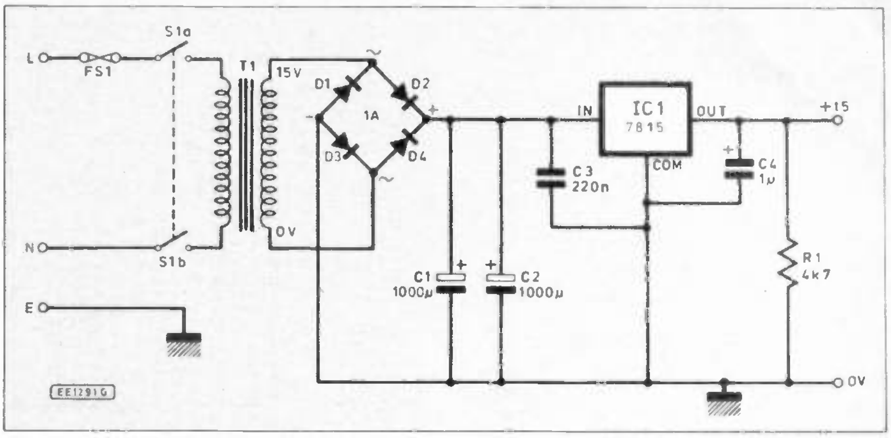


Fig. 12. Circuit diagram for the system power supply.

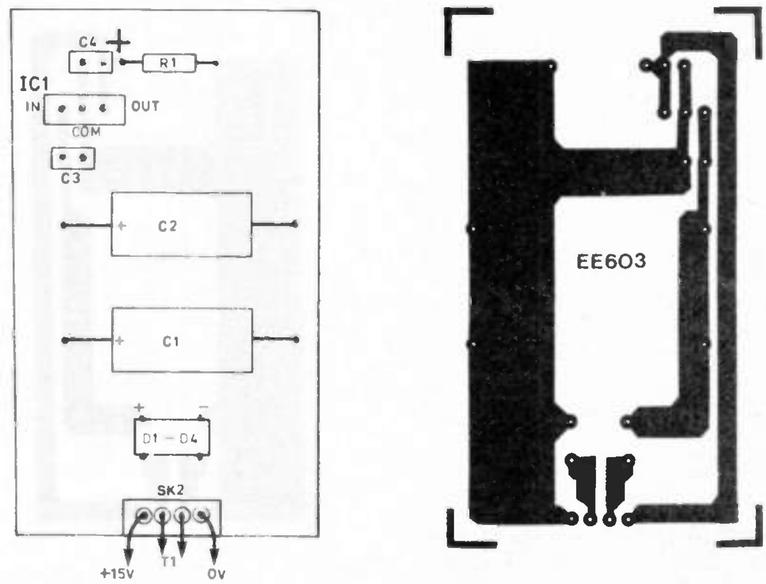
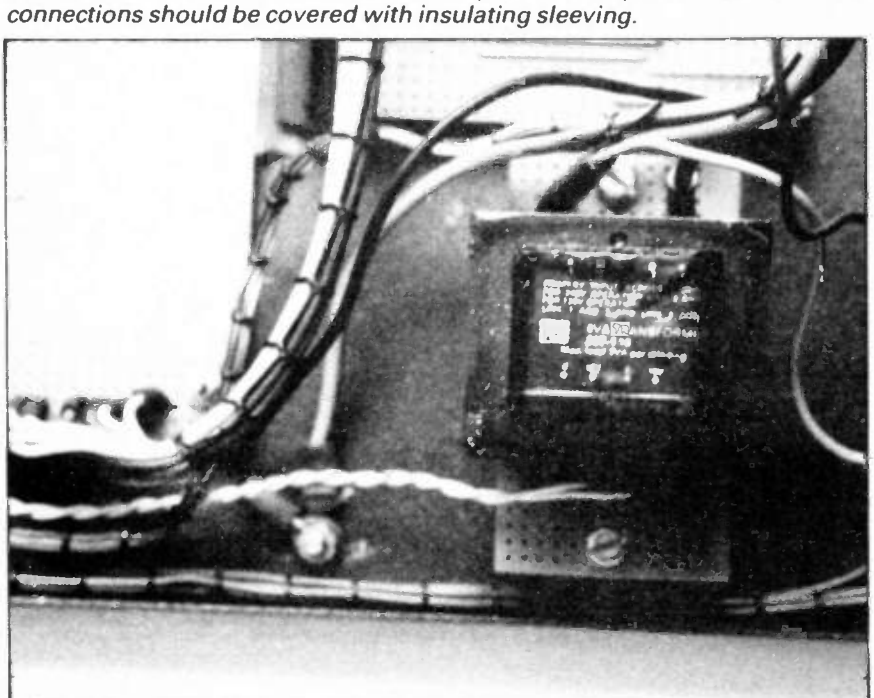


Fig. 13. Power Supply component layout and full size printed circuit board copper foil master pattern.

The mains transformer mounted on a piece of stripboard. Note that all connections should be covered with insulating sleeving.



COMPONENTS

POWER SUPPLY

Shop Talk
See page 360

Resistors
R1 4k7
0.25W 5% carbon

Capacitors
C1, C2 1000µF elec. 25V (2 off)
C3 220nF
C4 1µF, 25V Tantalum

Semiconductors
D1–D4 1A bridge rectifier
IC1 7815 15V regulator

Miscellaneous
T1 15V 6VA mains trans.
SK1 4-way p.c.b. connector (female)

Printed circuit board, available from *EE PCB Service*, code EE603.

Approx. cost Guidance only £9

When the supply has been constructed, check that all components have been put in the correct places and that there is no possibility of short circuits, switch on and check that the output voltage is 15V. Run the supply on a light load for a few minutes to ensure that nothing overheats, because a power supply failure could destroy *all* the integrated circuits on *all* the boards.

MOTHER BOARD

The mother board consists of a printed circuit board Fig. 14 (EE code 604), its component layout being shown in Fig.15. Each "daughter" board position consists of a male p.c.b. connector of the appropriate number of ways, soldered into the board. These mate with the female connector on the daughter board and carry the necessary power supplies and signals to the boards.

Great care must be taken to ensure that the board has no bridged tracks, because mains voltages are present on some parts of this board. When all connectors are inserted into the board each connector should be checked with an ohmmeter to ensure that the pins go where they should.

FINAL CHECKING

When all the boards have been constructed and tested, the whole unit can be put together. The transformer T1 should be mounted in the case first followed by the mother board which should be mounted in the bottom of the box using four half-inch mounting pillars.

The mains wiring should be carried out using good quality insulated wire run in a neat loom so that there is no possibility of a wire going astray. It is a good idea to lace all high voltage wires into one loom and low voltage wires into another. The mains input to the prototype goes to a twelve-way connector block and from there is distributed to the dimmers.

The mains earth wire should be connected to the case through a solder tag fixed with a 2BA or 4mm screw. Ensure that the metal underneath the solder tag is clean and free from paint and that a locking washer is placed above the tag.

DIMMER SWITCHES

Each of the cables going to the lamps is taken out through the back panel through individual grommets. Each of the dimmers in the prototype also has a miniature toggle switch in series with it so that individual channels can be disabled, this feature was added in case of problems when developing the system, but can be left out if desired.

Plug the power suppfy into the mother board, apply mains power and check that the low voltage supply is of the correct voltage and polarity, then switch the mains off. Plug a dimmer board into the mother board in the first dimmer position and connect a mains lamp to the appropriate points.

Apply a short circuit across pins nine and ten of the decoder mother board plug to simulate relay contacts. This is best done by wiring a mains switch to insulated wires so that there is no possibility of coming into contact with mains voltages.

When these contacts are shorted, the lamp should cycle between dim and bright as described before, but if this does not occur, switch off the power and check connections and components on the dimmer. Once the board has been shown to function, each dimmer should be plugged into this position and tested in a similar manner.

After all lamp dimmers have been tested and shown to be working, the remaining boards should be plugged in and the overall system tested. ***It is very important to remember to switch the mains off before handling any of the boards, as stated before, mains lamp dimmers are potentially lethal.***

The author's prototype is built into a metal

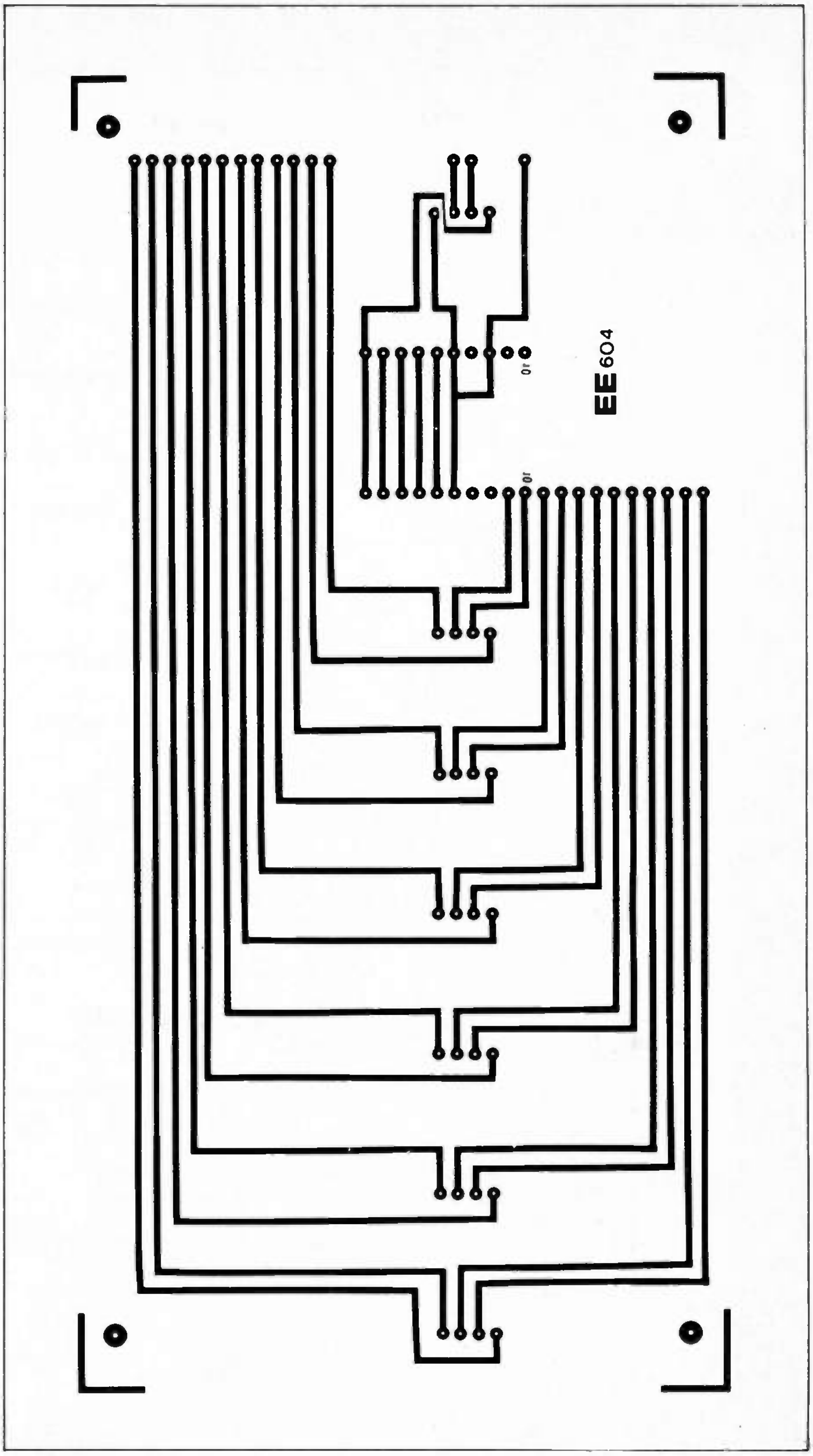


Fig. 14. The full size printed circuit copper foil master pattern for the Mother board. See Fig. 15 for topside layout

COMPONENTS

Mother Board

PL1, PL4-PL9	4-way p.c.b. connector (male)
PL2	10-way p.c.b. con- nector (male)
PL3	2×10-way p.c.b. connector (male)

Printed circuit board, available from *EE PCB Service*, code EE604.

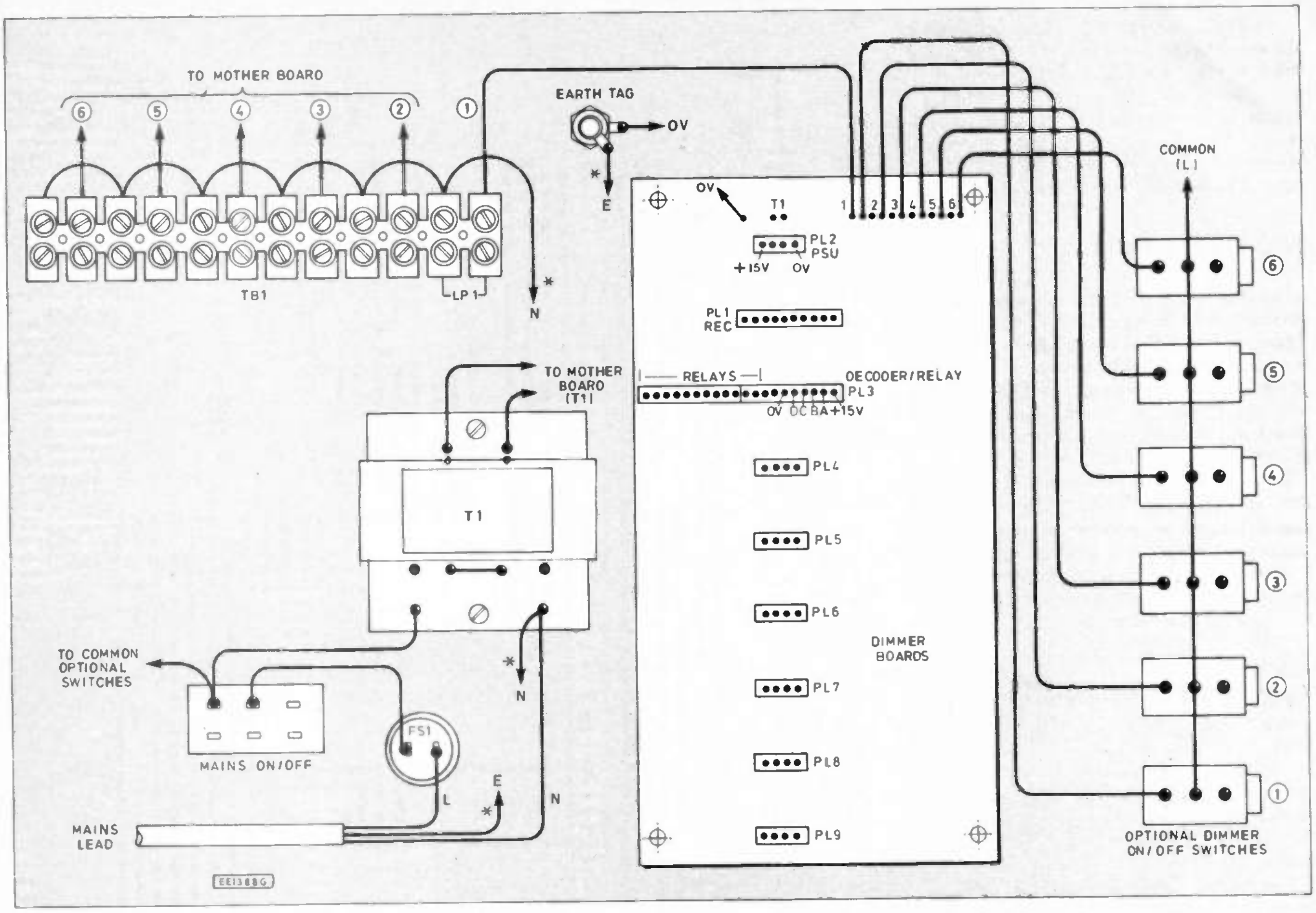


Fig. 15. Suggest component layout inside the case. The mains transformer is mounted on a piece of stripboard and cuts made in the copper strips around the board spacer fixings and between secondary and primary windings

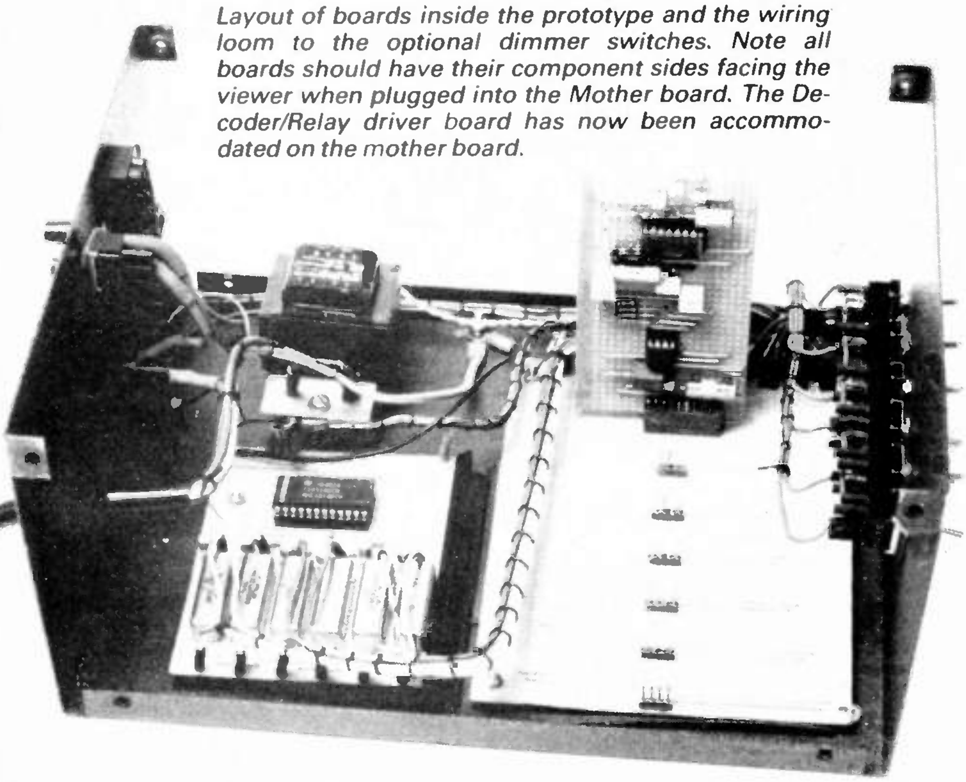
box which is designed to be installed in a cupboard with the infra-red diode mounted through a hole in the cupboard door. It is positioned so that an infra-red beam can be transmitted from any part of the room and will not be masked by furniture.

INFRA-RED SENSOR

The infra-red sensor diode can be mounted some distance from the case if screened cable is used for its connections, twin screened cable being ideal, with only the screen connected to "earth" or ground. If the connecting wire is very long or is run near mains wiring, it is almost certain that problems will occur with pick-up, so the diode should be mounted as close as possible to the box.

In the initial testing, it is a good idea to connect the diode right on the top of the receiver board to minimise noise pick-up. If the unit then operates badly when the diode is remote from the box, it is almost certainly pick-up that is to blame. Because of differing circumstances in each installation, no hard and fast rules can be given as to length of cable, the constructor may have to experiment a little to find the best set up.

The choice of case to use has been left to the individual because it will have to fit with the particular installation and almost any box will be suitable provided its dimensions are at least 190mm×130mm×125mm. The only desirable feature is to use a well earthed metal box which apart from protecting users from electric shock risk, will also reduce the amount of radio-frequency interference radiated from the lamp dimmers.



Layout of boards inside the prototype and the wiring loom to the optional dimmer switches. Note all boards should have their component sides facing the viewer when plugged into the Mother board. The Decoder/Relay driver board has now been accommodated on the mother board.

