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DECEMBER 1988

INCORPORATING ELECTRONICS MONTHLY

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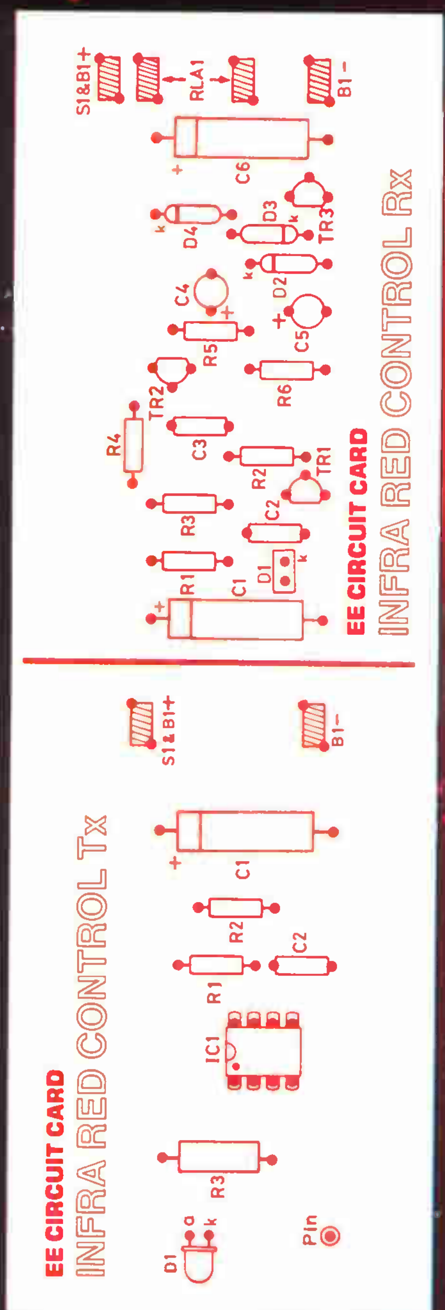

PERSONAL CASSETTE AMPLIFIER

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Special Oscilloscope Offer

PLUS FULL INDEX FOR 1988

The Magazine for Electronic & Computer Projects

VOL 17 No 12 DECEMBER '88

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

ABC

The Magazine for Electronic & Computer Projects

ISSN 0262–3617

PROJECTS . . . THEORY . . . NEWS . . .
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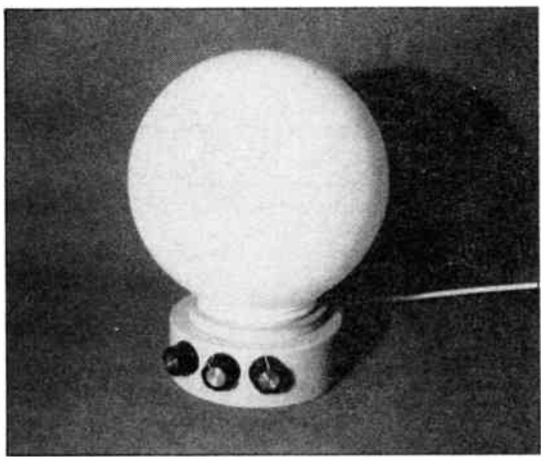


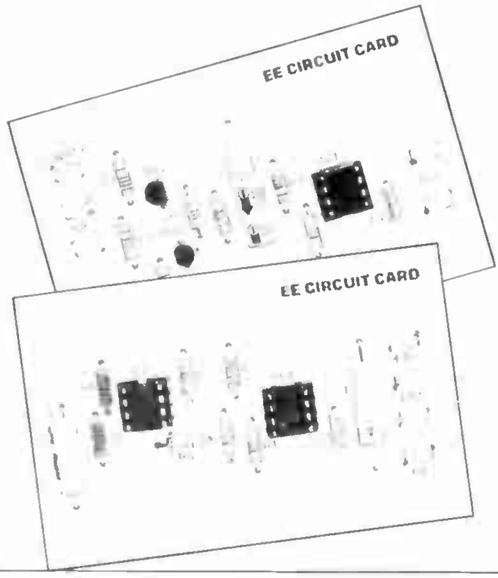
Our January '89 issue will be published on Friday, 2 December 1988. See page 687 for details.

Projects

Series

Features

FREE

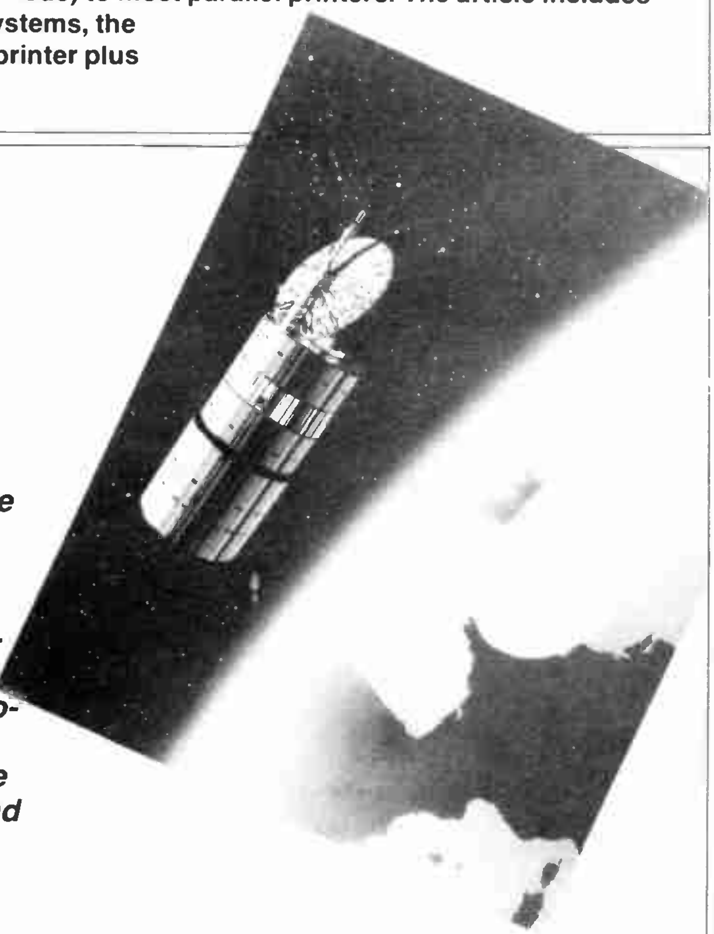


FREE CIRCUIT CARDS

Two more Circuit Cards will be attached to next month's issue of EE. These are similar to those that came with this issue but are for a Tilt Alarm and Siren. Once again they provide the chance to easily build a couple of simple solderless projects.

SPECTRUM PARALLEL PRINTER INTERFACE

A very simple interface—costing around £20 to build—that can link a Spectrum, Spectrum Plus or Spectrum 128 Plus 2 (in 48K mode) to most parallel printers. The article includes descriptions of parallel and serial systems, the functioning and timing of a parallel printer plus some user friendly software.



SATELLITE TELEVISION

Next year, small receiving dishes will begin to sprout on walls and roofs all over Europe to collect television programmes from space. Ian Graham reports on the technical progress and commercial competition in this new market-place. Has the dream of a single European system become a nightmare? Will the programmes be scrambled? Will Astra start and finish the race first?

EVERYDAY ELECTRONICS

JANUARY '89 ISSUE ON SALE DECEMBER 2

NEXT MONTH

MAGENTA ELECTRONICS Ltd

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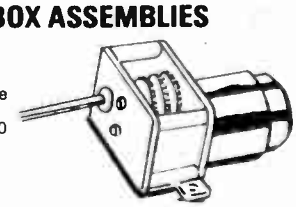

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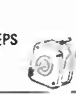

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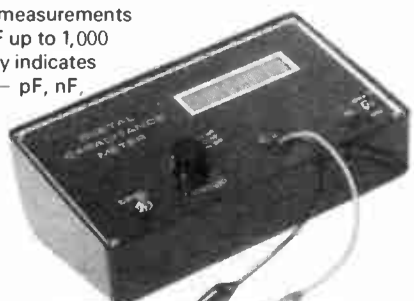

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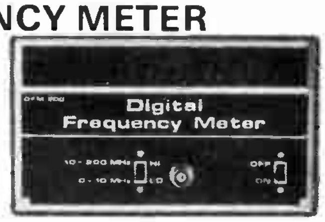

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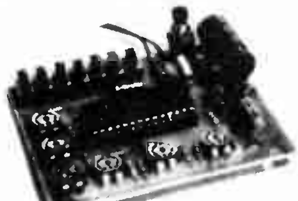

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ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL. 17 No. 12 **December '88**

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CIRCUIT CARDS

EVERY so often a new constructional method comes along which changes the face of hobbyist projects. I well remember as an apprentice back in the early sixties when Veroboard came out. It revolutionised the hobby almost overnight. For the first time hobbyists could produce projects using a form of printed circuit board—actual p.c.b.s for hobbyists did not appear until many years later.

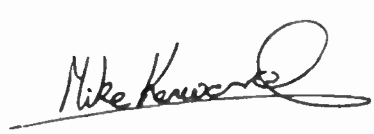
Now we have a solderless method of construction—again from Vero. Easiwire and various projects using this system are catching on fast—particularly in education where the absence of soldering is a particular advantage. Over the next few months we will bring you a range of eight projects designed to be built with the Easiwire system. You could of course build them up on plain matrix board with soldered connections if you so wish.

Obviously these projects will appeal particularly to those with little contructional experience since they eliminate one of the areas which can cause problems. We hope that our Free Circuit Cards will make construction of these projects virtually foolproof. To help a little further we have arranged a £1 off the Easiwire Kit from BICC-Vero—see page 703.

OFFERS

While on the subject of Special Offers to EE readers don't miss this month's 'Scope Offer (page 729). We know this type of equipment is rather expensive but this offer represents a good saving on the normal price and, of course, the 'Scope is one of the most useful and versatile items of equipment anyone interested in electronics could wish to own.

These Hameg 'Scopes are guaranteed for two years and should provide many, many years of reliable service to both hobbyists and professionals alike.



SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £14.50. Overseas: £17.50 (£34 airmail). Cheques or bank drafts (**in £ sterling only**) payable to Everyday Electronics and sent to EE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. **Subscriptions can only start with the next available issue.** For back numbers see below.

BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS are available price £1.50 (£2.00) overseas surface mail—£ sterling only please) inclusive of postage and packing per copy. Enquiries with remittance, made payable to Everyday Electronics, should be sent to Post Sales Department, Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH. In the event of non-availibility remittance will be returned. *Please allow 28 days for delivery.* **We have sold out of Sept., Oct., & Nove. 85, April, May & Dec 86, Jan., Feb., April, May, Nov. 87, Jan., March & April 88).**

BINDERS

Binders to hold one volume (12 issues) are available from the above address for £4.95 (£9.00 overseas surface mail) inclusive of p&p. *Please allow 28 days for delivery.*
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READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self-addressed envelope and international reply coupons.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

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We would like to advise readers that certain items of radio transmitting equipment which may be advertised in our pages cannot be legally used in the U.K. Readers should check the law before using any transmitting equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use.

The law relating to this subject varies from country to country; overseas readers should check local laws.

PHASOR

ANDY FLIND

*A light effects unit (up to 100W) with a difference. Suitable for parties, games, meditation or just plain relaxing. Ideal companion for the **"Seashell Sea Synthesiser"** described last month.*

OVER the last few months, the author has spent much time experimenting with electronic lighting effects. Up to four channels of coloured lights have been tried in various arrangements, operated by signal generators and filtered sound. During this work, it emerged that one of the most attractive effects consisted of a single bulb, either coloured or plain, placed inside one of those white translucent globes so often seen suspened from ceilings. The effect obtained is very pleasant and has so many possible uses that a special project especially for it seemed worthwhile.

With this project the globe is taken from its original fitting and placed "upside down" on a base, and the lamp is driven by a circuit that causes its brilliance to rise and fall slowly and continuously, at speeds from once every two seconds to once in twenty seconds or so. The speed of the effect, its depth and the overall brightness are all independently adjustable for a wide variety of possible effects. Apart from the attraction of the lamp itself, much fun can be had from simply playing with the controls.

BLOCK DIAGRAM

As the circuit is quite complex, the description will begin with a block diagram, Fig. 1, which shows the general principle of operation. The well-known "phase-angle" power control method is used, similar to most dimmer switches, but it is voltage-controlled. A zero-crossing detector provides a short pulse each time the mains voltage crosses zero, and this resets a ramp generator. The ramp output is compared to the internally generated control signal, and the comparator controls the load through a triac.

As phase-angle dimmers produce a fair amount of r.f. noise, suppression is fitted to keep this from entering the mains wiring. Low-voltage power for the electronics is supplied from a capacitive "dropper" circuit. The control signal is a slow, approximately sine-shaped voltage as this gives the best effect. Whilst a triangular waveform is easier to generate, the "corners" are clearly visible in the light output and spoil the smoothness of the effect.

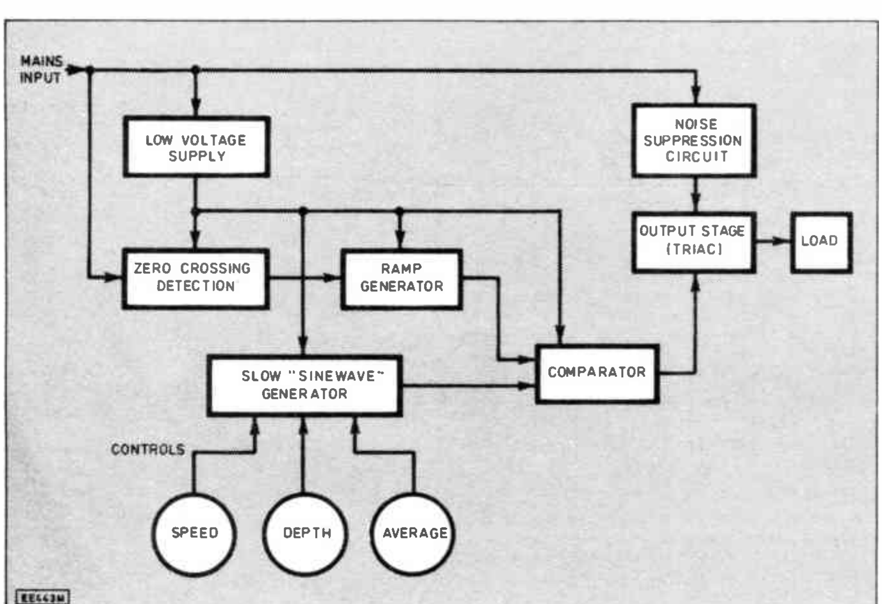
WAVEFORMS

The internal waveforms of the circuit are shown in Fig. 2. Diagram (a) shows the waveform of the 50Hz a.c. mains supply, (b) is the output from the zero crossing detector, though in practice the pulses are much shorter than shown. Note how they "straddle" the zero crossings so that drive to the triac is removed just before zero, allowing it to turn off reliably. The ramp waveform appears at (c), and again at (d), this time together with a steady signal voltage, these two being the inputs to the comparator stage.

The outputs from comparator and triac are shown in (e) and (f). In this example the input signal at (d) and corresponding output power to the load at (f) are both about fifty percent of their range.

Like most really effective circuits, this one is fairly complex. None of the parts are particularly expensive though, and the completed board is fairly compact. A detailed description of the full circuit, Fig. 3, follows.

Fig. 1. Block diagram for the Phasor light effects "globe".



CIRCUIT

To begin with, a source of regulated power for the low-voltage electronics is necessary. The triac to be used, a C206D device, has been found by the author to trigger more reliably when operated with negative gate drive. Since this must be delivered with respect to the neutral side of the mains, a single negative supply rail is used instead of the more usual positive one.

The low voltage is obtained from the live side of the mains, using the reactance of C1 to limit current flow. Positive half-cycles pass through D1 to neutral, negative ones flow through D2 into C3. At about 12 volts, Zener D3 conducts, returning further current to neutral. The unused current in this type of "dropper" circuit is almost purely reactive; it doesn't cause heat as a resistor would, and should not increase the electricity bill.

IC1 is a 5 volt negative voltage regulator feeding decoupler C4. This is the power supply section of the circuit, providing negative supplies of about 12 volts with crude regulation for the output stage and a well-regulated 5 volts for everything else.

ZERO CROSSING

The zero-crossing detection is carried out by TR1 and IC2, a CMOS 4011B. A small current flows directly from live through R3 with a slight forward phase shift introduced by C2. During negative half-cycles it flows to neutral through the base-emitter junction of TR1, turning it on, during positive half cycles it flows through D4 and the transistor is turned off. The collector of this transistor is thus alternatively high and low, the changeovers occurring just before the mains zero crossings. This signal drives IC2, a quad "NAND" gate device.

Gate "a" buffers (and inverts) the signal, gate "b" inverts it again. Each drives an input of gate "c" through a differentiator. The inputs of "c" are normally high, but each time the collector of TR1 changes state one of them is pulled briefly low, causing a short positive pulse to appear at the "c" output. This is inverted again by "d", giving a similar but negative-going pulse. With the component values shown the output pulses are theoretically about 400µS long and almost centred over the zero crossings.

These pulses turn on TR2, which charges C9. R8 discharges C9 by about a volt during the 10mS of each mains half-cycle. As this is only a small part of the C9/R8 time constant, the resulting ramp waveform is fairly linear. C10, R10, and R11 correct the d.c. voltage so that the average level of the ramp is half the supply voltage.

CONTROL SIGNAL

Ramp generation forms one side of the circuit, whilst the other is concerned with control signal generation. This is based around IC3, a TL064 quad op-amp. This particular device sports both low current consumption and high input impedance, both useful in this design. The first amplifier, "a", provides a low impedance mid-rail reference. "b" is an integrator, giving an output which ramps at a speed and direction depending on the input voltage to R17. It drives IC4, a "Schmitt trigger" with hysteresis of about 2 volts. The 3130 is used here instead of a TL064 amp because its output switches all the way to both supply rails.

Input for the integrator is taken from the 3130 through VR1, giving frequency adjustment from about one cycle per second to about one in every twenty seconds. The control is practically linear, making it easy to adjust. Output from this stage is a triangle wave but, as mentioned earlier, a sinewave is better for this application. IC3 "c" shapes the triangle, through non-linear feedback from diodes D5 and D6, into something similar to a sinewave in appearance, of about a volt peak to peak.

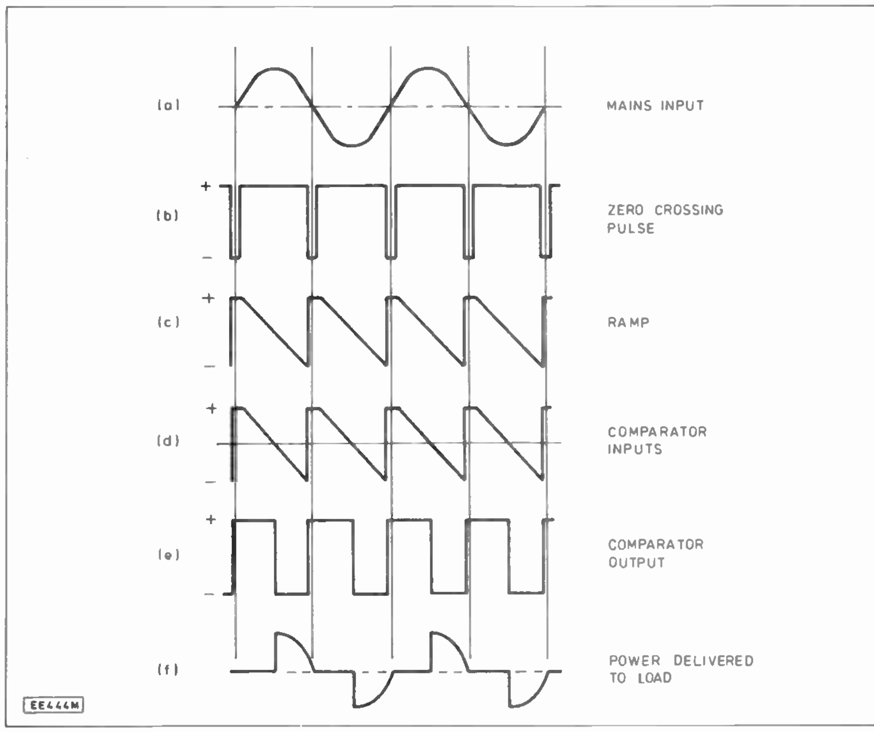
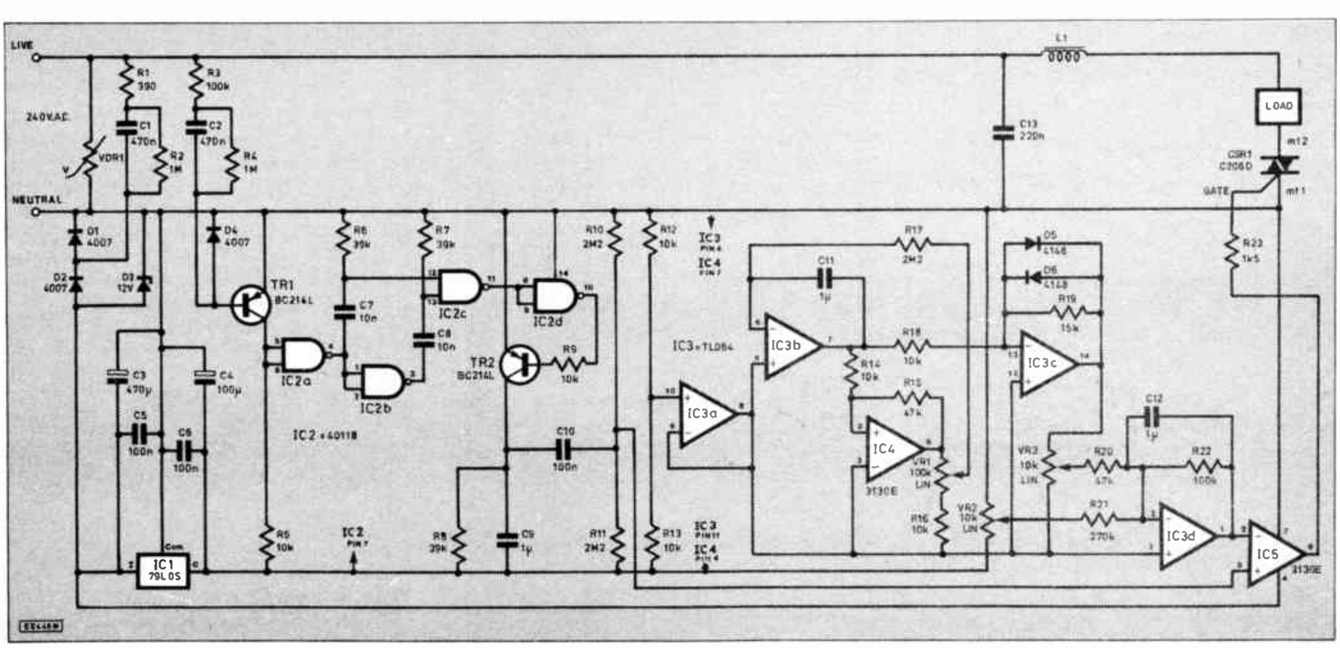


Fig. 2. Waveforms in Phasor circuit, at about half power.

The last of the four TL064 amps, IC3 "d", sets up the signal to the comparator. The "sinewave" input arrives via "depth" control VR3, allowing the fading effect to be varied from zero to overdrive, where the lamp virtually flashes instead of fading. An adjustable constant d.c. input from VR2 controls overall lamp brilliance. The outputs of this stage and the ramp generator go to comparator IC5 which drives the triac CSR1. IC5 is another 3130, they make excellent comparators. It is supplied directly from the 12 volt rail to improve the triac drive.

Suppresion is supplied by choke L1 and capacitor C13 to keep r.f. radiation to a minimum, and a transient suppressor VDR1 is included to protect the triac from any high voltage spikes in the mains supply.

Fig. 3. Complete circuit diagram for the Phasor lamp driver.



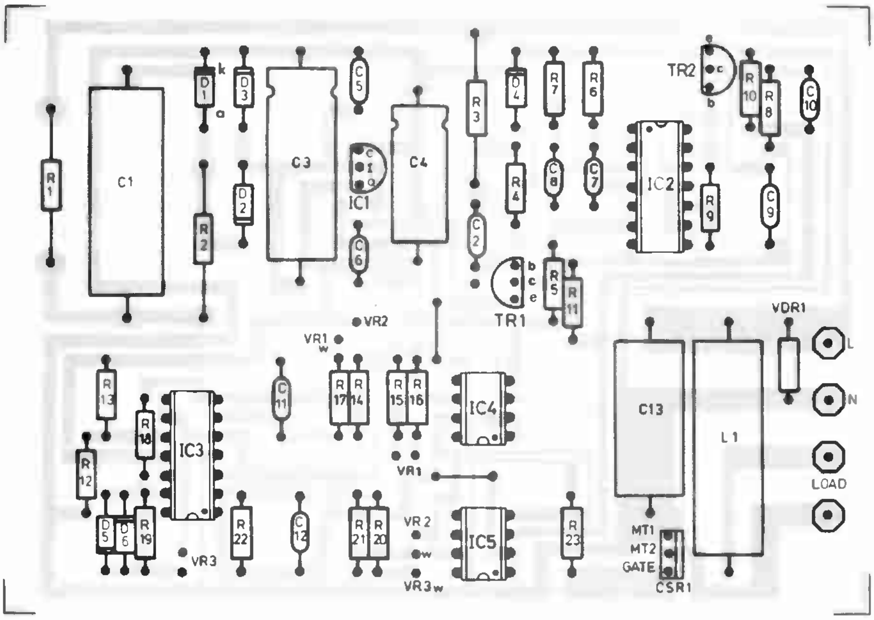
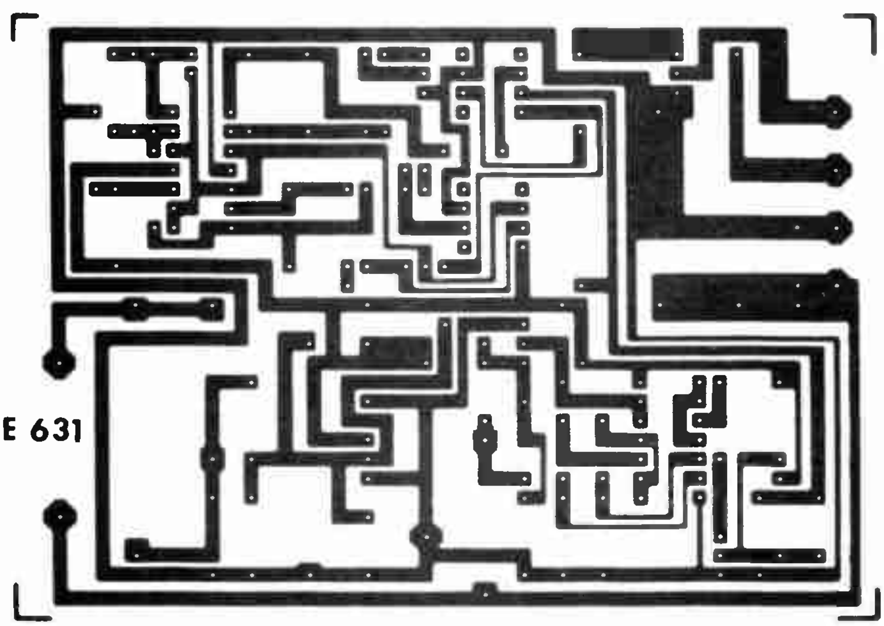
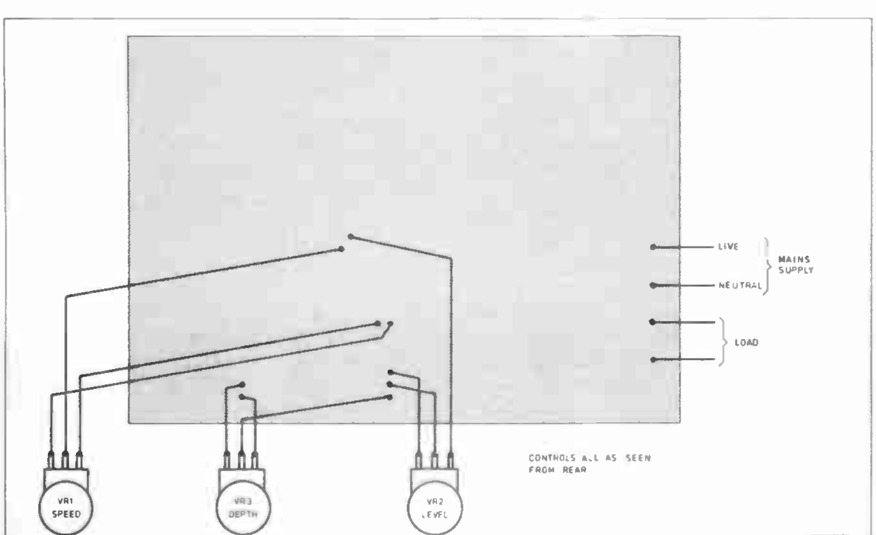


Fig. 4. Printed circuit board component layout and (below full size copper foil master pattern for the Phasor.



EE 631

Fig. 5. Interwiring from the circuit board to the "effects" controls.



COMPONENTS

Resistors

R1	390 1W
R2	1M 1W
R3	100k 1W
R4	1M
R5, R9, R12 to R14, R16, R18	10k (7 off)
R6 to R8	39k (3 off)
R10, R11, R17	2M2 (3 off)
R15, R20	47k (2 off)
R19	15k
R21	270k
R22	100k
R23	1k5

All 0.6 watt 1% except R1, R2, R3

Potentiometers

VR1	100k carbon lin. rotary
VR2	10k carbon lin. rotary
VR3	10k carbon lin. rotary

All plastic mounting bush and plastic spindle type

Shop Talk
See page 702

Capacitors

C1	0.47µ 250V mains suppression type
C2	470n polyester layer
C3	470µ axial lead elect. 25V
C4	100µ axial lead elect. 10V
C5, C6, C10	100n polyester layer (3 off)
C7, C8	10n polyester layer (2 off)
C9, C11 C12,	1µ polyester layer (3 off)
C13	0.22µ 250V mains suppression type

Semiconductors

D1, D2, D4	1N4007 silicon diode (3 off)
D3	BZX61C12 12V 1.3W Zener
D5, D6	1N4148 silicon diode (2 off)
TR1, TR2	BC214L *pnp silicon* transistor (2 off)
CSR1	C206D 3A 400V triac
IC1	*µA79LO5 −5V 100mA regulator*
IC2	*4011B CMOS Quad 2-input NAND gate*
IC3	*TL064 Quad BI-FET op-amp*
IC4	*CA3130E CMOS*
IC5	*Op-amp (2 off)*

Miscellaneous

VDR1 mains transient suppressor; suppressor choke, 3A; Printed circuit board available from the *EE PCB Service,* order code **EE631**; d.i.l. sockets 8-pin (2 off); d.i.l. sockets 14-pin (2 off); plastic control knobs (3 off).

Approx. cost Guidance only **£20**

CONSTRUCTION

Construction of this project is quite straightforward and should cause no special problems. Fig. 4 shows the component layout. The usual "height order" of component assembly is recommended, i.e. the tallest components go in last, simply because it makes things easier. Sockets should be used for all i.c.s except the regulator. Do not fit IC2 to IC5 or the triac at this stage. These will be fitted during testing.

Do PLEASE note that the i.c.s at the bottom of the board, that is numbers 3, 4 and 5, are positioned "head down", with pin one at the bottom. It's very easy to forget this when plugging them in later. Check the completed board carefully for errors, solder bridges etc., especially around the track that will carry mains live along the top.

TESTING

The following test procedure is strongly recommended. The infamous "Murphy's Law" often seems to be most active in the home constructor's workshop, so anything that helps thwart it should not be overlooked. In the prototype, the following checks revealed a faulty triac and incorrectly fitted TR2; even designers are not immune from Murphy!

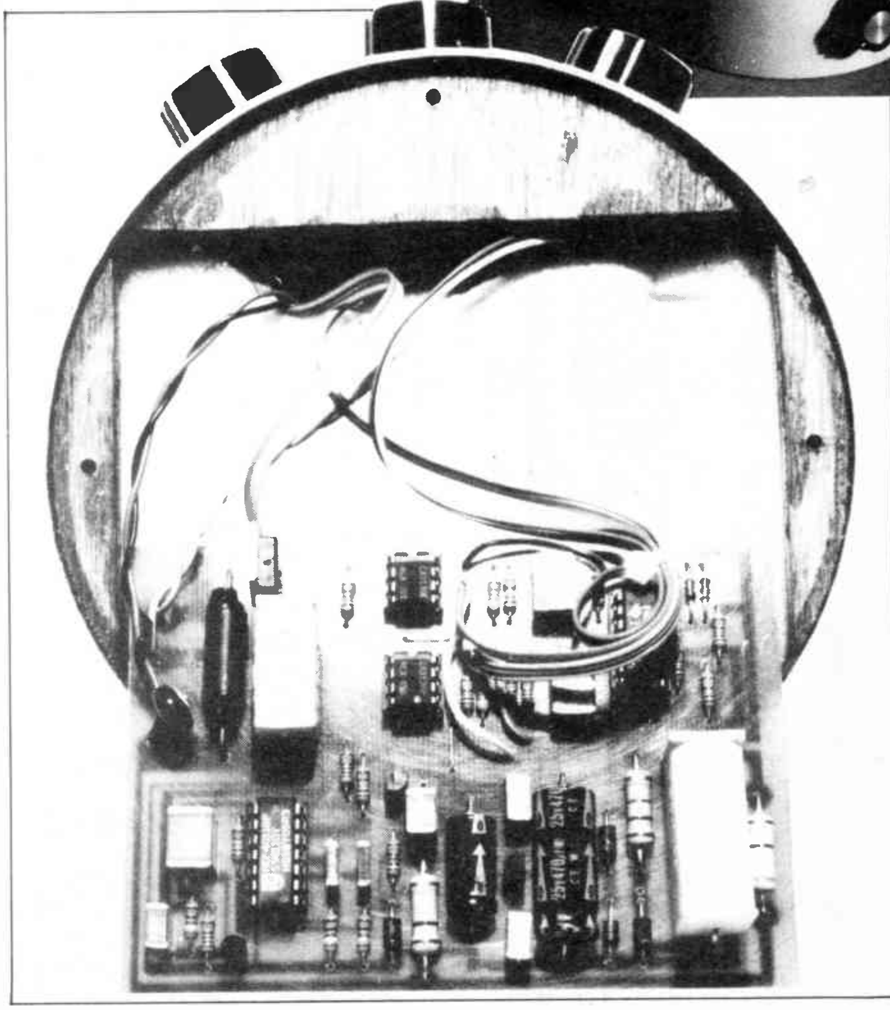
Useful testing can be carried out safely with a low-voltage supply, but some checks must be made with the project connected to the mains. ***When the mains supply is on, the whole must be treated with the greatest of care, all parts being treated as though they are LIVE. It is best to connect the test meter before plugging in.***

Testing should begin without i.c.'s (except regulator IC1) or the triac fitted. The transistors, however, should be in place, especially TR1. With no mains connection a 9 volt supply, such as a PP3 battery, can be connected across the 470μF capacitor C3. At this voltage Zener D3 should not conduct, so after a brief initial surge the drain should settle to about 2.5mA. Check the voltage across C6, which will be 5V if the regulator is working. If so disconnect the battery and connect the mains supply and (**with care!**) check the voltages across C3 and C4, about 11.5V and 5V respectively.

This completes the power supply tests, though a further useful check (again **with care**) whilst connected to mains is the voltage across R5, which should average 2.5V since this transistor is "on" half the time. Remember that the loading of your meter may have some effect, though.

With the board disconnected from the mains connect up the control pots as shown in Fig. 5 and plug in IC3 and IC4, the TL064 and the upper 3130. Note that these, and IC5, are orientated "upside-down". Reconnect the 9 volt battery supply to C3, and note the drain, which should now be about 3.5mA. If so, test between the negative side of C4 and pin 2 of IC5's empty socket, (second one up, right-hand side) with a meter on the 10 volt range. Turn the "depth" control VR3 right down (anti-clockwise), and observe the effect of "level" control VR2. This should allow adjustment of the voltage between about 1.5 and 3.5V. Set it to 2.5V, set the "speed" control VR1 somewhere near the top of its range, and advance the "depth" control VR3. The output should swing symmetrically about the original point, to a maximum of about 0.75V either way.

If all seems well disconnect the battery and fit the remaining two i.c.s (remember, the 3130 head down, the 4011 right way up), solder in the triac, attach a suitable load, such as a 100W light bulb, and **with care** try the completed board. If all is well it will be possible to adjust the pots—**do not touch any metal parts of the circuit or the pots as they must be treated as live at all times**—to obtain various speeds and depths of auto-fading action.



(above) The circuit board removed from the base of the "globe".

FAULT FINDING

Some tests that may help if it doesn't work follow. In the author's experience, triacs usually blow short circuit, so if the light will not dim this may be the problem. IC2 "a" and "b" should be switching in time with the signal from TR1, so their outputs, pins 4 and 3 respectively, can be checked for an average of 2.5V against the negative end of C4.

The output of "c" is a series of very short pulses, so it will measure only a fraction of a volt above negative. Output "d" is its inverse, and should, therefore, be a fraction below 5V. The voltage across C9 will be just below 4.5V. If these checks have to be made, take care as **all parts of this circuit must be treated a "live" whilst connected to the mains.**

At this point you will have, hopefully, a working *Phasor* circuit board. The maximum load should not exceed about 100W, resistive of course, such as a lightbulb, though the limit is set mainly by the lack of a heatsink for the triac. If this is moved off the board and fitted with a heatsink the specified device should be able to handle up to 500W with ease.

Applications for the board are limited only by imagination. It can be either boxed on its own with a socket outlet or incorporated into a lamp as an integrated unit.

It is essential that the unit is completely encased in a plastic or other fully insulated case and that the specified plastic style potentio meters and fixings are used. No part of the circuit should be exposed in any way.

IN USE

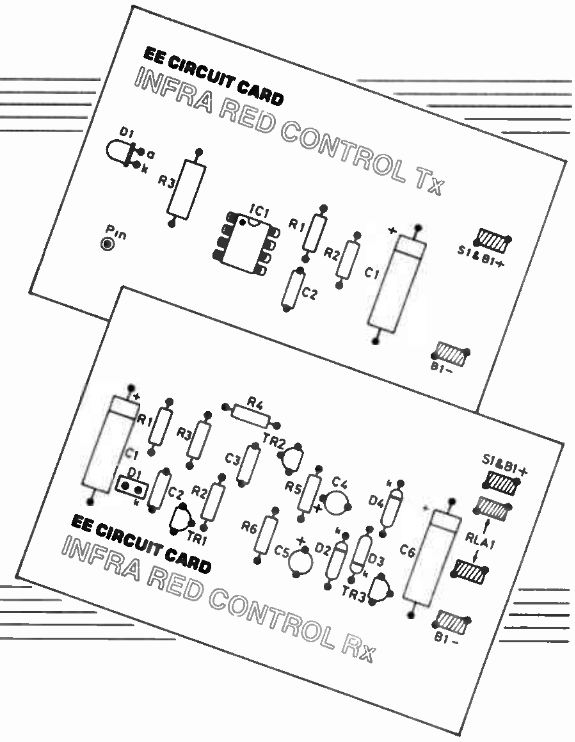
The prototype has a wooden base containing the board and controls, with a white globe on top as mentioned earlier. The effects obtainable range from a simple table lamp with dimmer control ("depth" turned right down) to something that appears straight out of "Dr. Who", enhancing the constructor's reputation as a "Mad Professsor"! Sound effects help here, such as the stereo "wave sounds" of another of the author's projects (published last month).

For those who practise meditation, the slowly pulsating light can be very relaxing, and at the opposite end of this scale it could be used in eye-catching advertising displays. Parties might benefit from it as a form of simple disco lighting, in fact it might even find a use in commercial discos if the triac is mounted off-board with suitable heat sinking.

As a final suggestion, the author recently wandered into an exhibition of palm-readers, fortune-tellers and the like. Almost all of these worthies were equipped with desk lights consisting of small white globes, of the kind described here, in china mounts shaped either as hands or snakes. At the time this project was under development and the effect it could have added was easy to imagine. The possible uses for this project really are almost unlimited. □

Circuit Card Project

I.R. REMOTE CONTROL



ROBERT PENFOLD

The first two projects in a set of eight that will use the Free Circuit Cards and BICC—Vero Easiwire solderless connection system.

A FEW years ago remote control systems were almost invariably of the ultrasonic variety, but these days infra-red systems are probably more common. They are generally less vulnerable to spurious triggering, and are less likely to annoy your pets! They can also carry quite complex forms of modulation. Their only real drawback when compared to ultrasonic systems is that the range is usually somewhat less, although for many applications a range of only a few metres is required. This is easily achieved using an infra-red system.

EASIWIRE

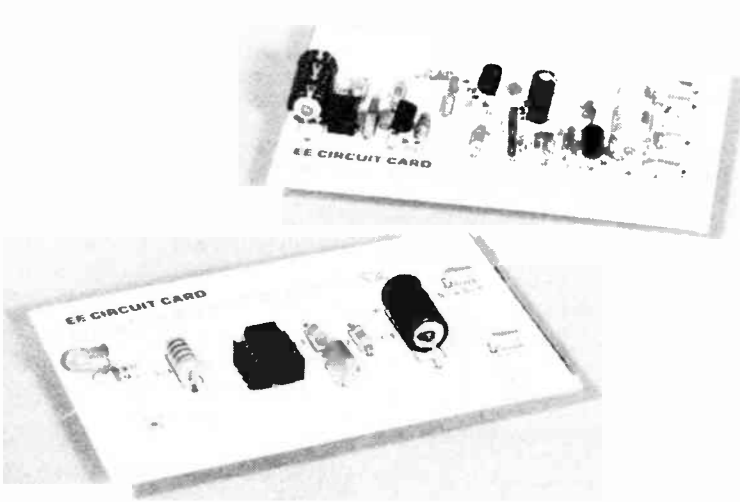
This infra-red remote control system has been kept as simple as possible so that it can easily be built using the BICC Vero Easiwire system (and the **Free *EE* Circuit Cards** supplied with this issue) by complete beginners to electronics contruction (see page 703 for information on using the Circuit Cards).

If you are not familiar with the Easiwire method of construction, its main claim to fame is that it is totally solderless. Despite the lack of any "proper" joints, it nevertheless provides neat and strong results that are suitable for most purposes. Refer to the June 1988 issue of *Everyday Electronics* for a full review of the Easiwire system.

CONTROL SYSTEM

The range of this control system depends on the emitter device used in the transmitter, and is around two to three metres using a wide-angle device, or about four to five metres using a narrow beam type. Although a narrow beam device gives better range, the aim of the transmitter must be quite accurate, especially when the system is operated close to its maximum range.

The unit provides a basic on/off action, where opening and closing a switch on the transmitter results in the contacts of a relay in the receiver switching on and off in sympathy. The system is suitable for simple remote control applications such as control of a small model car or boat. The equipment could also be used as a broken-beam type sensor for a burglar alarm system.



THE SYSTEM

In theory it is possible to have a d.c. system, where the signal from the transmitter is detected by a photocell at the receiver, and the photocell drives an amplifier which in turn drives the relay. In practice such a system is unusable as it provides a totally inadequate range. Boosting the sensitivity to improve range simply results in frequent spurious operations of the system.

The main problem is that of a certain amount of background infra-red signal. This background level could easily be strong enough to swamp the signal from the transmitter. There is also a problem with the inevitable drift that occurs in high gain d.c. amplifiers. An inordinate amount of readjustment could be needed with a sensitive d.c. coupled circuit.

Infra-red remote control systems normally use some form of pulse signal, and this one is no exception. The block diagram of Fig. 1 shows the basic arrangement of the system.

TRANSMITTER

The basic transitter signal is generated by an audio frequency oscillator. The exact operating frequency is not important, and anywhere in the upper regions of the audio range will suffice. Higher frequencies are less than ideal as the photocells and other parts of the unit will operate at less than optimum efficiency at these frequencies. Lower frequencies could make the equipment a bit sluggish in operation, and would make it relatively difficult to combat the background infra-red noise.

An l.e.d. converts the electrical pulses from the oscillator into pulses of infra-red radiation. This component is very much the same as the l.e.d.s used in clock displays etc., but its output is just outside the visible-red part of the spectrum and into the infra-red zone. It provides no significant visible light output, and does not noticeably glow when activated. In order to give an adequate output level the l.e.d. must be driven at a high current, and it is, therefore, driven from the oscillator via a buffer amplifier.

RECEIVER

The photocell at the receiver is a photo-diode. This is a type designed specifically for applications such as remote control systems. It has a spectral response that matches the output wavelengths of the l.e.d. at the transmitter, and it is a large area device that provides good sensitivity. At least, it provides good sensitivity by photo-diode standards.

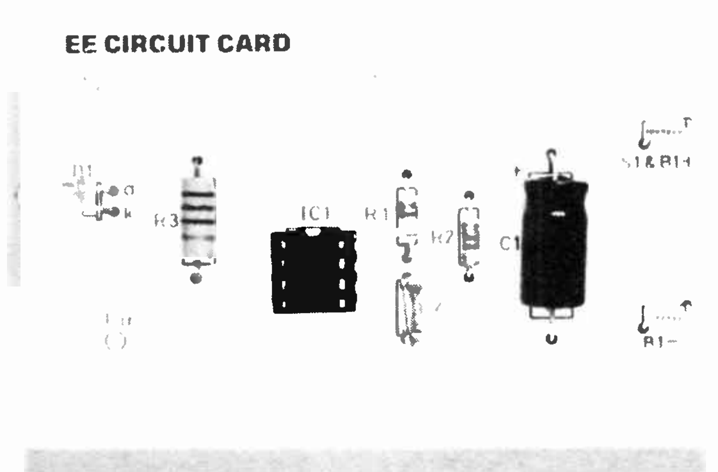
It still only provides an extremely low level output signal which must be amplified by a considerable amount in order to give sufficient drive to operate a relay. Most of this gain is provided while the signal is still in pulse form, and it is provided by two high gain amplifier stages.

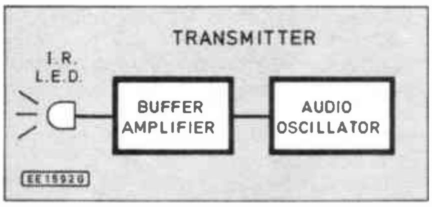
Under most circumstances the background infra-red noise level is not a problem. Reasonably constant infra-red signals will not affect the unit. It is only those that, like the signal from the transmitter, are amplitude modulated that will interfere with the unit by holding the receiver in the activated state.

The only likely source of such a signal is the 100 Hertz modulated signal produced by mains powered filament bulbs. As this is at a much lower frequency than the signal from the transmitter, some simple highpass filtering is all that is needed to remove any mains "hum" picked up by the photo-diode.

The output from the second high gain amplifier is fed to a rectifier and smoothing circuit. With a suitable input signal present, the output from rectifier circuit is a series of positive pulses. These are smoothed to produce a reasonably steady positive d.c. signal that can drive the relay.

The relay is controlled via an electronic switch that also provides a large amount of d.c. amplification. This enables the relatively weak output signal from the smoothing circuit to drive virtually any relay having a suitable coil voltage. A relay is merely a switch that is operated by an electromagnet, and its switch contacts are connected in one of the supply leads of the equipment which is to be controlled by the system.





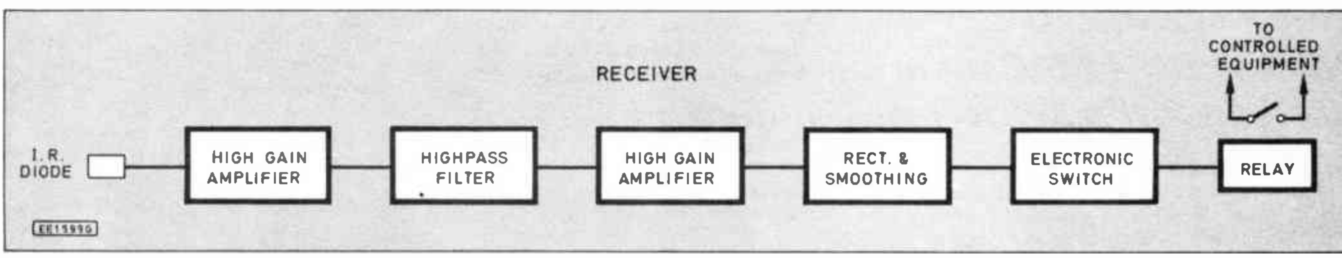


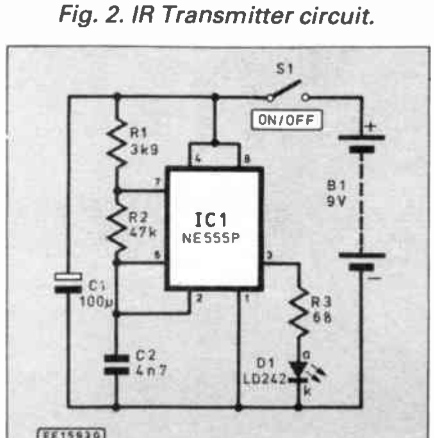
Fig. 1. Block diagram to show the operation of the IR Remote Control.

Of course, in the absence of any signal from the transmitter, the output from the second amplifier is only a low level noise signal, and the d.c. output from the smoothing circuit is inadequate to drive the electronic switch properly. Consequently, the relay (and the controlled equipment) are only switched on when the transmitter is activated.

TRANSMITTER CIRCUIT

The transmitter circuit is shown in Fig. 2, and as will be apparent from this, it uses very few components. It is based on the indispensible 555 timer integrated circuit. In this case it is operated in the standard astable (oscillator) configuration, and its output frequency is controlled by timing components R1, R2 and C2. They give an output signal with a mark-space ratio of roughly 1:1. In other words, the "on" periods of the l.e.d. (D1) are roughly equal to the "off" periods.

Fig. 2. IR Transmitter circuit.



Resistor R3 controls the output current to D1, and it sets this current at a little under 100 milliamps. However, as D1 is switched off for about 50 per cent of the time the average

COMPONENTS

TRANSMITTER

Shop Talk
See page 702

Resistors
R1 3k9
R2 47k
R3 68
All 0.25W 5% carbon except R3 (0.5W)

Capacitors
C1 100µ axial elect. 10V
C2 4n7 polyester (7.5mm pitch)

Semiconductors
IC1 NE555P timer
D1 LD242 high power IR l.e.d.

Miscellaneous
S1 s.p.s.t. sub-min toggle or push to make type (see text)
B1 9 volt (PP3 size)
Battery connector; 8 pin d.i.l. i.c. holder; case (see text); *EE Circuit Card* or Easiwire board; wire; Easiwire connectors; etc.

Approx. cost Guidance only **£3** *plus case*

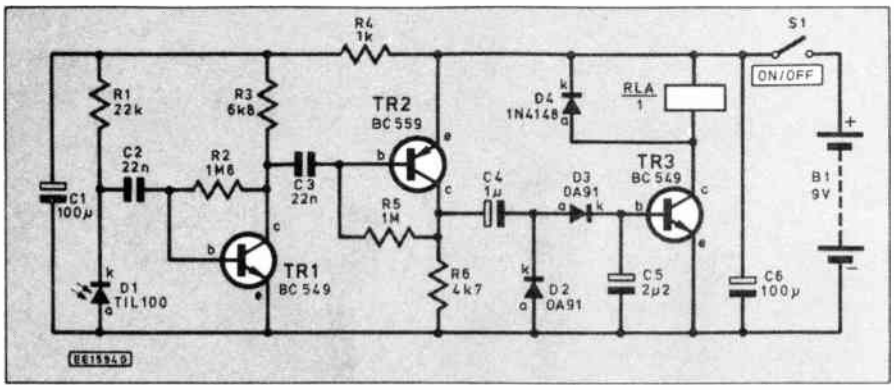


Fig. 3. IR Receiver circuit.

l.e.d. current is just under 50 milliamps. IC1 has a built-in output stage that enables these relatively high currents to be handled without the need for any external amplification.

RECEIVER CIRCUIT

The full circuit diagram for the receiver section of the system is shown in Fig. 3. D1 is the photo-diode, and it is used here in the reverse bias mode. R1 provides the reverse bias, and normally the current flow through D1 is only a minute leakage current. However, when it receives each pulse of infra-red radiation from the transmitter a pulse of increased current flows through the circuit. This generates small voltage pulses at the junction of R1 and D1, and these are coupled to the input of the first amplifier by C2.

Transistors TR1 and TR2 act as the basis of the two high gain amplifiers, and these are both common emitter stages. They are a.c. coupled and use the same basic configuration, but the first amplifier uses an n.p.n. device whereas the second is based on a p.n.p. type. They each provide a voltage gain of more than 40dB (one hundred times). The highpass filtering is obtained by using fairly low values for coupling capacitors C2 and C3. This gives simple two pole filtering, which is adequate for present purposes.

COMPONENTS

RECEIVER

Shop Talk
See page 702

Resistors
- R1 22k
- R2 1M8
- R3 6k8
- R4 1k
- R5 1M
- R6 4k7

All 0.25W 5% carbon film

Capacitors

C1, C6	100µ axial elect. 10V (2 off)
C2, C3	22n polyester 7.5mm pitch (2 off)
C4	1µ radial elect. 63V
C5	2µ2 radial elect. 63V

Semiconductors

TR1, TR3	BC549 silicon *n.p.n.* (2 off)
TR2	BC559 silicon *p.n.p.*
D1	TIL100 IR photo-diode
D2, D3	OA91 germanium signal diodes (2 off)
D4	1N4148 silicon signal diode

Miscellaneous

RLA1	6 volt relay with a coil resistance of 200 ohms or more, and contacts as required (see text)
S1	s.p.s.t. sub-min toggle switch
B1	9 volt battery (six HP7 size cells in plastic holder)

Battery connector; case (see text); *EE* Circuit Card or Easiwire *board; wire; Easiwire connectors; etc.*

Approx. cost Guidance only **£8** *plus case*

Diodes D2 and D3 are the rectifier circuit, and C5 is the smoothing capacitor. The output of this circuit drives a common emitter switch (TR3) which has the relay coil as its collector load.

When the relay is de-energised a high reverse voltage can be generated across the coil. D4 effectively short circuits this voltage spike and prevents it from damaging any of the components in the unit. C1, R4, and C6 are a supply decoupling network. These prevent low frequency instability due to feedback through the supply lines.

CONSTRUCTION

Details of the transmitter board and small amount of hard wiring are shown in Fig. 4. Equivalent details for the receiver unit are provided in Fig. 5. If the circuits are to be built on the *EE* Circuit Cards supplied with this issue rather than on pieces of the standard plastic Easiwire matrix board, then construction is much easier because the Cards are marked with component positions *and* the underside wiring. This makes it relatively difficult to make careless errors when constructing the boards. Despite this, you must still take reasonable care when fitting the components onto the boards. Make sure you read page 703 *Using The EE Circuit Cards* before starting construction.

Start with the transmitter board which is the more simple of the two. With Easiwire construction all the components are fitted onto the board and then they are wired up. Take care to fit C1 the right way round.

With the axial (horizontal mounting) electrolytics the correct orientation is shown by an identation around the body of the component (which indicates the "+" terminal). The shorter leadout of D1 in the transmitter is its cathode ("k") terminal.

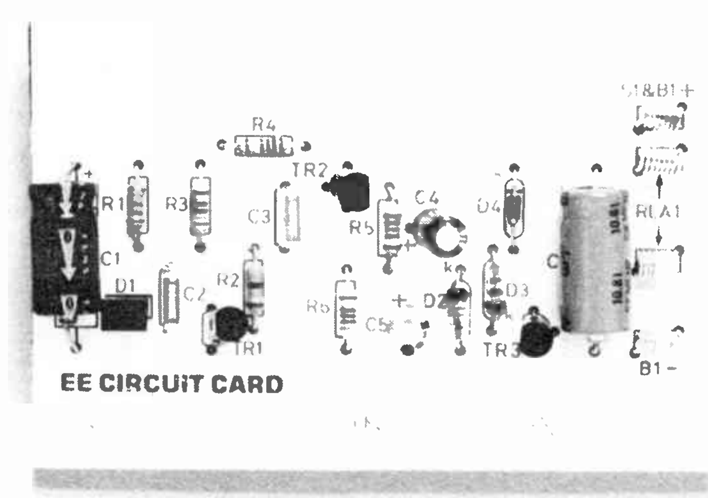
The LD242 gives optimum range but it is quite directional. Reduced range but a wider beam are obtained using an LD241 or a TIL38. Incidentally, some component suppliers sell these l.e.d.s simply as something like "high power infra-red l.e.d.s" rather than by type number.

An indentation at one end of IC1's body enables its orientation to be set correctly. Obviously there is no need to fit IC1 in a socket as there is no risk of heat damage with this method of construction. On the other hand, connections to it will be easier if they are made via a holder which has quite long pins.

Easiwire spring-like connectors are fitted to the board at the two points where connections to off-board components will be made. These connectors have their leads ready trimmed to length, but apart from IC1 the other components must have their leadouts cut so that only about three or four millimetres protrudes on the underside of the board.

WIRING UP

The wire which carries the negative supply rail must be routed around IC1. One way of keeping this wire in place is to fit a piece of the double-sided adhesive backing material onto the board. As only a single angle in the wire is needed, in this case an easier solution is to add a printed circuit pin to the board at the point



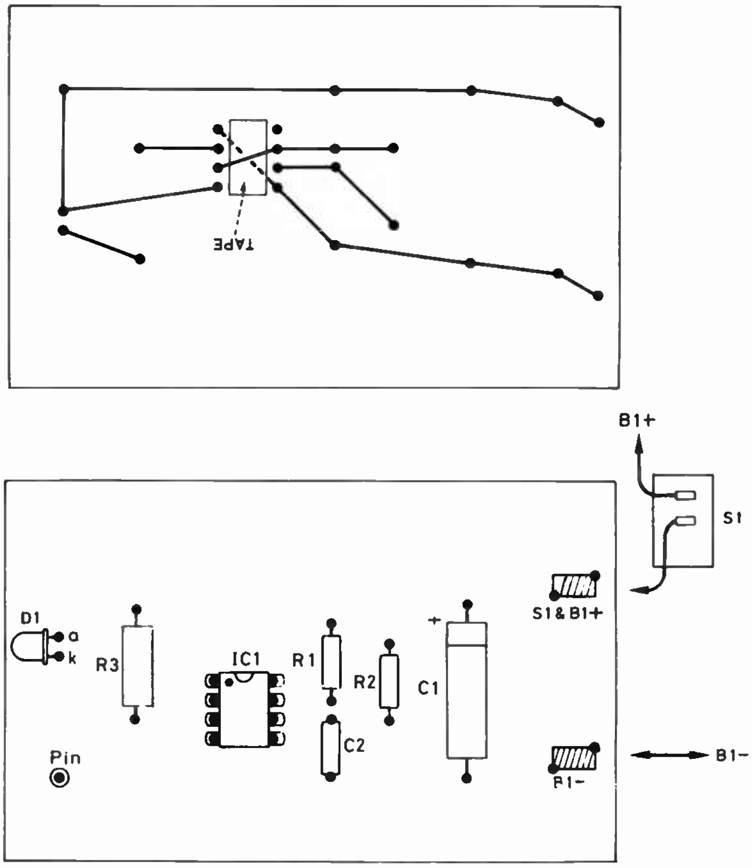
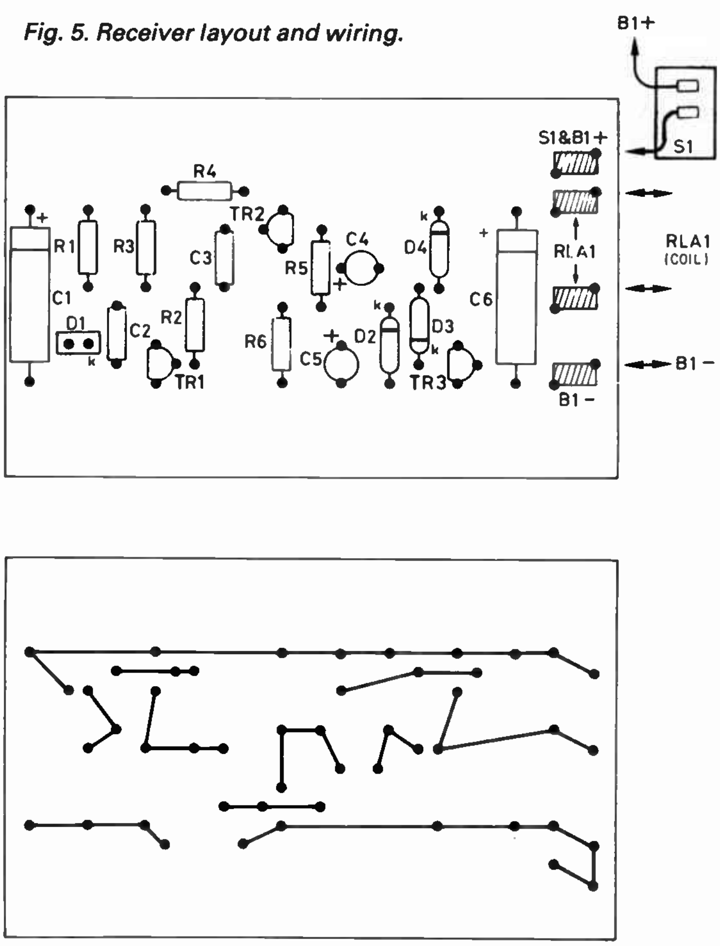


Fig. 4. Transmitter layout and wiring.

Fig. 5. Receiver layout and wiring.



indicated on the layout diagram/Card. In fact it does not even need to be a proper printed circuit pin, and a piece of wire trimmed from a resistor leadout is quite adequate.

Another minor complication to the underside wiring is that two wires must cross over one another. These are between IC1's two rows of pins. To avoid them short circuiting, add one wire, then cover it over with a piece of insulation tape, and then add the second wire.

The basic method of wiring up using the Easiwire "pen" is to first hold the end of the wire close to initial connection point. Then wind five or six turns of wire around the leadout, reasonably tightly, starting at the bottom and working upwards. Then repeat ths process working from the top downwards. This process is repeated at subsequent connection points until a complete line of joints has been completed. It is important to keep the connecting wire quite taut. Otherwise there is a risk of short circuits and a greater risk of wires becoming broken.

The blade built into the "pen" tool is used to cut the wire close to the final connection-point. It is a good idea to go back to the initial connection and trim off any excess wire . Leaving these "tails" of wire could lead to accidental short circuits.

There are a number of small plastic boxes that can accommodate the circuit board and battery, and an inexpensive 114 by 76 by 38 millimetre type should suffice. The component board is mounted on the base panel using M3 or 6BA fixings, including short spacers. Without these the components will be forced off the board as the mounting nuts are tightened. A window for D1 to "look" through must be made at a suitable position in one end of the case.

CONNECTIONS

The connections to the two connectors are made via the special Easiwire plugs. These are "crimped" onto the leads using a pair of pliers, and then they simply push into the on-board connectors. The connections to S1 can be soldered or made via miniature crocodile clips. A third option, and the one I favour, is to use the Easiwire "pen" to bind the bare ends of the leads to S1's tags. If the unit is to be used in an application where S1 will need to be closed for much of the time a minature toggle switch is the best type to use. Otherwise, a push to make release to break push-button type is better.

A high power PP3 battery is adequate if the transmitter will only be used in short bursts. If it will be used for long periods a higher capacity battery such as six HP7 size cells in a plastic holder is preferable. These holders use a standard PP3 style connector incidentally. Note that the use of a high capacity battery might necessitate the use of a larger case.

RECEIVER CONSTRUCTION

A lot of the notes on transmitter construction apply equally well to the receiver, and will not be repeated here. Some of the electrolytic capacitors are radial (vertical mounting) types. The polarity of these is usually marked by "+" and "−" signs on the bodies of the components. D1 is mounted with the large surface that carries the type number (and possibly other markings) facing towards R1. Note that its sensitive surface is the one opposite this, and that the output from the transmitter must be directed towards this side of the device. A window must be made in the case adjacent to D1.

Make sure the other diodes are also fitted the right way round. A band at one end of the body indicates the cathode leadout, but these days some diodes have three or four bands. In this case, one band should be broader than the others and positioned right at one end of the diode's body. This is the one that indicates the cathode leadout wire.

The relay can be any type that has a coil resistance of about 200 ohms or more, will operate reliably on a six volt supply, and has contacts of adequate rating for the equipment that the unit will control.

A 6 volt, 410 ohm coil, printed circuit mounting relay is a good choice. Its relatively high coil resistance helps to keep down the current consumption and give good battery life. Unfortunately, it is slightly too large to fit onto the circuit board. It can easily be fixed inside the case though, using its metal top plate as a base plate for mounting purposes. It can either be glued in place using a good quality general purpose adhesive, or small bolts will fit into the holes ready-drilled in the metal plate.

The tags of this relay are large and well spread out, making it easy to complete wire-wrap connections to them using the Easiwire "pen". Connection details for this relay are shown in Fig. 6. The two contacts are connected in place of the on/off switch in the controlled equipment. If you use a different type you will need to consult the retailers catalogue to determine the function of each tag, and the correct method of connection. For beginners it is probably better to use the specified relay. This has contacts that are rated at 50 watts for d.c. loads, and 1100 watts for a.c. loads.

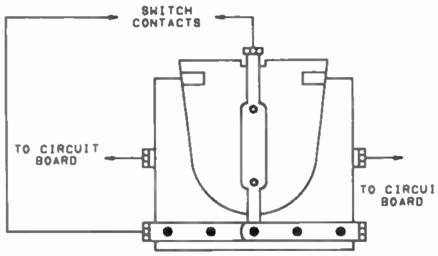


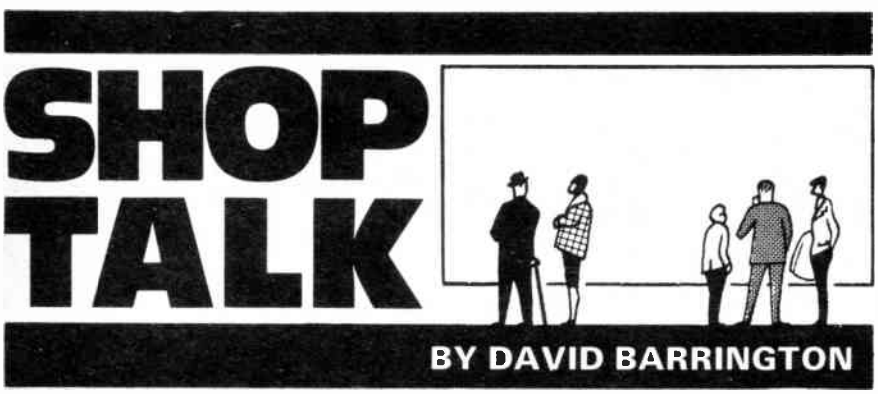
Fig. 6. Connections to the relay.

Although the relay is capable of handling mains powered equipment, the unit should only be used in this way **if it is built and installed in a fashion that is entirely safe.** Those of limited experience **should only use the Remote Control with low voltage battery powered equipment.**

IN USE

As with any projects, give the wiring a final and thorough check before switching on and testing the system. Try the system at close range initially. It can be tested even without having the relay contacts connected to the main item of equipment, as most relays produce a "click" sound as they switch on or off. The maximum range depends on the type of l.e.d. used, but should be at least a few metres.