OTHER USES

The prototype has been in use for some months now and has proved to be completely reliable. Apart from being very convenient to use, it provides a good talking point and fascinates everyone who sees it. As mentioned before, the remote control has several spare "codes" and the author intends to use some of these in the near future. One use under consideration at the moment is an essential piece of equipment for the modern home—a remote control curtain opener! □

Robot Roundup

NIGEL CLARK

WHEN plastic kits were first used in robotics they were seen as the poor relations to the larger, stronger and more complex arms, buggies and turtles. However as interest in robotics has grown the benefits of flexibility and lower cost have begun to take precedence over strength.

The benefits of low cost are obvious and the point which most kit suppliers are ever eager to push. However from an educational point of view there are additional points worth considering.

If the aim of buying some equipment is to see how it works as well as what it can do, selling items in kit form offers good opportunities. As the device is put together the student can see what goes on under the cover.

In trying to interest younger children it is often more important that they can make something happen with a small model they have made, rather than seeing what a ready-built robot arm is capable of.

It is of course possible to achieve those ends by buying the parts separately. However a growing number of parts suppliers have found it worthwhile collecting the various items needed into one box with the necessary instructions for building a variety of models and in some cases a range of support material such as programs and teacher packs.

LOW PRICE

Fischertechnik lead the way followed by Lego. Meccano and Plawco came later and now another supplier has come to my notice. Vento of Milton Keynes is providing small kits in the Betaflex material. A number of small motor-driven devices can be made, including a solar-powered buggy, a gear box and a crane. The most expensive kit costs less than £20 and they all come with worksheets.

A more expensive kit is being offered by Proops Brothers and Able Children. Costing about £80 the Junior Engineer Robotech Pack has parts to build a fairly robust four-axis arm with gripper which is capable of lifting about 1kg.

One reason for the relatively low price is that the kit includes only gears, motors, pulleys, switches and cables but not the structural parts. These have to be made separately from wood and plywood. Templates are provided to allow these parts to be cut accurately.

The finished product is mobile, being able to move forwards and backwards. It is controlled via a switch control panel.

The makers said that the Robotech was designed as an inexpensive alternative to the purpose-built arms, but an alternative which would be stronger than the usual kits.

For the future a kit to give Robotech computer control is being worked on. Likely to be given the highly original name of Robotech II, it is expected to be ready in a further six to nine months.

CONTROL

Computer-control is also being considered for the Meccano kits. The French company which took over the Meccano name some time ago is developing the hardware and software at the moment. Nottingham Educational Supplies, the UK distributor, said that it was hoped to have the work completed by the autumn and for kits to be available in this country for the spring term next year.

A CAD-CAM system is also being worked on at the same time. It will enable users to design a model on-screen and then the system will give a breakdown of the parts needed to make it. That should also be available next spring.

EXTENDED KITS

In the meantime the range of Meccano kits has been extended and the prices of some of them have been cut. There are now 10 kits starting with a set comprising 140 parts for a little more than £8 and going to one containing 3,100 parts, for more than £600, which comes in a desk-size cabinet. Sets 2 to 5 include motors, it being assumed that anyone who wants to build bigger models will already have a good collection of motors.

As mentioned in the April article Lego is extending its specialised kits into primary schools. They are expected to be ready by late summer. Apart from the usual Lego parts and controllers they will include touch sensors and optosensors to enable quite sophisticated buggies to be made, as well as simple arms and other devices. As with the secondary kits they will be supported by a wide range of projects, case studies and teacher packs. Including the interface, it is expected that the total package will cost about £300.

Control will be available from the BBC using Logotron's Control Logo. The product is the result of two years' work in which the initial ideas were put to schools, which then came up with suggestions for improvements. Those were incorporated into an improved version which is now being tested again.

All the work is being done in association with the Microelectronics Education Support Unit.

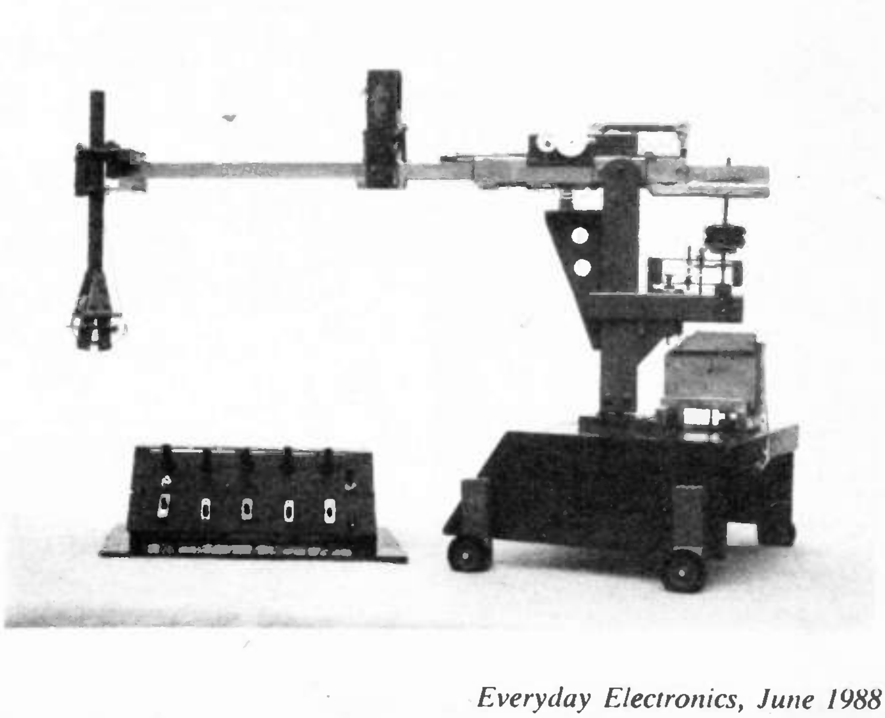
LEGO

The Lego Buggy, which has been available for some time, has had a facelift courtesy of Resource of Doncaster. Two connected circuit boards have been added to give it computer control from the BBC series. One board, attached to the front holds two bump sensors and an optical sensor for following lines and reading bar codes. The other contains the operating hardware and interface.

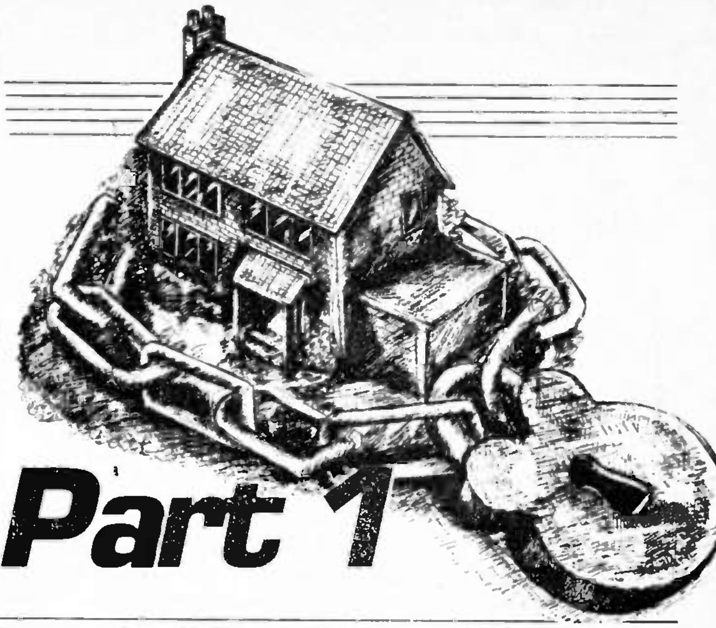
It comes with Buggy Basic, an extended version of Basic written specially for the kit, and two languages which have been around for some time, Control Basic and Control IT. The expansion pack costs about £40 on its own with a further £25 for the Lego Universal Buggy Kit. Resources say they have plans for producing more back-up materials.

The company also inform us that the delivery problems of its Robot Arm, mentioned last month, have been solved. They have bought large supplies from Spectravideo and are now able to supply orders from stock.

The finished Robotech—functional but a little "Heath Robinson".



Constructional Project



HOME SECURITY SYSTEMS Part 1

OWEN BISHOP

Part I The basic system

In this series our main concern will be securing the home against intruders, but we shall also describe devices for securing it against fire. The system is modular, so that you can adapt it to your needs.

THE first line of defence against intruders is a physical one—solid doors, secure windows, door locks to BSI specifications, door chains, window locks and similar hardware. An electronic security system backs up the physical security precautions at two levels.

First there is the *peripheral security system*. This monitors the doors, windows and any other points of entry to the home and warns if these have been breached. Even when the best door locks are installed, a thief may be able to remove the door by its hinges without having to tamper with the locks. The peripheral electronic system takes care of problems of this kind.

The second level of electronic security is provided by *internal security devices* (ISDs). If, despite the physical barriers and the peripheral system, an intruder manages to gain entry to the premises, the ISD detects his presence. ISDs include infra-red and ultrasonic detectors, described next month.

Commercially installed domestic security systems generally comprise only ISDs. It is much cheaper to instal such a system because wiring is required only from the ISD(s) and siren(s) to the control unit. The disadvantage is that the intruder is already in the house before the alarm sounds. In addition, such devices need careful maintenance if they are not to raise false alarms.

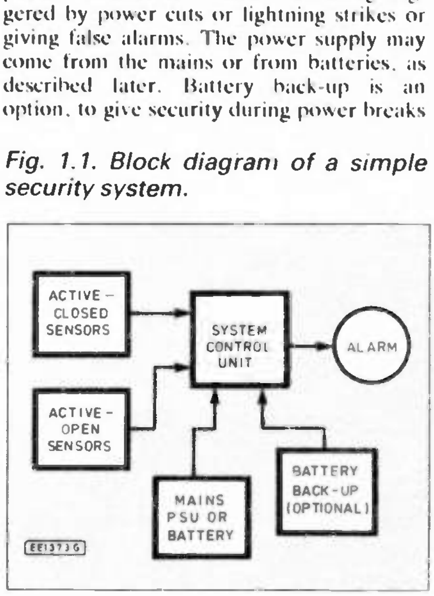
A peripheral security system, has the advantage that it raises the alarm *before* the intruder enters the premises. It is also more rugged and reliable, since its sensors consist of simple switches. But a peripheral system is more expensive. The labour cost of installing wiring to all windows and doors, and fitting numerous magnetic switches is high. The cost of materials is small, so you save a lot by doing the job yourself.

A good time to tackle the job is when rooms are being redecorated so that you can conceal the wiring. If you are moving into a new house, it is possible to wire up before the walls are plastered, or wires can be run underneath the flooring.

SYSTEM CONTROL UNIT

The System Control Unit is the heart of the security system (Fig. 1.1) for both intruder and fire detection. The system described here has run continously day and night for periods of months without ever being triggered by power cuts or lightning strikes or giving false alarms. The power supply may come from the mains or from batteries, as described later. Battery back-up is an option, to give security during power breaks

Fig. 1.1. Block diagram of a simple security system.



and to guard against the possibility of an intruder interfering with the mains power supply. The sensors operate switches which may be normally open and are closed when an intruder is detected (active-closed), or operate the other way about (active-open).

Examples of active-closed sensors are pressure mats. When an intruder stands on the mat, the upper and lower foils become pressed into contact. Examples of active-open sensors are the magnetic switches used to secure doors and windows. ISDs usually operate a relay, so we can arrange to make these either active-closed or active-open, whichever happens to be more convenient.

Being the centre of the system, the control unit must be highly secure itself. It must be located where it is very difficult for the intruder to reach without having to pass through an area protected both physically and electronically. For example, it could be hidden in a locked cupboard, with a pressure pad under the carpet in front of the cupboard, and with an infra-red sensor in the same room. How do you get to it to switch it off? See later.

CONTROL CONNECTIONS

Connections to the control unit are shown in more detail in Fig. 1.2. The active-closed sensors are wired in series in a loop. This is often referred to as the *peripheral loop*, as it runs around the periphery of the secured area, connecting all window and door switches. If any one of these is opened, the loop is broken and the alarm sounds. The advantage of this type of loop is that if the intruder cuts the wire at any point, the alarm sounds. For this reason, active-closed ISDs are preferred and are connected into this loop.

You can have more than one loop. It may be convenient to have one loop for the ground floor and one for the upper floor. When the house is occupied, only the ground floor loop need be activated, allowing the family to have bedroom windows open at night. Both loops are activated when the house is unoccupied. In the diagram we show an *exit loop*. This contains only one switch, on the *exit door*. This is the door by which the last person leaves the house when everyone goes out. With this on a separate loop

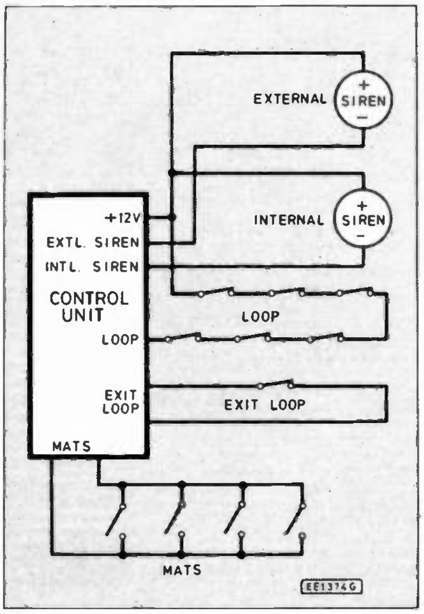


Fig. 1.2. Connections to the control unit.

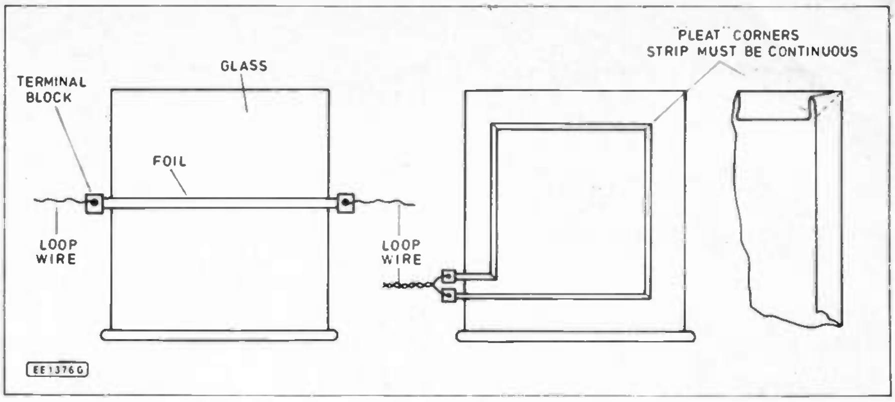


Fig. 1.4. Glass window foil fixing.

you can secure the house, yet authorised persons may enter and leave by the exit door.

The mats circuit consists of active-open devices, wired in parallel. This could also include panic-buttons. Wiring of this loop needs to be concealed as far as possible, since cutting the wire inactivates the loop. The diagram shows two sirens, though one is sufficient. Both alarms can be on the exterior of the house. But if, for example, the house is thick-walled and has double-glazing, an external siren may not be heard by the occupants. The internal siren would normally be of lower power.

ACTIVE-CLOSED SENSORS

Active-closed sensors include the following:

*1 **Magnetic reed switches:*** Fig. 1.3 shows two types. The surface-mounting type (b) is suitable for metal-framed windows, but the recessed type (a) is preferable since it is invisible when the door is closed, thus giving greater security as well as a neater appearance. Magnetic switches often have four leads, two of which are dummy leads joined to each other within the device. These can be used to confuse the intruder who may try to disable the alarm, but in this system they are not used and they may be cut short.

The neatest way of connecting magnetic switches into the loop is by way of a junction box. This has screw terminals to which the loop wires and wires to the switch are connected. The tamper-proof type has an internal switch which opens when the lid of the box is removed, so setting off the alarm.

*2 **Window foil:*** This makes it very difficult for the intruder to enter through the window by cutting away the glass. If your windows have small panes you will not need this. But if your windows (including skylight and glass lights over doors) have frames large enough for a person to climb through when the pane is removed, precautions are necessary.

Self-adhesive window foil is available in rolls. Special terminal blocks, also self-adhesive, are used for connecting it to the peripheral loop. The disadvantage of window foil is that it can be unsightly, especially on a window overlooking a delightful view. Fig. 1.4 shows some layout patterns.

*3 **Glass break detectors:*** These are an alternative to window foil. The sensor is fixed to the glass. A switch inside is normally closed but opens when the glass is struck strongly enough to possibly break it.

*4 **Microswitches:*** There is no end to the possibilities of making up your own sensors using microswitches. Use normally-closed types which open when pressure is applied to the lever or normally-open types held closed until pressure is released. Use them on the doors of cupboards, including the cupboard in which the control unit is hidden. Use them to protect a valuable object, as in Fig. 1.5; when the object is lifted the switch opens and the alarm sounds.

*5 **Mercury tilt switches:*** Use these too for protecting individual items of value.

*6 **Vibration detectors:*** These can be set so that the switch is normally closed, but a moving contact breaks the circuit when the device is shaken. The cover incorporates a second switch which opens if any attempt is made to tamper with it. Although these are primarily meant for car security, they have applications in the home.

*7 **Relays:*** These are operated by IDSs, as explained next month.

*8 **Panic buttons:*** Use a specially-designed panic button, or any other type of push-button switch that suits your purpose. Buttons should be located at strategic points around the house, including just inside the entrance door (out of sight of an intruder, but in easy reach of the person opening the door).

ACTIVE-CLOSED SENSORS

Pressure mats (Fig. 1.6) may be obtained in a variety of shapes and sizes. They are nailed or taped to the floor underneath the carpet. With certain types of carpet, such as cord carpet, the outline of the pad may show. Narrow pads are available for use on stairs. Placing pads on the stairs gives good security, as it is less easy for an intruder to avoid the pad. Pads on two adjacent stairs will detect the person who climbs the stairs two at a time.

One of the disadvantages of pressure mats is that they might be triggered by large pets

Fig. 1.3. Two types of magnetic reed switches.

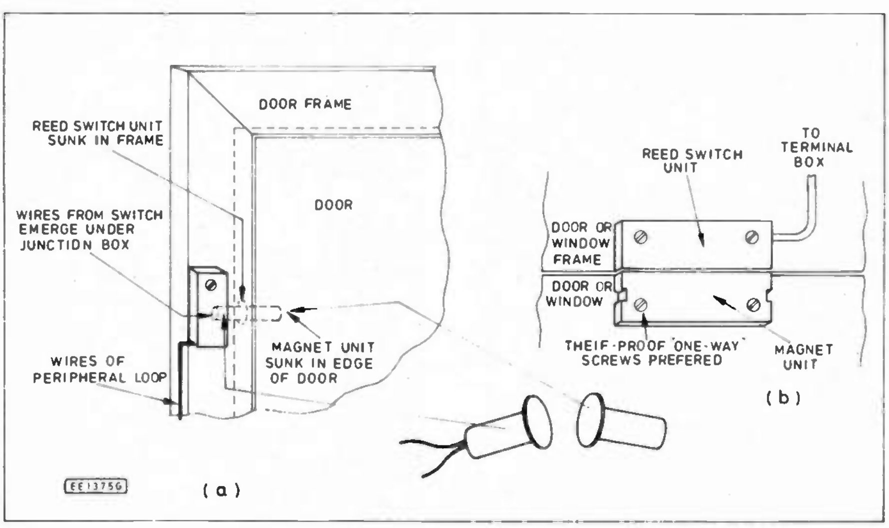
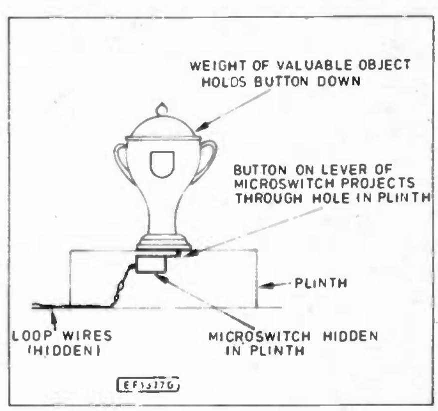


Fig. 1.5. Protecting a valuable object.