If good range is important, use the high gain "C" suffice devices for TR1, TR2 and TR3. A simple infra-red system of this type is strictly a line of sight system, and anything opaque between the transmitter and the receiver will almost certainly prevent the system from working. This is put to good effect in broken beam intruder alarm systems. With the transmitter and receiver spaced a couple of metres or so apart, anyone passing between the two will briefly block the infra-red signal from the receiver. This will result in the relay contacts opening momentarily, which can be used to activate a burglar alarm system. □



Phasor

If any readers have difficulty in locating a source for the mains transient suppressor (VDR1), required for the *Phasor* project, this was purchased from **Maplin,** code HW13P. They also supplied the high current r.f. interference suppressor choke, code HW06G (RF Supp Choke 3A).

High voltage mains interference suppressor capacitors may prove troublesome to locate locally but most of our advertisers seem to stock "high voltage caps" that will do the job. However, if in doubt the ones used in the designer's model came from Maplin, code FF57M and FF58N.

The only people we have found who list a potentiometer with an all plastic mounting bush, body and spindle is **Verospeed** ☎ *(0800 272555).* This is entered under their type 16P and 16PS range, however, the fixing nut and washer are both of metal construction.

Provided ***ALL*** plastic control knobs are used, with well recessed fixing grub screws, we can see no reason why the more common "plastic" spindle potentiometers cannot be used here. The Phasor printed circuit board is available from the *EE PCB Service,* code 631.

In view of the presence of mains voltages, do NOT work on the unit with it connected to the mains unless absolutely necessary. Even then, take extreme care to touch only those points you wish to test.

Reaction Timer

One or two components called for in the *Reaction Timer* could cause local sourcing problems and may prove difficult to purchase.

The p.c.b. connectors and ribbon cable should be available from most component suppliers. However, any readers who do experience troubles locating these connectors, the ones used in the prototype model were purchased from **Maplin** and are listed under their "Minicon" range.

The only source we have been able to locate for the Celdis combined switch and l.e.d. and the 3-digit multiplexed common cathode display (IC7) is from **Silicon Sound, Dept. EE, 61 Ide Lane, Exeter, Devon, EX2 8UT.** Other types of combined switch/l.e.d. may be used but the display p.c.b. may have to be adapted. You can, of course, use a separate rocker switch and a l.e.d. (TIL209) in place of S1/D1.

The crystal X1 should be available generally, such as **Cirkit,** and the semiconductors all appear to be "off-the-shelf" devices, except, of course, the display mentioned previously. The red plastic filter material should not cause any buying problems.

The printed circuit boards for the Reaction Timer are available through the *EE PCB Service,* codes EE626 and EE627. The case is left to individual choice; the one used in the prototype was purchased from Maplin, code LH90X.

Personal Cassette Amplifier

When purchasing components for the *Personal Cassette Amplifier,* be sure to specify the 14-pin version of the LM380 audio power amp i.c. This is usually designated LM380N-14 and is capable of 2.5W output. The eight pin version is only rated at about 0.6W output.

The volume control should be of the "Log. law" type and the size of speaker used is left to individual choice. The size of loudspeaker, will, of course, also govern the size of case and mounting position if used in a car.

Metronome

It is not essential to use the sub-miniature enclosed preset potentiometers specified in the *Downbeat Metronome* you can, of course, use standard sub-miniature skeleton types. The enclosed types were purchased from Maplin and come from their CITEC range.

When buying the BC184L transistor, it is important to purchase one with the suffix L as pin connections for this device vary. The printed circuit board is available from the *EE PCB Service,* code 629.

EPROM Programmer

Most of our larger component suppliers carry stocks of the EPROMs and interface chip required for the *EPROM Programmer*— this month's *On Spec* subject. They are currently being listed by **Cirkit, Maplin, Omni and Greenweld Electronics.**

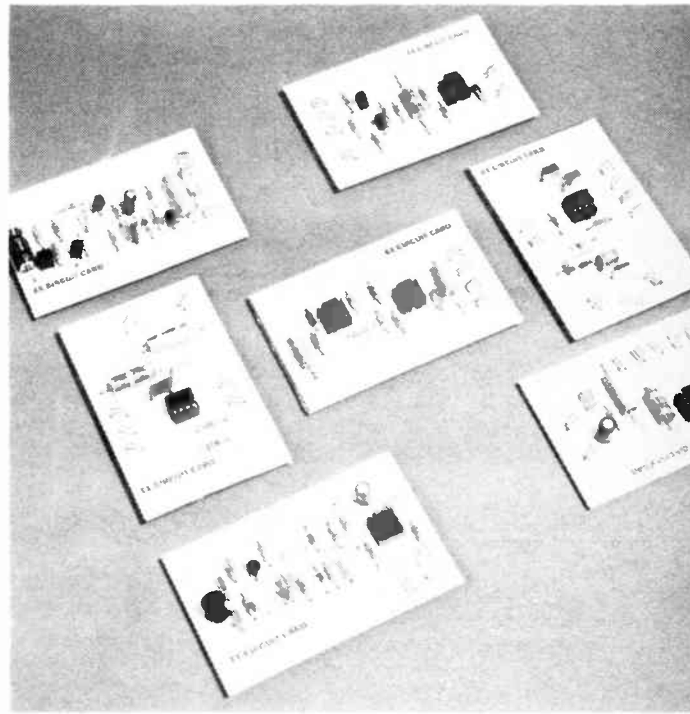
The printed circuit board may be obtained through the *EE PCB Service,* code 630 (see page 740).

I.R. Remote Contorl

We cannot foresee any component buying problems for the *I.R. Remote Control* project. The BICC-Vero "Easiwire" kit is now stocked by many of our advertisers.

The two circuit cards for the transmitter and receiver are attached to the front cover of this issue. Two new circuit cards will be given away with next month's issue—Why not place an order with your NEWSAGENT now!

USING YOUR CIRCUIT CARDS



THE CIRCUIT CARDS attached to the front cover of this issue have been specially designed for easy, solderless construction of projects using the BICC-Vero Easiwire system.

HOLE PUNCHING

Carefully remove your Circuit Cards from the cover taking care not to damage them, then cut them in half along the heavy line. Next, using the pointed end of the Easiwire unwrap tool, make holes through the board for the component leads. This is best done by placing the Circuit Card, component side up on a piece of thick cardboard or a pad of scrap paper then push the point through the Circuit Card at all the points marked with a "•".

Once all the holes are made you can use the Circuit Card, as described in the special articles in this issue, to build your projects. If you do not have a BICC-Vero Easiwire kit see the special offer below.

EASIWIRE SPECIAL OFFER

£1 OFF

FOR EE READERS

The BICC-Vero Easiwire kit allows you to build projects with a simple solderless wire wrapping system that is becoming very popular with hobbyists and in education. The system allows re-use of the components and it is easy to correct wiring mistakes with the special unwrap tool provided.

The kit contains a high quality wiring pen with spool of wire and a built-in spring loaded wire cutter, a double-ended unwrapping tool, a universal punched flexible injection moulded wiring board, plus a pack of spring loaded terminals, a spare spool of wire (approx. 40m long), instruction booklet and two sheets of self adhesive material to hold the wiring in place.

The system was reviewed by Robert Penfold in our June 1988 issue and has now been used as the construction medium for a range of eight projects for which Circuit Cards will be presented over the next few months.

To take advantage of our **"£1 off offer to EE readers"** you must send the coupon (correctly filled in) together with your payment of £14 (including VAT and postage) to: **BICC-Vero Electronics Ltd., (EE Special Offer Dept.) Flanders Road, Hedge End, Southampton, SO3 3LG.**

EE EASIWIRE OFFER—£1 OFF
Please send me one Easiwire kit price £14 inclusive

I enclose cheque/postal order for £ ...., made payable to BICC-VERO Electronics Limited

Please debit my credit card as follows: BARCLAYCARD VISA

Card Number ....

Expiry Date ....

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City and Guilds

Certificate Course

Introducing DIGITAL ELECTRONICS

Part 3: Materials and Tools

By Michael J. Cockcroft
Training Manager, Peterborough ITeC

This series of twelve articles has been designed as a complete course for the City and Guilds Introductory Digital Electronics syllabus (726 301). Full details on registering for C&G assessment, details of assessment centres, and information on the course in general were given in a booklet provided free with the October issue.

This month we investigate the raw materials and tools used for the purpose of assembling electronic systems. You will also learn how to make permanent electrical joints using a variety of connecting methods including soldering and crimping; and how to use the tools listed in the *Introducing Digital Electronics Booklet* given free with the October issue. Here are the City and Guilds objectives for this part of the course:

1.2 Materials
1.2.1 Identify at least six cable and wire styles selected from Appendix B of the Resource Document.
1.2.2 Identify at least six commonly available cable connectors and fuseholders selected from Appendix C of the Resource Document.
1.3 Tools.
1.3.1 Identify at least ten of the common hand tools listed in Appendix E of the Resource Document.
1.3.2 Demonstrate the correct use, care, and storage of at least ten of the hand tools listed in Appendix E of the Resource Document.
1.3.3 Select, for a given application, appropriate tools and use suppliers catalogues to determine costs.

Table 3.1 lists the wires, cables, and wiring accessories from Appendix B of the City and Guilds Resource Document.

Wires

Most wire used in electronic systems consists of one (solid conductor) or more (multi-stranded) copper conductors sleeved in rubber or plastic insulation. The two p.v.c. insulated wires in Fig. 3.1 are taken from the table; the one in Fig. 3.1a has an identification code of 1/0.6 which is interpreted as single conductor (solid) of 0.6mm diameter; similarly, the wire of Fig. 3.1b (code 7/0.2) is interpreted as having seven conductors each 0.2mm in diameter.

When selecting wire for a particular purpose care must be taken not to exceed its current rating, some example wires and respective current carrying limitations are:

7/0.2	1 Amp.
10/0.2	3 Amp.
24/0.2	5 Amp.
32/0.2	10 Amp.

We must also choose according to how liable the wire is to be continually flexed and how susceptible the wire is to flexing. Solid conductor wire should never be used in applications where the wire will be bent back and forth, as this may fracture the conductor and cause it to break. Multi-stranded wire is able to bend more often without breaking and should be used in cases where the wire will be frequently flexed and moved. The more conductors in a wire the more bending it can withstand; a wire with a large number of small diameter strands (for example, 55/0.1) is obviously made to be moved and flexed.

The ideal application for the solid conductor wire is chassis and p.c.b. work; it can easily be shaped for neat positioning but, once in place, it will no longer be flexed.

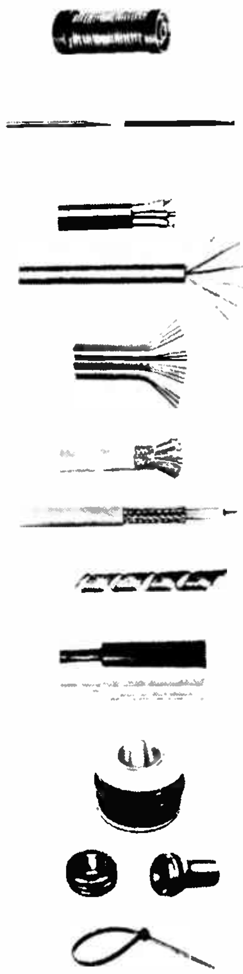
Solid conductor wire is also available without an insulating sleeve; this is called tinned copper wire. Tinned copper wire is pre-coated with solder and supplied in sizes of the Standard Wire Gauge (s.w.g.). Table 3.2 shows the s.w.g. sizes and corresponding diameters for tinned copper wire.

Tinned copper wire is ideal for making wire links on stripboard (in places where there is no danger of touching other bare wires or component leads which should not be connected—the term used to describe superfluous connections like this is "shorting") since time is saved by not needing to strip insulation from the wire.

Another type of solid conductor, with a more specialised application, is enamelled copper wire. This is also supplied in s.w.g. sizes and Table 3.2 shows the corresponding diameters

Table 3.1

WIRES		
Tinned copper	1/0.6mm	356-331
Enamelled copper	1/0.6mm	
PVC or PTFE insulated	1/0.6mm 7/0.2mm 16/0.2mm	
CABLES		
Mains PVC rubber	2 & 3 core 16/0.2mm; 3 cores 24/0.1mm; 3 core 40/0.2mm	
Telephone	1, 2, or 3 pair	
Ribbon	7/0.2mm 1/0.4mm	
Screened	Single & multicore, lapped or braided, various sizes	
Coaxial	TV, video or RF types, various wire sizes, cores insulations & types of braid	
ACCESSORIES		
Spiral wrapping	3.2mm, 6.4mm	
Sleeving, rubber	Hellerman—various sizes	
Sleeving, heat shrink		
Lacing cord	Rayon cord PVC or waxed cord	
Grommets	Various sizes	
Cable ties	Releasable or locking	



in millimetres. Enamelled copper wire is usually used for winding transformers, chokes, etc.; the enamel coating provides insulation to prevent adjacent windings from shorting out on one another and must be scraped off with a knife (rather than stripped with wire strippers) to make an electrical connection.

TABLE 3.2

Standard Wire Gauge	Tinned Copper Wire	Copper Wire
16	1.62	1.73
18	1.22	1.31
20	0.91	1.01
22	0.71	0.73
24	0.56	0.63
26 **(s.w.g.)**	0.46 **Dia. (mm)**	0.53 **Dia. (mm)**

Cables

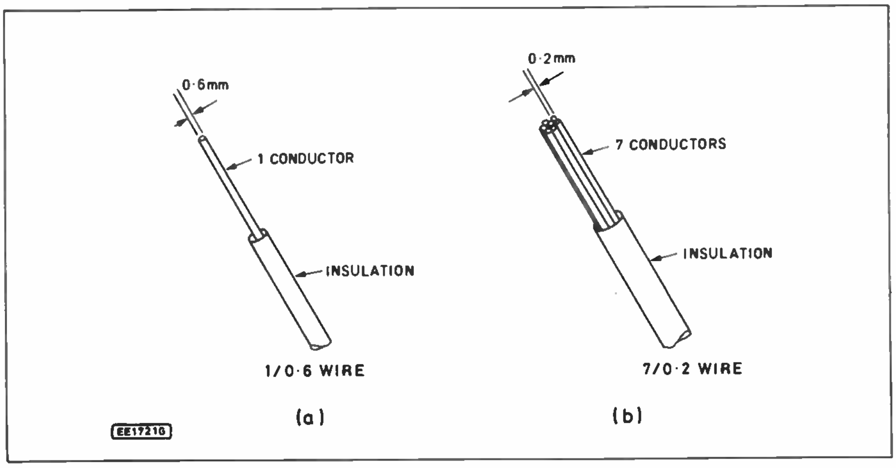
Cables have a varying number of wires called cores; the cable attached to an electrical appliance, for example, is identified as two or three core mains cable. Signal cables, often called multicore cables, can contain fifty or more wires. A small selection from a wide variety of cable types are given in Table 3.1.

Wires, whether parts of cables or not, are usually soldered or screwed to terminals, plugs and sockets, p.c.b.'s etc. There are, however, tools available which use special techniques on special cables to speed up the process of connecting cables to connectors. Ribbon cable is one such special cable. A 40 core ribbon cable can be joined to a connector by a technique, called "insulation displacement", in seconds.

A coaxial cable is the type used to connect a television set to its aerial. It has a conductor sleeved in a polythene insulator, surrounded by an outer braided (plaited) conductor. The braided conductor is called a "screen" and, when connected appropriately, protects the inner conductor from outside interference.

Ordinary multicore cable may also be screened, the cable cores (wires) may be individually screened or collectively screened depending on the application. Screened cable is used in cases where there is a possibility of one circuit picking up signals from another circuit.

Fig. 3.1 Two different types of p.v.c. insulated wire.



Wiring Accessories

A number of wiring accessories are listed in Table 3.1. These are various accessories for retaining wires and cables together in neat cable-forms. Lacing cord is the cheapest to buy but time consuming to apply; sleeves, wraps, and ties are all time saving alternatives to lacing.

Sleeving

Sleeves come in various shapes and sizes. In addition to the straight sleeves in the table, there are "T" junctions and multi-way junctions available. There are also small individual sleeves for covering plug and socket pins.

Heat shrink sleeving, in use, is slightly larger in diameter than the cable-form and when heated (by a powerful hairdryer or heat gun) the sleeve shrinks and grips the cable-form. Rubber sleeving, on the other hand, is selected to be smaller than the cable-form in order that it may be stretched over it using an application tool.

Spiral Wrapping

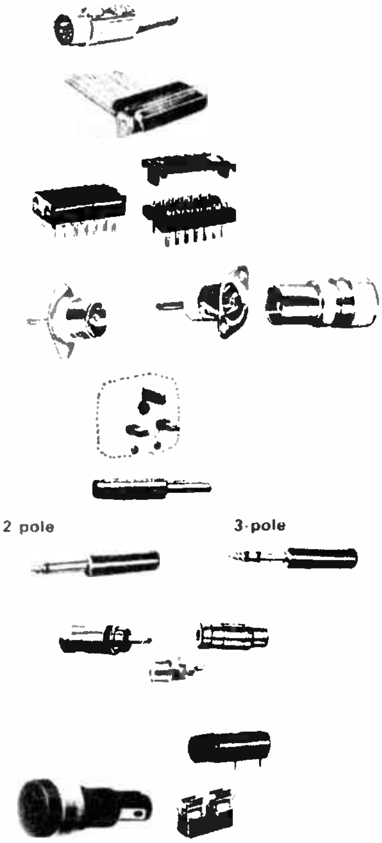
Spiral wrapping is a pre-formed plastic spiral which is wrapped around wires and/or cables by hand. The wrapping expands as it is applied, this exerts pressure on the wires to keep them in place.

Grommets

Grommets are used for safety and neatness where wires or cables pass through holes in equipment housings.

Table 3.3

PLUGS	
DIN, Series	2-7 pin types
'D' types	9, 15 & 25 way types
DIL types	*14 & 16 way*
COAXIAL	Standard Aluminium
MAINS	British standard 13 Amp
BANANA	4mm
JACK 2 or 3 Pole	0.25" 3.50mm 2.50mm
PHONO	PVC or metal case type
SOCKETS	
SELECTION (for recognition) to match plugs, including multiway P.C.B. edge connectors	
FUSEHOLDERS	
Line Chassis Mounting	1", 1.25", 0.625", 20mm
Panel, PCB Mounting sizes	



Connectors

Multipin connectors are used to interconnect items of equipment in cases where permanent connections are not wanted. Table 3.3 lists the connectors and fuseholders from Appendix C of the Resource Document.

There are different instructions for connecting cables and wires to each of the plugs and sockets in the table, and such detail is beyond the scope of this introductory course (you do, however, need to be able to identify all of these connectors by sight).

Suffice it to say, most of these connectors require soldered connections and it is advisable to insert a mating component during soldering (insert a plug/socket into the socket/plug being soldered) so that the heat of the soldering iron does not distort the shape of the connector. Also, don't let the joints get too hot so that the insulation on the wires melts.

Soldering

Soldering is the process of applying a material called solder to a mechanical joint between components, wires, or other metal parts. The solder is heated and melted over the join using a soldering iron.

Even firm mechanical wire-to-wire connections need the solder to make the joint permanent. This is because copper reacts with air after a time—a chemical reaction called oxidation—and prevents a good electrical path for current flow at the join (when copper oxidises an insulating coat forms on its surface). Solder protects the join from oxidation.

Solder

Solder is a soft metal alloy of tin and lead and comes in reels as shown in Fig. 3.2a or dispensers as in 3.2b. The combination of tin and lead in the solder is usually about 60% tin to 40% lead to give it a low melting point and lessen the risk of damage to sensitive components like transistors and l.e.d.'s; however, the actual proportions vary in solders for different applications. Sometimes very small quantities of other elements like Arsenic, Bismuth, and Sulphur are also added to the alloy to alter the solders characteristics for particular applications.

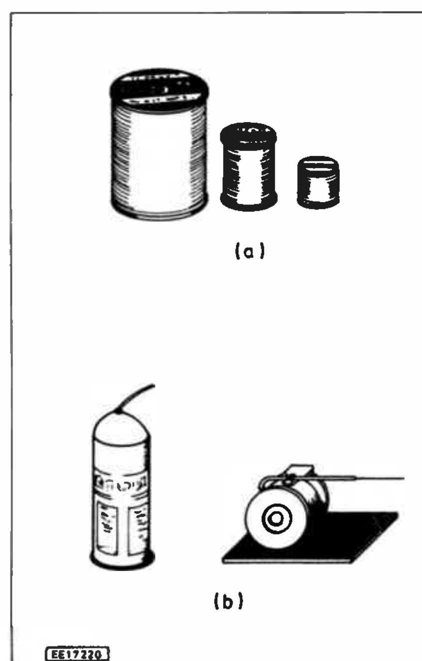
Applying heat to a join causes it to very quickly oxidise and so it is necessary to use a flux (an oxide remover), such as rosin, when making electrical solder joints. Although solder and flux may be purchased separately, most solder (such as that provided by Multicore) conveniently contains the rosin flux. Care should be taken not to buy solder containing corrosive flux.

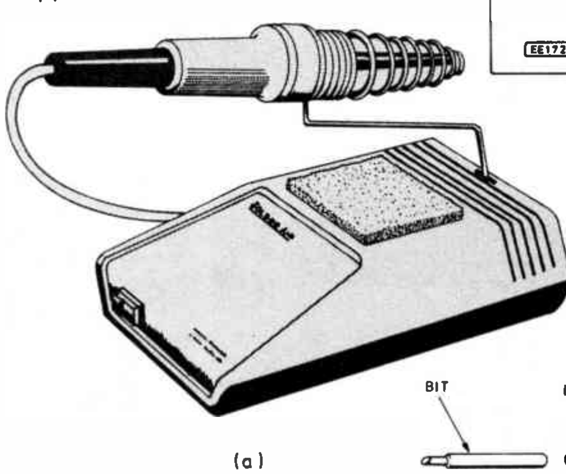
Solder should be of a diameter appropriate to the particular task: it should be as thin as possible, without using too much length too quickly, and thick enough to solder the joint in a second or so. The 22 s.w.g. rosin cored type is ideal for stripboard work and any of the experiments in this course.

Soldering Iron

A typical soldering iron for professional use is shown in Fig 3.3a, this one is designed to have a long life (hence replacement parts—Fig 3.3b) and to be used for all applications.

In industry it is often economical to buy expensive irons, like this one, since they are suitable for most applications. The temperature control allows the iron to match the melting point of the solder to the application,





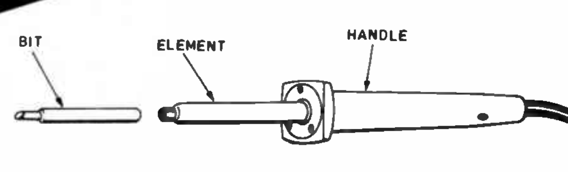


Fig. 3.2(a). Reels of solder (b) solder dispensers
Fig. 3.3(a). A typical temperature controlled "professional" iron (b) replacement parts of the soldering iron.

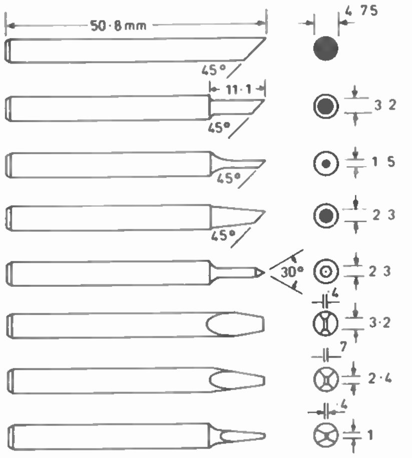


Fig. 3.4. A range of soldering tips or bits.

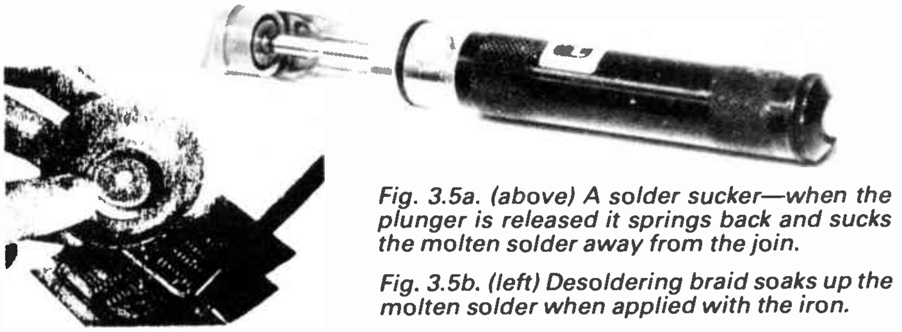


Fig. 3.5a. (above) A solder sucker—when the plunger is released it springs back and sucks the molten solder away from the join.

Fig. 3.5b. (left) Desoldering braid soaks up the molten solder when applied with the iron.

and a range of tips (Fig. 3.4) makes the iron suitable for tasks from intricate p.c.b. work to heavy solder tags and large components.

A variety of soldering irons are available. There are cordless soldering irons (gas or battery operated) for service engineers and other field professionals who may not have access to mains electricity, there are types which automatically feed solder wire, there are even special miniature irons for the purpose of soldering surface mount devices (s.m.d.'s) by hand.

You should choose one according to your budget and how serious you are about project work now and in the future. Because of the cost of an iron like the one of Fig. 3.3a, only a professional or serious hobbyist would consider buying one with similar features. A low cost miniature 15 or 25 watt mains soldering iron with a 2mm or 3mm bit will be adequate for this course.

Desoldering

Often it is necessary to remove a soldered component or wire from a printed circuit board or solder tag and there are tools—desoldering tools—available to allow an easy job of removing the solder. Desoldering is the process of removing solder from a joint. This can be done by sucking away the solder with a "solder sucker" (Fig. 3.5a) after first melting it with a soldering iron, or using the capillary action of desolder braid (Fig. 3.5b) when it is placed over the joint and heated with an iron. The solder sucker can be a bit harsh on fine p.c.b. tracks and care should be taken in this respect. Copper braid is much gentler on the p.c.b., but will very often damage sensitive components by overheating them; only use the braid on heat sensitive components if you are going to throw away the component after desoldering it.

Desoldering stations like the one in Fig. 3.6a are much used in industry, they have hollow bits connected to a solder collector and compressed air line. As shown in Fig. 3.6b, the bit is placed onto the joint to melt the solder, when melted the tip is moved in a circular motion (to prevent the component lead from sticking to the board while it cools) while the sucking action is activated (usually by a footswitch). As the solder is drawn into the glass collector the area about the joint is cooled.

Tools

For any kind of practical construction work, a number of tools are required. A minimal tool kit comprises a soldering iron, wire strippers, wire cutters, snipe nose pliers, and a small screwdriver (about 3mm with 50mm to 100mm long insulated blade). A more comprehensive set of tools is given in Table 3.4 (taken from Appendix E of the Resource Document). Readers must make sure that they can identify all of these tools and know how to use them all.

Making Connections

In order to solder (or otherwise join) wires or components together, there must be a good conductor-to-conductor contact to permit current flow. For this reason care should be taken that all insulation is removed from the parts to be joined and that the area be free from any grease, oil, or other foreign matter.

Stripping Wire

Wire stripping is the name given to the process of removing a length of insulation from a wire and is properly done with the aid of a pair of wire strippers such as those shown in Fig. 3.7.

Wire strippers like those of Fig. 3.7a are adjusted such that the jaws close enough to cut part way through the

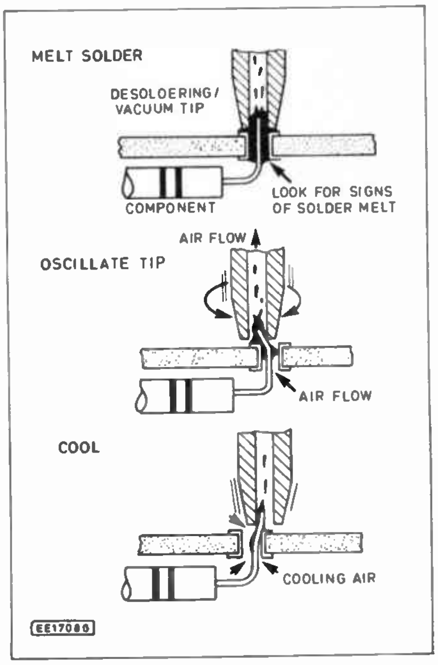


Fig. 3.6a. (below) A professional desoldering station. 3.6b. (right) desoldering process.

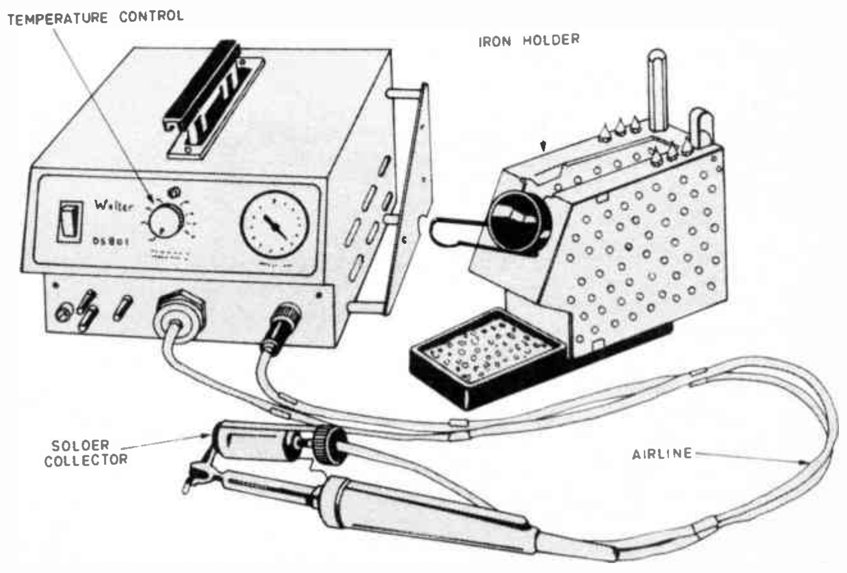
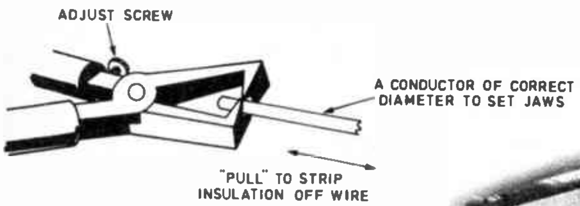


TABLE 3.4

INTRODUCTORY LEVEL TOOL SET

ALLEN KEYS:	A/F 1.27mm, 2mm, 4mm, 8mm.
CUTTERS AND PLIERS:	Wire Cutters, Wire Strippers, Pliers Plain, Pliers Pointed Nose, Pliers Combination, Crimping Tools.
FILES:	Set Switch Files, 200mm Hand (fine cut); 6mm Round (fine cut).
CLAMP AND GRIPS:	Pair G Clamps (50mm), Toolmakers Clamps, Mole Grips.
STEEL RULE:	300mm and 12 inch.
HACKSAWS:	Junior Type 150mm Blade.
HAMMERS:	4 oz. (Ball Pein), Soft Faced (hide/plastic).
HAND DRILL:	8mm Chuck
SCREWDRIVERS:	Plain Instrument Set, Plain 2mm, Plain 3mm, Plain 4mm, Plain 5mm, Phillips Small, Medium and Large. Pozidrive Small and Medium, Screw Hold Clips.
SOLDERING IRONS:	Small Electrical Instrument, Large Instrument—Suction Desoldering Tool or Brain.
SPANNERS:	One Small Metric Set, One Small BSF, One Small BA Set, Ring and Box-Selection, Two Adjustable—Small and Medium.
TWIST DRILLS:	H.S.S. P.C.B. Set and 1/16 in. to ¼ or Metric equivalent.



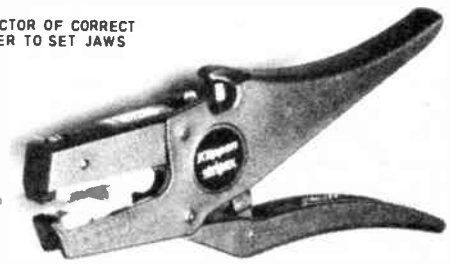


Fig. 3.7a. (above) Adjustable wire strippers.
Fig. 3.7b. (right) Automatic wire strippers.

insulation without cutting the conductor. When the tool is properly adjusted, tighten the locking nut.

To strip the wire place it between the jaws, inserting just enough to strip the right length of insulation, squeeze the handles firmly and pull. The strippers of Fig. 3.7b exemplify those professional tools in industry which automatically adjust to wire sizes within a range; the wire is placed between the jaws, the handles squeezed, and the insulation is removed without pulling on the part of the operator.

Connecting Wires to Terminals

Wire cutters and snipe nose pliers similar to those in Fig. 3.8 are essential to the electronics constructor. Cutters are used for cutting wire and trimming component leads, and snipe nose pliers are used to bend and shape wires and component leads when assembling p.c.b.'s and making terminal connections.

Fig. 3.8. Wire cutters—or side cutters—and snipe nose pliers.

Although a joint needs solder to make it permanent (solder adds strength to the joint and prevents oxidation) the mechanical connection should provide sufficient contact for current to flow without solder. Here is how to connect a wire to a terminal prior to soldering:

Step 1. Remove 10 to 20mm of insulation from the the end of the wire depending on the size of the terminal. If the wire is dull or discoloured, it is probably oxidised. The oxidised film must be removed by scraping it off with a knife or sandpaper. The terminal must also be clean and shiny.

Step 2. Insert the bare conductor of the wire into the terminal as shown in Fig. 3.9a. Notice that the wire is positioned with the insulated part close to the terminal.

Step 3. Using snipe nose pliers, wrap the conductor round the terminal as directed in Fig. 3.9b and snip off the free end.

Step 4. Compress the conductor to the terminal with the pliers as shown in Fig. 3.9c. The terminal is now ready for soldering.

Screw Terminations

Some terminals do not require soldering. Even people lacking the

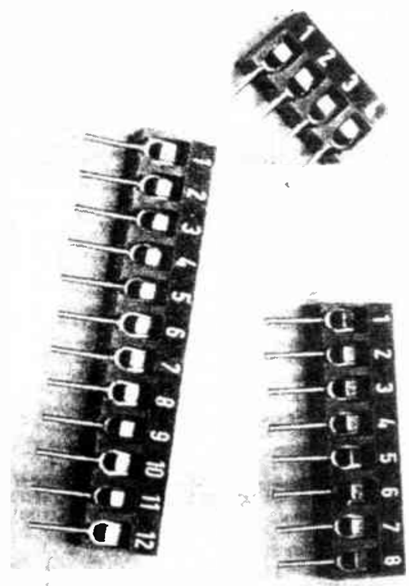
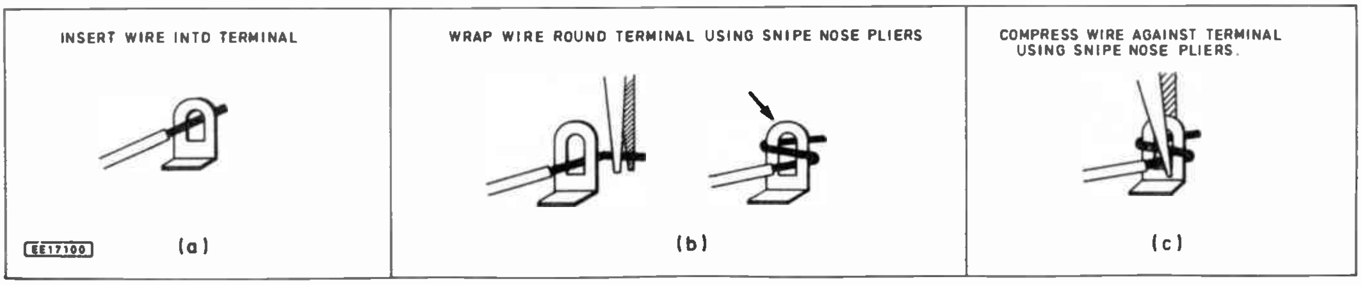


Fig. 3.10. P.C.B. mounting screw terminals.

Fig. 3.9. Connecting a wire to a terminal.



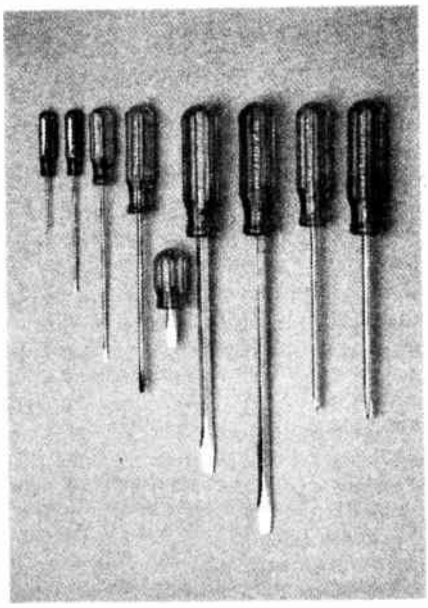


Fig. 3.11. Various screwdrivers.

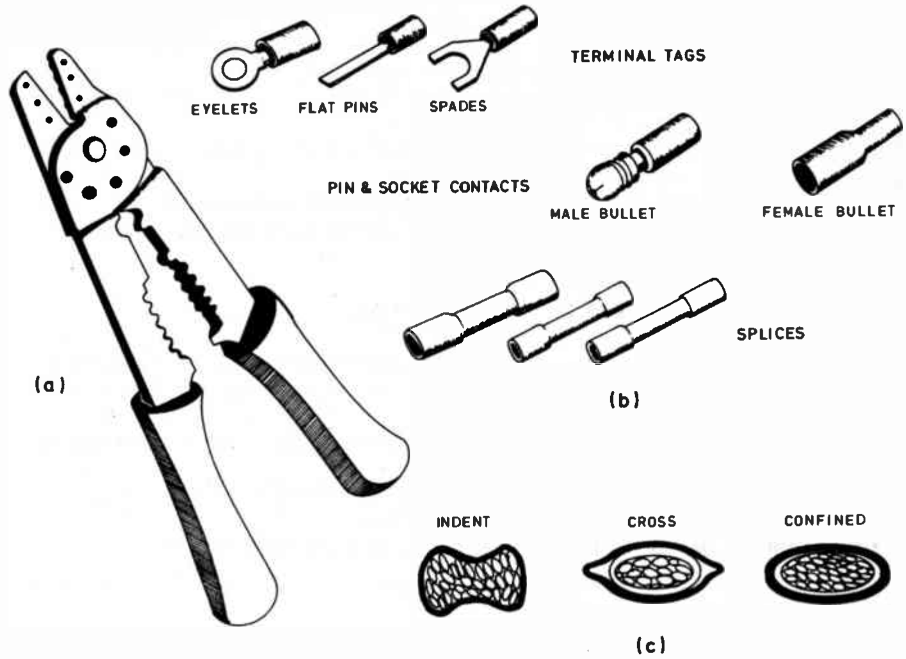


Fig. 3.13. A crimping tool, various crimp tags and the effect of various types of crimping.

slightest interest in electricity know of the screw terminals within mains plugs, sockets, and junction boxes. There are also screw terminal strips available for mounting on p.c.b.'s; three such types are depicted in Fig. 3.10. A set of flat blades and Phillips screwdrivers which would be ideal for electronic work is shown in Fig. 3.11, although the 4mm flat blade would serve for most purposes.

Connecting wires to these terminals is quick and simple; wire is stripped of the required length of insulation, twisted (if multi-stranded) between thumb and forefinger into a neat spiral, inserted between the clamps of the terminal, and screwed down while holding the wire in place. It is important that there are no stray stands of conductor left unclamped. These can cause untold problems if they touch the wrong part of the circuit.

Stranded wires usually splay once stripped of insulation, hence the need for twisting. But just twisting doesn't always keep the strands together, especially when trying to clamp them in a screw-down terminal.

There are a number of ways to prevent conductor strands from going astray: One way is to strip twice the required length of insulation from the end of the wire, then bend the conductor in half before insertion (Fig. 3.12a). Another way is to coat the end of the conductor with solder after twisting the strands together, a process called tinning the wire (Fig. 3.12b). A third method involves the use of a flat pin crimp tag (Fig. 3.12c).

Crimping

Crimping is the process of joining crimp connectors to wires using a crimping tool. A crimping tool which incorporates a wire cutting and stripping facility is depicted in Fig. 3.13a, and various crimp connectors (tag, pin & socket, and splice) are given in Fig. 3.13b.

Pin and socket connectors provide a neat termination to multi-stranded wires and are useful in applications where wires often need to be removed and replaced; terminal tag connectors provide a neat termination in the same way but are usually applied when the connection is expected to be more permanent; and splices make a neat permanent connection between wires.

A crimped joint is made by physically crushing connector to conductor using a crimping tool; Fig. 3.13c depicts the crushing effect at the join using various crimping tools. There are a number of specifications for

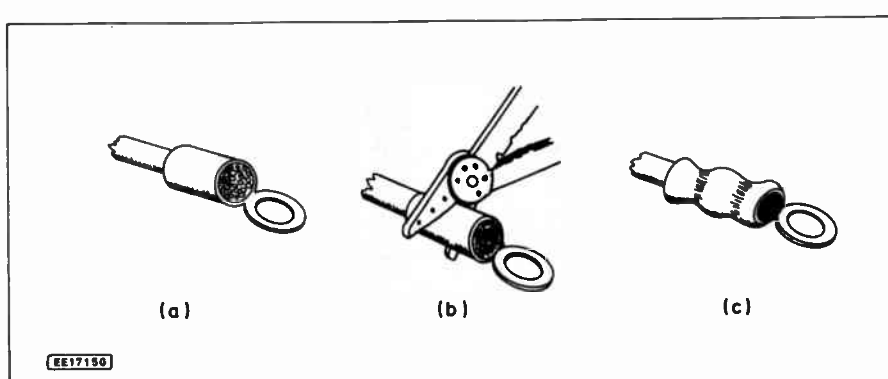
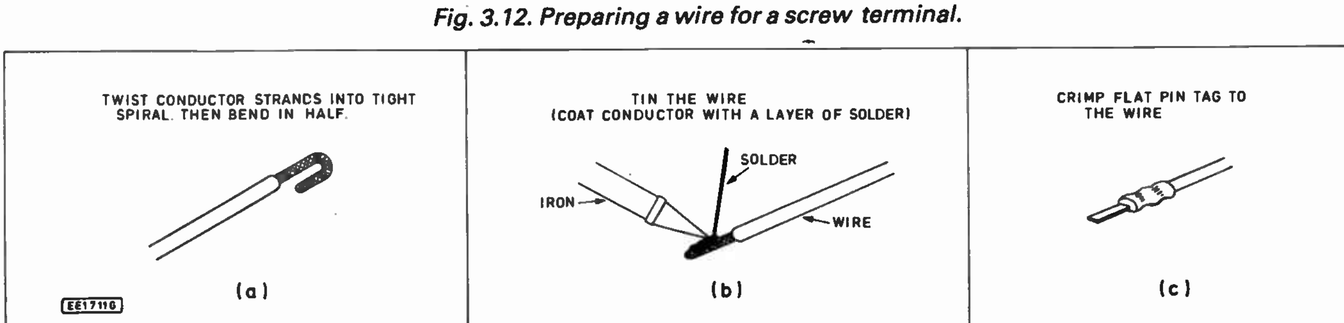


Fig. 3.14. Using a crimping tool.

Fig. 3.12. Preparing a wire for a screw terminal.



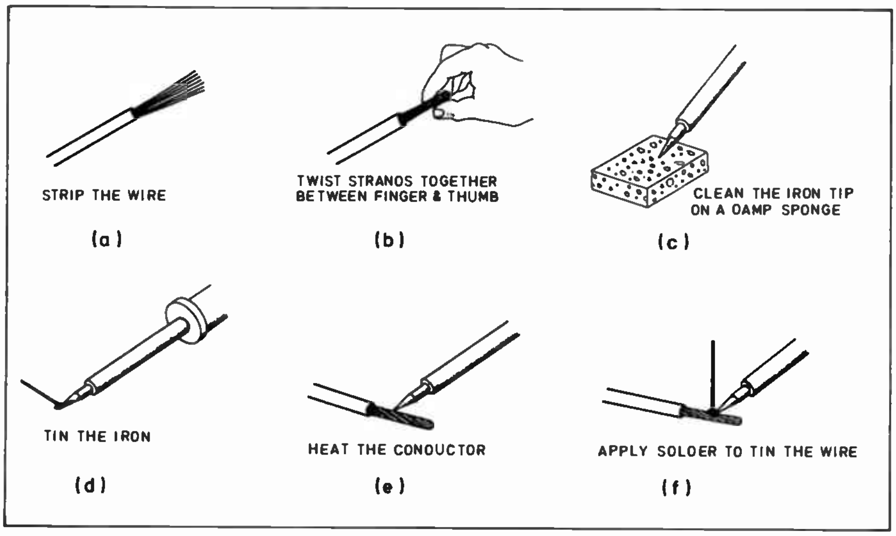


Fig. 3.15. Tinning the iron and the wire.

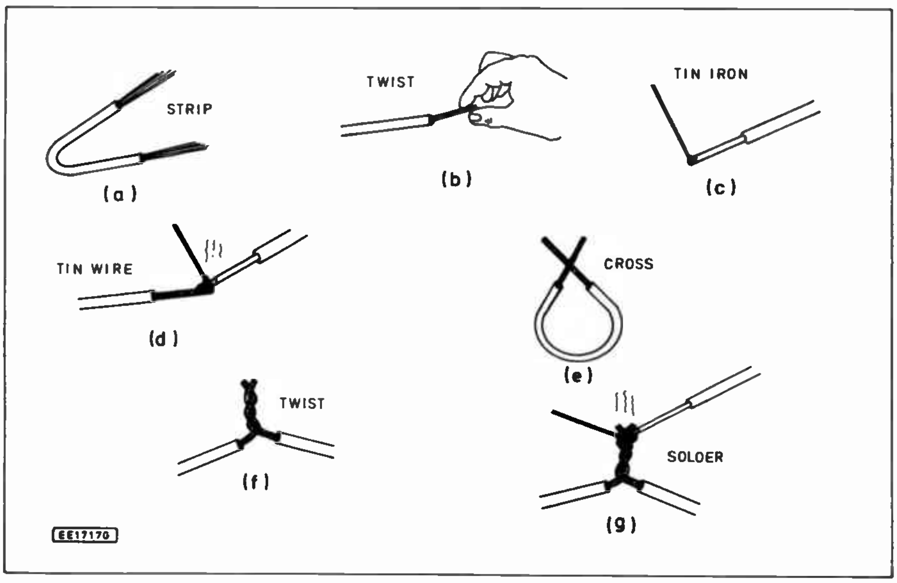


Fig. 3.16. Making a soldered joint.

crimping but, in general, after the wire is stripped, the bare conductor is inserted into the connector (Fig. 3.14a), placed between the jaws of the crimping tool (Fig. 3.14b), and crimped by squeezing the tool handles (Fig. 3.14c). There must be no loose strands of wire—these are a common cause of short circuits.

Making Soldered Joints

Soldering, like all manual skills, needs to be learned by actually doing it. The following exercise is designed to give you practice in soldering and in the use of hand tools:

Step 1. Strip 25mm of insulation from the end of a length of wire (Fig. 3.15a).

Step 2. Twist the strands of the bare conductor into a tight spiral (Fig. 3.15b).

Step 3. Dab the iron tip on a damp sponge to clean it (Fig. 3.15c).

Step 4. Touch rosin cored solder wire to the soldering iron tip very briefly to give it a thin coat of molten solder as shown in Fig. 3.15d. This is called "tinning the iron".

Step 5. Touch the iron tip against the conductor to heat it up (Fig. 3.15e). The conductor must get hot enough to melt solder when it is applied.

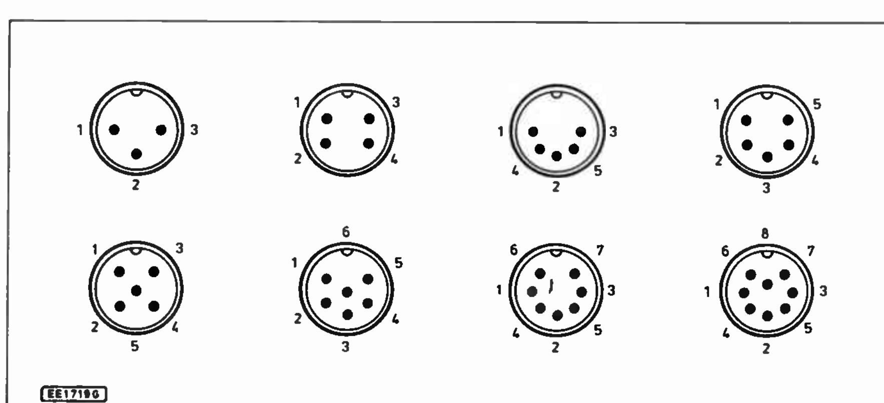
Step 6. Apply solder to the conductor (*not* to the iron) until it has an even coat of shiny solder (Fig. 3.15f). Always remove the iron after the solder when done. The wire is now "tinned".

Repeat this exercise a few times until you are able to tin a wire nicely at every attempt, then practice soldering the ends of a wire together by following the steps given in Fig. 3.16. There is more to be said about soldering when we begin assembling circuits in Part 5.

Questions

1. State the purpose of insulation on wires.
2. How many strands are contained in 32/0.2 wire?
3. State the overall diameter of 7/0.2 wire (not the diameter of each strand—you will need to consult a suppliers catalogue).
4. Identify the following plug and socket type.

5. Which of the following does *not* represent a true "D" type connector?
   9 way
   15 way
   20 way
   25 way
   37 way
6. Use a suppliers catalogue to help name the "DIN" connectors shown below



NEXT MONTH—Answers to the questions above plus Measurement and Testing.

PLEASE NOTE
Answers to lasts months questions are given on page 713

ASSESSMENT CENTERS
We have been contacted by a number of Assessment Centers and will publish a list with details next month.

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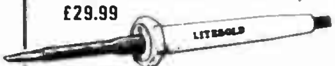

EC50 Mains Electronic Iron. £29.99

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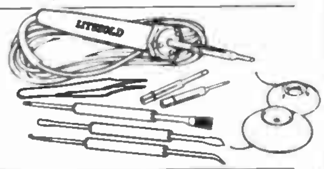

SK18 Soldering Kit. £16.70

Build or repair any electronic project. LC18 240v 18w iron with 3.2, 2.4, and 1.6mm bits. Pack of 18 swg flux-cored 60/40 solder. Tweezers. 3 soldering aids. Reel of De-Solder braid. In PVC presentation wallet.

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Possibly smallest mains iron in the world. Ideal for fine work. Slim nylon handle with finger grip. Interchangeable bits available 1.2, 1.6, 2.4, 3.4 and 4.7mm. Fitted with 2.4mm. 240v 12w (12v available). Presentation wallet.

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Soldering Iron Stands 3&4 £6.06 No. 5 £6.28

Designed specially for LITESOLD irons. Heavy, solid-plastic base with non-slip pads. Won't tip over, holds iron safely. With wiping sponge and location for spare (hot) bits. No 5 stand for EC50 iron No 4 stand for ADAMIN miniature Iron No 3 stand for LA12 and LC18 Irons.

Replacement Bits

For all above irons. Non-stick designs, machined from special copper alloy, with Inconel retaining rings. Two types – Chromium plated with copper face (for economy and ease of use) and Iron plated with Pre-tinned face (Long Life). State tip size, iron and type.

	Copper	L/L
EC50	–	£1.92
Adamin 12 and LA12	£1.06	£1.90
LC18	£1.20	£2.09

Yellow £1.38 Green £1.44 Blue £1.50 per Reel

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De-Solder Pumps £7.71

High Quality version of increasingly popular type of tool. Precision made anodised aluminium body, plunger guard and high-seal piston. Easy thumb operation. Automatic solder ejection. Conductive PTFE nozzle – no static problems.

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305 set 2 crosspoint and 3 hex wrenches 1.5 to 2.5mm £2.56
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Microcutters. £5.39 Light weight hardened and precision ground. Flush cutting. Screw joint, return spring, cushion-grip handles. Safety wire-retaining clip.

Soldering Aids.

Set of 3 £4.22
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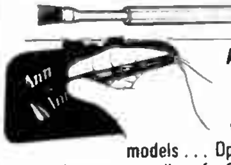

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ACTUALLY DOING IT!

by Robert Penfold

ALTHOUGH it is a hot and humid day in June as I write this piece, I would guess that by the time it gets into print a new electronics season will be well under way. Electronics construction is (of course) an all year round activity, but being primarily an indoor "sport" it tends to be pursued more vigorously in the non-summer months. The autumn is a time when most experienced electronics hobbyists start planning ahead for a busy winter of construction, and there are generally a lot of prospective newcomers to the hobby.

THE COMPONENTS

I suppose that I am stating the obvious when I say that electronics is a technical hobby. Even if you are only interested in the construction of projects and are not too bothered about how they work, the technicalities are not totally avoidable. Probably the best advice for those thinking about taking up electronics as a hobby is not to be put off by the intricacies.

The construction information in *Everyday Electronics* is very clear, but there are still likely to be points that you do not understand when reading through articles. Do not let this put you off. The types of project featured in *Everyday Electronics* are very diverse, as are the components they use. If you take the plunge and get underway with a project, the points that had you puzzled will almost certainly all become quite obvious once you have a complete set of bits.

If you are hesitating about electronics construction, do give it a try. It is a very interesting and rewarding hobby, and one that need not cost a great deal of money. You should start with a very simple project; not so that you are limiting your liability if things go wrong, but because this will give you a good chance of initial success. I mentioned previously that most problems will solve themselves once you have a complete set of components, but your first problem will be getting the right parts.

COMPONENT BUYING

When I first started electronics (the early 1960s) it was quite possible to take a trip to the local electronics shop and get all the components for practically any published project. The same is not true these days, even though my local electronics shop is now a Maplin's store and stocks many thousands of different components.

There is a vast range of electronic components now available, and it is unlikely that one store could hold stocks of all of them. There are a lot of specialised components that are only stocked by a few suppliers, and it is surprising how many projects (even simple ones) require at least one unusual component.

The solution to the components problem is to obtain as many of the mail order catalogues as you can get. Some of these are free, or cost very little. Others will cost a pound or two, although some or all of this may be redeemable when an order is placed. Although it may seem that money would be better spent on components and tools than on component catalogues, this is a myopic attitute.

Apart from making it easy for you to locate the components you require, the beginner can glean a great deal of useful information from the larger component catalogues. There is often information on component colour coding and useful details of various semiconductors. Also of great help to the beginner are the photographs and drawings of components. This information, plus the article describing the project, will help you to order the right components, and to sort them out properly when they are delivered. A project stands little chance of working if you muddle-up the components!

If all else fails you can contact the publisher of the project for help in locating a hard to find component. However, before you do this take a good look at the article concerned, the components list, and advertisements in the magazine. In the case of *Everyday Electronics* projects you should also consult the *Shop Talk* feature which will give advice on sources of supply for any unusual components.

It is not unknown for enquiries to be received from irate readers claiming that components are unobtainable when sources of supply are named in the magazine, or the component concerned is advertised in the same issue as the one in which the project appears! Please read the magazine carefully before enquiring.

A RECENT PROJECT

As your first project **choose one from a recent issue.** Some people get hooked on electronics when they are given some electronics magazines from a few years ago. Possibly a lot more people who are given old magazines get put-off electronics for life. Getting all the components for a project which is more than just a few years old can be very difficult, or even impossible.

While many of the components in use today have been in existence in much the same form for a long time, new components are always coming along while others become obsolete. In particular, many semiconductors that were popular five to fifteen years ago are no longer manufactured. The only chance of obtaining these is to look through the catalogues of retailers who deal in surplus components.

I still get the occasional enquiry on projects published ten to twenty years ago! It is unreasonable to expect much help with projects more than a few years old. Even if the relevant issue of the right magazine can be located, coming up with sensible answers to anything more than the most mundane of queries can be difficult.

You can, however, learn a great deal from old electronics magazines, and there should be no problem in building *simple* projects from them *if all the components are still current* items. Make sure that all the components can be obtained before ordering any of them, and start with some recent projects before attempting any older ones.

TOOLS OF THE TRADE

Many of the tools used in electronics construction are the type of thing that can be found in most households. Pliers and screwdrivers are the sort of general purpose tools that are needed for electronics work. You may need to buy some additional screwdrivers as you will often need very small types for electronics work. These are not to be found in every household, but generally cost a matter of pence and should not involve any major expenditure. Be sure to have at least one miniature cross point type. I have several pairs of pliers. Perhaps not surprisingly, the only pair I use to any extent are 'electricians" pliers (i.e. the short nosed, square ended type).

The main tool of the electronics constructor is the soldering iron, and this needs to be a small electric iron (about 15 to 25 watts) fitted with a miniature bit of about two to three millimetres in diameter. There is no need to go to great expense buying a temperature controlled type. A simple but good quality iron should only cost about £7 and this will be quite sufficient.

To go with the iron you will need a matching stand. A soldering iron stand should only cost about £2 to £3, and they usually include a sponge (which must be kept wet) on which excess flux and solder can be cleaned from the bit of the iron. You will also need some solder, and this should be a 60% tin/40% lead type having a multi-core non-corrosive flux. The 22 s.w.g. size is best for most electronic work, but it is handy to have some other thicker 18 s.w.g. solder for larger joints.

SOLDERING

Learning to solder is something you should do before you start your first project, rather than expecting to pick it up as you go along. The ability to produce good soldered joints is something that comes with experience, but you need to be reasonably competent before you start soldering in earnest. This is an important subject that we will return to next month.

A very important tool for the electronics hobbyist is a good pair of wire strippers and cutters. In fact this can be a combination tool or two separate tools. For many years I used a combination cutter/stripper tool, and found this to be the most convenient way of doing things. In recent years I have used separate tools because the combination tools I obtained did not seem able to cut thin wires (they just put kinks in them). If at all possible I would recommend the use of good quality separates, but a good combination type should suffice if funds are limited.

Even a cheap combination tool is much better than trying to improvise using scissors, knives, etc. Apart from possibly being a bit dangerous, these other methods are not likely to be very effective.

When trimming wires on the underside of a circuit board you need something that will cut the wires close to the board. When stripping sleeving from wires you need a tool that will cut the sleeving but which will not nick the wire (which would leave it vulnerable to breaking at that point). The proper tool or tools are the only ones that are likely to do these jobs really well.

This is basically all you need for the electrical side of project construction. There are other tools which will make life much easier, such as a magnifying glass for inspecting circuit boards when searching for solder splashes. A good desoldering tool is also a decided asset. Some components are virtually impossible to remove from a circuit board without the aid of one of these.

You will also need some tools for the purely mechanical side of project construction.These are the types of tool that you will probably have already, such as a power or hand drill, a range of drill bits, a hacksaw or junior hacksaw, a modelling knife, a small hammer, and a centre-punch. Something you will probably have to buy and which is worth having right from the start is a set of miniature files. They will mostly be used on plastics and aluminium, neither of which are particularly hard. An inexpensive set of files should, therefore, be perfectly adequate.

ODDS AND ENDS

There are a few odds and ends which you are bound to need sooner or later, and it is probably best to obtain them at an early stage. Probably the most important of these is wire. For wiring up projects you will need some p.v.c. insulated connecting wire, and for general use the multi-strand type is the best. 7/0.2 wire (i.e. seven cores of 0.2 millimetre diameter wire) is suitable for most wiring. A heavier duty wire such as 16/0.2 or even 32/0.2 is needed for high current wiring, but initially you are unlikely to build any projects that merit either of these.

Tinned copper wire (which is not insulated) is useful for link wires on circuit boards and short point-to-point style wiring. Either 22 or 24 s.w.g. wire should be suitable. Where a number of wires must run side by side it is generally easier to use ribbon cable than to tie several separate wires together. A couple of metres of 10 way multi-ribbon cable will be more than a little useful.

It is also helpful to have some p.v.c. sleeving. You are unlikely to use this very much, and a metre of 2 millimetre bore sleeving will probably last a few years. A roll of p.v.c. insulation tape is also worth having around.

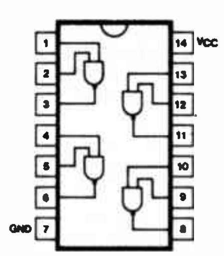
A selection of M3 or 6BA nuts, bolts and spacers are needed for mounting circuit boards. You can buy these as you need them, but most constructors prefer to have a stock of these items. It can be very frustrating if you have a project that is complete apart from a few "out of stock" nuts and bolts! For the same reason it can be worthwhile laying in a small stock of resistors. I would estimate that two resistors of each value would only cost around £2, but could save a lot of frustration.

Last but by no means least, it is a good idea to have some grommets of various sizes. These are a sort of p.v.c. or rubber washer that fits into a hole drilled in a panel. It is advisable to always use grommets in holes that cables are threaded through, but with a metal panel and a mains cable they are mandatory.

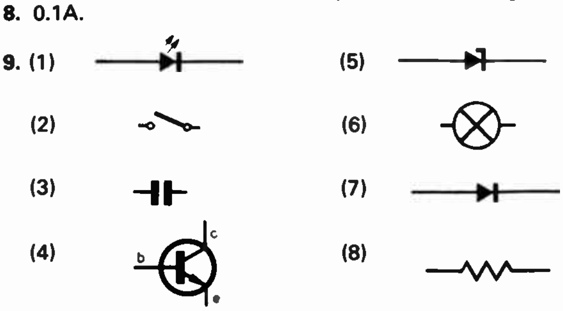
Introducing DIGITAL ELECTRONICS

ANSWERS TO PART 2 QUESTIONS

1. ±5%
2. The package is a 14 pin d.i.l. and the pin numbering of this quad 2-input NAND gate chip is:



3. Yes.
4. 68k ±10%.
5. Green, blue, black, black, yellow (reading from top to bottom).
6. 250V.
7. It would be written on the body of the resistor e.g. "2k2".
8. 0.1A.
9.



These are the basic symbols—there are of course variations to some of them).

10. A *potentiometer* is a variable resistor.
11. 4.7μF (4μ7) 35V (working voltage). The "+" indicates the +ve leadout.
12. (a) 1Ω±5% (b) 22k±5% (c) 47k±2% (d) 33k±20%.
13. dual-in-line.
14. Pin 3.
15. 47nF.

PLEASE TAKE NOTE

SEASHELL *(November 1988)*

The gremlins, and the postal strike joined forces to create a few errors in the *Seashell* project published last month. Regular readers will know that we do not normally have this problem and we apologise for it—by the way we can normally spell capacitors unaided!

In the main circuit R30 (10k) is marked R38, C5 should be 470n (not 470k). There is a drawing error around D10/C24/R43/R45—this network should be similar to the channel above; the p.c.b. is correct.

The second paragraph under SOUND WAVES should read:

"Each output pulse discharges C3 and C4 through diodes D1 and D2. These capacitors charge again through R4 and R5, taking about four seconds to reach half supply voltage where IC2a and IC2b switch, their outputs going low. These are differentiated by C5, R6 and C6, R7 so that the outputs from IC2c and IC2d each go high for about two seconds."

Below heading CONSTRUCTION, para. 4, 3rd sentence, should read "In particular, all the polyester capacitors are the miniature layer type, not the larger film variety." Same heading, para. 5, change C11 to C38. Same heading, last para., last sentence but one, should read "If the board is not cut, the power rails are completed by copper tracks so two of the connections shown will be unnecessary."

Basically all the construction details are correct as published so constructors should not have problems.

Robot Roundup

NIGEL CLARK

ROBOT ping pong has entered a new phase. It has left the low cost, high ingenuity area of the British and passed into the high cost, high powered area of the rest of Europe.

At the European finals in Zurich this year the deciding game saw a rally of four shots. That was a long way from the previous year's event which was decided by which machine was most likely to hit the ball on a service. This year the organisers were able to bring in more of the rules of human table tennis to decide the best machine.

The contrast between the winners in 1987 and 1988 could not have been greater. Last year John Knight's Charlie from Britain won with a system powered by an old Dragon computer, the software for which was stored on cassette. Charlie had a home-made vision system using a spinning mirror and phototransistors. The whole device cost less than £100. This year the Swiss entry, Toughy, by contrast was controlled by a MicroVax and a number of 68020 chips. The arm, operating around a central pillar, could move from point to point in a fraction of a second. Its total cost was far greater than that of Charlie.

This year's British entry (Charlie) was further hampered by being in the middle of a redesign. Last year the vertical movement of the bat on an X-Y frame was a problem and Knight's efforts to correct it were not complete, resulting in accurate horizontal movement but erratic vertical movement. However, the final score was relatively close at 21-13.

Regular followers of the ping pong contest over the years will be impressed that it has progressed to this relatively advanced state even if much of the scoring is still the result of failure by the server rather than positive action.

SCORING

The scoring follows that of table tennis in that a set is played until one player reaches 21 and is two points clear of the opponent. A player holds serve for five points when it automatically passes to the opponent.

In robot ping pong the ball is delivered by a mechanism attached to the top of the frame placed at the net and the server must hit it through a ½ metre square at the opponent's end of the table. The server has two attempts after which, if both are failures, a point goes to the receiver. If having made a successful shot the receiver fails to return it the server wins a point.

The two other contestants were from Sweden and Finland. The Finns' Byrokrat was driven to Zurich to prevent a repeat of the previous year when the finals were held in Venice. Unfortunately, they were then unable to get the machine through airport customs in time for the contest.

Both entries followed the high-powered path. Byrokrat used two 68008 micros, c.c.d. cameras and d.c. motors of up to 433 watts. The Swedes' GIRL had two interfaced cameras and "home-grown" 24–bit computers.

However, when they came face to face they both had an off day and neither was capable of making a scoring serve. The scoring reverted to that of previous contests with a touch being worth one point, two for a net clearance and five for a proper serve. On that basis the Finns took a 9-1 lead and the Swedes conceded.

The Finns then took on Knight's Charlie. Unfortunately for the British, Byrokrat was in better form and despite a few impressive serves from Charlie, Knight conceded when the score was 13-7.

GIRL also improved and was leading Toughy after a good start. However, the Swiss at last found the correct settings, coming back to win 21-16 and a place in the final against the Finns.

Byrokrat began the better with five good services from its first ten against five failures by the Swiss to lead 10-5 when the Swiss began their second set of serves. At that point Toughy began to get services in, but Byrokrat managed to return them, generating the first simple rallies seen since the contest began four years ago. At 6-10 the four hit rally occurred.

The Finns stayed in control and were leading at 17-12 but then the Swiss came back to draw level at 18-18 followed by three good serves to take the match. Next year the contestants are being invited to a practice match in Edinburgh in the spring.

All the events were witnessed by John Billingsley who thought up the contest and devised the rules between lecturing duties at Portsmouth Polytechnic. He has also been writing a book on control technology, *Controlling With Computers*, which is coming out soon, published by McGraw-Hill.

EDUCATION

Meanwhile British companies are still trying to find the best way to service demand for robotics in education. The developers of the Robotech 1 arm kit, described in *EE* June 1988 have been making major changes to their product. The original kit included electronic and mechanical parts which, with the addition of wooden structural parts for which templates were included, an arm could be produced.