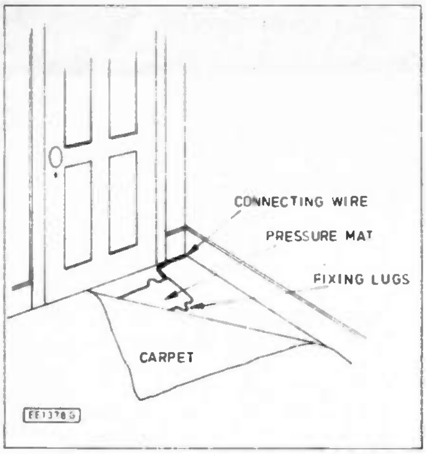


Fig. 1.6. Pressure mat location.

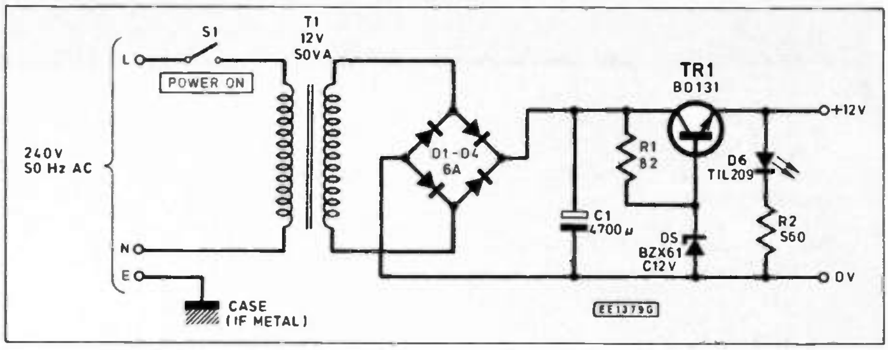


Fig. 1.7. A simple mains power supply unit.

left alone in the house. Special pet-proof types are made which are not activated unless the "footprint" is as large as a human foot, but even these can be triggered if the pet decides to lie down just where the mat is situated!.

The system allows you to include ready-made ISDs that operate a relay. If the relay is active-closed, it is wired in parallel with pressure mats.

CIRCUITS

The system can be powered either from a mains p.s.u. or from batteries. The supply voltage required is 12V, though it will also operate at 6V or 9V. A circuit for a mains p.s.u. (Fig. 1.7) is shown but, unless you are experienced in constructing mains equipment, the simplest course is to purchase a ready-made "mains adaptor" unit. One delivering 1A unregulated will meet most requirements but, if the system is to provide power for several internal security devices, a more powerful p.s.u. may be required.

If your system is not required to provide power for ISDs, current requirements are low. An inexpensive 12V, 300mA mains adaptor is all that you need. Or, if you prefer to build the p.s.u. of Fig. 1.7, the power rating of all components may be reduced and you need only ZTX300 transistors. Alternatively use a battery.

An optional part of a mains-powerd system is the *battery back-up* (Fig. 1.8). This is based on a purpose-designed i.c. which normally passes the mains current to the security circuits, but switches in the battery if the mains fails. For the i.c. to operate, the mains voltage must be slightly greater than the battery voltage. In practice this is so, for the Zener diode is rated at 12V and, with the 0.6V forward voltage drop of the tramsistor in Fig. 1.6, the actual output voltage is 12.6V.

Use ZTX500 transistors in a low-power circuit.

Fig. 1.9 shows the control circuit. This is built around a single NAND gate logic i.c. The circuit is simple but very reliable. The detector gate received two inputs, "A" from the active-open sensors, and "B" from the active-closed sensors. "A" is normally held high because the *other* end of the loop is connected to the 12V line. Current flows from the 12V supply through all the closed switches in the loop, including S3 and S2, to "A".

When the loop is disabled, S2 connects "A" directly to the 12V line through R1, so cutting out the loop. When the loop is enabled and any one of the switches is

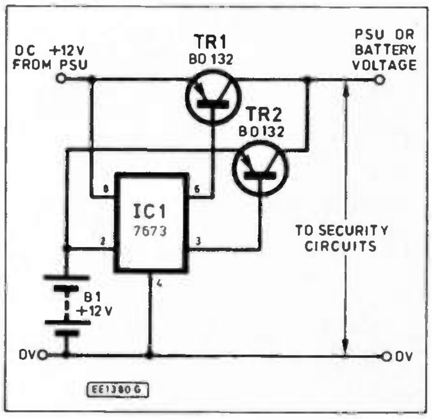


Fig. 1.8. Circuit for a battery back-up.

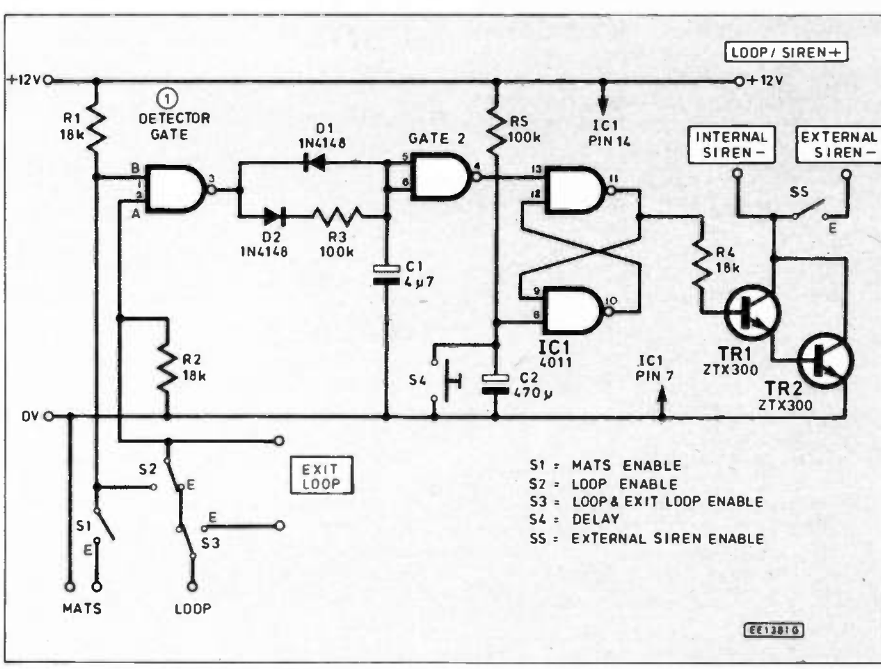
opened (or the wire cut), "A" is pulled low, through R2. Input "B" is also normally held high, this time by R1. When S1 is open the mats are disabled. When S1 is closed (to enable the loop) and any pressure mat is stood on, "B" becomes connected to OV, pulling the input low. Thus both inputs to the detector gate are normally high. Since it is a NAND gate, its output is normally low. When an intruder is detected, one or possibly both of the inputs go low and the output goes high. This triggers the control circuit.

TRANSIENT PREVENTION

When the output of the detector gate goes high, current flows through D2 and R3, charging C1. The voltage on the capacitor and, consequently, at the inputs of gate two takes about 0.5 seconds to rise to 6V. Both inputs of gate two are now high and its output goes low. If the output of the detector gate goes low again before the voltage has risen to 6V, C1 discharges rapidly through D1. Thus the output of the detector gate must remain high for about 0.5 seconds if it is to trigger the system. This prevents transient voltages on the loops from setting off the alarm. This precaution is essential since a large loop of wire running around the house is very sensitive to any electrical disturbances in its vicinity.

Switching on room lighting, or the automatic switching of a refrigerator or thermostat generates pulses in the loops, which may trigger the system. The diode/capacitor network virtually eliminates this possibility. The low- going output from gate two sets the bistable. Its output goes high, turning on TR1 and TR2. These are connected as a Darlington pair, so they are turned fully on by the current from the bistable. They have one or more sirens as their colector load. The sirens sound.

Fig. 1.9. Circuit diagram of the Home Security System control unit.



COMPONENTS

POWER SUPPLY UNIT

Resistors

R1	82 0.5W
R2	560 0.25W

Capacitors

C1	4700μ, 25V, elect.

Semiconductors

D1 to D4	PWO1, bridge rectifier, 6A
D5	BZX61, Zener diode, 12V, 1.3A
D6	TIL209 or similar l.e.d. and mount (optional)
TR1	BD131 *npn* power transistor

Miscellaneous

T1	mains transformer, 12V, 50VA.
S1	s.p.s.t. toggle switch, or key-operated switch.

Heat sink, small finned type (optional); bolts; shakeproof washers and nuts for mounting transformer and circuit board; cable grip for mains cable; grommet for mains cable; stripboard and terminal pins.

BATTERY BACK-UP (optional)

Semiconductors

TR1, TR2	BD132 *pnp* power transistor (2 off)

Integrated circuits

IC1	ICL7673 battery-backup i.c.

Miscellaneous

B1	backup battery, 12V (dry cell, such as HP1)

8-pin d.i.l. socket for IC1

Shop Talk

See page 360

CONTROL UNIT

Resistors

R1, R2, R4	18 k (3 off)
R3, R5	100k (2 off)

Carbon ¼W ±5%

Capacitors

C1	4μ7 elect. 16V
C2	470μ elect. 16V

Semiconductors

D1, D2	1N4148 signal diodes (2 off)
TR1, TR2	ZTX300 *npn* transistors (2 off)
IC1	40011 quadruple 2-input NAND gate

Miscellaneous

S4	Push-to-make push-button

Toggle switches, s.p.s.t. and s.p.d.t. as required; 14-pin d.i.l. socket for IC1; 1mm sockets and plugs, various colours as required.

LOOPS ETC.

Magnetic switches; connecting boxes; window foil or glass break detectors; window foil terminal blocks; pressure mats; vibration sensors; panic button; micro-switches, mercury tilt switches etc; connecting wire (possibly a 100m reel)

£12.50 *plus loop sensors, wire etc.*

EXIT DELAY

The system is reset by pressing S4, which resets the bistable, causing its output to go low, turning off the transistors and the sirens. S4 has a capacitor C2 across it, which recharges slowly through R5 after S4 has been released. Approximately 50 seconds later, the charge on C2 reaches 6V and the system becomes operable again. The delay on this reset button is for use when the system is first switched on.

If the system is turned on and S4 is pressed, the unit allows 50 seconds in which to vacate the house. The alarm sounds during that time only for as long as any door or window is open, or any pressure mat is trodden on. As you leave the house, opening and shutting the door *quickly*, the siren emits a short "beep" but that is all.

Once the 50 seconds has expired, any subsequent triggering of the system makes the siren sound continuously until the reset button is pressed again. The problem remains of how to re-enter the house without waking up the entire neighbourhood. This problem bothers the intruder too! There are two solutions to this. The simplest is to wire a second reset button in parallel with S4 and locate this in a concealed position outdoors. When you return home, press the button. You then have 50 seconds in which to enter the house, go the control unit and switch it off.

An intruder, even if he found the concealed button, is not likely to know where to find the control unit within 50 seconds of entering the house. An alternative system, which gives even greater security, is described next month.

Fig. 1.9 includes switches wired to enable you to activate different parts of the system independently. This is only one of many possible configurations. S1 enables the mats. Having "mats only" may be adequate if one of the occupants is out late and the others have gone to bed. S2 enables the peripheral loop. "Loop only" is better during the daytime or evening if windows and doors are closed; the occupants do not have to avoid stepping on pressure mats. Enable both loops and mats for full security at other times. The exit door loop, if fitted, enables the exit door separately as already described.

SWITCH

S5 in Fig. 1.9 allows you to switch out the external siren. This feature is useful for testing the system without disturbing people outside. It is good practice to enable the external alarm *after* switching on the system. If any windows or doors have accidentally been left open, the internal alarm sounds to warn you. Incidentally, this is a convenient way of checking that the house is safe to be left unoccupied.

SIRENS

The term "siren" includes any type of piezo-electric audible warning device from a small solid-state buzzer to a powerful two-tone siren. For external use you need a sound output of 100dB or more at one metre, operating on 12V. The siren should be weatherproof, or be contained in a weatherproof housing. The more efficient ones require only 20-30mA, allowing the system to be battery powered. If you choose one which requires more that 500mA, a mains p.s.u. is recommended; replace TR2 (Fig. 1.9) with a medium power transistor such as BD131.

INSTALLATION

Plan carefully before you begin installing the system. First decide on the location of the control unit. It may need to be close to a mains socket, preferably hidden in a lockable cupboard, and certainly well out of reach and out of sight of persons outside the house. Also it should be located so that it is convenient to run wiring to and from the unit.

Next decide the route of the peripheral loop. It must run to all windows and doors on the ground floor and, if you think it necessary, on upper floors as well. Take into account any other devices such as infra-red detectors and panic buttons, that may be included in the loop. Plan its route in detail to avoid visible wiring as much as possible. Finally decide on the positions of pressure mats and the wiring to them. Use the negative line and positive lines of the pressure-pad system as the power lines for ISDs.

Inexpensive connecting wire such as 7/0.2 is suitable for all wiring outside of the control box (except to the mains supply). This is conveniently concealed beneath carpets, under window-sills and around door- frames. It can run alongside central heating pipes and often be threaded through the wall from one room to another where pipes pass through.

The external siren must be mounted in an inaccessible position on the wall of the house. Run the wire up to the loft; again the crevices made by central heating pipes can provide a convenient route. You may need to borrow a masons's drill to make a hole though the external wall.

NEXT MONTH—Construction of the control unit on Veroboard plus a time-limited alarm and exit door protection.

ON... SPEC

a regular feature for the Spectrum Owner...

by Mike Tooley BA

In answer to several requests from readers, we start this month's instalment of *On Spec* by recommending four books which are of particular interest to Spectrum owners. We also provide some further information on using restarts and include a short demonstration routine to provide readers with an example of how to make use of the Print Character Restart in their own programs.

Spectrum Bookcase

Most readers will be well aware that the good old "Speccy" is well catered for as far as dedicated books is concerned. Unfortunately, many of these books are superficial and thus of limited use to the more dedicated enthusiast. It is, therefore, not surprising that a common request received from readers is for details of books dealing with Spectrum hardware projects. Fortunately, in this particular field there are several titles which are well worth recommending!.

First amongst these must be Graham Bishop's *Spectrum Interfacing and Projects* (published by McGraw-Hill, ISBN 07-084702-9). After a brief introduction to Spectrum hardware and software, the book describes an analogue-to-digital converter (ADC) based on the 7581 (together with minimal additional circuitry to interface an analogue joystick, a variety of light level sensors and a light pen), a simple parallel output latch, and a digital-to-analogue converter (DAC) based on the 0801.

The book also contains a number of projects concerned with sound, light and home energy management. Printed circuit layouts are provided for the ADC, DAC and parallel latch and cassette software is available for those who prefer not to type in the numerous demonstration BASIC and machine code programs. Altogether, this book is highly recommended to anyone with an interest in Spectrum hardware interfacing.

The *Spectrum Hardware Manual* by Adrian Dickens (published by Melbourne House, ISBN 0-86161-115-2) provides some useful information on Spectrum hardware and also contains a number of add-on hardware projects, including details of how to add a Z80-PIO, a hand-held joystick keypad, and an ADC based on a ZN427E.

Unfortunately, since it was written before the Spectrum-Plus and 128K machines appeared, this book is now beginning to show its age! Despite this, readers should find something useful within its pages and one can only hope that Melbourne House will be tempted to bring out a new edition which includes details of the more recent models of the Spectrum.

Owen Bishop's *Interfacing to Microprocessors and Microcomputers* is not dedicated to any particular machine but does contain a host of hardware projects. It is important to note that, by virtue of the lack of a "user port" on the Spectrum, Spectrum owners will have to build the programmable I/O interface (based on the 8154) before other projects can be used. Other projects deal with sensing light, temperature, sound and position. L.E.D. and l.c.d. drivers are described as are the more usual loudspeaker and relay driver circuits.

Other projects include an analogue controller, a sound effect generator, a timer and a light pen. Those who require an even more ambitious project may even be tempted to try their hands at the infra-red remote control system which forms the final chapter of the book!

Finally, David Pritty's *Practical Interfacing to Popular Microprocessors* (published by Addison-Wesley ISBN 0-201-14566-9) provides a very comprehensive introduction to microprocessor interfacing. The book is again aimed at a variety of machines (including the Dragon, Apple II, and BBC Microcomputers) but is worth looking at if you need a more general text which deals with everything from basic logic design to driving servomechanisms and stepper motors.

It must be emphasised that, unlike the other three books previously mentioned, this book does not attempt to describe complete constructional projects and therefore readers are on their own when the time comes to producing working circuits and component layouts!

More on Restarts

Last month we attampted to throw some light on the Z80's restart instructions. This month we shall show how RST 10H can be used within assembly language programs to provide a simple method for printing on the Spectrum's screen.

In order to make use of the Spectrum's "Print Character" restart (RST 10H), the Z80's accumulator must be loaded with the corresponding byte immediately prior to making the restart. RST 10H is quite versatile since it can cope with control codes as well as the standard ASCII character set.

As an example, the following lines of assembly code will print character 'A' at the current screen character print position:

```
LD A,41H ; Load ASCII code for 'A'
RST 10H ; and print the character
```

There are two things to note about the foregoing example. Firstly, the screen channel (Channel 'S') must be open in order for the restart to function and, secondly, the character will be printed with whatever attributes (i.e. INK and PAPER colours) have been previously established.