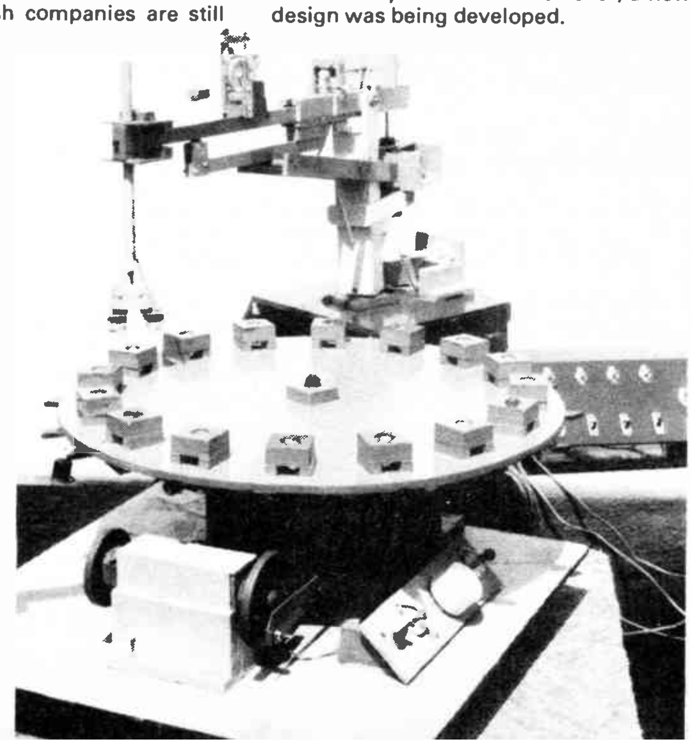
An interface for the BBC series is now almost ready. Tests are being carried out and it should be available by the end of the year. The arm has also been given sensors.

However, the original kit is being phased out to be replaced by three kits. George Walker, one of the Robotech creators, said that in response to reactions to Robotech 1 they were offering the series to give a range of options to teachers.

The first one contains plans for the robot arm, a mechanically indexed turntable and a wiring diagram for the BBC interface, all for about £80. The turntable is another new addition to the set, and works at a pre-set rate so that the arm has to be programmed to synchonise with it.

The second kit is the one nearest to the Robotech 1 with hardware suitable for building the plan in the first kit as well as photographs and notes showing how the items provided can be put together for other models. As with Robotech 1 the wooden structure still has to be provided by the builder. The final kit provides all the items, including the wooden parts and costs about £250.

Walker said that teachers notes were included with each pack so that they could decide how much of the available information could be given to students, allowing them to develop their own courses. He added that the plans were to build the Robotech 1 as there had not yet been time to make any alterations. However, a new design was being developed.



The Robotech 1 robot working with the mechanically indexed table.

Constructional Project

DOWNBEAT METRONOME

ANDY FLIND

Master the art of good "time-keeping". Build and practice with the aid of this pocket-sized low-cost, accented beat metronome and you should always be on cue.

ALL BUDDING musicians eventually face a common problem; learning to keep time. A good teacher can help, but lessons are expensive and a great deal of practice can be needed to acquire the knack. A metronome provides a cheap and effective solution to this difficulty, giving a steady loud ticking to set the beat.

Better still is an "accented" metronome, with a "ping" every few beats to indicate the start of each bar. These are rather expensive to buy, but one may be built very cheaply from readily obtainable components. This one is also pocket-sized, so if your instrument is portable you can take it with you and practice anywhere.

BLOCK DIAGRAM

The heart of this project is a stable, slow-running oscillator built with an inverting integrator and a Schmitt trigger as shown in block diagram, Fig. 1. The integrator is the standard op-amp arrangement. Its reference is set to half the supply, so when the input to "R" is higher than this the output ramps downwards, when lower it ramps up. When it reaches the Schmitt threshold in either direction this rapidly changes state and the ramping direction is reversed.

The output of the op-amp is thus a triangle wave, with amplitude fixed by the Schmitt hysteresis, whilst complementary squarewave outputs are available from the Schmitt circuit used in this design. The frequency is determined by the values of R, C, the Schmitt threshold, and the voltage applied to R in each state.

To vary the tempo, one of the above parameters must be variable. C can be ruled out immediately, as suitable variable capacitors just don't exist. The frequency is inversely proportional to R and the threshold, so varying these results in an awkward non-linear scale on the control. It is directly related to the applied voltage, however, so if this is made adjustable the control will have evenly spaced calibrations. This was the reason for the choice of this oscillator circuit, which offers a considerable improvement over many earlier designs.

CIRCUIT

In the full circuit, Fig. 2, the oscillator consists of integrator IC1 with a Schmitt circuit formed by two NAND gates, IC2a and IC2b. VR3 offers adjustable attenuation of the Schmitt output before it is fed back to IC1.

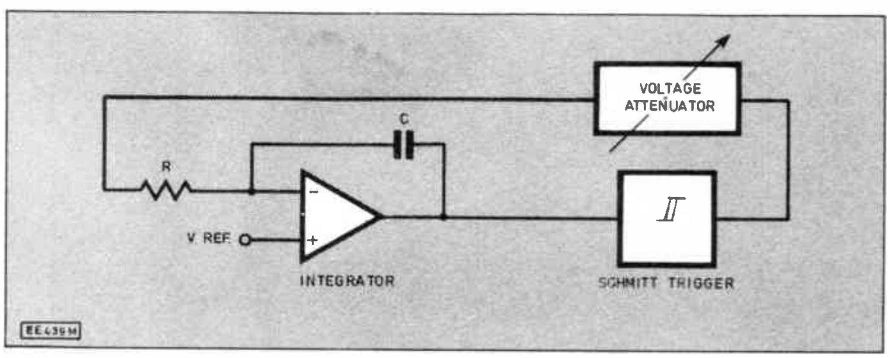


Fig. 1. Block diagram for the metronome oscillator.

The overall operating point is set by R1 and R2 to half the supply. As the whole circuit operates around this point, and the Schmitt output switches from rail to rail, the frequency is independent of the actual supply voltage, making regulation unnecessary.

The circuit in fact maintains excellent stability to below 5 volts, and is also very insensitive to changes in temperature. Most metronomes are required to produce 40 to 200 beats per minute, so the lower and upper limits are adjustable to these values with VR1 and VR2 respectively.

The Schmitt output is a squarewave which is differentiated by C4, R10 and C5, R9 and buffered by IC2c and d to produce positive-going pulses of suitable duration. From IC2c a pulse of about 33mS drives l.e.d. D1 to give a clearly visible flash. No series resistor is needed as the gate's internal resistance is sufficient to limit the l.e.d. current. Miniature loudspeakers produce loud clicks from pulses as short as $100\mu S$, so the $330\mu S$ drive from IC2d is in fact rather generous.

The pulse needs current boosting, this being done by transistors TR1, TR2 and TR3. More "steam" is required in the positive direction than the negative, so two transistors are used here. This part of the circuit now produces a loud, steady ticking and a flashing light for the main beat.

The oscillator also drives the counter IC3. A minor problem was encountered here due to the slowly rising input to gate IC2a. The switching point is approached slowly and, despite the positive feedback from the following gate, it was still obviously managing a few output "glitches" as it changed, as the counter output was practically random. These pulses must have been very short, as the introduction of a luS time constant with R8 and C3 completely eliminated the problem. In fact it works with R8 alone, using the counter's input capacitance, but C3 ensures complete reliability.

IC3 can divide by zero up to ten, depending on which of its outputs is returned to "reset". It's a simple matter to select the appropriate one with a switch, and if reset is left high, with pull-up resistor R12, counting ceases altogether. The output is taken from pin 2 and pulses IC4 through a 47mS time constant set by C6 and R13.

Two of the gates flash the l.e.d. D2 for this period. The other two form an oscillator with a frequency of about 3kHz, which is enabled for the duration of the pulse. The output of this goes to the output along with the "tick", resulting in a short "ping" sound.

COMPONENTS

Approx. cost Guidance only **£15**

Resistors
- R1, R2, R6, R8, R11, R16 10k (6 off)
- R3 270k
- R4, R5 2k2 (2 off)
- R7 47k
- R9 330k
- R10 33k
- R12, R14 100k (2 off)
- R13 470k
- R15 18k

All 0.6W 1% metal film type

Shop Talk See page 702

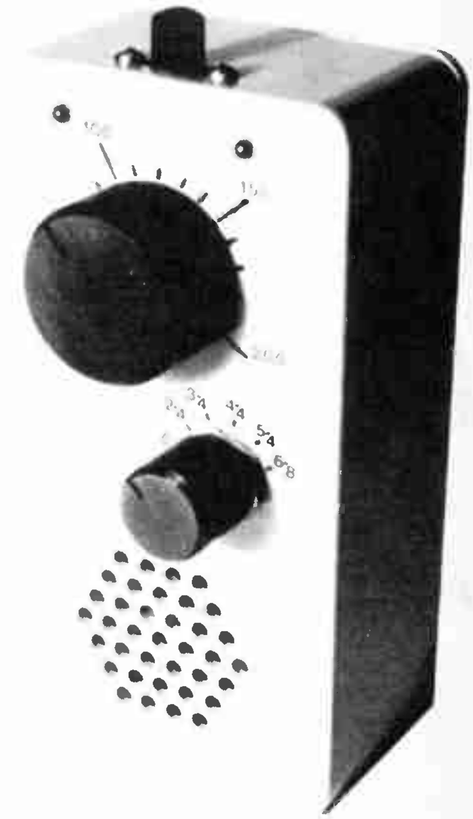
Potentiometers
- VR1 4k7 hor. preset
- VR2 220k hor. preset
- VR3 10k rotary carbon, lii

Capacitors
- C1 1n ceramic plate
- C2 1µ poly layer
- C3 100p ceramic plate
- C4, C9 10n poly layer (2 off)
- C5, C6 100n poly layer (2 off)
- C7 100µ axial elect. 10V
- C8 470µ axial elect. 10V

Semiconductors
- D1, D2 L.E.D., High-brightness 3mm, red (2off)
- D3 1N4001
- TR1 BC184L
- TR2, TR3 BC214L (2 off)
- IC1 3130 CMOS op-amp
- IC2, IC4 4011B CMOS quad NAND gate
- IC3 4017B CMOS divide-by-N

Miscellaneous

S1, rotary 2-pole 6-way, break-before-make.
S2, 1-pole 3-position slide-switch.
LS1 Speaker, 45mm 8-ohm.
Case, ABS plastic, 120×65×40mm; knobs (2 off); PP3 battery connector; 8 pin d.i.l. socket; 14 pin d.i.l. sockets (2 off); 16 pin d.i.l. socket; p.c.b. available from the *EE PCB Service*, order code EE629.

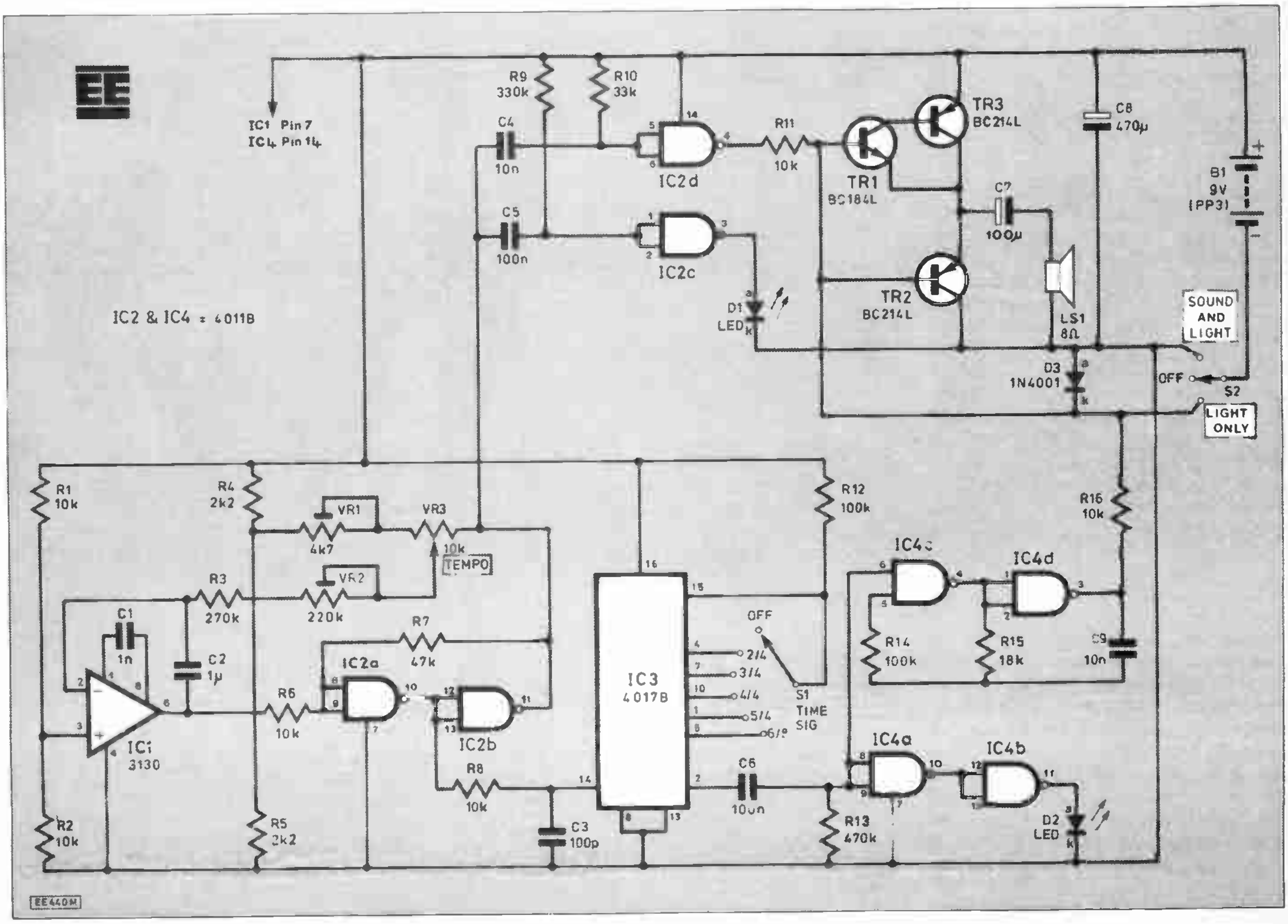


SOUND AND LIGHT

There may be occasions when the lights are required without sound so this is arranged through D3, with a 3-position switch in the negative battery supply. When set to "sound and light" negative goes directly to the circuit rail and everything runs whilst D3 is reverse biased and has no effect.

When just lights are required, the supply is connected to the other end of D3, which also happens to be the input for the output stage. This holds the output low regardless of drive through R11 or R16, so there is no sound. The negative rail is powered through D3 however, so the lights still operate. At first sight this may seem a strange arrangement, but it works well and keeps the switch wiring simple.

Fig. 2. Complete circuit diagram for the Downbeat Metronome.



CONSTRUCTION

Earlier, it was stated that this project would be pocket-sized. Although it's not too tightly packed into the case, some care is necessary in construction and a fine-tipped soldering iron should be used. The choice of components is also of some importance. The "polyester layer" capacitors are the miniature, silver-coloured layer type, whilst the two ceramics, C1 and C3 are also miniature.

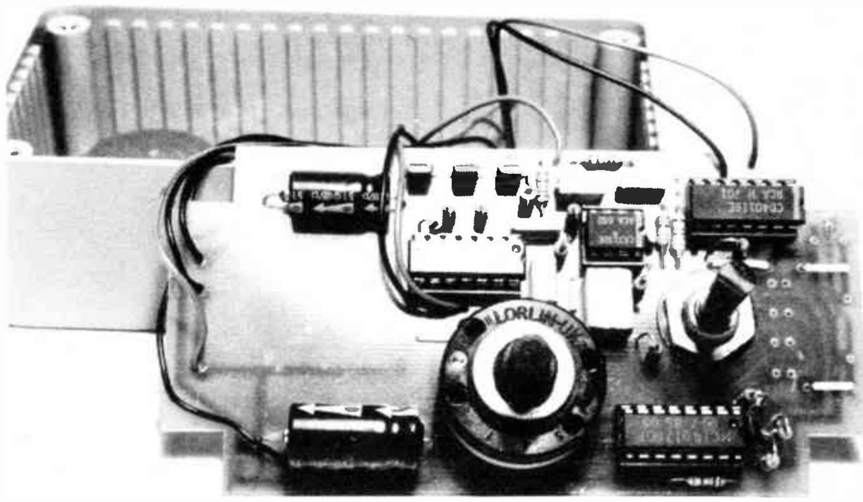
The switch is a standard plastic rotary type, which will fit directly to the board. The loudspeaker especially should be of the correct size; the prototype was fitted with one measuring 45mm diameter and 16mm deep.

Preparation of the printed circuit board should be complete before construction commences. If necessary the corner cutouts (to clear pillars in the box) and the hole for VR3's bush should be cut, and the holes for S1 terminals may need enlarging. The terminals are wire "stalks" about 5mm long, topped with "eyes" which should be cut off leaving the stalks as long as possible. After component fitting they are pushed through the holes and soldered. The holes will need to be about 1.5mm diameter, and it would be as well to check the switch fits.

Also, check that the board fits the case! Before construction it can be used as a template to mark the case for S1 and VR3. Note that whilst S1's bush passes through the case, VR3 is fitted to the board so clearance should be for the shaft only. This done, component assembly can be carried out as shown in Fig. 3. Everything except VR1 and VR2 can be fitted, though sockets are adviseable for the i.c. points. Take care to place D3 correctly, with the marked (cathode) end connecting to the transistors.

The two presets are soldered to the copper side of the board. This leaves space for S2 on the component side, and allows adjustment when the project is complete. Miniature horizontal presets usually have legs which are thick near the body and narrower below, to create a gap when fitted to a board. These can be bent out at right angles and cut short, after which it will be easy to solder them to the tracks with a small-tipped iron, as shown in Fig. 4. Set them initially to half-scale.

After component assembly S1 can be fitted as described above, pushed fully home and soldered. The p.c.b. is secured by this switch; on the prototype a single thin washer between its body and the case produced the correct spacing, allowing the board to rest flat on top of the speaker, with the battery pressing it down from the other side for extra rigidity. It would be as well to check the fit with switch and speaker in position before finally soldering, though.



The completed circuit board showing the rotary "time" switch mounted on the component side and the "tempo" control VR3 spindle and bush protruding through from the copper side.

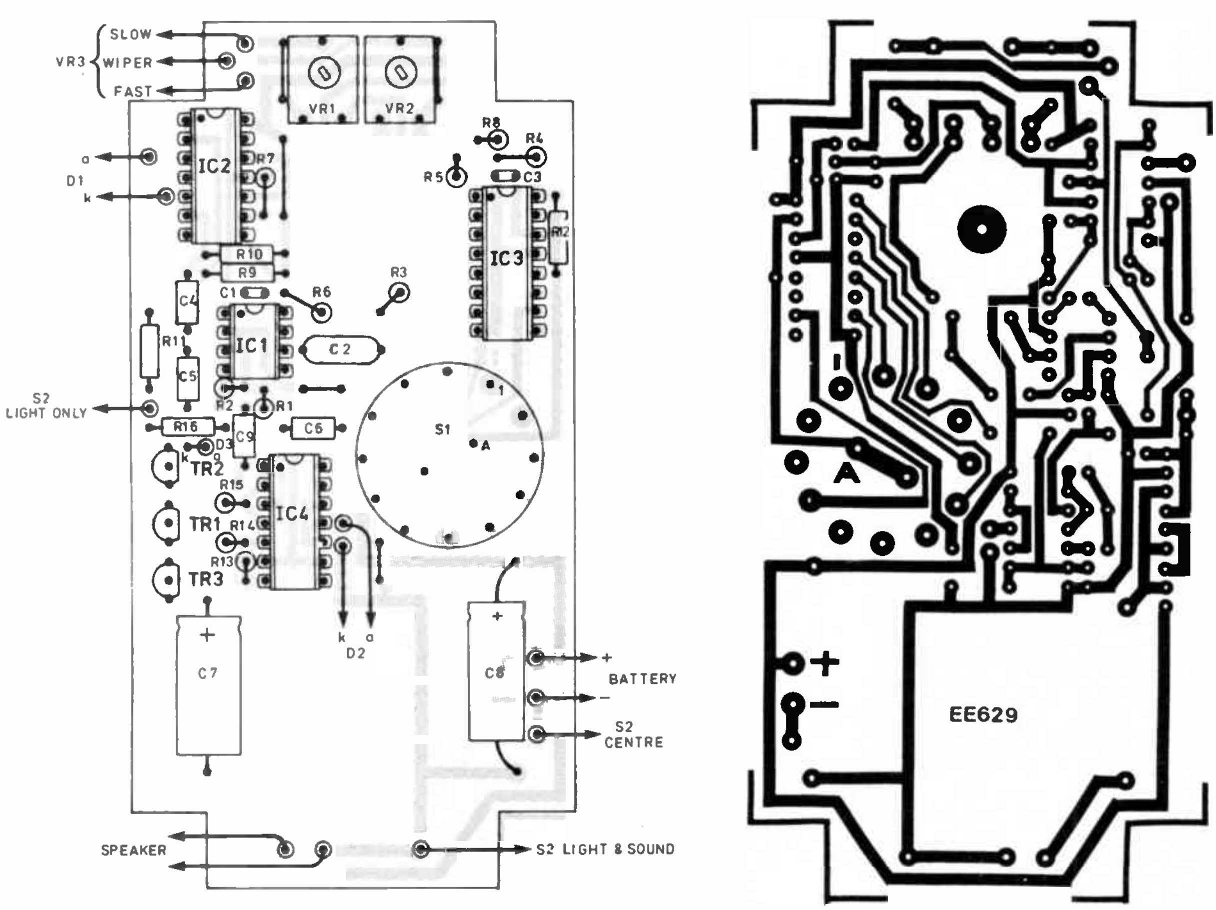


Fig. 3. Printed circuit board component layout, interwiring and full size copper foil master pattern.

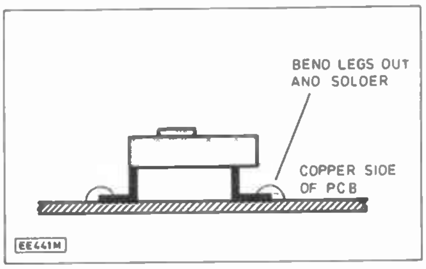


Fig. 4. Mounting the presets on the copper side of board.

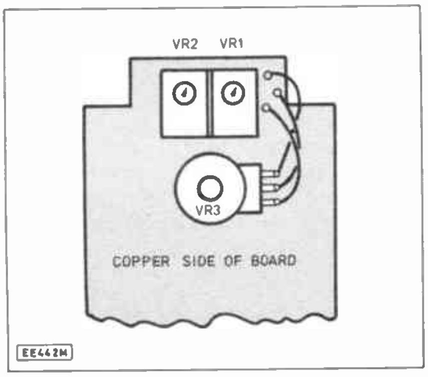


Fig. 5. Location and wiring of VR3.

VR3 is fitted to the copper side of the board and connected with short wires as shown in Fig. 5, a washer will give extra clearance between the body and the soldered joints if needed. Care should be taken to see that no metal parts short to the copper tracks. Leads can now be fitted to all external connection points, with the two l.e.d.'s D1 and D2 soldered to the ends of theirs, ensuring correct polarity.

TESTING

As an initial test, power can be applied before any of the four i.c.'s are inserted into their sockets. After the capacitor charging surge, the current drain should settle to about 5mA. If it takes much more than this, switch off and recheck the construction carefully. If all seems well, fit IC1, IC2 and temporarily connect the speaker. Power up again; D1 should flash and the speaker should tick. Adjustment of VR3 should alter the tempo.

If this works, switch off, fit IC3 and IC4 and try again. This time, providing the switch is not set to position 1, there should be a "ping" with every so many ticks, accompanied by a flash from D2.

Check that the switch selects the correct number of beats, every two in position 2, every three in 3, and so on up to six. The switch has an adjustment (at the base of the bush) to select the number of available positions, so check this is in the correct stop. The final task on the p.c.b. is to ensure the solder joints for the lower ends of C7 and C8 are low and smooth, so that they won't short against the case of the battery. If they have any sharp or projecting bits, file them down and run over them once more with the soldering iron.

The battery is insulated from the board by a small piece of foam plastic, which will also hold it firmly in place and press the p.c.b. down against the speaker. The battery connector should be soldered to the copper side of the board.

FINISHING

Switch S2 is fitted to the top of the case, as close to the front as possible, to clear the p.c.b. A hole is drilled to each side of it to take the l.e.d.'s, which are secured with a drop of glue. The speaker is placed centrally at the very bottom of the case, where it will clear the board components around it; a pattern of holes makes a neat "grille". It is glued into place with "Evostik" or a smilar adhesive.

Switch connections are made as shown, and the board secured in place by S1. This is spaced from the case with a plain washer wide enough to rest against its plastic body as pressure on the position adjuster may interfere with the action. Check none of the connecting wires are trapped before finally tightening the nut.

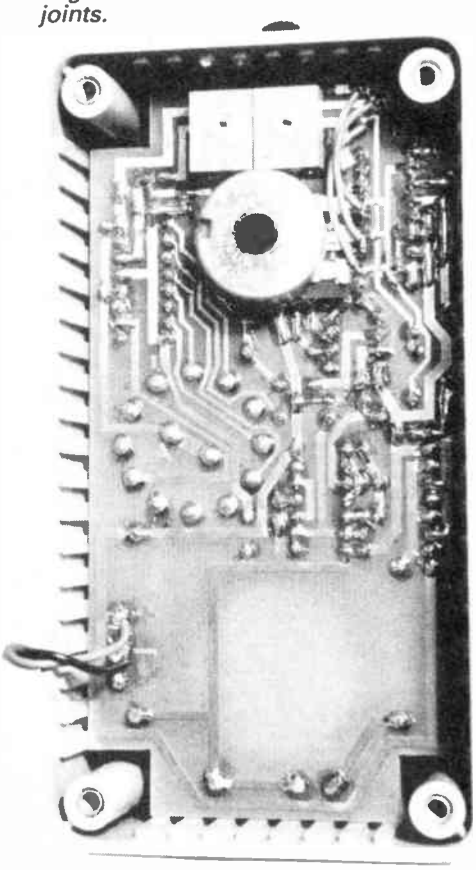
Calibration consists of adjusting VR2, with VR3 at its highest position, for 200 beats per minute, and VR1 with VR3 low, for 40 beats per minute. Make the adjustments in this order as VR2 alters the entire range, whilst VR1 alters only settings below maximum. VR3 can be scaled with patience and a stopwatch, but should prove to be more or less linear, depending on pot accuracy. Some pots seem to have "dead" areas at the ends of their scales.

Musical speeds, should these be needed on the scale, are "largo", below about 60 beats per minute, "Larghetto", 60 to 65, "Adagio", 65 to 75, "Andante", 75 to 105, "Moderato", 105 to 120, "Allegro" (nothing to do with BL cars!) 120 to 170, "Presto", 170 to 190, and "Prestissimo", above 190.

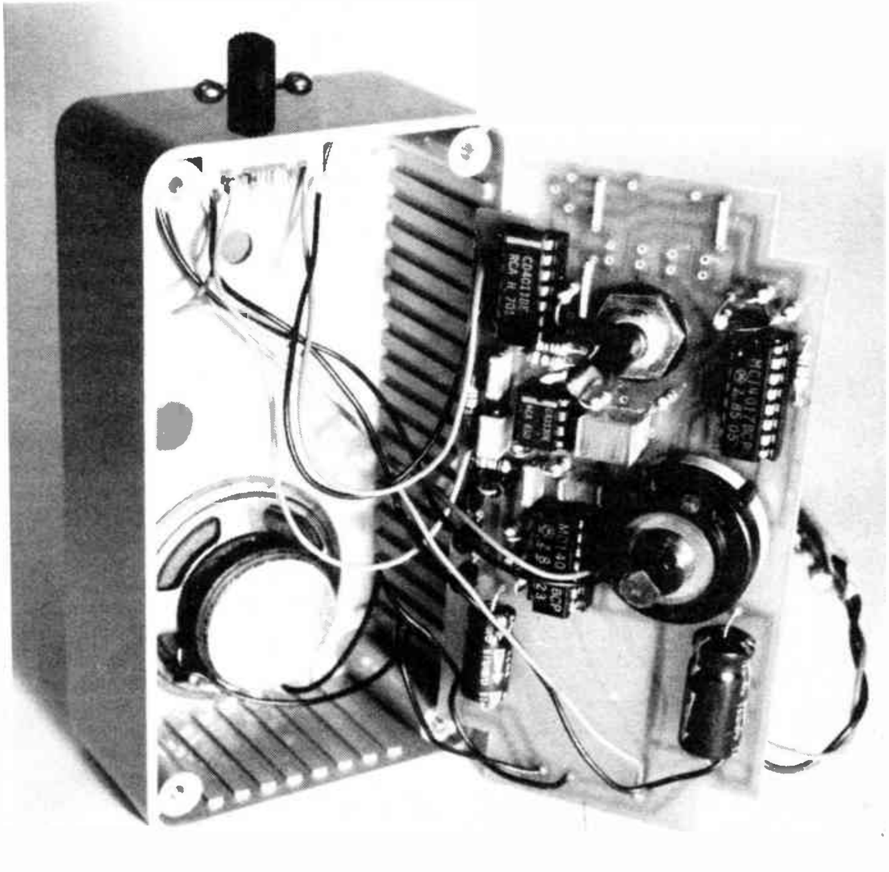
Practice with this simple device should improve the timekeeping of any musician, and it will be found invaluable by those who have to learn, for some of the time, alone. Beginners may also find it helpful in deciphering the timing of some written pieces, which can be extraordinarily difficult for those not used to sight reading.

□

The completed unit showing positioning of presets and control VR3 on the track side of the printed circuit board. A washer should be inserted between the board and VR3 to give clearance from the soldered joints.



Finished metronome with circuit board removed showing the loudspeaker glued to the "bottom" of the case and wiring to the slide switch S2, mounted in the "top" of the the case.



ON SPEC

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month we shall be devoting the bulk of *On Spec* to another major project for Spectrum hardware enthusiasts. We begin, however, by attempting to provide a solution to a problem which is often raised by Spectrum programmers.

Disabling BREAK

Adrian Thomas, a regular reader of this column, complains that there is no obvious way of disabling the Spectrum's BREAK key. Adrian is developing some educational software and he is anxious that the user is not able to exit from the program by means of the BREAK key.

The solution to this particular shortcoming of ZX-BASIC involves a straightforward POKE which should be added to the beginning of the program (e.g. line 1). The following line of BASIC will do the trick:

1 POKE 23613, (PEEK 23730)−5

To re-instate the BREAK key, the following line of code should be added at the end of the program:

9999 POKE 23613, (PEEK 23730)−3

Note that, in the event of an abnormal return to BASIC (i.e. one that does not involve the program executing line 9999), the BREAK key will be inoperative and the POKE should be entered in immediate mode directly from the keyboard (omitting, of course, the line number!).

EPROM programmer

In the past few months I have received an increasing number of requests for an EPROM programmer for use with the Spectrum. It was, therefore, particularly pleasing to learn that *Trevor Brown* (well known in amateur television circles) has produced just such a project for his own use and that this unit has been duplicated by several British Amateur Television Club (BATC) members.

Trevor's original design has appeared in the club's magazine, *CQ TV*, but I have taken the liberty of extending Trevor's basic design by adding a regulated 21V d.c. supply to provide the necessary EPROM programming voltage. Trevor writes;

Like it or not, EPROMs are becoming part of our everyday lives and the ability to look at the stored data, make backup copies, and in some cases store your own code in one is now an every day need. This simple little unit can be made in a single evening.

A simple menu-driven program then provides the user with a variety of options, including loading data into memory from an EPROM (so that it can be examined) or copying data from memory into a blank (previously erased) EPROM. The unit has been designed to function with two of the most popular EPROM devices; the 2764 (8K byte) and 27128 (16K byte).

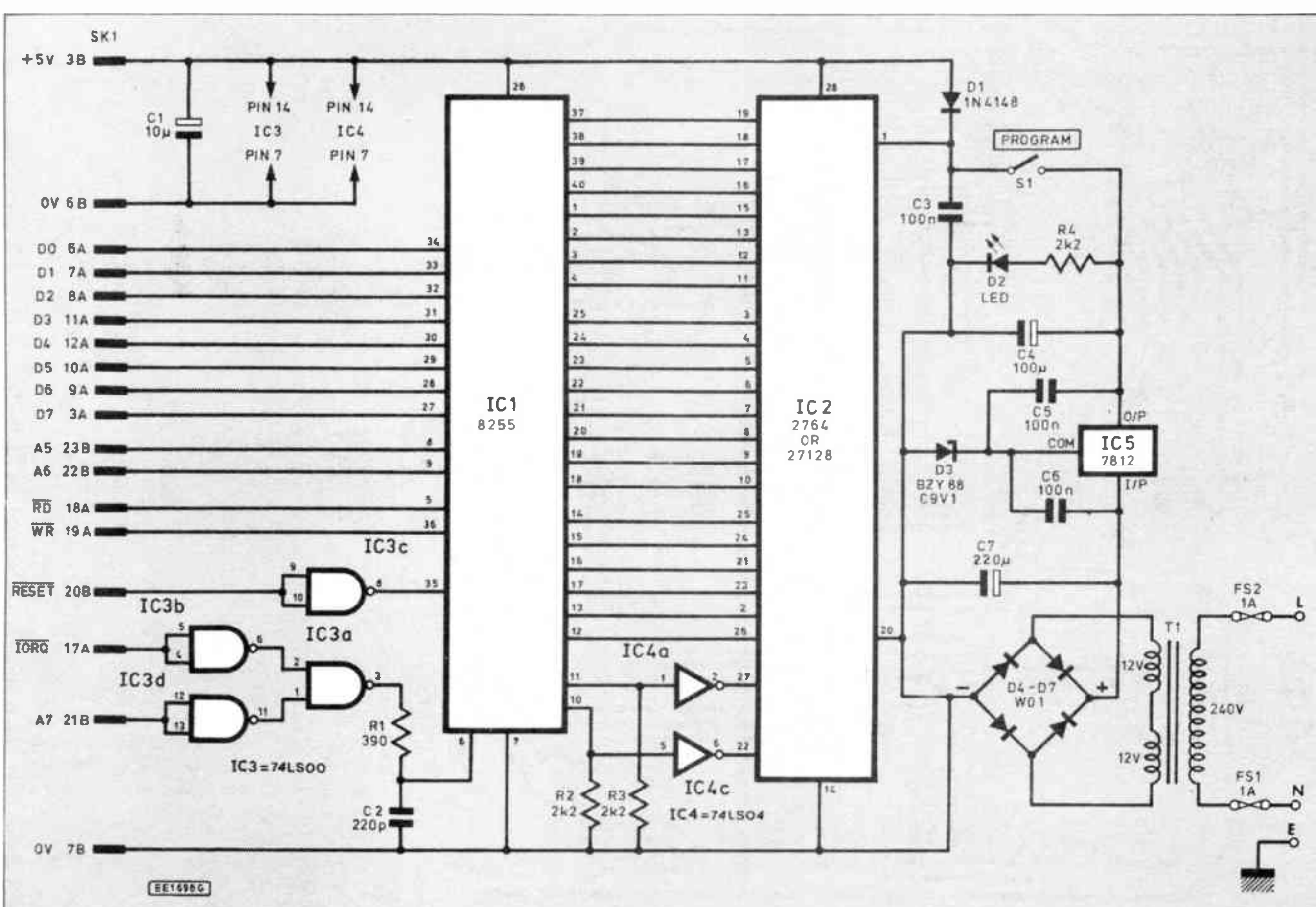
The programmer works well with Hisoft's Devpac assembler with the source code organised to run at any address and SAVEd to tape or Microdrive for later transfer to EPROM. When programmed, the EPROM can be removed and installed into a microcomputer or microcontroller for testing and evaluation.

Circuit description

The complete circuit of the EPROM programmer is shown in Fig. 1. Trevor's design makes use of the 8255 PPI (Programmable Parallel Interface). This device was featured in an earlier *On Spec* and thus will need no further introduction to our regular readers. IC2, a 2764 or 27128, is the EPROM to be programmed. The unit will also program the low-power versions (27C64 and 27128A) in which case D3 should be omitted and replaced with a shorting link.

IC3a, IC3b and IC3d provide partial I/O address decoding such that IC1 is enabled whenever A7 goes low during an I/O read or write operation. IC3c simply inverts the Spectrum's $\overline{\text{RESET}}$ line to satisfy the active-high RESET input on IC2. The two inverters of IC4 are somewhat unusual and are used to activate the output enable ($\overline{\text{OE}}$) and program ($\overline{\text{PGM}}$) inputs of the EPROM.

Fig. 1. Complete circuit of the EPROM programmer



All three of IC1's ports default to inputs on power-up and hence the inputs of IC4a and IC4c are pulled-down by R3 and R2 to ensure that the EPROM's $\overline{OE}$ and $\overline{PGM}$ inputs both default to the inactive (high) state. Trevor's letter continues with this theme:

The PIO is often re-initialised by the programming part of the software in order to reverse the direction of the A-port between programming and reading. This change of direction will default the address carried by the B and C ports to zero and, if it was not for the inverters (IC4a and IC4c), the output enable would also be low which would cause a data clash along with a program pulse at address zero.

The machine code program will soon move things out of this undesirable default state but the inverters ensure that the EPROM data bus is in a tristate condition. The EPROM programmer's port assignment is as follows:

Port	Address (dec.)
A	31
B	95
C	63
Control	127

Construction

The EPROM programmer is assembled on a p.c.b. measuring approximately 120mm×135mm, the copper foil layout for which is shown (actual size) in Fig. 2. The p.c.b. is fitted with a 28-way double sided edge connector which mates directly with the expansion bus connector at the rear of the Spectrum.

The component layout on the upper (forward facing) side of the p.c.b. is shown in Fig. 3. Note that a total of six links are required on the upper (forward facing) surface of the p.c.b. The recommended sequence of locating and soldering components to the p.c.b. is as follows: edge connector, links, i.c. sockets, resistors, capacitors, diode, bridge rectifier, l.e.d. and regulator. Furthermore, constructors are advised to carefully check the orientation of all polarised components (including electrolytic capacitors, diode, bridge rectifier, l.e.d. and regulator).

When the p.c.b. wiring is complete, a careful visual inspection should be carried out, paying attention to checking for dry joints, inadvertent short-circuits between tracks and i.c. pins, and solder splashes. A few moments devoted to this task can often save many hours of frustration at a later stage!

After confirming that all is as it should be, the integrated circuits can be inserted into their sockets (taking care to ensure correct orientation) and the unit connected to the rear of the Spectrum, *after first disconnecting the power supply*. This latter precaution is essential since **permanent damage can result if external circuitry of ANY sort is connected to, or disconnected from the Spectrum's expansion bus whilst power is applied.**

When power is re-connected, the usual copyright message should be generated on the display. If this is not the case, disconnect the power, remove the EPROM programmer p.c.b. and carefully check again!

Software

Trevor's machine code program for the EPROM programmer is too long to reproduce in *On Spec*. However, to assist readers (and also to avoid the usual problems that can result from simple typing errors), Trevor has kindly agreed to make the software available to constructors at a modest cost; £2 for readers in the U.K. and £4 for overseas readers. Both prices include cassette, postage and packing. Trevor Brown can be contacted at Tall Trees, 14 Stairfoot Close, Adel, Leeds, LS16 8JR.

The program provides the following five options:

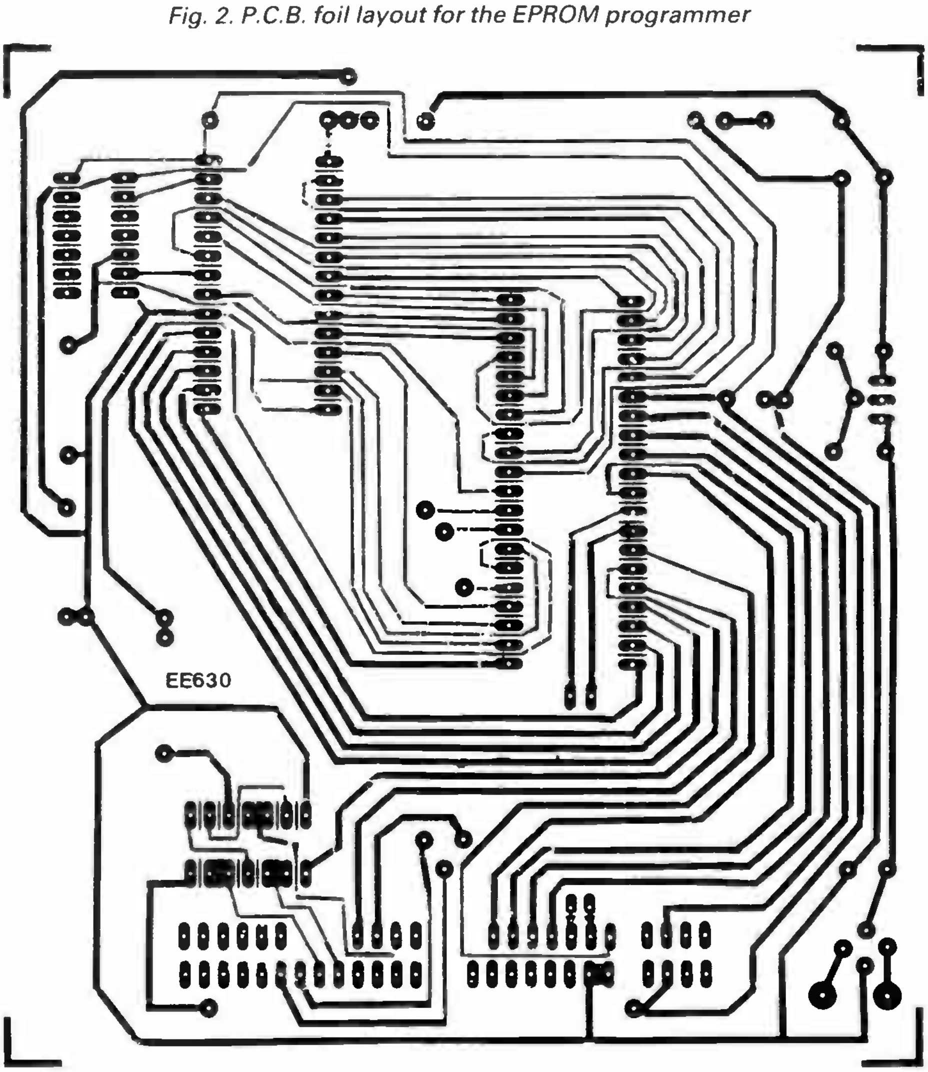
1. Load an EPROM into memory
2. Blow a 2764 EPROM
3. Blow a 27128 EPROM
4. Examine memory
5. Enter BASIC

Trevor makes the following comments on the EPROM programmer software:

Option 1 will load either a 2764 or a 27128 into memory so that data can be examined using Option 4. 16K of data is moved so if a 2764 is loaded the data will repeat after 1FFF. This is not a problem and helps keep the program simple and small (less than 1K of code). When the program is first loaded, the memory is filled with FF (i.e. all bits are logic 1). This is useful for checking that an EPROM is erased.

Insert the EPROM and select Option 2 or 3 but do not switch the programming voltage (V_{PP}) "on". This "verify mode" compares the EPROM with the contents of memory; if all is well, the user will be returned to the menu, alternatively a failure message will be generated along with the address at which an error is detected. By this means, it only takes a few seconds to check an EPROM for erasure.

Fig. 2. P.C.B. foil layout for the EPROM programmer



COMPONENTS

Resistors

R1	390
R2-R4	2k2 (3 off)

All 0.25W 5% carbon

Capacitors

C1	10µ p.c. elect. 16V
C2	220p polystyrene
C3, C5, C6	100n polyester (3 off)
C4	100µ p.c. elect. 50V
C7	220µ p.c. elect. 50V

Semiconductors

IC1	8255 PPI
IC2	2764 or 27128 EPROM
IC3	74LS00
IC4	74LS04
IC5	7812 12V 1A regulator
D1	1N4148
D2	red l.e.d.
D3	BZY88 C9V1 Zener
D4-D7	WO1 (50V 1A bridge rectifier)

Shop Talk See Page 702

Miscellaneous

S1 s.p.s.t. miniature toggle switch.

28-pin zero insertion force (ZIF) socket; 40-way low-profile d.i.l. socket; 14-pin low-profile d.i.l. socket (2 off); printed circuit board—available from the *EE PCB Service*, order code 630; 20mm fuse holders (2 off); 20mm 1A quick-blow fuses (2 off).

T1 12 or 20VA mains transformer with 2×12V secondary windings; enclosure for transformer and fuses; mains connector; 28-way open end double-sided 2.54mm (0.1 inch) pitch edge connector (e.g. Vero part number 838-24826A).

Approx. cost Guidance only £29

Depending upon program size, programming may take up to 15 minutes. No short cut algorithms are used, but each byte is first read and the "blow" operation is skipped if not required.

Option 5 puts users into BASIC so that data resident in memory may be SAVEd to, or LOADed from tape or Microdrive. The required syntax for a cassette tape SAVE is:

SAVE "filename"CODE,28000,8192

for a 2764 or

SAVE "filename"CODE,28000,16384

for a 27128

A microdrive SAVE requires the extra syntax of:

SAVE * "m";1;"filename"CODE,28000,8192

or

SAVE *"m";1"filename"CODE,28000,16384

for 2764 and 27128 EPROM devices respectively.

Files may be loaded into memory for programming by using the commands:

LOAD "filename"CODE,28000

or

LOAD * "m";1;"filename"CODE,28000

(Note that the load address, 28000, may be omitted if a previous SAVE specified this address as a deflault).

Not all our readers will be familiar with the techniques used for data storage in an EPROM and Trevor has provided a few general hints together with a warning which all constructors should carefully observe. Trevor continues:

For those who are not familiar with this means of data storage, the EPROM programmer can only change a logic 1 to a logic 0. An EPROM can be erased by exposure to ultraviolet light of about 2537 Angstrom. Exposure to a small 8W tube at a few inches for about 20 minutes will be required to erase a previously stored program. This process will fill the EPROM with logic 1's (or a byte of FFH at each address). Erasure can be checked by loading the EPROM into memory (using Menu Option 1) and then examining it (using Option 4).

WARNING: Ultra-violet light is dangerous to the eyes and skin and some form of opaque shielding should be used. Furthermore, Ozone can be produced and inhalation may cause respiratory irritation.

Clearly, there are a few important precautions to observe when erasing an EPROM. The best solution is with the aid of a specialised EPROM eraser in which the ultraviolet tubes are contained in a light-proof enclosure fitted with a timer. Such devices are available from several suppliers but they can be rather expensive. Since low-power ultraviolet tubes can be obtained quite cheaply, a possible alternative is that of building one's own eraser, full details for such a unit were given in the ***October '88 issue of EE.***

Finally, my own crude but quick method for erasing EPROMs involves nothing more than a common-or-garden sun-ray lamp! The particular unit in question will erase an EPROM in approximately 10 minutes when the EPROM is placed at a distance of 200mm from the lamp.

It is important to note, however, that overexposure may effectively reduce the number of programming cycles that can be performed so exposure should be kept to the minimum that will ensure that all cells revert to logic 1. Furthermore, with a high-power ultra-violet source it is **ABSOLUTELY ESSENTIAL** to observe the precautions mentioned earlier, carefully following the recommendations of the sun-ray lamp manufacturer concerning skin exposure and eye protection.

Next month: we shall be tackling a seasonal *On Spec Project* in the form of a Christmas lights controller. In the meantime, if you would like a copy of our "On Spec Update", please drop me a line enclosing a large (250mm×300mm) *adequately* stamped addressed envelope.

Mike Tooley, Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

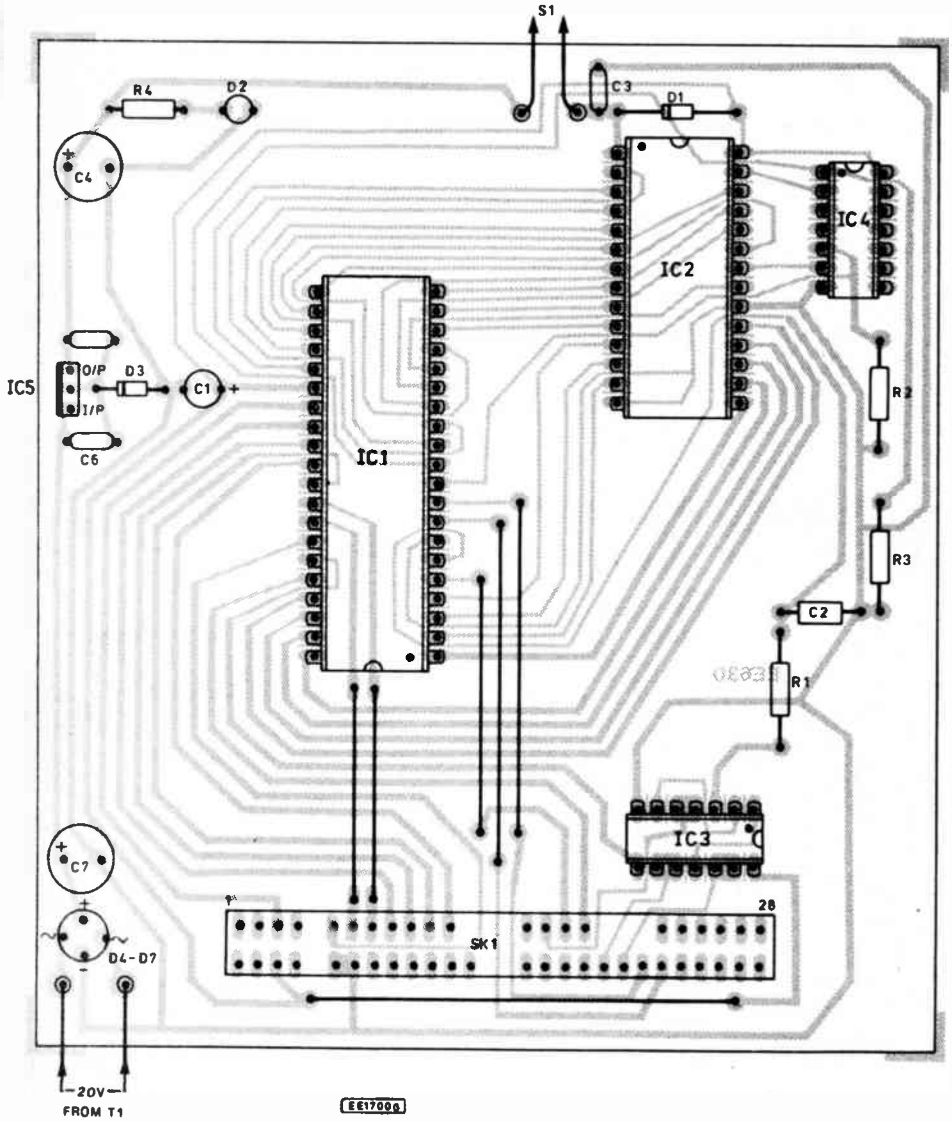


Fig. 3. P.C.B. component layout for the EPROM programmer

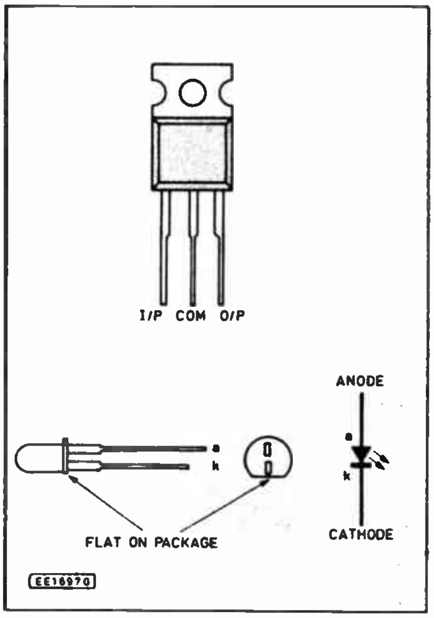


Fig. 4. Connections for the regulator and l.e.d.

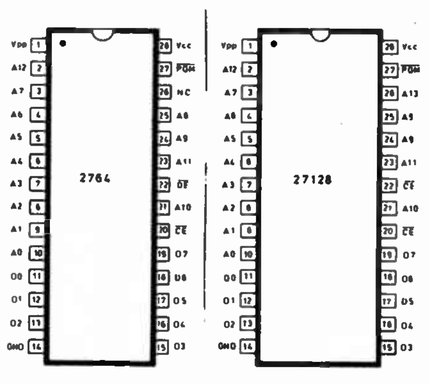
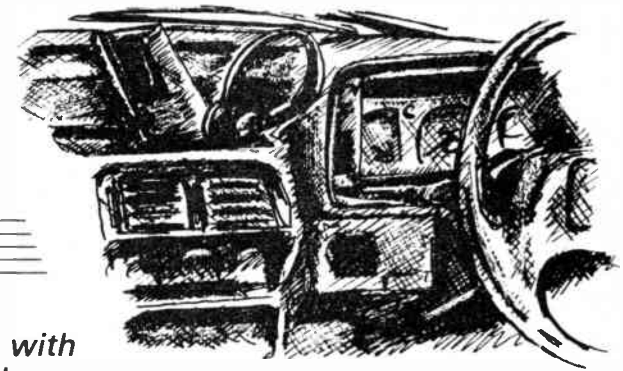


Fig. 5. Pin connections for 2764 and 27128 EPROM

PERSONAL CASSETTE AMPLIFIER



R. S. POWELL

Budget-priced solution to providing in-car music, with the added advantage that personal cassettes are less renowned for damaging tapes than some cheap car players. Provides just over 2W output.

MANY car owners like to listen to music of some form whilst driving, be it from a car radio or cassette. Unfortunately car cassette players are either expensive or unreliable and tend to attract thieves. This article describes the construction of a simple little amplifier which may be used with a personal cassette player to enable tapes to be played in the car.

An amplifier of this type can be easily hidden, and the cassette player may be removed when one leaves the car. This simple system offers a low cost solution to providing in-car music with the added advantage that personal cassette units are less renowned for damaging tapes than cheap car players.

The amplifier can of course be used in a wide variety of other applications.

The Amplifier

The basic circuit for the amplifier is shown in Fig. 1. This may be used in either of two ways:

(1) The circuit may be used with two resistors connected to the amplifier input—one to each channel of the stereo output from the player, as shown in Fig.1.

alternatively:

(2) Two of the circuits may be used to provide stereo by omitting R1 from each amplifier and connecting one circuit to each output channel. A dual-gang potentiometer should then be used for the volume control.

Circuit

The LM380 will deliver about 2 Watts into an eight ohm speaker, which is perfectly adequate for reasonable volume levels, even at motorway speeds. The actual circuit is very simple; R1, R2 and R3 constitute a passive mixer, forming a single signal from the left and right channels. As the headphone output usually matches impedances between 32 ohms and 11 kilohms, values of 100 have been chosen for R1 to R3. The signal developed across R3 is amplified by the LM380. VR1 varies how much signal is sent to the inverting input and hence determines the gain. The output is fed to the speaker via capacitor C3.

One should note C2 and R4 which are different from values usually used with the LM380. R4 helps prevent distortion and replaces the usual Zobel network, whilst C2 has been increased to 10µ for the same reason.

Capacitor C4 is a decoupling capacitor and should be 1000µ or more to stabilize the supply for the amplifier. The circuit will run from the car battery (or any other d.c. supply of 12 to 18V at about 500mA) and an l.e.d. indicates when the circuit is turned on. A short length of screened cable should be used to link the amplifier input to a jack plug for the headphone socket on the cassette unit.

Construction

The unit is easily constructed on Veroboard as shown in Fig. 2. Note that pins 3, 4, 5, 7, 10, 11 and 12 of the LM380 are all earthed to help form a heatsink for this i.c. For stereo, two such boards may be produced omitting R1 from each. Take care to solder the capacitors the correct way around, and for the inexperienced constructor the use of an i.c. socket is recommended.

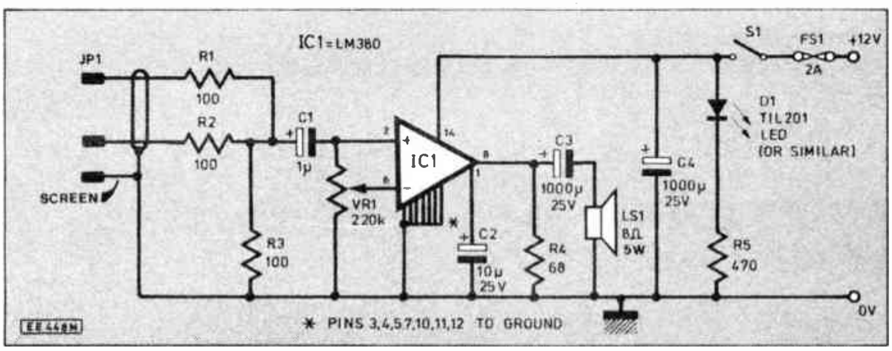
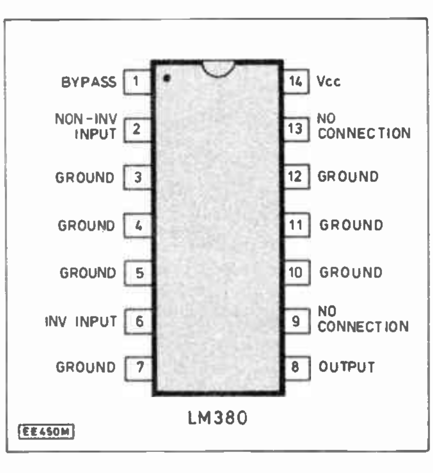


Fig. 1. Complete circuit diagram for the Personal Cassette Amplifier and below pinning details for the LM380 amplifier i.c.



A reasonable length of screened cable should be connected to the amplifier and terminated in a stereo 3.5mm plug suitable for the cassette unit in use. The only controls are the on/off switch and volume control, along with the "on" indicator l.e.d. if this is required. Remember the circuit should be powered via an in-line fuse as with all electrical circuits in the car. A two amp fuse as normally used with a car radio will suffice.

When fitting the unit into the car take care to check if the speaker/s are earthed and if so which lead. The unit may be mounted in a plastic box or, for example, in a console unit within the car. The author's unit is mounted behind the car-radio blanking cover along with an l.c.d. clock unit. From the outside there is no visual indication of any "audio" apparatus within the car which is ideal in helping prevent would be thieves from even attempting to enter the car.

COMPONENTS

Resistors
R1, (see text)
R2, R3 100
All ¼W carbon

Shop Talk Page 702

Potentiometer
VR1 220k log. (see text)

Capacitors
C1 1μ tantalum
C2 10μ elect. 25V
C3, C4 1,000μ elect. 25V (2 off)

Semiconductors
D1 TIL201 l.e.d. (or similar)
IC1 LM380 amplifier

Miscellaneous
JP1 3.5mm stereo jack plug
FS1 2A in line fuse and holder
LS1 8 ohm 5W speaker
Veroboard 16 strips by 28 holes, screened stereo lead, connecting wire etc.

Approx. cost Guidance only £7 inc. spk.

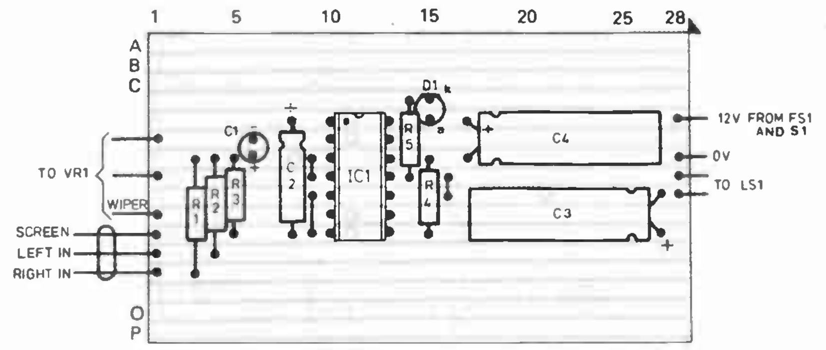
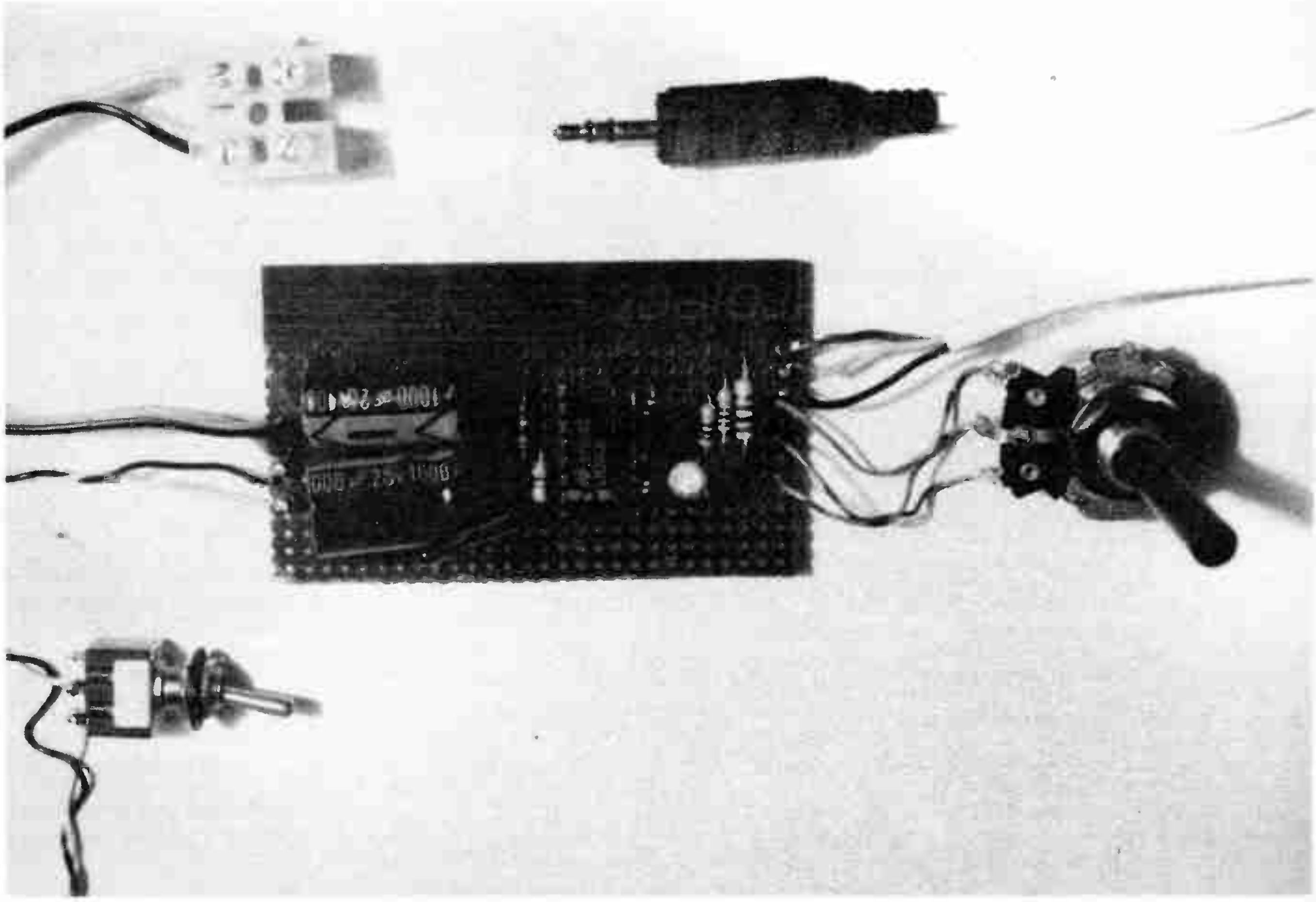


Fig. 2. Stripboard component layout and details of breaks required in the underside copper strips.

Using the Amplifier

Once the amplifer has been fitted into the car a small bracket to hold the cassette unit can be made by bending the end of a short length of metal rod and screwing this against a flat surface in the car. The author's unit mounts nicely on the car console.

The cassette player may be powered by ordinary batteries but a good alternative is to use rechargable nickel cadmium cells available from many high-street stores. These rechargable batteries are quite sufficient for even long journeys. If one is concerned at the idea of the batteries running flat in the middle of a tape a simple circuit may be built to power the unit from the car battery using an LM317M. Details of such a circuit are readily available—most suppliers catalogues give details. □



FOR YOUR ENTERTAINMENT

BY BARRY FOX

Encryptology

The satellite encryption system used in the US is called *VideoCipher*. The scrambler at the transmission end strips out the sync pulses which keep the pictures steady on screen, inverts the video signal by converting black to white, and alters the level of the burst signal used as a reference for colour information.

In addition, the sound is converted into digital code and slotted into the ends of the picture lines. The sound code is then encrypted by rearranging the digits–just as text messages are encrypted for security.

A set decoder, costing about $400, generates digital sync pulses, decodes the digital audio and restructures the picture. But it can only do this when a code word burned into the decoder firmware matches a code word transmitted along with the signal. Otherwise the screen goes completely blank.

The transmitted codes are labelled so that they address only those decoders for which subscriptions, or pay-per-view payments, have been made. This technique is called *"conditional access"*

Pirates can't "hack" the codes controlling de-encryption because they follow the US Government's DES (Data Encryption Standard) which takes even the smartest computer a decade to unravel by trial and error. So the pirates buy a batch of legitimate decoders from GI's appointed manufacturers and pay a subscription on one of them.

So this one decoder gets an authorised code word burned into its firmware. The pirates then hack out the code and burn it into all the other decoders they have bought. So one subscription pays for viewing on dozens, or hundreds, of decoders.

EuroCipher

The system which GI is developing for BSB is called *EuroCipher*. The digital sound which accompanies the MAC picture signal is encrypted with DES codes. Also each line of the MAC picture is cut up into segments and the segments juggled so that each line ends up as a jumbled combination of several others.

De-encryption is under control of DES codes and an identifying word burned into the firmware, as in the US system. This will control subscription viewing.

For pay-per-view the set-top decoder will be connected to a central billing point by telephone line. For this an extra "sidecar" with telephone modem will be needed, at an unspecified extra price.

There is a widespread problem in the US over piracy admits GI, with a total of 950,000 decoder units shipped to manufacturers, but only around 650,000 accounted for, i.e. owned by people who are paying subscriptions. Trade estimates in the US are that at least one-third, and perhaps as many as two-thirds, of all VideoCipher decoders sold so far are receiving television programmes for which they are not authorised.

Piracy Epidemic

So will there be a piracy epidemic here too?

They admit that the piracy boom in the US is the result of mistakes made in the original VideoCipher hardware design. The chips which store the user's personal identification number were too easily accessed by computer buffs who then produced replica chips for fitting in unauthorised decoders.

Even existing VideoCipher units in the US are prey to hackers, because signals running between four separate chips can be tapped. The next stage is to integrate all the electronics in a single chip.

But even this will not prevent hackers with access to an electron microscope, e.g. in a University lab, from shaving down the firmware chip and reading out the codes. To stop that, GI will have to use chips which are sealed in inert gas, rather than a plastics casing. They will then self-destruct when opened.

But all this puts up the price and reinforces doubts on BSB's £250 tag, they are paying GI £100 million up front to develop the system, in addition to £M50 to ITT for four million D-MAC chip sets.

Says Dr. Mark Medress of GI. *"EuroCipher is based on the lessons we have learned with VideoCipher over the last two and a half years since encryption began in the US. We now know how the pirates work and think."*

Hair-Raising

The electronics industry moans about British safety regulations, and it is true that the bureaucracy is cumbersome. However, the Spanish way is much worse.

Hotels all round Europe have standardized on a neat hairdryer made in Switzerland. The Aliseo is designed for mounting on the wall of a bathroom. The motor and heating element are sealed inside a plastic body, which connects with a hand-held air vent via a flexible plastic tube.

The user never needs to touch anything that is carrying an electric current. All that comes down the hand held tube is hot air; all electrical connections are hard wired inside the plastic casing.

In Barcelona recently I stayed at a posh hotel which had Aliseo's on the bathroom walls. But with wonderful naivety, the Spaniards had provided an open, unshuttered two-pin mains socket alongside the hair dryer and next to the bath and washbasin. To run the hair dryer a guest with wet hands and bare feet has to push a bare, two-pin plug into the bare socket—thereby negating all the careful safety features built into the hair dryer.