In order to make a (temporary) change to the PAPER or INK colours, the control codes for PAPER (hexadecimal 17) or INK (hexadecimal 16) must be loaded into the accumulator before making the restart. The numerical value corresponding to the colour required is then placed in the accumulator before making a further restart. The colour values are as follows:

Colour	Value
Black	0
Blue	1
Red	2
Magenta	3
Green	4
Cyan	5
Yellow	6
White	7

Now for a working demonstration: let's assume that we wish to print two characters on the screen (at this stage we won't spoil the fun by telling you what they are!). We shall print with yellow ink on red paper (colour codes 6 and 2 respectively) and, assuming that we start the code at 8000H (32768 decimal), the code will run along the following lines:

```
8000 3E 17 LD A,17H ;   Set PAPER
8002 D7    RST 10H  ;
8003 3E 02 LD A,02H ;   to RED
8005 D7    RST 10H  ;
8006 3E 16 LD A,16H ;   Set INK
8008 D7    RST 10H  ;
8009 3E 06 LD A,06H ;   to YELLOW
800B D7    RST 10H  ;
800C 3E 45 LD A,45H ;   One Character,
800E D7    RST 10H  ;
800F 3E 45 LD A, 45H ;  and another!
8011 D7    RST 10H  ;
8012 C9    RET      ;
```

We have included addresses (in the left hand column) and hexadecimal machine code values in case you wish to make use of our "On Spec Hex Code Loader" (available in the Update package). Alternatively, the following BASIC program will both load and execute the demonstration code:

```
10  REM Everyday Electronics
20  REM June 1988
30  CLS
40  PRINT "Restart Demo"
50  REM Load machine code
60  FOR x=32768 TO 32876
70  READ z
80  POKE x,z
90  NEXT x
100 DATA 62,17,215,62,2,215,62,16
110 DATA 215,62,6,215,62,69,215
120 DATA 62,69,215,201
130 REM Call the routine
140 RANDOMIZE USR 32768
150 REM  Wait for a keypress
160 PRINT
170 PRINT "Press any key"
180 LET r$=INKEY$
190 IF r$=" "THEN GO TO 180
```

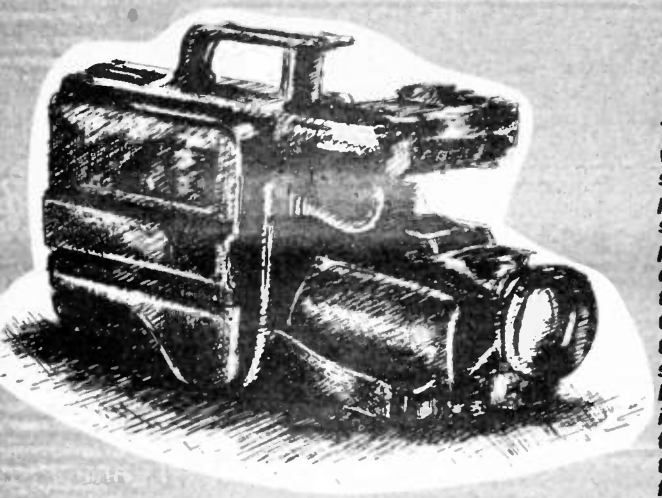
For a slightly more interesting display, readers may like to delete line 160 and add the following lines:

```
135 FOR n=1 TO 320
145 NEXT n
```

As mentioned previously, the Print Character Restart requires that the screen channel is currently open. Hence, when using RST 10H in more complex programs, it is important to ensure that the screen channel is open. Where this is in doubt, the following lines of code should be added to the start of any routine that makes use of RST 10H:

```
LD A, 02    ; The screen is channel 2
CALL 1601   ; Now open it using the
              CHAN-OPEN ROM routine
```

NEXT MONTH



VIDEO WIPER

The most basic method of editing a home video is simply to cut straight from one scene to the next, but much more professional results can be obtained using some form of fader or wiper. What is probably the best general purpose wipe effect, and the one provided by this unit, is the top to bottom type. At the end of a scene the screen is progressively blanked from the top downwards, at the beginning of the next scene the screen is restored from the bottom upwards. This wiper will also do an inverse of this, where the screen is blanked from the bottom upwards, and restored from the top downwards. It incorporates an audio fader control.

UNIVERSAL CHARGER/ POWER SUPPLY

Nickel cadmium batteries (Nicads) are so cheap in the long run, that it is a wonder that ordinary non-rechargeable batteries are still used. This project will give you the opportunity to discover these savings. It is able to charge almost any size of cell. The unit will also double as a mains adapter so you will not have to drain your batteries whilst using the equipment at home.

SPIKE EATER

Ever had the experience of hearing a loud CRAAAK! from your stereo system when the 'fridge switches on? Or spent all afternoon entering a long listing into your computer only to have the whole lot corrupt? Perhaps you've come home looking forward to watching EastEnders which you set the video to record while you were out, only to find a blank tape as the machine somehow "forgot" its settings. These are all actual mishaps which have been caused by spikes and noise on the mains. The Spike Eater will work for you on these "nasties".

ISOLINK

The "Isolink" conducts voltage signals from d.c. to around 30kHz between its input and terminals. "Amazing!", you might say, "but surely two bits of wire can do that?" Well yes, but the Isolink does offer some significant advantages over wire. For a start, it will withstand high voltages between the input and output connections without passing current, allowing measurements to be made on normally inaccessible circuits such as those connected directly to live a.c. mains. With a very high input impedance the unit also has obvious applications in many areas of electronics, but should be of especial interest to bio-feedback enthusiasts. The prototype was in fact designed to assist with the development of a brain-wave monitor circuit.

EVERYDAY ELECTRONICS

JULY ISSUE ON SALE FRIDAY JUNE 3

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

LOST 40 YEARS

By a slip of a typing finger I wrongly stated, in the March column, that Morse keys went back to 1884. In fact, the Morse key was invented by Alfred Vail, Samuel F. B. Morse's assistant and partner, in 1844.

There had been a very cumbersome arrangement before that, whereby a narrow tray was loaded up with letters or numbers rather like printers' type. Every piece of "type" had a sawtooth protrusion above it representing the code symbol to be sent.

The tray was fed through a mechanism with a pivoted lever riding up and down over the saw-teeth. The other end of the lever then dipped up and down to form a bridge between two bowls of mercury, thereby forming an electrical switch to activate the signalling circuit.

Not surprisingly, this was a slow process and Vail soon realised that all that was needed was a simple up-and-down hand-operated lever to perform the same function. The first hand key, called a Correspondent by Morse and Vail, was effectively a strip of spring metal which was depressed to send a signal and which held itself apart from the contact by its own spring tension when not in use. Soon after that Vail evolved the principle on which all Morse keys have since been designed—described by him as "a lever acting on a fulcrum".

Over the years many improvements followed, often devised by the operators themselves. It is no wonder, therefore, that many Morse operators today have a special affection for the key and love to obtain old ones, and use them whenever they can.

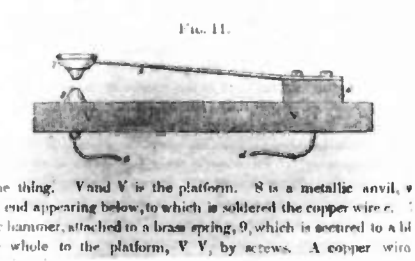
A fascinating six-part series, *"The Story of the Key"*, by Louise Moreau, W3WRE, an acknowledged expert on the history of communications, is currently running in *Morsum Magnificat*, the journal for Morse enthusiasts. According to Louise there have been some three hundred patents for Morse keys in the USA since 1844, excluding military versions. Add to that the very large number of "foreign" versions, often with distinct national characteristics, and you can see why this is an interesting area for collectors.

BETTER ON 40?

"Region 1 News", journal of the International Amateur Radio Union Region 1, reports that at the ITU World Administrative Radio Conference for HF Broadcasting, 1987, there was a re-affirmation and improvement of a resolution requesting all administrations responsible for broadcasting stations operating in the amateur band 7000-7100kHz to take action to stop such operation immediately. This is the 40 metre bank which, unlike some other bands, is allocated exclusively for amateur use.

In the evenings in particular, interference from unauthorised high-power broadcasters is so bad that it is very difficult for amateurs to operate. Such are the skills required to effectively communicate on 40m in these conditions, it is sometimes referred to as the "man's band"!

The Secretary of Region 1, John Alloway, G3FKM, reports in *Radio Communication* that all broadcasting transmissions in the 40m band from one of the greatest offenders, China, have apparently now ceased and that the IARU Monitoring System has discerned an all-round reduction in the number of intruders, including Albania which has been another serious offender.



The first "Morse Code" key developed by Alfred Vail, Samuel Morse's partner, in 1844.

EUROPEAN COMMON LICENCE

Another encouraging item from "Region 1 News" is that Belgium has agreed that foreign amateurs from 25 European countries may now operate their radio-transmitters in Belgium without a special "guest licence". There is similar news from Sweden except that only amateurs from countries having similar arrangements can operate under the new rules.

National societies in all CEPT countries are negotiating with their governments towards the achievement of a common licence permitting European licenced amateurs to operate anywhere in Europe without the need for reciprocal licences. The Belgian and Swedish decisions bring the total agreements obtained so far to 12, and it is expected that agreement by Greece and Portugal will follow shortly.

While British amateurs can now operate in some of these countries simply by producing their UK licence, the same does not yet apply in reverse. For Britain to participate in the common licence scheme the existing UK licence conditions need to be revised to fit in with the common format. The Radio Society of Great Britain has announced a number of changes to the licence that it wants to negotiate with the DTI, and presumably the requirements of the common licence will be taken into account during these negotiations.

HAMBIT 87

The use of computers is increasing, as evidenced by the *2nd International Congress on Amateur Radio and Computers* held in Florence last November sponsored by the Italian Amateur Radio association, ARI. With over 300 participants, the conference received top-level support in the form of a telegram from the President of Italy, Francesco Cossiga, himself a radio amateur with the call-sign IOFCG.

Papers presented ranged from reports on pure research to practical application, including means of helping blind people to use computers with amateur radio. Next year it is intended to publish papers in English to enhance the international nature of the conference and to offer incentives such as reimbursement of travelling expenses to the best foreign contributors.

CHESS BY RADIO

The idea of radio amateurs, possibly thousands of miles apart, playing chess by radio is not new. In the past various informal groups have been organised in the USA but since 1982, according to an article in Australia's *Amateur Radio* magazine, an international organisation has been building up a following.

Known as "Chess and Amateur Radio International", CARI, this extends at present across the Pacific, from the USA to Australia, with hopes of worldwide membership and participation as the new sunspot cycle progresses. Activities so far have included setting up matches across the USA for children who like chess, and, when radio conditions were good, Pacific wide amateur radio chess versions of the America's Cup.

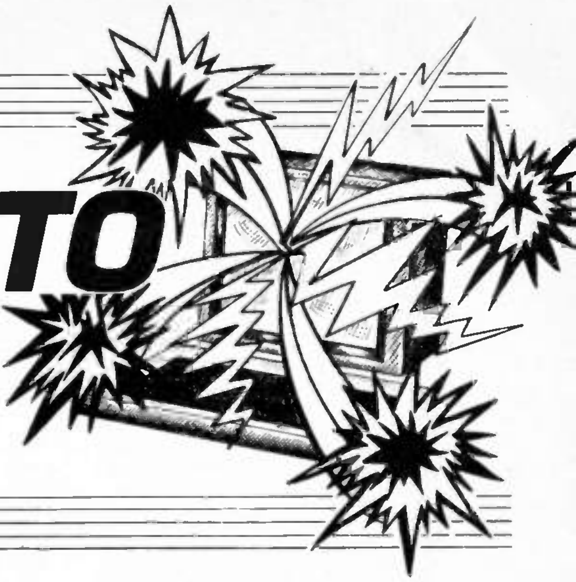
In seeking to extend its activities CARI wrote to the official address for all communications with amateur radio in the Soviet Union—Box 88, Moscow—inviting Russian amateurs to join in their activities. The invitation was turned down but they swear the letter they got back was covered in tears!

On a happier note the creation of CARI resulted in the lifting of an earlier ban on radio chess in Australia after a letter of support from the President of the American Radio Relay League helped the Wireless Institute of Australia negotiate this with the Department of Communications. CARI thinks that the original official Australian objection to radio chess was related to the possible use of "secret ciphers" when describing the moves over the air, and one supposes that could be the basis of the Russian objection too!

Of course, you don't need speech to play chess. It can equally be done, and has been many times, by Morse code so perhaps it's not surprising that this innocent activity is capable of being misunderstood.

Constructional Project

BBC SOUND TO LIGHT UNIT



M. P. HORSEY

An unusual project that will provide an interesting and colourful display on the computer monitor.

This project employs the analogue interface of the BBC "B" computer to produce a colourful display on a TV screen. The display pulses with sound fed via a microphone or audio system. The circuit may be driven by a wide variety of sources, including moving coil microphones, and a simple program is listed which causes a triangle to move up and down the TV screen, in phase with the sound input (various spectacular effects can be achieved with other software). The triangle also changes colour with the volume of the music. The project was used to great effect in a school play, where a TV screen was "dressed up" as a mechanical mouth, opening and closing with speech fed via a microphone.

CIRCUIT DIAGRAM

The circuit (Fig. 1) divides into two halves, with the first matching and (in the case of small signals) amplifying an audio signal. The second provides control over the bass and treble response, before converting the a.c. signal into d.c., suitable for the computer analogue interface.

The op. amps chosen were type CA3140. Very similar to the 741 i.c., the CA3140 has a FET input, and will also work on the five volt supply which is available at the BBC analogue interface. Type 741 i.c.'s will almost certainly work in this circuit, though they are not designed for such a low voltage. While a dual version of the CA3140 is available, two single versions are less expensive, and helpful if a long fault-finding session is necessary, since they can be swapped.

It should be noted that the CA3140 is sensitive to static electricity, and should be handled with care. The circuit should not be soldered whilst this i.c. is fitted in its holder.

NON-INVERTING AMPLIFIER

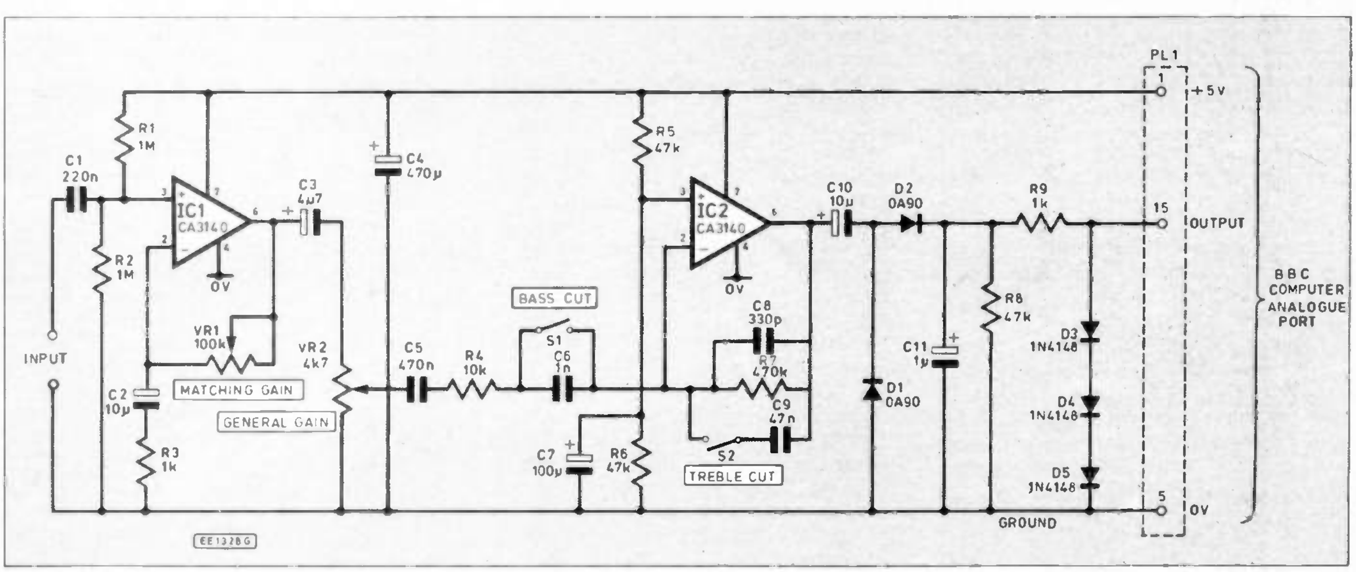
The audio signal is fed via d.c. blocking capacitor C1 to the non-inverting input (pin 3) of IC1. This input is held at half the supply voltage by R1 and R2, as the i.c. is connected to a single rail supply. The input impedance is about 500k—high enough to not impose any significant loading on the amplifier, microphone etc.

The output is connected to the inverting input (pin 2) via VR1, to provide negative feedback and limit the gain to a reasonable level. With VR1 set to 100k, the gain of IC1 will approach 101 (providing it is not saturated), since the gain is given by the formula, Gain=(VR1/R3)+1. With VR1 set to zero ohms, the gain will be unity (i.e. the output voltage will equal the input voltage). In effect, the output is then connected directly to the inverting input, making the i.c. a "voltage follower". VR1 thus provides a gain control allowing a wide variety of signal sources to be matched.

Capacitor C2 has no effect on the calculation, since it conducts the a.c. frequencies of concern here. Its purpose is to block the flow of d.c., thus ensuring that the full d.c. component at the output will feed back to pin 2. This total d.c. feedback will ensure that the d.c. voltage at pin 6 is at half the supply voltage. If this voltage were allowed to drift up or down, the tops or bottoms of the a.c. output signal would be clipped.

Capacitor C3 prevents a flow of d.c. to

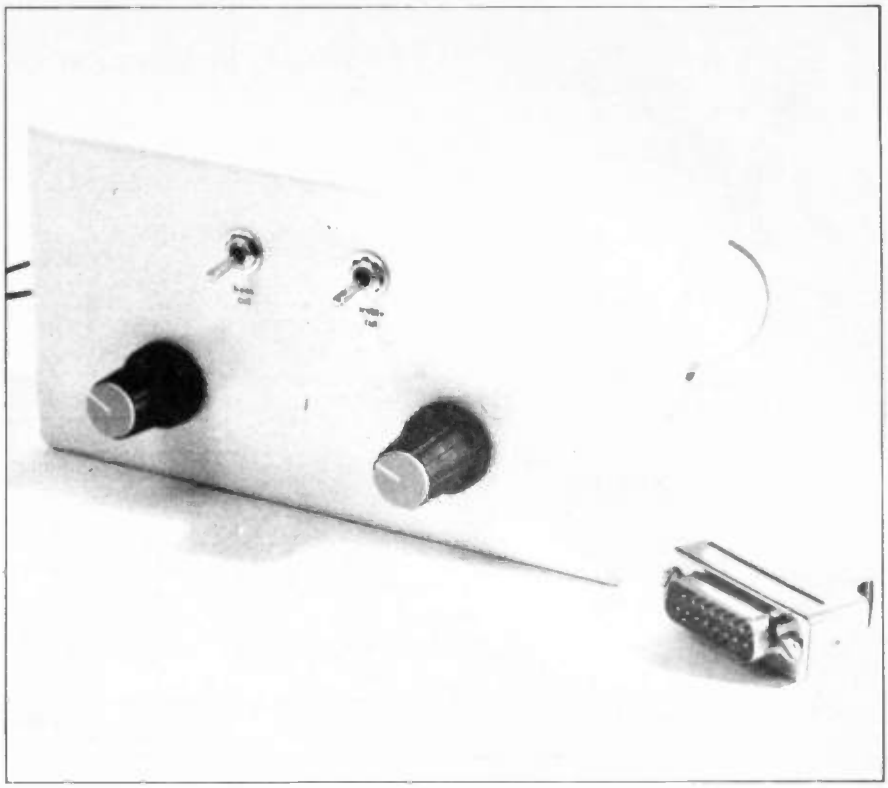
Fig. 1. Complete circuit diagram of the BBC Sound To Light Unit.



ground, and the a.c. signal passes to VR2. This allows the user full control over the size of the triangle on the TV screen. While VR1 and VR2 are both gain controls, their effects are different (as described later) since VR1 matches the circuit with the received signal, and can control the amount by which IC1 becomes saturated. This allows part of the triangle to be maintained on the TV screen at low signal levels, without moving beyond the top of the screen at high levels.

INVERTING AMPLIFIER

The audio signal now passes via d.c. blocking capacitor C5, and then via R4, (assuming S1 is closed) to the inverting input (pin 2) of IC2. Pin 3 is held at half the supply voltage by means of R5 and R6, with decoupling provided by C7. The output from pin 6 is fed back to the inverting input via R7. Assuming S2 is open, the possible gain will be the ratio of R7/R4. Capacitor C8 reduces the gain at very high frequencies, and with switch S2 closed, C9 provides a substantial "treble cut" making the circuit respond mainly to bass frequencies. If switch S1 is opened, the small



value of capacitor C6 impedes the passage of low frequencies, thus providing bass cut. This type of control is necessary, particularly with pop music, which tends to be at a constant overall sound level.

The best values for C6 (bass cut) and C9 (treble cut) are a matter for conjecture, and will depend to some extent on the type of audio equipment in use. Increasing the value of C6 will *reduce* its effect (and vice-versa) and increasing the value of C9 will *increase* its effect (and vice-versa).

Capacitor C10 blocks the flow of d.c., and diodes D1 and D2 act as a voltage doubler and rectifier to charge C11 to a voltage which fluctuates in step with the strength of signal received at the input. Diodes D3, D4 and D5 limit the output voltage to about 1.8 volts. Thus in the event of a serious fault or other problem, the voltage applied to the computer is strictly limited.