Sound Track

People in North London were combing the streets this last summer, looking for the source of odd sounds like rolling, rhythmic thunder — and wrongly accusing neighbours of playing their hi-fi's too loud.

If you were one, look no further. It was the sound of new hi-tech sound equipment being used this year for concerts at Wembley stadium.

Brent council licences pop concerts at Wembley and has set a sound level limit of 98 decibels inside the stadium to keep Wembley residents happy. But this year Brent has been getting complaints from far further afield.

At first the council's health officers couldn't work it out. Now they have twigged. The concert promoters at Wembley have been using new sub-bass woofer loudspeakers which reproduce the full 98dB sound level right down to 20Hz.

These frequencies are so low that they roll around the whole of North London, cutting through walls like butter. At this pitch the human ear is non-directional so no-one knows where the sound is coming from.

On the Bank Holiday weekend the bass sound of Michael Jackson came close to drowning out the open air classical concert at Kenwood, a full 6 miles away — even though (and not a lot of people know this) the live sound from the Kenwood orchestra is always boosted by speakers hidden in the trees.

Illegal Broadcasting

Anyone watching ITV's *Telethon* fund raising event in June may have stumbled on an odd page of teletext; P169 on ITV contained lists of cryptic text and numbers. You will probably see the same page used during future ITV network marathon events.

There are already pages of teletext which carry coded secret messages which only "closed user group" recipients can read with special decoding equipment. They are used by large retail chains, to send price information round the country. Each branch has a modified TV set.

In doing this both the BBC and ITV are sailing very close to the wind legally. By law they are only allowed to broadcast—*not carry private messages* like British Telecom, Mercury or the Post Office. But more of this when, as sure as night follows day, someone complains that closed user group teletext is by definition not broadcasting.

The *Telethon* page was not coded and not a Closed User Group. The plain English abbreviations identified regional ITV companies, like Tyne-Tees, Anglia, Central, London Weekend and so on. The numbers were times.

The page was being used to help regional producers slot their programmes together, following a precise timetable that could be instantly updated over the air. Once in a while they used it for messages too, for instance explaining that one producer's studio control link had gone wrong, so that he could hear incoming messages, but not say anything in reply!

... REPORTING AMATEUR RADIO ...

TONY SMITH G4FAI

TO THE SOUTH

I previously mentioned the Northern California DX Foundation, which provides substantial financial assistance for DXpeditions. These expeditions set up temporary amateur stations for extensive operating activity in unusual locations.

An example of such activity was the operation of stations 3Y1EE and 3Y2GV from Peter 1 Island in the Antarctic last year. The Norwegian Polar institute chartered a ship for a government sponsored mapping and research expedition to the island, and agreed that two radio amateurs, members of the LA(Norwegian)-DX-Group, could go as well provided they paid their own way.

A large sum of money was required for this purpose and contributions and support came from amateur radio groups and organisations interested in DX activities in a number of countries. Transceivers, amplifiers, antennas, tuners, rotors, and a generator, were provided by companies and individuals, and all were shipped to New Zealand for the start of the expedition.

NCDXF made the largest single grant in its history, $30,000. They guaranteed $10,000 for the trip, promising to pay that sum even if the amateurs were unable to get ashore and make any contacts. The full $30,000 would be paid if they did get ashore and made over 15,000 QSOs (contacts on the air), which was the DXpedition's target

In the event they made well over 16,000 QSOs during a period of 10 days, giving operators around the world the first ever opportunity of working this uninhabited, ice covered, volcanic island which, although first sighted in 1821, was not landed on until 1929.

Financial support for the DXpedition was so good that the LA-DX-Group have now been able to return $10,000 to NCDXF as "seed money" for future expeditions to other rare locations. This was an outstanding example of yet another of the many facets of amateur radio. DXpeditions, some equally ambitious, others more modest, are taking place all the time, visiting other islands, deserts, mountains, or places which have little or no normal amateur radio activity. Wherever there is some isolated or exotic spot on the globe, you can be sure that if radio amateurs haven't got there yet it's only a question of time before someone mounts a DXpedition to reach it!

PICPRO

A recent article in CQ Magazine, in the USA, described a new aspect of packet radio communication (see this column, March 1987). This is PICPRO, a PICture PROgram for the PC and compatibles, written by Bob Slomka, WD4MNT, which displays a picture in colour as it is received via packet radio. This is automatically saved to disc and can be displayed later or be printed by a graphics printer.

The article, by Buck Rogers, K4ABT, claims that the process is so different and spectacular that it ushers in a totally new era in packet and data communications. PICPRO functions as a terminal program operating in conjunction with the Kantronics MAXFAX weather facsimile receiving system. K4ABT says he developed a packet picture passing technique a few years ago but the new technique could well have passed into oblivion but for its final evolution via the Kantronics system.

He claims that colour packet pictures are not subject to the noise and streaking found on slow-scan t.v. and that they are, as in the nature of packet itself, error free. *"Since frame checking is an integral part of the packet picture, just like standard text packet, the same error checking is performed as the picture is transmitted and received. This presents the receiving station with a picture identical to the picture at the transmitting station."*

Despite its success so far PICPRO is in a constant state of improvement, with WD4MNT re-writing and adding new features in the light of on-the-air trials between dedicated experimenters. It is an interesting area of activity, bringing together computer and radio interests, and this is the combination which many national radio societies see as the formula for continuing growth, attracting new entrants to amateur radio.

GOLDEN JUBILEE

The Royal Air Force Amateur Radio Society (RAFARS) celebrates its Golden Jubilee this year. The story was told, in *QRV*, (journal of RAFARS), winter 1947 issue, that although the Society was founded in 1938, amateur radio began in the RAF in 1924 when Flt. Lt. Durrant designed a 30 metres CW (Morse) transmitter. He sent constructional details to RAF Signals stations at Malta, Cairo, Jerusalem, Baghdad, Mosul and Delhi and suggested they keep a listening watch every evening for his own station at RAF Gosport.

He was quickly in communication with all these stations. Contacts with other amateur stations soon followed and the RAF overseas amateur network, operating from exotic locations, was in great demand.

An historic moment came when an urgent official message could not get through from Mesopotamia (now Iraq) on the regular long wave Inter-Command network, on 4,800 metres, and was relayed through the amateur stations instead. As a direct result of this the amateur Gosport to Hong Kong network became the official RAF short-wave W/T Inter-Command network!

In 1936 the Cranwell Amateur Radio Transmitting Society came into being, having its own callsign, G8FC, and in 1938 it published a CARTS journal, titled *QRV*. As personnel were posted from Cranwell they wanted to keep in touch with the Society and soon there were members around the world. By 1938 it was realised that CARTS was, in effect, an RAF-wide organisation so in that year, with Air Ministry blessing, the Royal Air Force Amateur Radio Society, with headquarters at Cranwell, came into existence.

In 1951, headquarters were moved to No. 1 Radio School, RAF Locking, where it remains to this day, still producing *QRV* and operating G8FC. Its members are radio amateurs or short-wave listeners serving in, or retired from, the RAF or who have close connections with the Service. It has activities throughout the year.

Apart from G8FC, it can be heard with a number of other call-signs, all containing the suffix RAF. There is a daily UK "net" on 3.710MHz, at 1830 hrs, controlled by G2FIX, and a number of local weekly nets serving specific areas, where RAFARS members can meet on the air. Enquiries about membership of RAFARS should be made to the Admin Secretary, RAFARS, RAF Locking, Weston-super-Mare, BS24 7AA.

NETS

Mention of amateur "nets" calls for some explanation. The word is an abbreviation of "network", and a net is a group of amateurs, all transmitting and receiving on the same frequency. A "controller" is in charge to ensure net discipline, making a note of stations joining the net, calling them in turn to transmit and ensuring that no-one monopolises the proceedings. Listeners can hear all that is going on by tuning to a single frequency.

Some amateurs love nets and others can't abide them. If there are more than a few stations participating then each operator will only have the opportunity to transmit for a few minutes during the period of the net, which can be frustrating for some. On the other hand, regular participation in nets enables one to make and keep in touch with a number of friends and be up-to-date with the news of the organisation running the net.

In Australia, a group of Morse enthusiasts have been trying a different sort of net based on the American "traffic nets". In these nets, stations are paired off onto other frequencies for the purpose of passing greetings messages for the general public, coming back to the control frequency for fresh instructions when they have finished.

The Australians have adapted this system for chat nets so that the control frequency becomes a meeting point for stations to call in, with the controller then pairing them off using the same procedures and disciplines as in the traffic nets. The Aussies doing this think it is an improvement over the traditional net system, but I don't know if this idea has been tried in the UK.

SPECIAL SCOPE OFFER

Once again *EE* is pleased to be able to offer all readers the chance to buy an oscilloscope at a discount price. We have joined forces with BK Electronics to offer two different oscilloscopes at exceptional prices.

As many readers will be aware a 'scope is one of the most versatile items of test gear and a digital storage oscilloscope can be particularly useful. These 'scopes come with a two year warranty which includes the c.r.t.—they are made in West Germany and can be serviced by Hameg in the U.K., should the need ever arise.

Each 'scope is supplied with two switchable (10:1 and 1:1) probes, a trimming tool for the probes and d.c. balance, plus a mains cable and an excellent manual, which includes detailed operating instructions and circuit diagrams etc.

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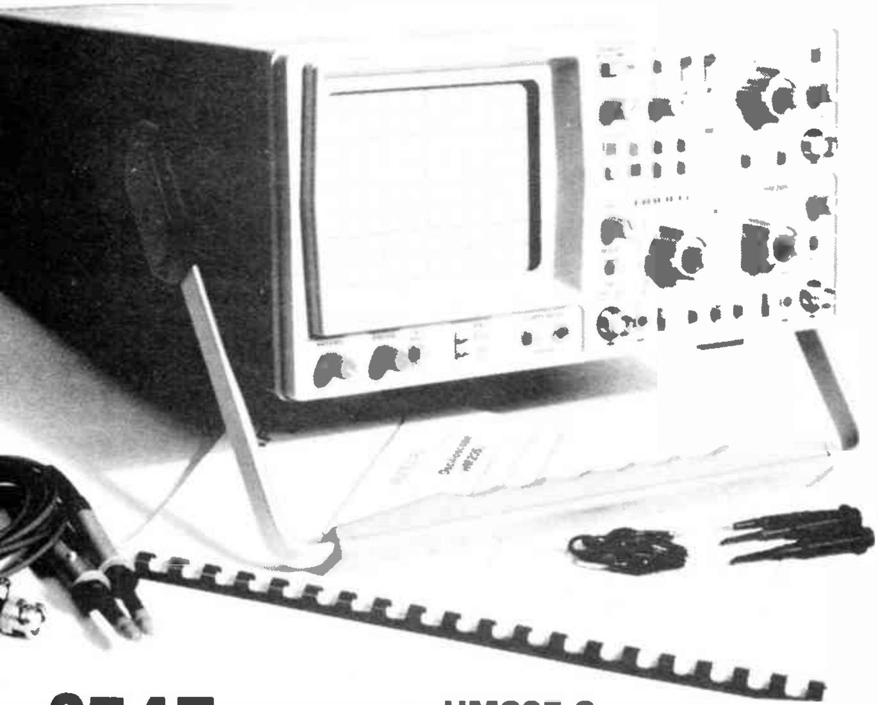

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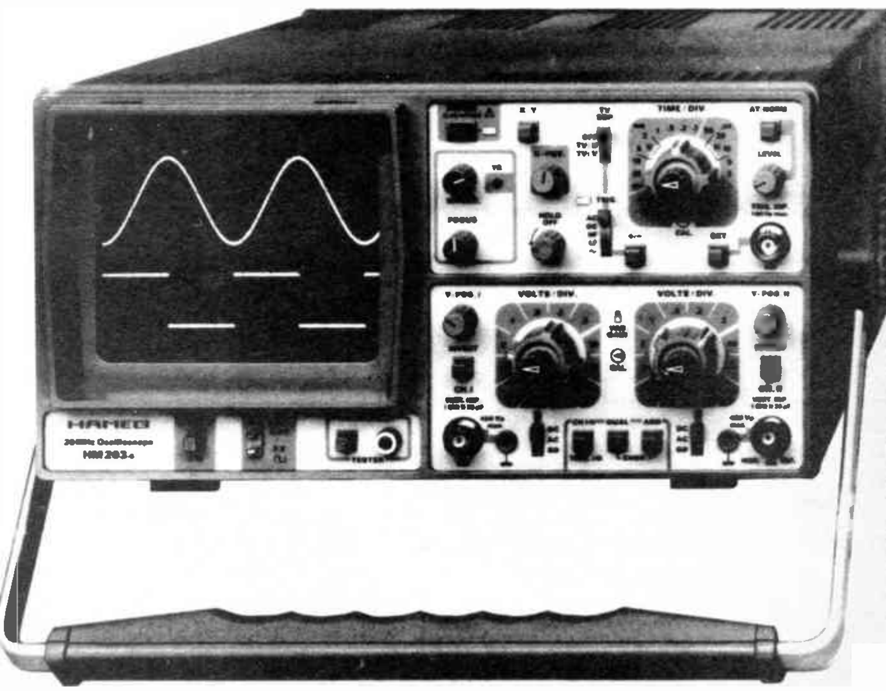


Random Number Generation

IN THE *BEEB Micro* series we like to look at a mixture of serious applications for the BBC microcomputers and more lighthearted matters. This month we will be considering one of the less serious aspects of computing—random numbers. The RND function in BBC BASIC is used to generate random numbers. This function is mostly used in games, but it can also be used for other purposes, in particular to generate random data to test programs (for example, random numbers to test the efficiency of a sorting routine).

Random Number Generator

The numbers generated are not, in fact, truly random, being generated by a mathematical function. The series of numbers generated is, however, so long and so convoluted that the numbers may be considered random for all practical purposes. They are, however, more correctly termed pseudo-random.

If you turn on the computer and start generating random numbers, the series will always be the same. To avoid this, it is possible to "seed" the random number generator, giving it a starting value other than that provided by default. In some versions of BASIC there is a special statement to do this, usually RANDOMISE (or RAND), but in BBC BASIC the RND function is used, with a negative argument.

If the same argument is used each time, the same series will be produced, but it will be different to the default series. To produce a different series each time, an unpredictable seed value must be used.

The most common way of doing this is to use the BASIC TIME function. As this changes every 1/100 second, it is most unlikely that the RND function would execute twice when the TIME function returns exactly the same value. Even a difference of 1 in the seed will produce a totally different series of numbers. RND is a function, so it must always be on the right of an equals sign, or follow a PRINT statement, for example

```
dummy=RND(-TIME)
PRINT RND(-1)
```

The dummy variable will take the value of the argument to RND. In the second example—1 will be printed.

The ability to produce the same sequence of random numbers several times by using a constant seed can be useful, especially in testing the relative speeds of sort routines. However, you should always perform several comparative tests, using different data for each comparison, in case any one series of random numbers should favour one routine over the others.

If no argument to RND is given (e.g. X=RND), it will generate random numbers betwen −2147483648 and +2147483647. Giving a positive argument causes some processing of the random number generated so that it comes within a specific range.

```
X=RND(1)
```

will cause X to take a value between 0 and 0.999999. If you need non-integer numbers larger than 1, you must use RND(1) and multiply the result by a suitable factor. For example

```
X=RND(1)*10
```

will yield numbers between 0 and 9.99999. **RND(0)** will repeat the last number generated by **RND(1).**

If a value larger than 1 is given as the argument, random integers between 1 and the argument (inclusive of these values) will be generated. For example, to generate numbers from 1 to 6 for a dice simulation, you would use

```
X=RND(6)
```

If you need to generate a series of integers which could include 0, you must use an integer one more than the highest value you want to generate, and subtract 1 from the result returned by RND. For example, to generate digits from 0 to 9 you would use

```
X=RND(10)-1
```

A similar technique can be used to obtain starting values higher than 1. To generate random ASCII codes for capital letters, you could use

```
code=RND(26)+64
```

there being 26 letters in the alphabet, and the ASCII code for A being 65 (1+64).

Alternative Randomness

Probably most BBC micro programmers who require a random number turn to the RND function without giving a second thought to alternative methods. If you are programming in some other language there may well be no equivalent to the BBC BASIC RND function, and an alternative means then has to be sought.

Questions about methods of producing random numbers when programming in assembler or some other non-BASIC language seem to be quite commonplace in the letters pages of computer magazines. It is something that seems to be quite simple until you actually try to sit down and work out a method that will really work properly in practice.

There are solutions to the problem that only use software, but a hardware or semi-hardware solution is an equally valid way of doing things. As explained previously, a common ploy is to seed the BBC BASIC RND function from the timer so that a different set of numbers is obtained each time a program is run. Taking things a stage further, it is possible to use a timer as a form of random number generator.

The 6522 of the BBC computer that provides the printer and user ports includes two 16 bit timer counters. These are both available for user applications, and would seem to offer good scope for random number generation.

In order to use one of the timer/counters in this way it must be made to continuously count down at high speed. Reading the timer/counter then provides a number of between 0 and 65535. At least, it does if both the high and low bytes are read. For most purposes simply reading the low byte would probably suffice. This would give a number from 0 to 255 inclusive.

With the counter driven at high speed there is no way to predetermine what value will be read from it, and there is no obvious way in which there could be a bias towards any particular number or range of numbers. It is debatable as to just what constitutes a genuine random number and what is really a pseudo random number, but for most purposes the number read from the timer should be random enough.

Using Timer 2

Either of the two timer/counters are suitable for this application, but the more simple of the two (timer 2) is probably the best choice. This has only two modes of operation—the one where it is fed with the internal 1MHz clock signal and the one where it is driven from a clock signal fed to PB6 of the user port. These two modes are selected by writing a value of 0 (internal clock) or 32 (external clock) to ?&FE6B. For most purposes the internal clock signal should suffice.

The timer 2 registers are at addresses &FE68 (low byte) and &FE69 (high byte). Try this simple program which sets timer 2 for operation with the internal clock, and then reads the low byte and prints the value on the screen each time a key is pressed.

```
10 CLS
20 ?&FE6B=0
30 X=GET
40PRINTTAB (10,10) ?&FE68
50 GOTO 30
```

Obviously it is unlikely that an application will require a random number in the 0 to 255 range provided by the low byte of timer 2, or the 0 to 65535 range provided by both bytes. However, some simple mathematics will normally be sufficient to convert the returned number to one that is suitable for a practical application.

As a simple example, assume that we wish to use the low byte of timer 2 to provide a number in the range 1 to 6 to act as a die for a games program. This short program demonstrates how this can be achieved. It merely prints a number from 1 to 6 on the screen each time a key is pressed.

```
10 CLS
20 ?&FE6B=0
30 X=GET
40 DIE=?&FE68
50 IF DIE > 251 THEN GOTO 40
60 DIE =DIE DIV 42
70 DIE=DIE+1
80 PRINTTAB (10,10) DIE
90 GOTO 30
```

At line 40 the value in the low byte of timer 2 is placed in variable "DIE". For our present purpose we require a maximum number that provides an integer when divided by six, and 255 does not fit the bill. Line 50 effectively reduces the maximum figure for "DIE" from 255 to 251. If a value of more than 251 is placed in this variable, the program goes back and tries again, and keeps on doing so until an in-range value is obtained.

Although 251 does not provide an integer when divided by six, you have to bear in mind that the minimum number from the timer is 0 and not 1. Accordingly, there are 252 different values, and 252 divided by 6 is 42. Line 60 divides the value of "DIE" by 42 and discards any remainder. This gives a random number from 0 to 5, but 1 is added to this at line 70 so

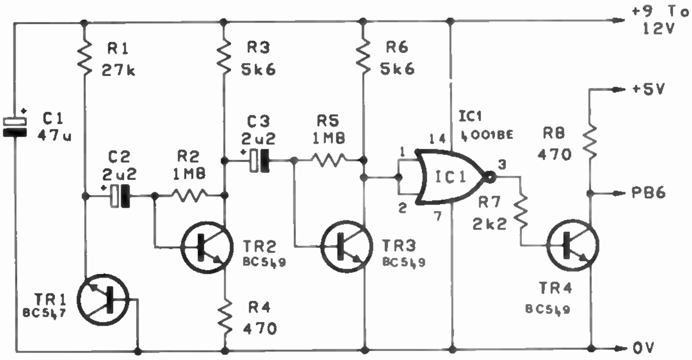


Fig. 1. The random clock generator circuit diagram

as to give the required 1 to 6 range. Line 80 prints the value on screen and line 90 loops the program indefinitely.

When manipulating the numbers returned from the timer in order to obtain the desired range a certain amount of care needs to be exercised, as it is very easy to introduce a bias to certain numbers. Also, bear in mind that you cannot have more possible values in the final number range than the timer can produce.

If more than 256 different values are required, then both bytes of the timer must be used. BASIC is possibly a bit slow to read the timer properly, as it is likely that the count will move on in the time between the first and second bytes being read. As in this case it is not precise times we are after, but simply random numbers, this is not necessarily significant.

Using both bytes of timer 2 there are 65536 different values, which should be adequate for most purposes. However, if necessary timer 1 could be used as well, with the two values being added together to give a single large value, or multiple reads of timer 2 could be used to give much the same effect.

Improved Randomness

One way in which this means of random number generation could lack true randomness is that if the timer is read several times in rapid succession it will produce what is really a form of mathematical progression, rather than a series of truly random numbers. In practice it may well be read too infrequently for this to be noticeable, as it takes only about a fifteenth of a second for one complete down count of timer 2. Also, although it might seem that the timer was being read at regular intervals, interrupts would tend to slightly randomise the times between readings.

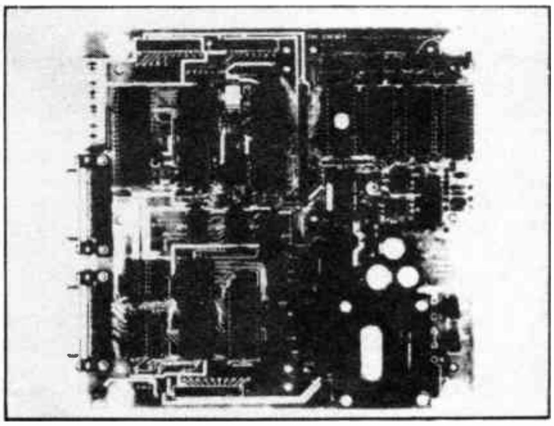
It is possible to totally avoid problems with multiple reads of the timer by ensuring a relatively long delay between one reading and the next (say a second or more) and using a noise signal as the clock source. With the timer counting at a random rate, reading it at regular intervals will not provide a mathematical progression. Fig. 1 shows the circuit diagram for a simple random clock generator.

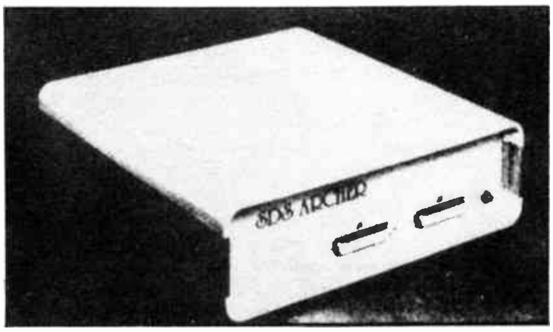
Noise Source

The noise source is a reverse biased base—emitter junction (TR1). The bias voltage is high enough to cause the junction to avalanche, like a Zener diode. Also like a Zener diode, it produces noise spikes, but most silicon transistors used in this mode provide a very much stronger output than a Zener diode. However, a Zener diode having an operating voltage of about 4.3 to 7.5 volts would probably work quite well in this circuit. If a transistor is used, note that no connection is made to the collector terminal.

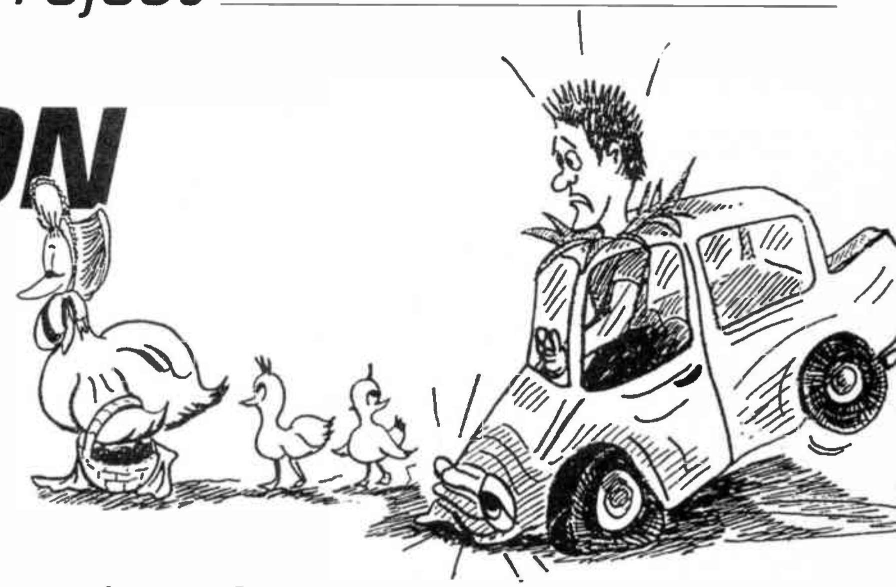
Whichever noise source is used, the output signal will still be quite low, and a large amount of amplification will be required in order to give a logic compatible output signal. This amplification is provided by two common emitter amplifiers. These drive a CMOS NOR gate (connected to act as an inverter) followed by a common emitter switch. The latter merely acts as a level shifter which gives an output at standard 5 volt logic levels.

The +5 volt and 0 volt supplies are taken from the user port, and the output of the unit connects to PB6 of this port. Remember to set ?&FE6B to a value of 32 to enable operation of timer 2 with a clock signal on PB6. 5 volts is insufficient to operate much of the circuit properly, and so a 9 to 12 volt supply is needed. This could be provided by a 9 volt battery, or the +12 volt output of the computer's power port could be used. The current consumption of the circuit is only a few milliamps from this supply.





REACTION TIMER



PAUL HARDING

Just how good do you think your reactions are? Build this pocket size, cheat proof unit and find out!

REACTION timers have long been popular as "party" type games; often a row of lights are used and these indicate the subject's reaction time, albeit in a rather crude fashion. The circuit presented here is a rather more sophisticated design; it features a digital display with a resolution of 1ms, and a crystal controlled oscillator, which removes any need for calibration—the prototype's oscillator has an accuracy of better than 0.1 per cent.

In use, the front panel pushbutton is pressed, an l.e.d. flashes to indicate the "set" state, and, a pseudo-random time later (ensuring that the circuit cannot be pre-empted) the display illuminates and starts incrementing. Pressing the pushbutton again will freeze the display, indicating the subject's reaction time. The display automatically blanks about five seconds later to conserve the battery.

Pressing the pushbutton before the display illuminates will return the circuit to its quiescent state. It is not possible to obtain an apparently very fast reaction time by holding the pushbutton down after the initial press since the circuit is *edge*—and not *level*—sensitive. The display freezes at 999, and so, again, it is not possible to obtain a fast time by pressing the pushbutton on the counter's "second time around".

CIRCUIT DESCRIPTON

The overall block diagram for the Reaction Timer is shown in Fig. 1. The 1kHz oscillator constantly sends pulses to the counter, a three digit BCD multiplexed type. In the circuit's quiescent state, the counter is held Reset by the flip-flop, via the pulse delay/stretch element. While the counter is in this state its on-chip multiplex system is inhibited and no display results.

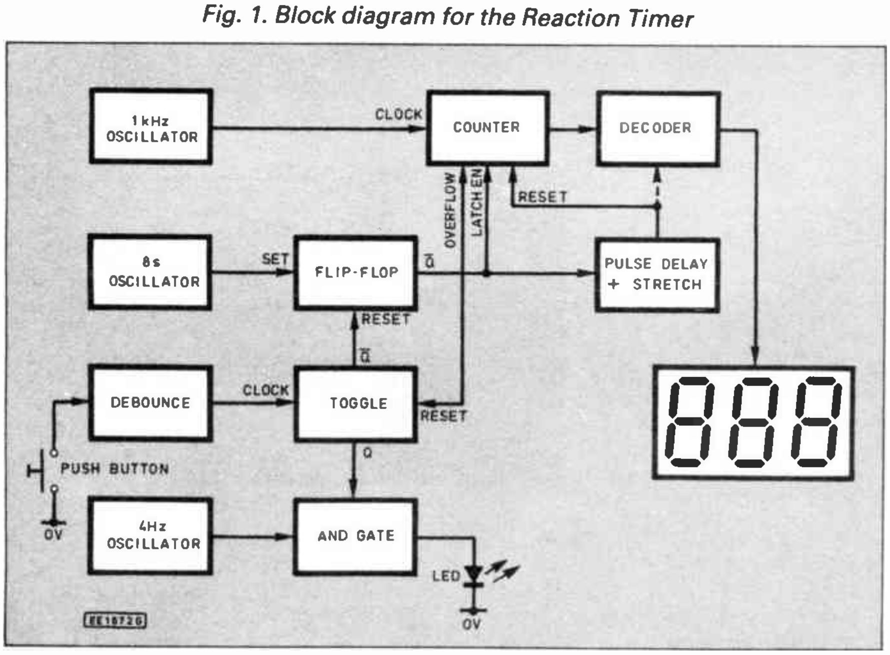
When the pushbutton is pressed, the debounced signal obtained causes the $\overline{Q}$ output of the toggle to go low, removing the Reset condition from the flip-flop. Sometime later the output from the eight seconds (8s) oscillator goes high and Sets the flip-flop. The pulse delay/stretch is triggered, and about two seconds later the Reset on the counter is removed. The display illuminates and starts counting upwards.

Pressing the pushbutton again returns $\overline{Q}$ on the toggle high, which Resets the flip-flop, taking the counter's Latch EN input high, freezing the count, and hence displays the user's reaction time. This positive going edge on Latch EN is delayed by the pulse delay/stretch, to enable the reading to be seen before the counter is reset and the circuit returns to its quiescent state.

If the pushbutton is not pressed again the Overflow output of the counter will reset the toggle which then initiates the same sequence of events as described above, with the display showing 999. The l.e.d. is driven from the ANDed outputs of the 4Hz oscillator and the toggle, and indicates when the circuit is in its "Set" state.

Since the eight second (8s) oscillator runs continuously, it is almost impossible to predict when its output will next go high and so a degree of randomness in the switch on, of the counter is obtained.

Fig. 1. Block diagram for the Reaction Timer



CLOCK/COUNTER

Looking now at the complete circuit diagram for the Reaction Timer, Fig. 2, the 1kHz oscillator is configured around IC1, a 4060. This chip was specifically designed for use in crystal or R/C oscillators/dividers. In this application, the crystal frequency of 4.096MHz is divided by 2^{12} (i.e. 4096) to give 1kHz. This signal is further divided to give 250Hz, which is then fed to another binary divider, IC2, to generate the 4Hz and 8s clocks.

Resistor R3, capacitor C1, and IC4b act as the debounce circuit, driving the toggle element, IC3a, a D-type flip flop. Every press of switch of S1 rapdily discharges C1, which then takes a very much longer time to recharge via R3. IC4b "cleans up" the pulse's slowly ramping trailing edge.

When the circuit is in its quiescent state, pin 5 and pin 2 of IC3a are high, holding IC3b RESet (pin 10), and so the latter's complementary output, pin 12, is also high. IC4c's output is low and capacitor C2 is discharged. IC5, the counter, is held RESet.

If S1 is pressed pin 2 of IC3a swings low, and when, sometime later, pin 15, IC2 (the 8s oscillator's output) goes high, $\overline{Q}$ of IC3b is forced low. IC4c's output swings high and capacitor C2 starts to charge via D4 and R6. The LE (latch enable) signal on pin 10 is removed from IC5, but at this point it is still in its RESet state.

When the voltage across capacitor C2 crosses IC4d's upper input threshold, the latter's output goes low and the RESet on the counter is removed. The display, IC7, is illuminated, and IC5 starts counting.

Pressing S1 again RESets IC3b via IC3a causing the instantaneous count in IC5 to be latched on the display. Capacitor C2 starts to discharge, via the now low output of IC4c, through R5 and when the voltage across it falls below IC4d's lower input threshold, IC5 is RESet and the display blanks ready for the next attempt. The BCD data from IC5 is decoded by IC6 to a seven segment format suitable for displaying on the display module IC7.

DISPLAY

Moving on to the display stage of the circuit diagram, Fig. 2. The BCD counter IC5 also provides digit select outputs, and these drive the *pnp* emitter follower transistors, TR1 to TR3, to illuminate each digit at the correct time. Resistors R7 to R13 limit the drive current to IC7 to approximately 10mA to 12mA per segment.

The "set" l.e.d. (D1) is driven by the NOR gate resistor R4, diodes D2, D3, and IC4a, which, because of the logic used in the circuit, is functionally equivalent to the AND type shown in the block diagram. Capacitor C4 is a supply decoupling component and C3 sets the frequency of IC5's multiplex oscillator, its value is not critical.

Although only IC4b and IC4d are required to be Schmitt types, for reasons of space and cost efficiency all the NAND gates are in fact of this nature. This has no detrimental effect on circuit performance.

CONSTRUCTION

The component layout and full size copper foil master patterns for the Reaction Timer are shown in Fig. 3 and Fig. 4 respectively. These boards are available through *EE PCB Service*, codes EE626 and EE627.