COMPONENTS

Shop Talk

See page 360

Resistors

R1, R2	1M (2 off)
R3, R9	1k (2 off)
R4	10k
R5, R6, R8	47k (3 off)
R7	470k

All ¼W±5%

Potentiometers

VR1	100k linear
VR2	4k7 linear

Capacitors

C1	220n polyester
C2, C10	10µ elect. 10V (2off)
C3	4µ7 elect. 10V
C4	470µ elect. 10V
C5	470n polyester
C6	1n ceramic or polyester
C7	100µ elect. 10V
C8	330p ceramic
C9	47n ceramic or polyester
C11	1µ elect. 10V

Semiconductors

IC1	CA3140
IC2	CA3140
D1, D2	OA90 (2 off)
D3, D4, D5	1N4148 (3 off)

Miscellaneous

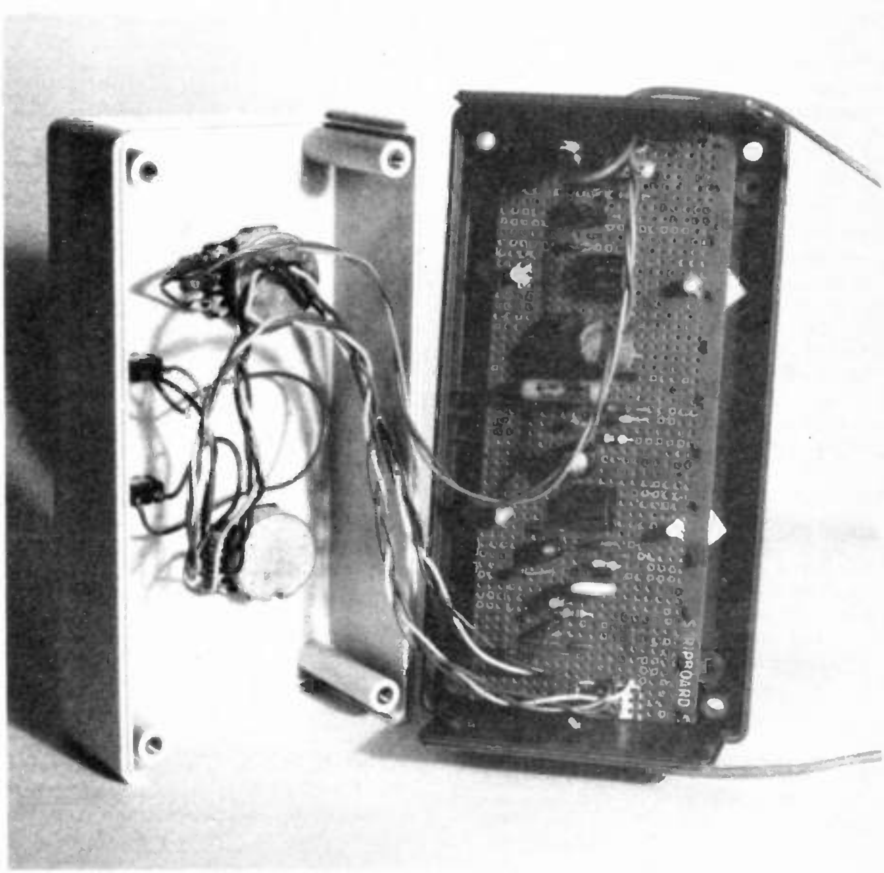
S1	on/off toggle switch
S2	on/off toggle switch

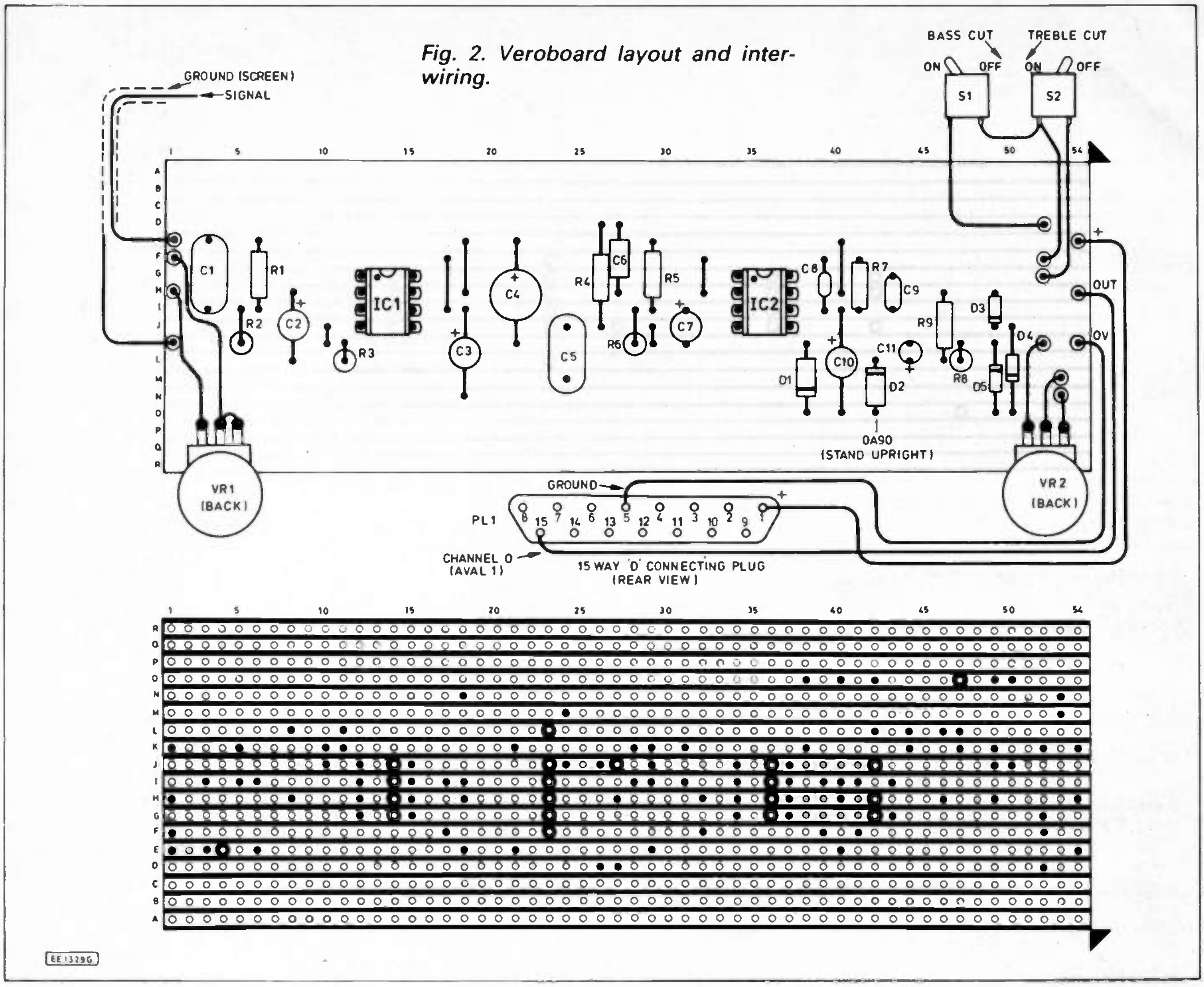
8 pin i.c. holders (2 off); stripboard 54 holes by 18 tracks; stripboard mounting pillars (self-adhesive); Verobox measuring 150 by 80 by 50mm; knobs for potentiometers (2 off); computer connector – 15-way "D" plug; moulded cover for "D" plug; single core screened cable; 3 core wire for output; wire, solder etc.

Approx. cost Guidance only £11 plus case

CONSTRUCTION

The circuit is constructed on a piece of 0.1inch pitch stripboard measuring 54 holes





by 18 tracks. The number of tracks is greater than that required by the circuit, in order to accommodate mounting pillars, see Fig. 2.

Begin by labelling the stripboard carefully, and marking the positions of the breaks on both sides. Note that i.c. holders are essential as the i.c.'s are sensitive to static charges. Solder in the holders, short wire links and small components, finishing with the largest components. Note that the diodes and electrolytic capacitors must be fitted with the correct polarity (the correct way round). Next, add the flexible wires to link the potentiometers and switches. Solder on the three wires which will link the stripboard to the computer, but *do not* connect to the computer plug until the circuit has been tested. A piece of screened cable should be used for the signal input.

Before removing the i.c.'s from their protective packaging, touch an earthed metal object (e.g. a bare metal part of an appliance plugged into the mains) to earth any static charge on your body. Plug in the i.c.'s the correct way round, retaining the packaging material in case they need to be removed later.

TESTING

The circuit should NOT be connected to a computer before it has been thoroughly tested. Connect a voltmeter between the output, and zero volts line, and set it to about 5 volts f.s.d. Connect the circuit to a 5 or 6 volt supply, and apply an audio signal to the input, either from a speaker output, line or tape output. Switch S1 should be closed (on), and S2 should be open (off). Adjust VR1 and VR2 to about mid-way.

During loud sounds, the voltmeter should rise to between one and two volts. Adjust VR1 and VR2 if necessary, to obtain proper high and low readings.

If the circuit does not work, check that the voltage across pins 7 and 4 of each i.c. equals the supply voltage. The current used by the circuit should be between 2mA and 6mA. This could be checked if a suitable ammeter is available.

The d.c. voltage at pin 6 of each i.c. should be about half the supply voltage. The two input pins of each i.c. should also be at about half the supply, but the resistance of the voltmeter used may affect the accuracy of such readings.

An oscilloscope will quickly establish the point at which the signal is lost. Alternatively, a high impedance earpiece may serve a similar purpose, providing it is connected between the negative side of C3 or C10, and zero volts, to test the respective outputs.

COMPUTER CONNECTOR

The BBC "B" computer requires a 15-way "D" PLUG to connect with the analogue interface. Pin 1 provides a positive five volt supply; pin 5 is an "analogue ground", and pin 15 is ADVAL channel 0, which is confusingly, called ADVAL (1) in a program. Any three core wire may be used, not forgetting to pass it through the hole in the case before soldering to the connector.

CASE

A Verobox measuring 150 by 80 by 50mm. may be used to house the stripboard and controls. Begin by drilling holes for the two potentiometers, two switches, audio lead and computer lead. The stripboard may be drilled as shown to enable fixing by means of self adhesive p.c.b. pillars. When mounting the switches, note that S1 should be closed when "up" and S2 should be open when "up". Thus S1 is switched "down" for bass cut, and S2 is switched "down" for treble cut.

COMPUTER PROGRAM

The example program listed should cause the TV screen to go blank. When an audio signal is applied to the input, a solid triangle should appear from the bottom of the screen. The triangle should move up as the sound level increases, and appear to crumble down as the level decreases. Larger level increases should make the triangle change colour.

Line 50 returns a number between 0 and 65520 according to the voltage at ADVAL(1) (called channel 0 on the connector). This is divided by 40 to provide a num-

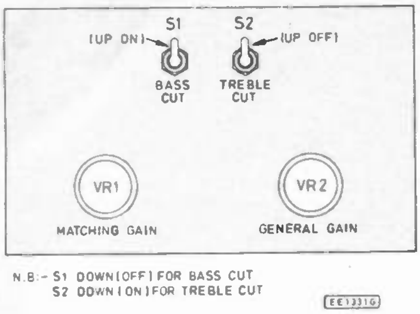


Fig. 3. Control positions/functions.

```
 10 MODE 4
 20 *FX16,1
 30 VDU 23,1,Ø,Ø,Ø,Ø
 40 LET H=Ø:C%=1
 50 LET A%=ADVAL(1)/4Ø
 60 IF A%>=H THEN T=A%:GOTO 8Ø
 70 LET T=H
 80 IF A%-H>5Ø THEN C%=C%+1
 90 IF C%=7 THEN C%=1
100 LET H=A%
110 VDU 19,1,C%,Ø,Ø,Ø
120 IF T>H THEN 15Ø
130 MOVEØ,Ø:MOVE128Ø,Ø:PLOT85,64Ø,T
140 GOTO 5Ø
150 MOVEØ,H:MOVE128Ø,H
160 PLOT87,Ø,T:PLOT87,128Ø,T
170 GOTO 5Ø
```

Fig. 4. Simple demonstration software.

ber (A%), for plotting on the TV screen. Variable "T" is the actual Y-coordinate used for plotting, and variable "H" is used to remove the triangle as the level of sound decreases.

Line 80 checks for larger sound increases; if the new reading A% minus the old reading H is greater than 50, then C% (the colour of the triangle) increases by 1. When C% reaches 7, line 90 returns it to 1, as only six colours are available.

Line 130 plots the triangle, and line 160 plots two triangular blank spaces, making the first triangle appear to crumble as the sound decreases.

FINAL SETTING UP

Connect the circuit to the computer. Allow the TV to warm up before switching on the computer, so that any malfunction will be immediately obvious by the usual message not appearing on the screen.

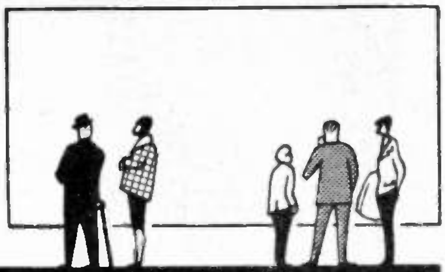
Turn VR1 to its highest resistance (fully clockwise), set VR2 to about mid-way and check that S1 is closed (on) and S2 is open (off). Connect an audio signal to the input. The triangle should pulse to about the top of the screen. If this is not the case, line 50 may be altered. The number which is divided into ADVAL(1) may be reduced for a higher triangle, or increased for a lower triangle. It should now be possible to "push" the triangle beyond the top of the screen by advancing VR2, or reduce it to nothing by turning VR2 fully anti-clockwise.

Thus VR2 (called General Gain) is a "stretch control" which sets the highest point of the triangle. VR1 may be used to match a variety of audio inputs to the circuit, and can also compress most of the movement into the top part of the screen if desired, by saturating IC1.

Operating the bass cut, or treble cut switches should produce the desired effect, though the potentiometers may need re-adjusting.

The program listed is only an example of what can be achieved. All manner of graphic effects are possible, from a sound level graph, to bursting stars. Avoid long programs if a moving graphic display is required, as the program running speed is important. Alternatively, write a program in machine code for the most spectacular effects. □

SHOP TALK



BY DAVID BARRINGTON

Multi-Channel Remote Light Dimmer

Last month we had difficulty locating a source for the components called for in the *Multi-Channel Remote Light Dimmer*.

This month we have received news that all the semiconductor devices required for this multi-board project are carried by **Xen Electronics (☎0983 292847)** at competitive prices. It might even be worth asking for a "special" price for all the semiconductors as a single package. Also, as mentioned last month, all parts for this project are stocked by **TK Electronics (☎01-567 8910)**.

The main cabinet, housing the receiver, power supply and all control boards, is left to individual choice and pocket, however, it must be a METAL type and be well "earthed". The printed circuit boards for this project are available from the *EE PCB Service*, codes EE599/604 (see page 373).

Audio Mini-Bricks

The master printed circuit board (£7.90) is available from **Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.**

Home Security

Most of the components required for this month's circuits in our new series on *Home Security* are standard products and should be stock items. However, the battery back-up i.c. is only listed by **Maplin,** code UH36P (ICL7673).

A large range of specialist intruder sensors are stocked by **Riscomp** and they should be able to supply all of the various "detectors" called for in this series of articles. **Riscomp Ltd., Dept. EE, 51 Poppy Road, Princes Risborough, Bucks, HP17 9DB (☎084 44 6326).**

Light Level Detector/Light Triggered Alarm

The 7611 low power CMOS op. amp called for in the Light Level Detector and Light-Triggered Alarm—this month's Exploring Electronics projects— may cause some local supply problems and appears to be only listed by Omni and Xen Electronics. The rest of the components seem to be standard off-the-shelf items and should not cause any purchasing difficulties.

Headlight Reminder

The piezoelectric resonator specified in the *Headlight Reminder* components list is now a very common item amongst suppliers' stocks and, like the rest of the components, should not cause any purchasing problems.

The Scotchlock connectors should be available from any good car spares shop or garage parts counter. The small printed circuit board is available through the *EE PCB Service*, code EE611.

BBC Sound-To-Light

Most of the components required for building the *BBC Sound-To-Light* unit are standard items and should not cause any undue sourcing problems.

The CA3140 f.e.t. input op. amp i.c. is stocked by most of our advertisers and although a dual version is available it is cheaper to buy two single i.c.s. It is also easier to fault find the circuit as the two devices can be swapped over. Note that it is important to use i.c. holders for mounting the op. amps on the circuit board.

The 15-way D-type computer connector plug, screened and 3-core cable is stocked by most good component suppliers. The standard 741 op. amp may work in this circuit but they have NOT been tried.

We cannot foresee any component buying problems for the "Easi-Wire" *Transistor Tester* demonstration project, the wiring kit is, of course, available from BICC–Vero (see page 329).

PLEASE TAKE NOTE

DIGITAL COUNTER/FREQUENCY METER—*July '87.*

Page 369. The components list shows R6 and R11 as 100 ohm resistors, these should be 100 kilohms types. The circuit diagram Fig. 1 is correct.

DOOR SENTINEL—*May '88.*

Page 286, Fig. 4. The p.c.b. foil master pattern should be viewed from the other side. (The view shown is looking through the board from the top side.)

SUPER SOUND GENERATOR—*May '88.*

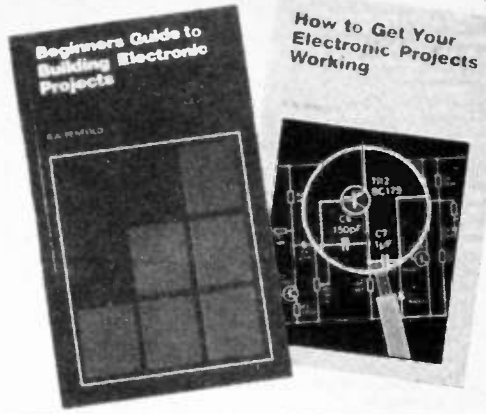
Page 292, Fig. 1 and components list. Transistor TR2 should be a type BC213 and not as shown.

AUDIBLE SMOOTHNESS TESTER—*May '88.*

Page 302, Fig. 2. The tint overlay on the top diagram is incorrect. A tracing of the lower diagram can be made and turned over to align with the top diagram corner "key" in the top right.

DIRECT BOOK SERVICE

The books listed have been selected as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.



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CIRCUITS AND DESIGN

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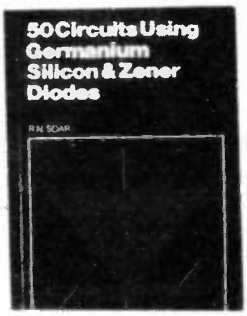

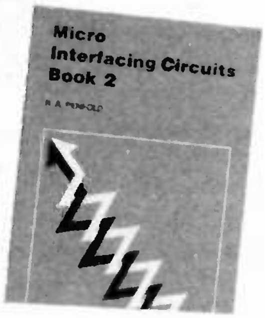

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This book aims to explode two popular misconceptions concerning the design of electronic circuits: that only those with many years of experience should undertake circuit design and that the process relies on an understanding of advanced mathematics. Provided one is not too ambitious, neither of these popularly held beliefs is true.
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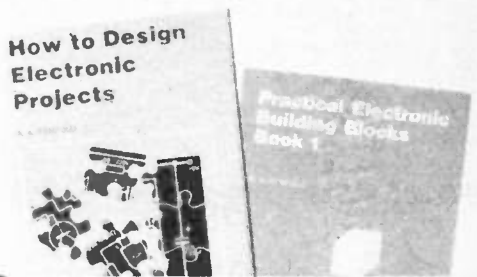

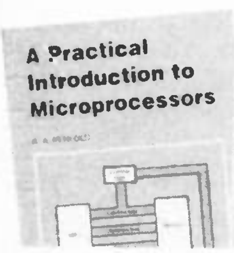

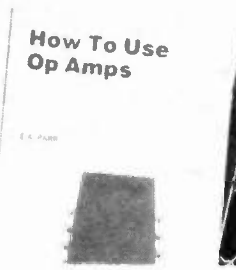

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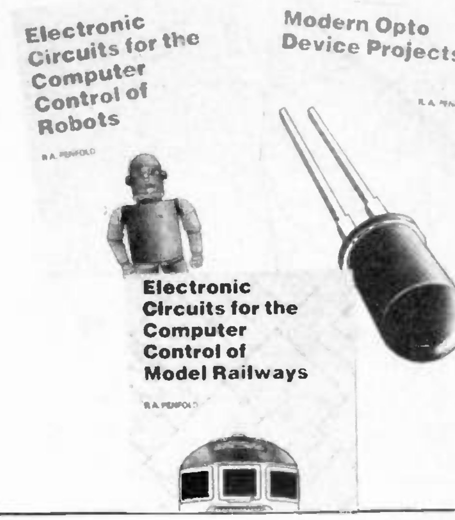
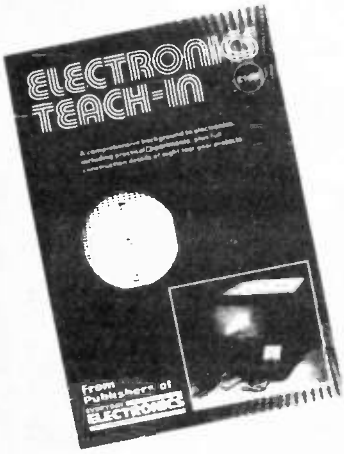
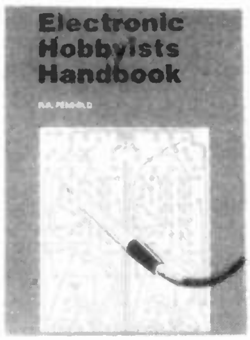
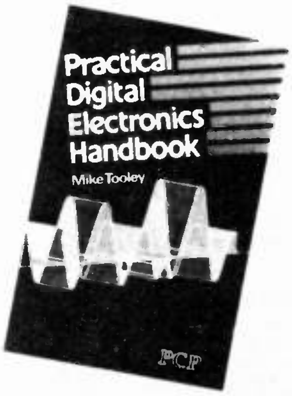


DATA AND REFERENCE







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Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular semiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.
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K. H. Recorr
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B. B. Babani
Although this chart was first published in 1971 it provides basic information on many colour codes in use throughout the world, for most radio and electronic components. Includes resistors, capacitors, transformers, field coils, fuses, battery leads, speakers, etc. It is particularly useful for finding the values of old components.
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M. H. Banani, B.Sc.(Eng.)
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FOR . . .
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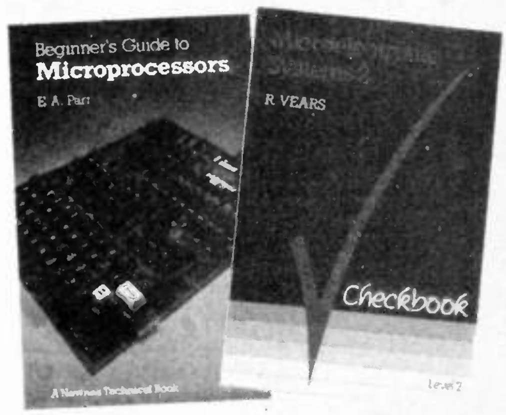
Mike Tooley (Published in association with *Everyday Electronics*)
The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and test equipment; regulated bench power supply; logic probe; logic pulser; versatile pulse generator; digital IC tester; current tracer; audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.
208 pages Order code PC100 £6.95



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E.A. Parr
An excellent grounding in microprocessors, this book is broadly relevent to the whole of our Introducing Microprocessors course. It is easy to read and well illustrated.
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MICROELECTRONIC SYSTEMS 2 CHECKBOOK
R. Vears
The aim of this book is to provide a foundation in microcomputer hardware, software and interfacing techniques. Each topic is presented in a way that assumes only an elementary knowledge of microelectronic systems and logic functions. The book concentrates on 6502, Z80 and 6800 microprocessors and contains 60 tested programs, 160 worked problems and 250 further problems.
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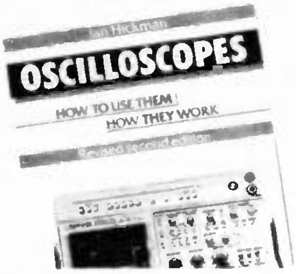
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models is available. But which is the right 'scope for a particular application? Which features are essential, which not so important? What techniques will get the best out of the instrument?

Ian Hickman, experienced in both professional and hobbyist electronics, has revised this well-established book to help all oscilloscope users—and potential users.

133 pages **Order code NE09** **£5.95**



PRACTICAL ELECTRONICS HANDBOOK
Ian Sinclair

Ian Sinclair has now revised this useful and carefully selected collection of standard circuits, rules-of-thumb, and design data for professional engineers, students and enthusiasts involved in radio and electronics. Covering passive and active components, discrete component circuits (such as amplifiers, filters and oscillators) and linear and digital i.c.s, the book includes many items which are not elsewhere available in a single handy volume. The operation and functions of typical circuits are described, while mathematics is limited to that necessary for deciding component values for any application.

This revised edition contains more details on computers and microprocessors and has been brought up to date throughout.

199 pages **Order Code NE06** **£5.95**

BEGINNER'S GUIDE TO HI-FI
Ian Sinclair

The *Beginner's Guide to Hi-Fi* will appeal to the audio enthusiast, whether newly won over by advances in technology or well established and wondering whether to update equipment. The book deals with the sound from its sources in the studio to its ultimate end in your ears, and shows what sound is, how it is recorded and how it is reproduced.

Every aspect of Hi-Fi, from pickup cartridges to loudspeakers, has been covered, and the emphasis has been on explaining design aims. Cassette systems have been given considerable prominence, including the more modern Dolby C and dbx noise reduction systems. The CD record has been covered in detail so that you can find out just why this system of sound reproduction is so superior.

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COMMUNICATION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

A look at the electronic fundamentals over the whole of the communication scene. This book aims to teach the important elements of each branch of the subject in a style as interesting and practical as possible. While not getting involved in the more complicated theory and mathematics, most of the modern transmission system techniques are examined including line, microwave, submarine, satellite and digital multiplex systems, radio and telegraphy. To assist in understanding these more thoroughly, chapters on signal processing, the electromagnetic wave, networks and transmissions assessment are included, finally a short chapter on optical transmission.

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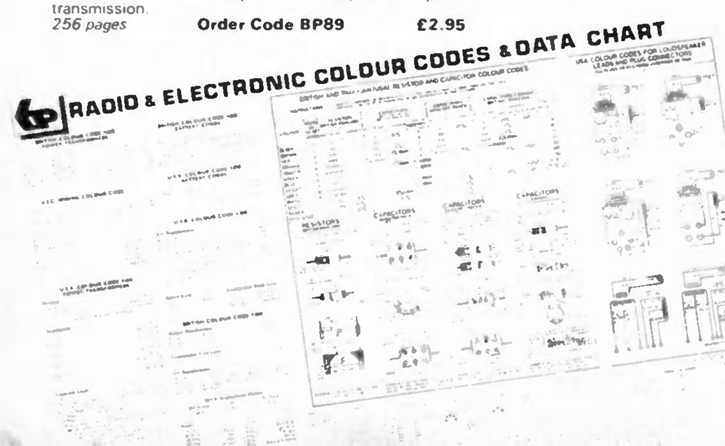
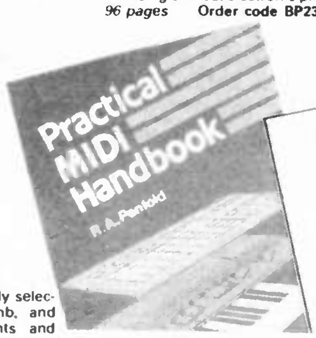


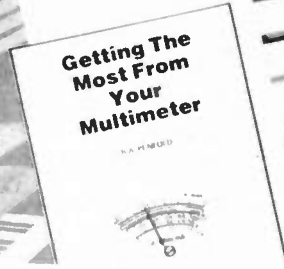
GETTING THE MOST FROM YOUR MULTIMETER
R.A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£2.95**





PRACTICAL MIDI HANDBOOK
R.A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those equipment manuals.

128 pages **Order code PC101** **£5.95**

INTRODUCTION TO DIGITAL AUDIO
Ian Sinclair

Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** **£5.95**

INTERNATIONAL TRANSISTOR EQUIVALENTS GUIOE
A. Michaels

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C. E. Miller

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Chart **Order code BP70** **£0.95**

OIGITAL IC EQUIVALENTS AND PIN CONNECTIONS
A. Michaels

Shows equivalents and pin connections of a popular selection of European, American and Japanese digital i.c.s. Also includes details of packaging, families, functions, manufacturer and country of origin.

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A. Michaels

Shows equivalents and pin connections of a popular selection of European, American and Japanese linear i.c.s. Also includes details of functions, manufacturer and country of origin.

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A. Michaels

Designed to help the user in finding possible substitutes for a large selection of the many different types of diodes that are available. Besides simple rectifier diodes, also included are Zener diodes, l.e.d.s, diacs, triacs, thyristors, OCIs, photo and display diodes.

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E. A. Parr

Newnes Electronics Pocket Book has been in print for over twenty years and has covered the development of electronics from valve to semiconductor technology and from transistors to LSI integrated circuits and microprocessors. To keep up to date with the rapidly changing world of electronics, continuous revision has been necessary. This new Fifth Edition takes account of recent changes and includes material suggested by readers of previous editions. New descriptions of op.amp. applications and the design of digital circuits have been added, along with a totally new chapter on computing, plus other revisions throughout.

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RADIO/TELEVISION

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R. A. Penfold
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INTERNATIONAL RADIO STATIONS GUIDE
P. Shore
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:
Listening to Short Wave Radio; ITU Country Codes; World-wide Short Wave Radio Stations; European, Middle East and North African Long Wave Radio Stations; European, Near East and North African Medium Wave Radio Stations; Canadian Medium Wave Radio Stations; USA Medium Wave Radio Stations; Broadcasts in English; Programmes for DXers and Short Wave Listeners; UK FM Radio Stations; Time differences from GMT; Abbreviations; Wavelength/Frequency Conversion.
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F.G. Rayer Second edition revised by Gordon King G4VFV.
Whether you are new to radio, or have become interested by way of CB, it is hoped that this book, will further whet your appetite and put you in good stead for passing the Radio Amateur's Examination and becoming a licensed radio amateur.
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F.A. Wilson
As a definitive introduction to the subject this book is presented on two levels. For the absolute beginner or anyone thinking about purchasing or hiring a satellite TV system, the story is told as simply as such a complex one can be in the main text.
For the professional engineer, electronics enthusiast, student or others with technical backgrounds, there are numerous appendices backing up the main text with additional technical and scientific detail formulae, calculations, tables etc.
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COMPUTING

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Takes the reader through the basics of microprocessors and machine code programming with no previous knowledge of these being assumed. The Z80 is used in many popular home computers and simple programming examples are given for Z80-based machines including the Sinclair ZX-81 and Spectrum, Memotech and the Amstrad CPC 464. Also applicable to the Amstrad CPC 664 and 6128.
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R. A. & J. W. Penfold
No previous knowledge of microprocessors or machine code is assumed. Topics covered are: assembly language and assemblers, the register set and memory, binary and hexadecimal numbering systems, addressing modes and the instruction set, and also mixing machine code with BASIC. Some simple programming examples are given for 6502-based home computers like the VIC-20, ORIC-1/Atmos, Electron, BCC and also the Commodore 64.
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FOR YOUR ENTERTAINMENT

BY BARRY FOX

Made In Britain!

A subsidiary of Sony, Aiwa, is the only firm making CD players in Britain, at a factory in Gwent, Wales. Aiwa also makes midi system amplifiers, tuners, cassette decks and turntables. The Japanese have now decided to invest £3.1 million and double production, currently valued at £M20 a year.

Doubtless the promise of a government grant worth £0.4 million helped them make their decision. The new factory will make more audio, including portables, and perhaps video as well, now that Sony has bitten the bullet, accepted the failure of Beta, and decided to back the VHS system.

Just what exactly does Aiwa mean by "make"? When I visited the Gwent factory it was unashamedly nothing more than an assembly line, putting together complete construction kits imported from Japan.

The factory managers made no bones about the fact that this was the only way they could work. Designing in Britain was just not feasible, because the UK is only one of many world markets for identical products. Finding British, or even European, sources of component supply was impractical, if not impossible.

In the absence of any news to the contrary I can only assume that Aiwa's Gwent factory is still only assembling kits and the £3.5 million now to be spent will merely expand assembly . This secures jobs, and could create another 200, but it all brings Britain one step closer to becoming an off-shore assembly line for the Far East. It's like an industrial revolution in reverse.

Research and Development

Although all the major Japanese electronics companies now have manufacturing plants in the UK, British scientists and engineers still have no hope of finding research and development work with them.

Takao Negishi, European Director for the Electronic Industries Association of Japan, says he would like the situation to change but admits that the time is not yet right for his members to build research and development laboratories in Britain.

In 1970, all Japanese products sold in Britain were made in the Far East. Now nearly 60 Japanese manufacturers, most of them electronics companies, have built factories here. Most make colour TV sets and video recorders. Soon others will follow the Aiwa lead and start making compact disc hifi equipment, because the European Commission in Brussels is investigating a complaint by Philips that Japanese factories are dumping CD players at below cost.

So far all the research, development and design work for Japanese factories in Britain has been done in Japan. "Manufacturing is like the growth of a child from birth to maturity" says Negishi. "We are still in the first stage, the simple transfer of manufacturing capacity from Japan to Britain."

"The next stage is putting money into R and D. We will need to recruit the best brains. The English are very inventive—very creative. But we are not yet at the second stage of investing in brains".

"IBM invested in Japan in the 1920s", says Negishi. "Now they have a wonderful research centre there. Japanese companies have not yet reached that point in Europe".

In the summer of 1985, Shigeru Hayakawa, head of Matsushita's research laboratories in Japan, made news throughout Europe when he said the company was planning to build an R and D lab in Britain. As sceptics predicted, nothing has happened but the EIAJ continues to nag Matsushita. "We will do it quite soon", Matsushita said in January. The trigger may be the new *MAC* satellite TV transmission system which is unknown technology in Japan.

"We are accused of building screwdriver assembly plants—sometimes even importing the screws and drivers as well as the components to assemble", admits Negishi. "We would like to buy British components but they are seldom good enough. This is a crucial problem in the UK".

Whatever happens, Negishi is resigned to the fact that the Japanese cannot win unless they fail commercially. "We are prisoners of prejudice" he says.

Off The Rails

There is a flip side to the miracle of modern technology.

Last December, Transport Secretary Paul Channon unveiled Network South East's 21st century train at Victoria Station. Later that same day, on the next platform, I saw a young woman ask a ticket collector whether the train just leaving went to Catford.

He sent her off with a flea in her ear, telling her she should look at the TV screen displays and not waste his time with questions. Distraught, the girl ran up and down the platoform trying to find a passenger who could tell her where it went.

I very much doubt that she had been too idle to look at the TV screens. More likely she was in the embarrassing position of having poor eyesight or being illiterate.

If so, she would also have been unable to read the sign overhead the bullying inspector which reads *"Thank you for travelling Network South East"*.

Bookmark

Every day now the postman brings some fresh announcement about some new Desk Top Publishing system. There are seminars on DTP, conferences on DTP and DPT sales conventions.

The way things are going, every desk in Britain will soon have the potential to publish. Essentially DTP is a simple way of producing pages of text which are clean and clear enough to mass-reproduce as books, magazines or brochures, or transfer to slide, film or video for projection or monitor display.

Recently, I heard of one publisher who boasted his own desk top system. The author promised to produce a book but as the publisher put it: "He didn't warn me it would take twice as long and be full of spelling mistakes; the highest tech publishing gadgetry still depends on having the right words to publish".

I also met a graphics artist, who has spent his life drawing sketches and graphs which advertising and PR agencies turn into 35mm slides for projection. They use them for sales pitching.

When a large company wants to employ a new advertising or PR agency they invite tenders from competing agencies who then put on a presentation or "sales pitch" with slides and chat. Often the company with the best pitch isn't the best company for the job, but that's another story.

Is desk top publishing putting you out of business, I asked the artist?

"Not a bit of it", he told me cheerfully. "I kept expecting it to finish me off but I'm at retirement age now, and have never been so busy in my life".

No Character

Agencies have found that although it is easy to use DTP systems to prepare slides or graphs, they end up looking much the same. It's because the system has no imagination—no character of its own.

Companies looking for a new agency, find that they are faced with several presentations, all looking much like the others because they have all been generated by computers. And often the slides contain typographical errors that no-one has spotted on the computer screen.

"It's like shop window dressing" said the artist. "Walk down Oxford Street in London and look in all the large store windows. We used to know which store was which, from the individual style of window dressing. Now they all look the same".

Unwittingly emphasising the point, the magazine *Personal Computer World* gave away a calendar with the last Christmas edition. It was a reproduction of the magazine cover for last April which showed an Apple Mac displaying colourful, graphics.

"Although some readers thought that the image was created on some form of computer art package" explained a footnote to the calendar "it was in fact an illustration".

The magazine illustrator had used an airbrush on a photograph, because when the Mac was reviewed there had been no colour graphics software available to run on it.

exploring electronics

OWEN BISHOP

This series is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. There will not be masses of theory or formulae but straightforward explanations and circuits to build and experiment with.

Part 24—Op. Amp Comparator and Light-Triggered Alarm

THIS MONTH we have an entirely different application for the versatile op. amp. But instead of using the 741 i.c. we use the 7611 integrated circuit, one of innumerable variations on the op. amp theme.

The 7611 is a CMOS op. amp, CMOS being short for "*Complimentary Metal Oxide Silicon*", which describes the type of transistor used in its construction. We are also using a CMOS logic i.c., the 4011 quad 2-input NAND gate.

The advantage of using CMOS is that it requires exceedingly small currents to operate it. The 4011 logic i.c. takes less than a tenth of the power of its TTL 7400 equivalent (see *EE Sept. 1987*). Another advantage of the CMOS op. amp is that it will operate on lower voltages than the 741 and its output can swing to within a few millivolts of the positive and negative supply.

OP. AMP COMPARATOR

When an op. amp is used as a comparator, we rely solely on its exceedingly high gain. The two voltages to be compared are fed to its two inputs. If there is any difference between them, the output voltage swings sharply "high" or "low", as far as it can go. If the voltage at the non-inverting input (+) is greater than that at the inverting input (−), it swings high; if the voltage at the inverting input is greater than that at the non-inverting it swings low.

LIGHT LEVEL DETECTOR

Our Comparator demonstration circuit takes the form of a Light Level Detector and the full circuit diagram is shown in Fig. 24.1. The light sensor used is a TIL100 photodiode.

Like any other diode, it passes current in one direction only. In Fig. 24.1 it is connected so that no appreciable current passes through it—it is said to be *reverse biassed*.

However, as with all reverse-biassed diodes, there is a very small *leakage current* of a few microamps passing through the diode. When light falls on the photodiode D1, the leakage current increases. It flows through R1, causing a voltage to develop across the resistor.

Thus, the voltage at point *A* increases with the amount of light falling on the diode. This voltage is monitored by the inverting input (pin 2) of the op. amp IC1. The non-inverting input (+) receives a steady voltage from the potential divider (VR1).

The potentiometer VR1 is adjusted until the voltage at the non-inverting input (pin 3) is very slightly less than that at the inverting input (pin 2). Under this condition the output of the op. amp is low (very close to 0V) so transistor TR1 is switched off and the audible warning device (WD1) is silent.

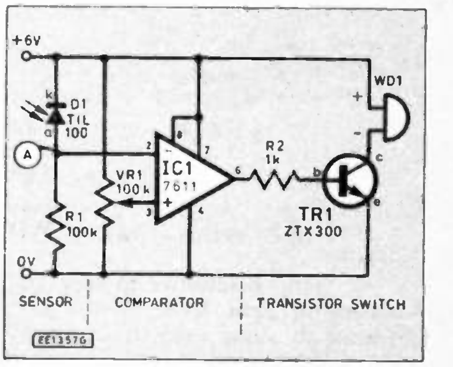
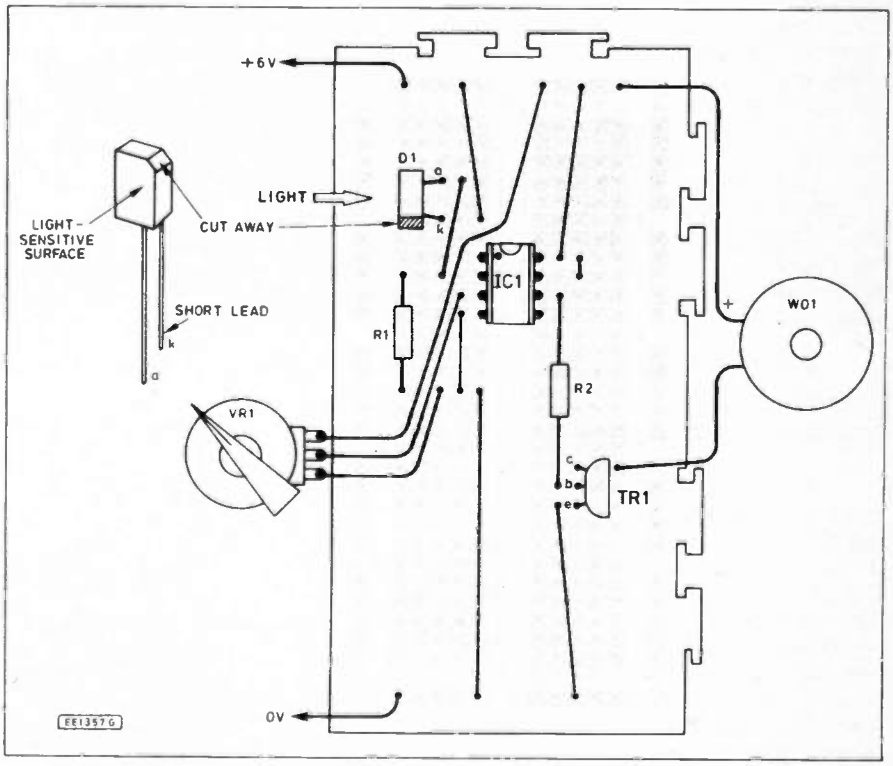
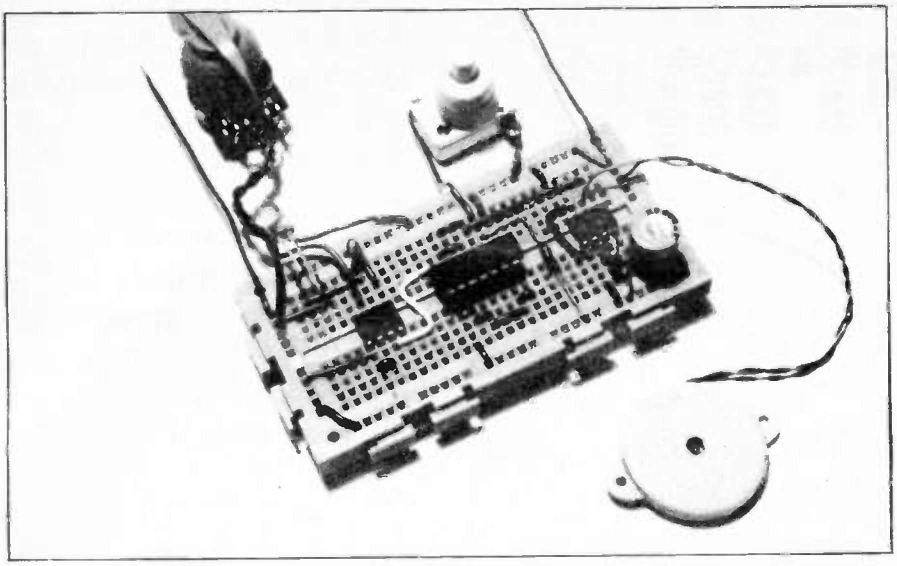


Fig. 24.1. Using the op. amp as a comparator.

Fig. 24.2 (below). demonstration breadboard component layout for the op. amp comparator Light Level Detector.





When the amount of light reaching photodiode D1 is reduced (either by a beam of light being broken, or perhaps at dusk), the voltage at *A* falls. The (−) input is now at a lower voltage than the (+) input, so the output swings high, almost to +6V. This turns the transistor on and the warning buzzer WD1 sounds.

The circuit is sensitive to very small changes in light level, and can be adjusted to sound the alarm at a precisely set light level. Another feature is that the photodiode responds much faster than a light-dependent resistor (LDR) (*EE Sept. 1986*).

CONSTRUCTION

The demonstration breadboard component layout for the Light Level Detector is shown in Fig. 4.2.

Commence construction by inserting the i.c. holder and link wires followed by the resistors and the photodiode D1. Take care when mounting the photodiode to ensure the leads are connected the right way round.

Next the supply, potentiometer and buzzer leads should be plugged into the "test-bed". Finally, before inserting the i.c. in its holder, the layout should be given a final check over against the circuit diagram.

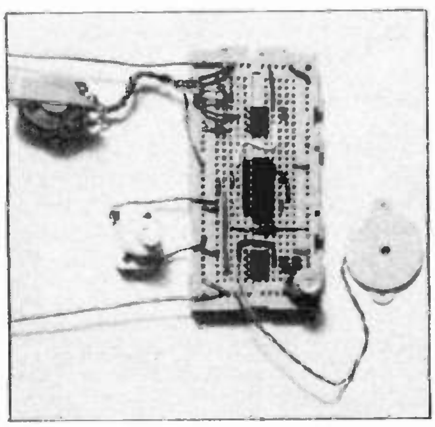
LIGHT-TRIGGERED ALARM

Another application where the comparator is most useful is in a Light-Triggered Alarm and a demonstration circuit diagram is shown in Fig. 24.3. This has applications for an intruder-detection system.

The sensor and comparator section of the circuit is the same as Fig. 24.1, except that the connections to the op. amp IC1 inputs are reversed. Consequently, the op. amp output *falls* when the light beam is broken. This output goes to a bistable IC2 (*EE Sept. 1987*) built from two NAND gates of the 4011 CMOS i.c.

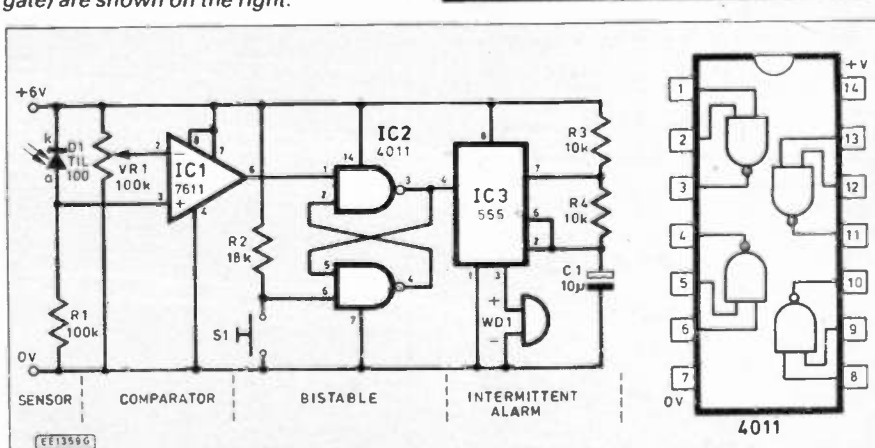
A "low" input to the bistable (IC2) triggers it to change state. This makes the trigger input of the 555 timer IC3 go "high".

The timer is wired as an astable, running at about 1Hz. When its trigger input is made high its output voltage, previously low, begins to rise and fall



Completed Light-Triggered Alarm. Our model shows a different photodiode, but we recommend that the more sensitive TIL100 device be used.

Fig. 24.3. Complete circuit diagram for the Light-Triggered Alarm. The pin-out details for the 4011 (quad 2-input NAND gate) are shown on the right.



COMPONENTS

LIGHT LEVEL DETECTOR

Resistors
R1 100k
R2 1k
All 0.25W 5% carbon

Potentiometer
VR1 100k lin.

Shop Talk
See page 360

Semiconductors
D1 TIL100 infra-red photodiode
TR1 ZTX300 *npn* transistor
IC1 7611 CMOS operational amplifier

Miscellaneous
Breadboard (Verobloc); WD1 Piezoelectric buzzer (PB2720); 8-pin i.c. holder; B1 6V battery and connector clips; connecting wire.

LIGHT-TRIGGERED ALARM

Resistors
R2 18k
R3, R4 10k (2 off)
All 0.25W 5% carbon

Potentiometer
VR1 100k lin.

Capacitors
C1 10μ elec.

Semiconductors
D1 TIL100 infra-red photodiode
IC1 7611 CMOS op. amp
IC2 4011 CMOS quad. 2-input NAND gate
IC3 555 timer

Miscellaneous
Breadboard (Verobloc); B1 6V battery and connectors; WD1 Piezoelectric buzzer (type PB2720); 8-pin i.c. holder (2 off); 14-pin i.c. holder; S1 push-to-make pushbutton switch; connecting wire.

Approx. cost Guidance only **£5 each**

about once a second. This turns the buzzer WD1 on intermittently.

The intermittent "*buzz-silence-buzz-silence-buzz-. . .*" is more attention-catching than a continuous tone. The alarm continues until the reset button S1 is pressed, changing the bistable back to its original state.

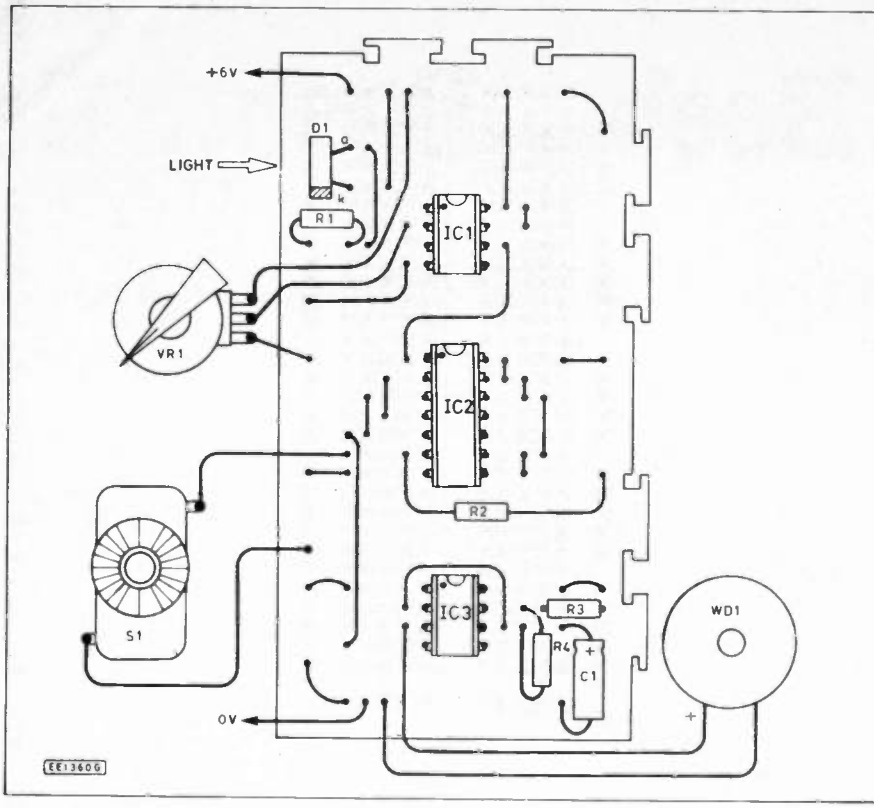


Fig. 24.4 (left). Demonstration "test-bed" component layout for the Light-Triggered Alarm. It is suggested that i.c. sockets be used to mount all i.c.s on the board.

CONSTRUCTION

The demonstration "test-bed" component layout for the Light-Triggered Alarm is shown in Fig. 24.4.

Commence construction by first inserting all the i.c. holders in position on the breadboard followed by the link wires (20 off). The resistors, photodiode and capacitor should be mounted next followed by the pushbutton switch, potentiometer, buzzer and battery leads.

Once all the wiring has been completed, the breadboard should be given a final check over against the circuit diagram and the i.c.s plugged into their respective holders. Take care to observe the correct polarity for the i.c.s, photodiode and capacitor when mounting these components on the board.

CMOS logic i.c.s do not work properly if inputs are left unconnected. This is why Fig. 24.4 shows the inputs to the unused gates (pins 8, 9 and 12, 13) of IC2 wired to +6V.

Next Month: Using Diodes and building a "Diode Pump".

EE CROSSWORD 5 ANSWERS

ACROSS
1 TERTIARY
4 DRUM
8 RESET
9/11 BOOSTER DIODE
10 METRES
11 See 9
12 FOSTER
13 SPEECH
17 SPIKE
19 DRIFT
20 MHO
21 YAGI
22 EMISSION

DOWN
1 TERA
2 RASTERS
3 INTERMEDIATE
5 RATIO
6 MORSE
7 LOUDSPEAKERS
9 BASS
12 FARADAY
14 EPROM
15 H.F.
16 MEGOHM
17 SWING
18 HORN

b...Beeb...Beeb...Beeb...Be

... EPROM Programming ... EPROM Programming ...

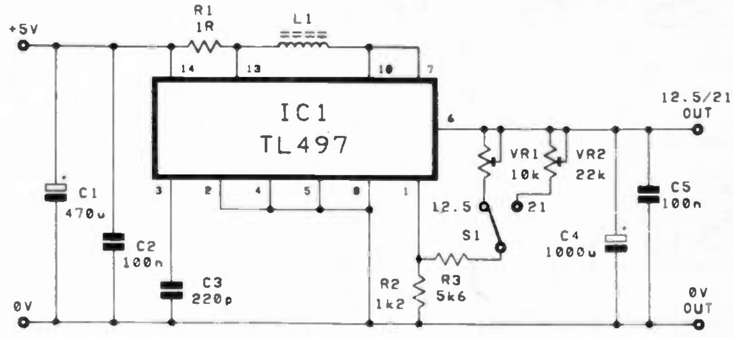


Fig. 1. The voltage booster circuit.

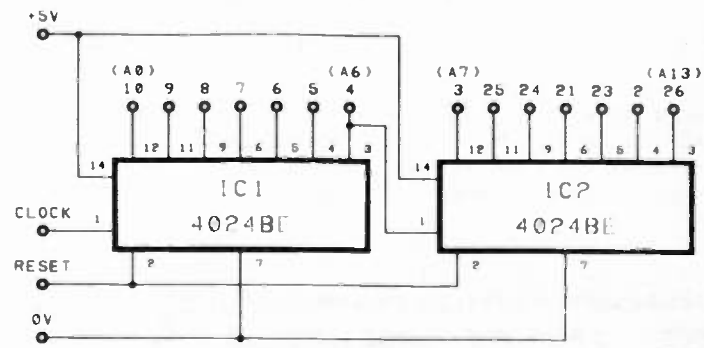


Fig. 2. Using binary counters to provide the address bus.

CARRYING on from last month with the subject of EPROM programming using the BBC micro, and the problem of obtaining the programming voltage, the circuit of Fig. 1 will provide both 12.5 and 21 volt outputs from the five volt supply of the BBC machines. The supply current drawn from the V_{pp} terminal can be as much as 50 milliamps, but the circuit can supply this quite comfortably even with the output potential set to 21 volts.

For those who are not familiar with switch mode power supplies it should perhaps be explained that they provide for d.c. supplies the same basic action that a transformer provides for a.c. supplies. Thus, a boost in output voltage can be obtained, but only by having an input current that is higher than the output current. The input power must always be at least equal to the output power.

In practice there are inevitable losses in a switch mode power supply circuit, and the output power is typically about 50 to 80 per cent of the input power. In this unit, under worse case conditions with an output voltage of 21 volts and the current drain at 50 milliamps, the input current must be something over 200 milliamps. In practice it is likely to be much nearer to 300 milliamps. However, assuming that the BBC computer is not powering a lot of other peripheral devices, it is well able to supply this.

Circuit

The circuit is based on the TL497 which is specifically designed for low power switch mode power supply applications. It does not provide the last word in performance, but it is a good, practical device that is very reliable and not easily damaged. Its level of performance is certainly quite adequate for the present application.

Operation of the circuit revolves around inductor L1. An on-chip oscillator and switching transistor are used to repeatedly short circuit the right hand terminal of L1 to the 0 volt supply rail. Each time the transistor switches off, a high reverse voltage is generated across L1, and is effectively added to the input voltage. This is much the same as the high reverse voltage spike generated across a relay coil as it is switched off, but here this effect is put to good use rather than being a nuisance. The boosted voltage spikes are smoothed by C4, and an internal diode of IC1 prevents the switching transistor from discharging C4 during its "on" periods.

Regulator

A regulator circuit is included in IC1, although this is rather basic when compared to "state of the art" switch mode regulators. The overall action of the circuit is basically that of a relaxation oscillator. The main oscillator is activated if the output voltage falls below a certain threshold level, and disabled when it goes above this level. The output waveform is therefore bursts of pulses and not a standard pulse width type.

The nominal threshold voltage is 1.2 volts, but this can be boosted by adding a potential divider between the output and the feedback input. This sets the output voltage in standard feedback power supply fashion. In this case there are two switched preset resistors (VR1 and VR2) which are adjusted for output voltages of 12.5 and 21 volts respectively.

The circuit has built-in current limiting, and this has the limit current set via a discrete resistor (R1). This limits the input current to about 500 milliamps.

Inductor

Switch mode power supply circuits can look slightly suicidal when you examine them in detail. In this case, L1 is short circuited across the supply lines for about 50 per cent of the time! This is fine provided it has suitable characteristics. If not, the result will be reduced and not boosted output voltage. L1 needs to have a fairly high Q at the frequencies and currents involved here, and this requires the use of a ferrite potcore.

The term "core" is perhaps a bit misleading, as the ferrite fits around the coil as much as it goes inside it. The core is supplied in two halves, and the coil is wound on a bobbin which is normally sold separately. The bobbins normally have several printed circuit pins, and as only two terminals are required in this case, any bobbin should suffice.

I used an LM8 size potcore (B65811 J0000R041) with 25.5 turns of 22 s.w.g. enamelled copper wire on the bobbin. The ends of the winding are taken out through holes in the base of the component and soldered to separate pins of the coil former. The top and bottom halves of the core are then fitted onto the former, and are held together by a pair of metal clamps (which are also normally sold separately).

Do not worry if you are not familiar with potcore assemblies—it is pretty obvious how everything fits together once you have the parts. Home made coils do tend to put some people off building any projects that require them, but this type of coil is very easy to wind, and the circuit will still work quite well if the winding is not very neat. All the parts needed to produce L1 are available from Electrovalue Ltd. (28 St. Jude's Road., Englefield Green, Egham, Surrey [Tel. 0784 33603]). As far as I am aware, suitable ready-made inductors are not available.

When power is first applied to the circuit there will probably be a slight "ticking" sound from L1. This will change to a higher pitched buzzing sound when a load is placed on the output of the supply. Remember to adjust VR1 and VR2 for the correct voltages before connecting the unit to an EPROM, and always remember to set the right voltage prior to fitting an EPROM into the programmer. Using 21 volts on a 12.5 volt type will almost certainly destroy the device.

Count On It

As explained in last month's article, it is not necessary to have fourteen output lines in order to drive the address bus of the

EPROM. All that is needed is two output lines plus a fourteen bit binary counter. A suitable circuit is provided in Fig. 2. This actually uses two CMOS 4024BE seven bit binary counters connected in series, so as to effectively form a single fourteen bit counter.

Before programming is commenced, the "RESET" input is pulsed high so that all the outputs are set at logic 0, and the EPROM is set to address 0. After each address has been programmed and verified, a pulse is applied to the "CLOCK" input so as to advance the counter (and the EPROM) onto the next address. This is continued until all the addresses have been programmed and verified. With fourteen outputs the circuit is suitable for both 27128 and 2764 EPROMs. Of course, with 2764 EPROMs the final output connects to a "NC" terminal of the device, and is effectively unused.

Getting It Together

So far I have described three separate circuits (including the monostable last month), but how can these all be brought together to act as an EPROM programmer? There are numerous ways of driving them from the BBC computer, but the method shown in Fig. 3 has the advantage of only using the built-in ports, without the need for any additional hardware. The data bus of the EPROM is driven from the eight bit input/output of the user port. The bidirectional nature of these lines enables them to both output data, and to then read it back to verify correct programming.

The monostable is driven from CB2 of the user port, which is used as a straightforward digital output. The +5 volt output of the user port is used to supply power for both the EPROM and the programmer circuits. The "GND" terminal of the EPROM connects to the 0 volt line of the user port, as does the "CE" ("chip enable") input, which is not required when programming.

This leaves three output lines still required, but only one spare line of the user port (CB1). However, as CB1 can only operate as an input it is of no use in this application. Port A of the 6522 VIA used to provide the user port is available at the printer port. These lines are buffered, and can only operate as outputs, but this is obviously quite satisfactory for current purposes.

The three least significant lines of the printer port are used to provide the other three outputs. If the printer port is otherwise engaged, the easiest solution is to add an output port to the 1MHz Bus, and then use the three least significant lines of this port.

Two of these extra lines are required to drive the clock and reset inputs of the counter. The third is used to drive the "OE" ("output enable") input of the EPROM. This should normally be high, but is taken low when reading the EPROM to verify correct programming.

ZIF

It is normal to fit EPROM programmers with a ZIF (zero insertion force) socket for the EPROMs. This is a socket where the integrated circuit can simply be dropped into place, and then locked in place by operating a small lever. The main advantage of a ZIF socket is supposedly that it does not risk buckling the pins of the integrated circuits when they are plugged into the holder. In this application there is a more important advantage in that the EPROM is not connected into circuit when it is placed in the holder, but as the lever is operated. This minimises any risk of damaging EPROMs as they are plugged into the programmer (or removed from it for that matter).

A 28 pin ZIF socket is quite expensive, but much cheaper than damaging a few EPROMs! Make quite sure that the EPROMs are always connected the right way round. As I learned the hard way, getting this wrong momentarily gives you a LEE-PROM ("light emitting" EPROM), followed immediately by a DEPROM (a "dud" EPROM!).

Testing

The accompanying listing is suitable for checking the programmer. This merely outputs values from 1 to 23 into the twenty-three base addresses of the EPROM. Each value is read back and printed on the screen. Therefore, when run, and if programming is being carried out properly, values from 1 to 23 will be printed down the left hand side of the screen. It is assumed that the printer port is used to provide the three additional output lines. The relevant addresses must be changed to suit if an output port on the 1MHz Bus is used instead.

Programme

It is worth considering the operation of the programme in some detail, as proper software for use with the unit must be based on the same routines. Lines 20 and 30 set the user and printer port lines as outputs, and the next line sets CB2 high. The initialisation is completed at lines 50 and 60 which take PA1 high and then low. This resets the counter. Note that PA2 is left high so that the EPROMs outputs are disabled at this stage.

The rest of the programme is a FOR . . . NEXT loop which outputs values to the EPROM and then reads them back. A proper programmer programme would be similar, but would be outputting values read from a large (8K or 16K) block of memory. Line 80 outputs values to the EPROM, and the next two lines then produce a negative pulse on CB2 that triggers the monostable and programmes the current EPROM address. Another FOR . . . NEXT loop then provides a delay to give the programming time to finish, after which the user port lines are set as inputs, and PA2 is set low in order to enable the EPROM's outputs.

Line 140 reads the value just programmed into the EPROM and prints it on screen. The outputs of the EPROM are then set back to the high impedance state, and the user port lines are set back to the output mode (in that order!). Finally, a pulse is produced on PA0 at lines 170 and 180 so that the EPROM is incremented to the next address. The programmer is then ready for the process to be repeated so that the next address is programmed.

Further software for the unit will be provided next month, and we will also take a look at an interesting low cost ready-made EPROM programmer.

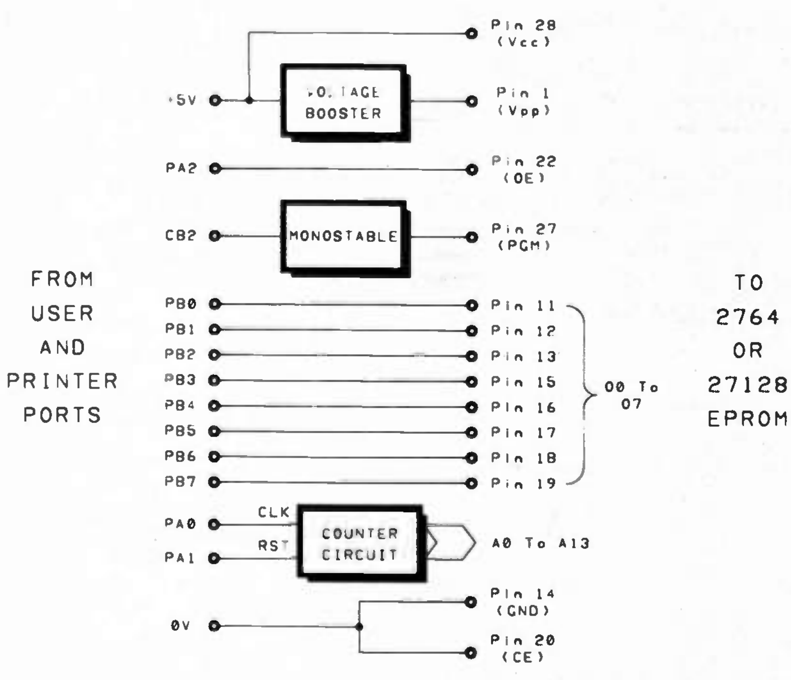


Fig. 3. Suggested method of driving the EPROM programmer from a BBC computer.

EPROM TEST PROGRAM

```
 10 REM BBC EPROM TEST PROG
 20 ?&FE62 = 255
 30 ?&FE63 = 255
 40 ?&FE6C = 224
 50 ?&FE61 = 6
 60 ?&FE61 = 4
 70 FOR X = 1 TO 23
 80 ?&FE60 = X
 90 ?&FE6C = 192
100 ?&FE6C = 224
110 FOR D = 1 TO 60:NEXT D
120 ?&FE62 = 0
130 ?&FE61 = 0
140 PRINT ?&FE60
150 ?&FE61 = 4
160 ?&FE62 = 255
170 ?&FE61 = 5
180 ?&FE61 = 4
190 NEXT X
```

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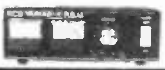

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8085 INSTRUCTION SET

Mnemonic	D7	D6	D5	D4	D3	D2	D1	D0	Operations Description
MOVE, LOAD, AND STORE									
MOVr1 r2	0	1	D	D	D	S	S	S	Move register to register
MOV M.r	0	1	1	1	0	S	S	S	Move register to memory
MOV r.M	0	1	D	D	D	1	1	0	Move memory to register
MVI r	0	0	D	D	D	1	1	0	Move immediate register
MVI M	0	0	1	1	0	1	1	0	Move immediate memory
LXI B	0	0	0	0	0	0	0	1	Load immediate register Pair B & C
LXI D	0	0	0	1	0	0	0	1	Load immediate register Pair D & E
LXI H	0	0	1	0	0	0	0	1	Load immediate register Pair H & L
STAX B	0	0	0	0	0	0	1	0	Store A indirect
STAX D	0	0	0	1	0	0	1	0	Store A indirect
LDAX B	0	0	0	0	1	0	1	0	Load A indirect
LDAX D	0	0	0	1	1	0	1	0	Load A indirect
STA	0	0	1	1	0	0	1	0	Store A direct
LDA	0	0	1	1	1	0	1	0	Load A direct
SHLD	0	0	1	0	0	0	1	0	Store H & L direct
LHLD	0	0	1	0	1	0	1	0	Load H & L direct
XCHG	1	1	1	0	1	0	1	1	Exchange D & E, H & L Registers
STACK OPS									
PUSH B	1	1	0	0	0	1	0	1	Push register Pair B & C on stack
PUSH D	1	1	0	1	0	1	0	1	Push register Pair D & E on stack
PUSH H	1	1	1	0	0	1	0	1	Push register Pair H & L on stack
PUSH PSW	1	1	1	1	0	1	0	1	Push A and Flags on stack
POP B	1	1	0	0	0	0	0	1	Pop register Pair B & C off stack
POP D	1	1	0	1	0	0	0	1	Pop register Pair D & E off stack
POP H	1	1	1	0	0	0	0	1	Pop register Pair H & L off stack
POP PSW	1	1	1	1	0	0	0	1	Pop A and Flags off stack
XTHL	1	1	1	0	0	0	1	1	Exchange top of stack, H & L
SPHL	1	1	1	1	1	0	0	1	H & L to stack pointer
LXI SP	0	0	1	1	0	0	0	1	Load immediate stack pointer
INX SP	0	0	1	1	0	0	1	1	Increment stack pointer
DCX SP	0	0	1	1	1	0	1	1	Decrement stack pointer
JUMP									
JMP	1	1	0	0	0	0	1	1	Jump unconditional
JC	1	1	0	1	1	0	1	0	Jump on carry
JNC	1	1	0	1	0	0	1	0	Jump on no carry
JZ	1	1	0	0	1	0	1	0	Jump on zero
JNZ	1	1	0	0	0	0	1	0	Jump on no zero
JP	1	1	1	1	0	0	1	0	Jump on positive
JM	1	1	1	1	1	0	1	0	Jump on minus
JPE	1	1	1	0	1	0	1	0	Jump on parity even
JPO	1	1	1	0	0	0	1	0	Jump on parity odd
PCHL	1	1	1	0	1	0	0	1	H & L to program counter
CALL									
CALL	1	1	0	0	1	1	0	1	Call unconditional
CC	1	1	0	1	1	1	0	0	Call on carry
CNC	1	1	0	1	0	1	0	0	Call on no carry

Mnemonic	D7	D6	D5	D4	D3	D2	D1	D0	Operations Description
CZ	1	1	0	0	1	1	0	0	Call on zero
CNZ	1	1	0	0	0	1	0	0	Call on no zero
CP	1	1	1	1	0	1	0	0	Call on positive
CM	1	1	1	1	1	1	0	0	Call on minus
CPE	1	1	1	0	1	1	0	0	Call on parity even
CPO	1	1	1	0	0	1	0	0	Call on parity odd
RETURN									
RET	1	1	0	0	1	0	0	1	Return
RC	1	1	0	1	1	0	0	0	Return on carry
RNC	1	1	0	1	0	0	0	0	Return on no carry
RZ	1	1	0	0	1	0	0	0	Return on zero
RNZ	1	1	0	0	0	0	0	0	Return on no zero
RP	1	1	1	1	0	0	0	0	Return on positive
RM	1	1	1	1	1	0	0	0	Return on minus
RPE	1	1	1	0	1	0	0	0	Return on parity even
RPO	1	1	1	0	0	0	0	0	Return on parity odd
RESTART									
RST	1	1	A	A	A	1	1	1	Restart
INPUT/OUTPUT									
IN	1	1	0	1	1	0	1	1	Input
OUT	1	1	0	1	0	0	1	1	Output
INCREMENT AND DECREMENT									
INR r	0	0	D	D	D	1	0	0	Increment register
DCR r	0	0	D	D	D	1	0	1	Decrement register
INR M	0	0	1	1	0	1	0	0	Increment memory
DCR M	0	0	1	1	0	1	0	1	Decrement memory
INX B	0	0	0	0	0	0	1	1	Increment B & C registers
INX D	0	0	0	1	0	0	1	1	Increment D & E registers
INX H	0	0	1	0	0	0	1	1	Increment H & L registers
DCX B	0	0	0	0	1	0	1	1	Decrement B & C
DCX D	0	0	0	1	1	0	1	1	Decrement D & E
DCX H	0	0	1	0	1	0	1	1	Decrement H & L
ADD									
ADD r	1	0	0	0	0	S	S	S	Add register to A
ADC r	1	0	0	0	1	S	S	S	Add register to A with carry
ADD M	1	0	C	0	0	1	1	0	Add memory to A
ADC.M	1	0	0	0	1	1	1	0	Add memory to A with carry
ADI	1	1	0	0	0	1	1	0	Add immediate to A
ACI	1	1	0	0	1	1	1	0	Add immediate to A with carry
DAD B	0	0	0	0	1	0	0	1	Add B & C to H & L
DAD D	0	0	0	1	1	0	0	1	Add D & E to H & L
DAD H	0	0	1	0	1	0	0	1	Add H & L to H & L
DAD SP	0	0	1	1	1	0	0	1	Add stack pointer to H & L
SUBTRACT									
SUB r	1	0	0	1	0	S	S	S	Subtract register from A
SBB r	1	0	0	1	1	S	S	S	Subtract register from A with borrow
SUB M	1	0	0	1	0	1	1	0	Subtract memory from A
SBB M	1	0	0	1	1	1	1	0	Subtract memory from A with borrow
SUI	1	1	0	1	0	1	1	0	Subtract immediate from A
SBI	1	1	0	1	1	1	1	0	Subtract immediate from A with borrow

Continued over

RS-232 waveforms

In most RS-232 systems, data is transmitted asynchronously. This simply means that it is transmitted as a series of "data packets". Each data packet comprises a single ASCII character and contains sufficient information for the character to be decoded without the need for a separate clock signal.

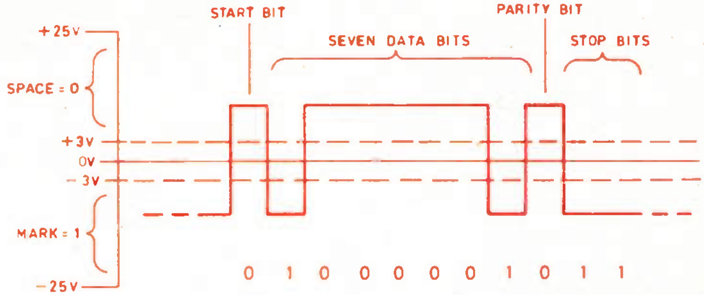
ASCII characters (see Data Card 2) are represented by seven binary digits (bits). The upper case letter "A", for example, is represented by the seven-bit binary word; 1000001. In order to transmit this character via an RS-232 system, we need to add extra bits to signal the start and end of the data packet. In addition, we may wish to add an extra bit to provide a simple parity error detecting facility.

One of the most commonly used schemes involves the addition of one start bit, one parity bit, and two stop bits. The commencement of the data packet is signalled by the start bit which is always low irrespective of the contents of the packet. The start bit is followed by the seven data bits representing the ASCII character concerned. A parity bit is added to make the resulting number of 1's in the group either odd ("odd parity") or even ("even parity"). Finally two stop bits are added. These are both high.

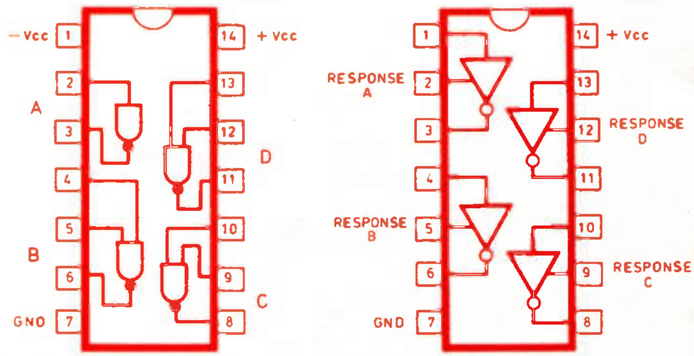
The complete asynchronously transmitted data word would thus comprise eleven bits (note that only seven of these actually contain data!). In binary terms the word can be represented as: 01000001011. In this case, even parity has been used and thus the ninth (parity bit) is a 0.

The voltage levels employed in an RS-232 system are quite different from those used to represent the digital signals within a microcomputer. A positive voltage (of between +3V and +25V) is used to represent a logic 0 (or "SPACE") whilst a negative voltage (of between −3V and −25V) is used to represent a logic 1 (or "MARK"). The figure shows how the ASCII character "A" would appear on RS-232 TXD or RXD lines.

The problem of level shifting and buffering from TTl to RS-232C signal levels (and vice versa) is accomplished using special "line driver" and "line receiver" chips, typical examples of which are the 1488 and 1489 devices.



ASCII character A as it appears on a typical asynchronous RS-232 serial data communications link.



Pin connections for the 1488 line driver and for the 1489 line receiver.

8085 INSTRUCTION SET (continued)

Mnemonic	D7	D6	D5	D4	D3	D2	D1	D0	Operations Description
LOGICAL									
ANA r	1	0	1	0	0	S	S	S	AND register with A
XRA r	1	0	1	0	1	S	S	S	Exclusive OR register with A
ORA r	1	0	1	1	0	S	S	S	OR register with A
CMP r	1	0	1	1	1	S	S	S	Compare register with A
ANA M	1	0	1	0	0	1	1	0	AND memory with A
XRA M	1	0	1	0	1	1	1	0	Exclusive OR memory with A
ORA M	1	0	1	1	0	1	1	0	OR memory with A
CMP M	1	0	1	1	1	1	1	0	Compare memory with A
ANI	1	1	1	0	0	1	1	0	AND immediate with A
XRI	1	1	1	0	1	1	1	0	Exclusive OR immediate with A
ORI	1	1	1	1	0	1	1	0	OR immediate with A
CPI	1	1	1	1	1	1	1	0	Compare immediate with A
ROTATE									
RLC	0	0	0	0	0	1	1	1	Rotate A left
RRC	0	0	0	0	1	1	1	1	Rotate A right
RAL	0	0	0	1	0	1	1	1	Rotate A left through carry
RAR	0	0	0	1	1	1	1	1	Rotate A right through carry

Mnemonic	D7	D6	D5	D4	D3	D2	D1	D0	Operations Description
SPECIALS									
CMA	0	0	1	0	1	1	1	1	Complement A
STC	0	0	1	1	0	1	1	1	Set carry
CMC	0	0	1	1	1	1	1	1	Complement carry
DAA	0	0	1	0	0	1	1	1	Decimal adjust A
CONTROL									
EI	1	1	1	1	1	0	1	1	Enable interrupts
DI	1	1	1	1	0	0	1	1	Disable interrupt
NOP	0	0	0	0	0	0	0	0	No-operation
HLT	0	1	1	1	0	1	1	0	Halt
NEW 8085AH INSTRUCTIONS									
RIM	0	0	1	0	0	0	0	0	Read Interrupt Mask
SIM	0	0	1	1	0	0	0	0	Set Interrupt Mask

NOTE:
1. DDS or SSS: B 000, C 001, D 010, E 011, H 100, L 101, Memory 110, A 111.

EE DATA CARD (8)

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