COMPONENTS

See page 702

Resistors

R1	10M
R2	820
R3, R4	100k (2 off)
R5	1M8
R6	220k
R7–13	560 (7 off)

All 0.25W 5% carbon

Capacitors

C1	0.47µ radial elec. 16V
C2	10µ radial elec. 16V
C3	1n Mylar
C4	47µ radial elec. 16V

Semiconductors

D1	See switch S1 (orTIL209)
D2-4	IN4148
TR1-TR3	BC309 *pnp* (3 off)
ICl	4060B oscillator/divider
IC2	4040B binary divider
IC3	4013B dual D-type flip flop
IC4	4093B quad Schmitt NAND
IC5	4553B 3 digit BCD counter
IC6	4511B BCD–7 segment decoder
IC7	6203RVL red, 3 digit multiplexed, common cathode display

Miscellaneous

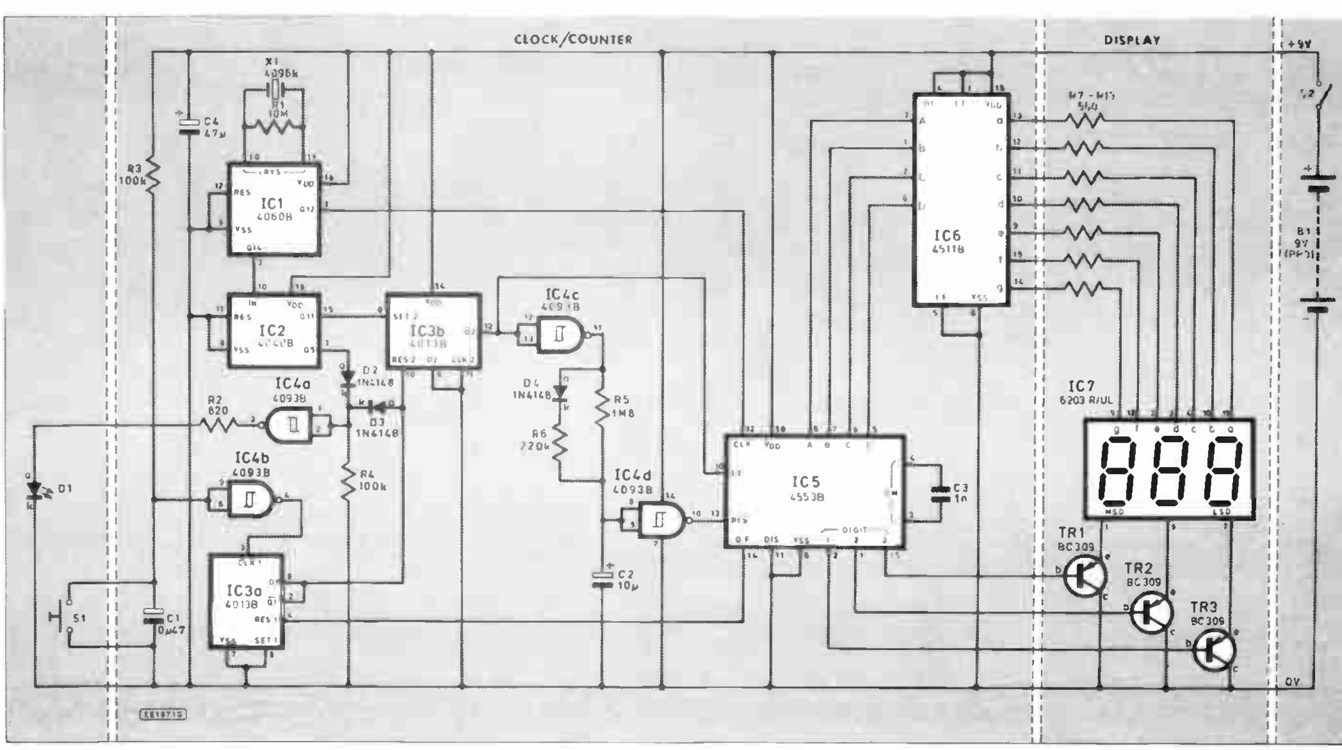
X1	4.096MHz crystal, HC18/U case style
S1/D1	B3J2 2100 combined switch and l.e.d.
S2	Ultra miniature slide switch

Minicon connectors:
- 8-way cable shell (1 off)
- 6-way cable shell (1 off)
- terminals (13 off)
- 8-way right angle header (1 off)
- 6-way right angle header (1 off)

Printed circuit boards, available from *EE PCB Service*, codes EE626 and EE627; plastic case, 65mm×35mm×120mm; 200mm ribbon cable, 7-way or greater; 14-pin i.c. sockets (2 off); 16-pin i.c. sockets (4 off); red filter plastic; PP3 battery and clips; p.c.b. guides; wire; solder; etc.

Approx. cost Guidance only £26

Fig. 2. Complete circuit diagram for the Reaction Timer. Switch S1 and l.e.d. (D1) are mounted on the Display board.



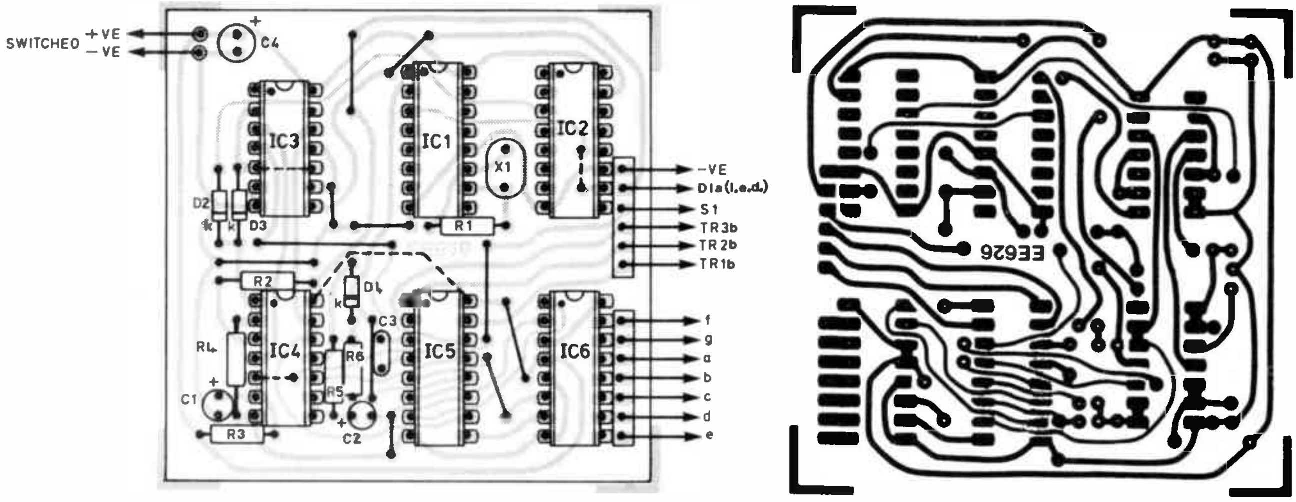


Fig. 3. Main printed circuit board component layout and full size copper foil master pattern.

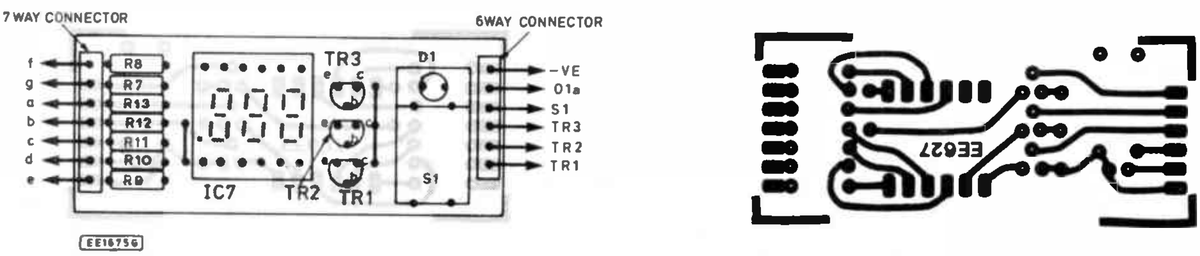
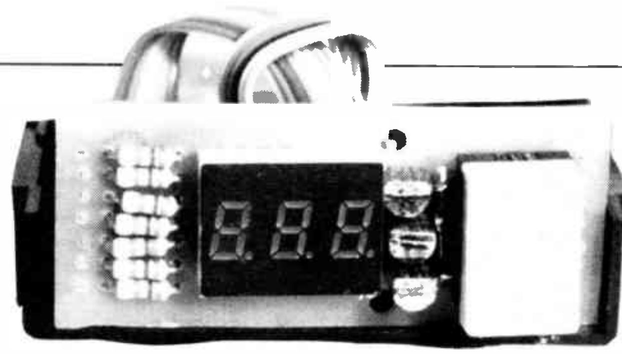


Fig. 4. Component layout and full size copper foil master pattern for the Display board.



The completed display board showing the 7-segment display and the combined switch and l.e.d.

Referring to the main circuit board component layout, Fig. 3, insert and solder the wire links (noting that four of the links, shown dashed, are under the board). The link adjacent to capacitor C3 may require insulating.

Next, insert and solder the resistors, diodes, i.c. sockets, capacitors and crystal, in that order. Ensure that the orientation of the diodes (cathode (k) shown as a black band on the overlay) and the polarised capacitors are correct.

It is preferable to use p.t.f.e. insulated wire for the underboard links because p.t.f.e. does not melt at normal soldering temperatures, thus reducing the risk of shorts. Note that capacitor C4 must have a lead pitch of 2.5mm or 0.1 in., so check before ordering. Do not insert the i.c.s yet.

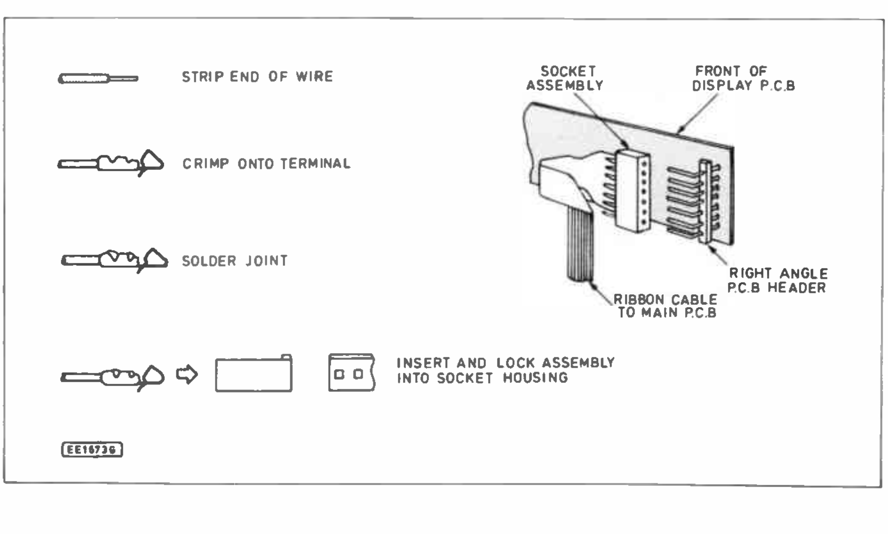
Prepare two lengths of ribbon cable approximately 90mm/3.5 inches long, one 6-way and the other 7-way, as per Fig. 5. Be careful not to put too much solder onto the joints of the terminals as this can prevent them from deflecting properly when they are plugged onto the p.c.b. header. Strip and tin the other end of the ribbon cables and solder them to the main p.c.b.

Since, 7-way p.c.b. headers and sockets are not available, 8-way parts need to be converted by cutting off the extra pole. This is best done with a sharp craft knife. Similarly, the ribbon cable will require any additional wires to be stripped off.

Solder a length of thin insulated wire from the switched positive point on the p.c.b. to the centre pole of the On/Off slide switch, S2, and the red lead of the battery clip to one of its outside poles. The battery clip's black lead should be soldered directly to the negative point on the p.c.b.

The i.c.s can now be inserted into their sockets, taking care to observe the usual CMOS static precautions. Do not remove them from their conductive packaging until just before insertion, and do not touch their pins.

Fig. 5. Interwiring details for interconnecting the p.c.b.s.



DISPLAY BOARD

Display p.c.b. construction: The same notes as above apply here, using Fig. 4 as the overlay diagram. When inserting the resistors, take care not to overstress their leads. Most 0.25W types will fit without too much difficulty.

Ensure that the transistors are mounted as close to the board as possible. This means bending the centre (base) lead quite sharply back along the transistor package. Solder the leads quickly to avoid heat damaging them. Also make sure that the display is inserted correctly.

Lastly, insert and solder the combined switch and l.e.d. if used, and solder the 6 and 7-way p.c.b. headers, with their pins pointing inwards, onto the back (copper side) of the display board. Connect the two p.c.b.'s together with the ribbon cables, connect a PP3 battery, and give the unit a functional check.

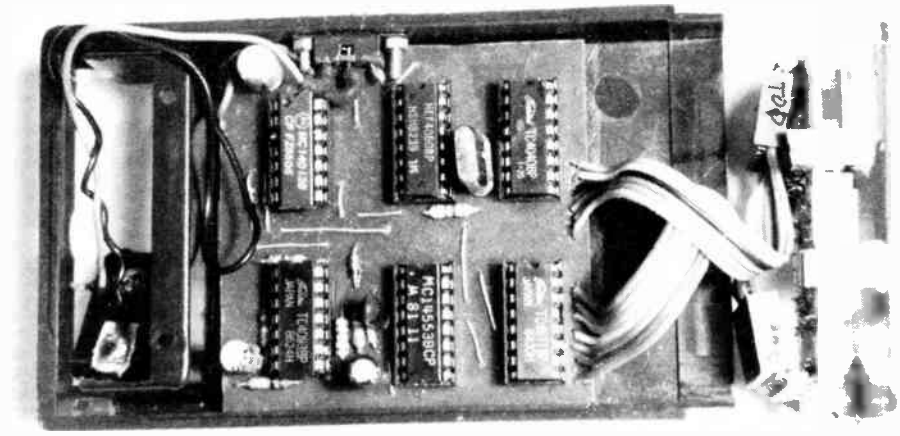
CASE

Cut out the required holes in the case's front panel for the display and the switch. This can be done by chain drilling a series of, say, 1mm diameter holes around the required cutout, and then filing its edges smooth.

A piece of filter plastic can be glued across the display's aperture. Alternatively, cut a piece of filter plastic to the same size as the front panel, and use it as a replacement for the latter, this saves cutting a hole for the display and gives the front panel a more flush appearance. However, in practice it was found best to use the original front panel and glue the filter in place with an ABS solvent (used for "welding" plastic plumbing pipes).

The display board can be mounted by glueing short p.c.b. guides to the front panel. This needs to be done with the board inserted into the guides because the switch must protrude through its hole.

Cut a hole in the side of the case for the switch, ensuring that it will not foul any of the components on the main board. The main p.c.b. can be secured in the case with a couple of adhesive coated foam pads.



Completed timer showing the main printed circuit board, battery compartment and wiring to the on/off switch

FAULT FINDING

If the circuit does not work when it is tested, the circuit description should give some help as to where to look for the fault. Correct operation of the toggle, flip-flop, 8s and 4Hz oscillators, AND gate, and the output of the pulse delay/stretch can be checked with an ordinary voltmeter. The other sections of the circuit will probably need an oscilloscope for checking, although an audio signal tracer could be used on, say, the 1kHz clock.

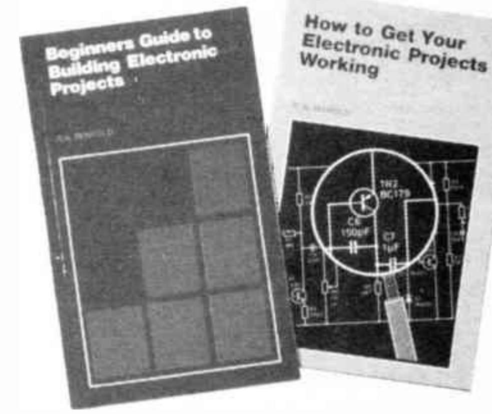
Before taking any extensive circuit measurements, it is worth ensuring that all the i.c.s are receiving a supply voltage. Looking at the i.c. package with its pin one identification mark uppermost, the positive supply should be present on the top right hand pin, with respect to the "negative" (0V) supply at the bottom left hand pin.

The most common faults are incorrectly placed or orientated components, dry joints and solder splashes. In tracing the fault, look at the problem logically in conjunction with the block and circuit diagrams. For instance, if only one digit illuminates, the fault will probably be with the multiplex capacitor, C3, the driver transistors TR1 to TR3, or the latters' connecting leads.

Since the circuit is essentially clock driven, failure of the main oscillator (e.g. a dry joint on the crystal) will cause the entire circuit to appear dead. □

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.



PROJECT CONSTRUCTION

HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. Penfold
We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.
96 pages **Order code BP110** **£2.50**

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R. A. Penfold
Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.
80 pages **Order code BP121** **£1.95**

BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS
R. A. Penfold
Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also includes examples in the form of simple projects.
112 pages **Order code No. 227** **£1.95**

PRACTICAL ELECTRONIC BUILDING BLOCKS–BOOK 1
PRACTICAL ELECTRONIC BUILDING BLOCKS–BOOK 2
R. A. Penfold
These books are designed to aid electronic enthusiasts who like to experiment with circuits and produce their own projects, rather than simply following published project designs.

BOOK 1 contains Oscillators—sinewave, triangular, squarewave, sawtooth, and pulse waveform generators operating at audio frequencies. Timers—simple monostable circuits using i.c.s, the 555 and 7555 devices, etc. Miscellaneous—noise generators, rectifiers, comparators and triggers, etc.

BOOK 2 contains Amplifiers—low level discrete and op-amp circuits, voltage and buffer amplifiers including d.c. types. Also low-noise audio and voltage controlled amplifiers. Filters—high-pass, low-pass, 6, 12, and 24dB per octave types. Miscellaneous—i.c. power amplifiers, mixers, voltage and current regulators, etc.

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CIRCUITS AND DESIGN

ELECTRONICS SIMPLIFIED —CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
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MICRO INTERFACING CIRCUITS–BOOK 2
R. A. Penfold
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Book 1 is mainly concerned with getting signals in and out of the computer; Book 2 deals primarily with circuits for practical applications.
Book 1 *112 pages* **Order code BP130** **£2.25**
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ELECTRONIC CIRCUITS HANDBOOK
Michael Tooley BA
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.
Specifically, this book aims to provide the reader with a unique collection of practical working circuits together with supporting information so that circuits can be produced in the shortest possible time and without recourse to theoretical texts.
Furthermore, information has been included so that the circuits can readily be modified and extended by readers to meet their own individual needs. Related circuits have been grouped together and cross-referenced within the text (and also in the index) so that readers are aware of which circuits can be readily connected together to form more complex systems. As far as possible, a common range of supply voltages, signal levels and impedances has been adopted.
As a bonus, ten test gear projects have been included. These not only serve to illustrate the techniques described but also provide a range of test equipment which is useful in its own right.
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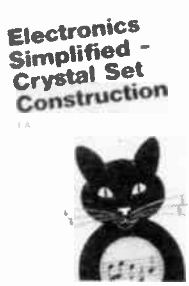

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Provides an introduction which includes a very simple microprocessor circuit which can be constructed so that the reader can experiment and gain practical experience.
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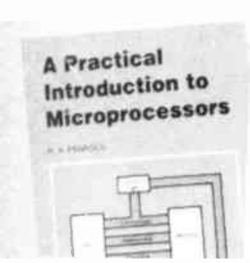

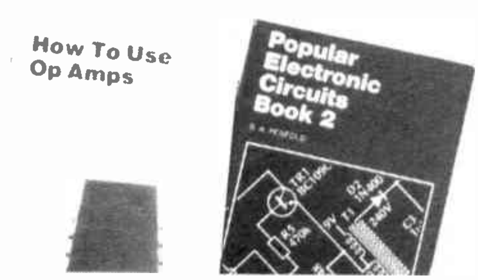

HOW TO DESIGN ELECTRONIC PROJECTS
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POPULAR ELECTRONIC CIRCUITS –BOOK 2
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R.A. Penfold
Home computers may easily be applied to the control of model railways and really quite sophisticated control, which needs only simple programming, is not too difficult to achieve. The main problem lies in interfacing the computer to the layout, but fortunately it is not too difficult or expensive to build suitable interfaces, and this book shows you how.
The projects consist of various types of controller, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control etc. The use of computers does not have to be restricted to massive layouts. Something as simple as an oval of track with a single siding can be given a new dimension by adding computer control and much fun can be had from these relatively simple set-ups.
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MODERN OPTO DEVICE PROJECTS
R.A. Penfold
In recent years, the range of opto devices available to the home constructor has expanded and changed radically. These devices now represent one of the more interesting areas of modern electronics for the hobbyist to experiment in, and many of these devices have useful practical applications as well. This book provides a number of practical designs which utilize a range of modern opto-electric devices, including such things as fibre optics, ultra bright l.e.d.s and passive IR detectors etc.
While many of these designs are not in the "dead simple" category, they should be within the capabilities of anyone with a reasonable amount of experience in electronics construction and some of the more simple designs are suitable for beginners.
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ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS
Robert Penfold
Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kits and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.
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DATA AND REFERENCE

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RECOMMENDED READING
FOR INTRODUCING MICROPROCESSORS

PRACTICAL DIGITAL ELECTRONICS HANDBOOK
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.
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ELECTRONICS TEACH-IN
Michael Tooley BA and David Whitfield MA MSc CEng MIEE (published by *Everyday Electronics*)
This value for money *EE* book provides a comprehensive background to modern electronics including test gear projects. A complete course in basic electronics; designed for the complete newcomer it will however also be of value to those with some previous experience of electronics. Wherever possible the course is related to "real life" working circuits and each part includes a set of detailed practical assignments. Includes details of eight items of related test gear giving full constructional information and diagrams for each one. They are: Safe Power Supply; Universal LCR Bridge; Diode/Transistor Tester; Audio Signal Tracer; Audio Signal Generator; RF Signal Generator; FET Voltmeter; Pulse Generator. An excellent companion for anyone interested in electronics and invaluable for those taking G.C.S.E. and BTEC electronics courses.
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Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias—tedious and higher mathematics have been avoided where possible and many tables have been included.
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G. T. Rubaroe, T.Eng (C.E.I.), Assoc.I.E.R.E.
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R.A. Penfold
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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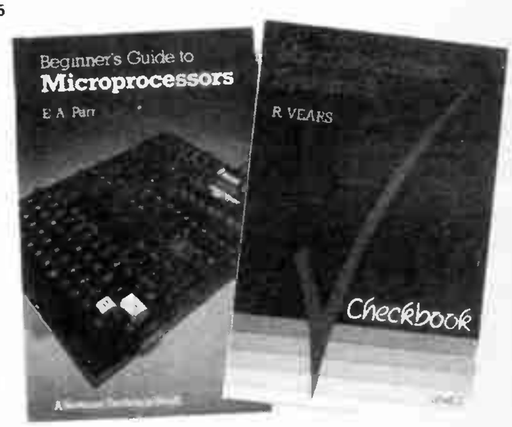

BEGINNERS GUIDE TO MICROPROCESSORS
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224 pages **Order code NE03** **£4.95**

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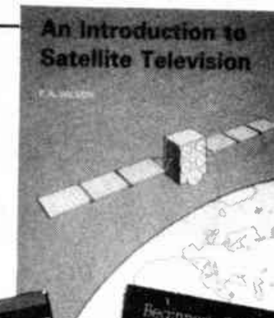

OSCILLOSCOPES: HOW TO USE THEM–HOW THEY WORK
Ian Hickman

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.

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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.

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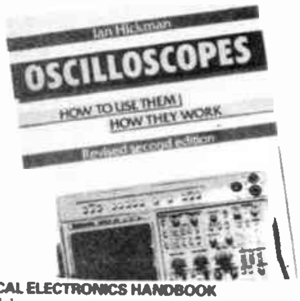

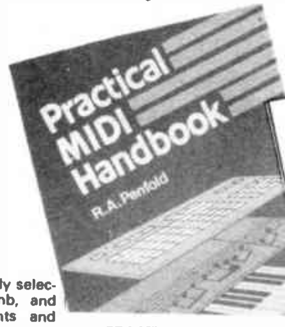

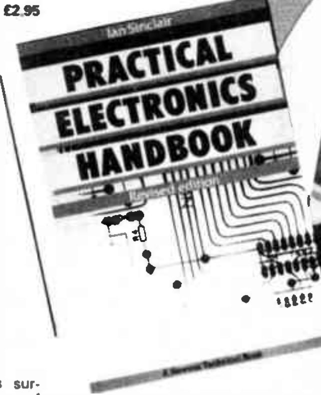

PRACTICAL ELECTRONICS HANDBOOK
Ian Sinclair

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** **£7.95**

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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R. A. Penfold

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At every stage in the book there are practical tests a d experiments that you can carry out on the demonstrator unit to investigate the points described and to help you understand the principles involved. You will soon be able to go on to more complex circuits and tackle fault finding logically in other circuits you build.

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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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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.

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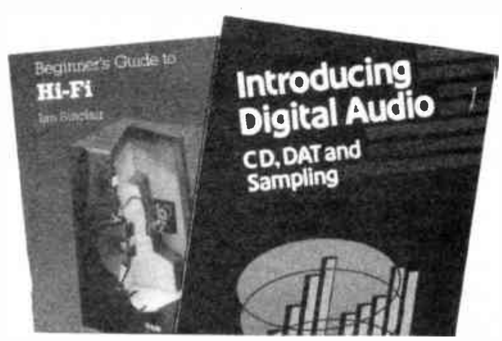
INTRODUCTION TO DIGITAL AUDIO
Ian Sinclair

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 GUIDE
A. Michaels

Helps the reader to find possible substitutes for a popular selection of European, American and Japanese transistors. Also shows material type, polarity, manufacturer and use.

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C. E. Miller

Used properly, should enable the reader to trace most common faults reasonably quickly. Across the top of the chart will be found four rectangles containing brief description of these faults, *vis*—sound weak but undistorted, set dead, sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

Chart **Order code BP70** **£0.95**

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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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LINEAR IC EQUIVALENTS AND PIN CONNECTIONS
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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INTERNATIONAL DIODE EQUIVALENTS GUIDE
A. Michaels

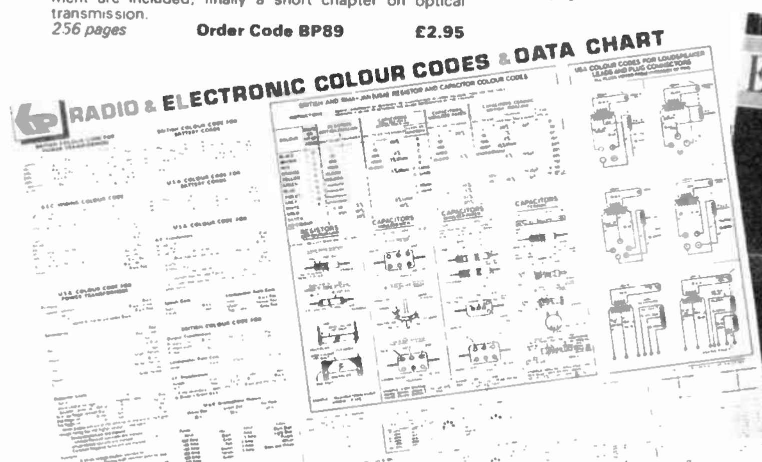
Designed to help the user in finding possible substitutes for a large selection of the many different types of diodes that are available. Besides simple rectifier diodes, also included are Zener diodes, l.e.d.s, diacs, triacs, thyristors, OCIs, photo and display diodes.

144 pages **Order code BP108** **£2.25**

NEWNES ELECTRONICS POCKET BOOK
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.

315 pages (hard cover) **Order Code NE02** **£9.95**



TRANSISTOR SELECTOR GUIDE

This unique guide offers a range of selection tables compiled so as to be of maximum use to all electronics engineers, designers and hobbyists.

Section 1: Covers component markings, codings and standards, as well as explaining the symbols used.

Section 2: Tabulates in alpha-numeric sequence the comprehensive specifications of over 1400 devices.

Section 3: Tabulates the devices by case type.

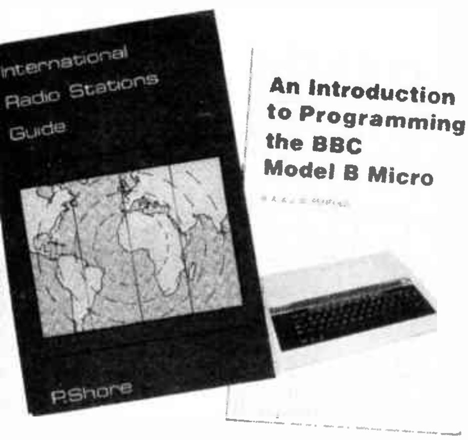
Section 4: Considers particular limits to the electrical parameters when compiling the tables.

Section 5: Illustrates package outlines and leadouts.

Section 6: Consists of a surface mounting device markings conversion list.

192 pages **Order code BP234** **£4.95**

RADIO/TELEVISION



AN INTRODUCTION TO RADIO DXING
R. A. Penfold
Anyone can switch on a short wave receiver and play with the controls until they pick up something, but to find a particular station, country or type of broadcast and to receive it as clearly as possible requires a little more skill and knowledge. The object of this book is to help the reader to do just that, which in essence is the fascinating hobby of radio DXing.
112 pages **Order code BP91** **£1.95**

INTERNATIONAL RADIO STATIONS GUIDE
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JANUARY 1988
TO DECEMBER 1988

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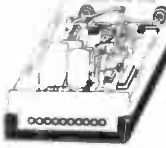

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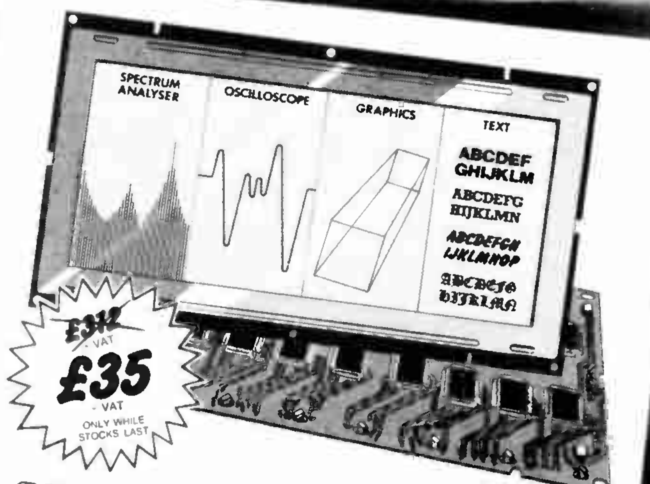

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But it's an ill wind that blows nobody any good. Because of their bad management, you now have the chance to own a high grade graphics display module at a tiny fraction of the normal price. Hitachi distributors will charge £312 each for these displays. From us, while stocks last, the price is £35!

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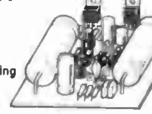
To help organise the display, mounted on the back is a control board with 20 LSI ICs. This keeps track of all the individual dots and allows the screen to be filled via a simple eight-bit-at-a-time interface.

To use the display, you will need to be fairly self-sufficient in logic design – you must know how to organise a frequency divider and serial data transfer. Apart from these basics, the data supplied with the module will tell all you need to know to get it up and running.

ARMSTRONG 75W AMPLIFIER

FEATURED IN PE
JULY 1988



A.J. Armstrong's exciting new audio amplifier module is here at last!

Delivering a cool 75W (conservatively rated – you'll get nearer 100W), this MOSFET design embodies the finest minimalist design techniques, resulting in a clean uncluttered circuit in which every component makes a precisely defined contribution to the overall sound.

You can read all about it in the July issue of PE, but why bother with words when your ears will tell you so much more?

Parts set includes top grade PCB and all components.

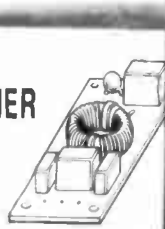
SPECIAL INTRODUCTORY PRICE FOR FULLY UPGRADED MODULES.

SINGLE PARTS SET **£14.90** + VAT
STEREO PAIR **£25.90** + VAT

Please send SAE + £1 for data and circuits (free with parts set), including diagrams for matching pre-amp and power supply. This amplifier will not be available from your usual audio supplier – we produce the only designer approved parts set.

MAINS CONDITIONER

FEATURED IN ETI
SEPTEMBER 1986



Cleans up mains pollution easily and effectively. You'll hardly believe the difference in your Hi-Fi, TV, Video, and all other sensitive equipment.

PARTS SET **£4.90** + VAT
RUGGED PLASTIC CASE **£1.65** + VAT

BIO-FEEDBACK

FEATURED IN ETI
DECEMBER 1986

Bio-feedback comes of age with this highly responsive self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

PARTS SET **£13.95** + VAT
BIO-FEEDBACK BOOK **£3.95** (no VAT)

Please note, the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book and will only be of interest to intelligent adults.

POWERFUL AIR IONISERS

[illegible]

The Direct-ion caused a sensation when it appeared as a project in ETI. Two years later, in October 1988, the Mistral was unveiled. Which will you go for – the compact, powerful, value for money Direct-ion or the sophisticated, no compromise Mistral? The choice is yours.

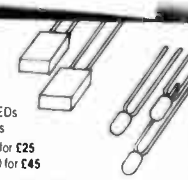
MISTRAL IONISER PARTS SET **£24.80** + VAT
DIRECT-ION PARTS SET (BLACK CASE) **£11.50** + VAT
DIRECT-ION PARTS SET (WHITE CASE) **£11.80** + VAT

LM2917 EXPERIMENTER SET

Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 EXPERIMENTER SET **£5.80** + VAT

LEDs



Green rectangular LEDs for bar-graph displays

50 for £3.50	500 for £25
100 for £6	1000 for £45

DIGITAL AND AUDIO EQUIPMENT LEDs
Assorted 3mm LEDs: red, green, yellow and orange
25 of each (100 LEDs) for **£6.80**

BRAINWAVE MONITOR

FEATURED IN ETI
AUGUST 1987

The most astonishing project ever to have appeared in an electronics magazine. Similar in principle to a medical EEG machine, this project allows you to hear the characteristic rhythms of your own mind! The alpha, beta and theta forms can be selected for study and the three articles give masses of information on their interpretation and powers.

In conjunction with Dr. Lewis's Alpha Plan, the monitor can be used to overcome shyness, to help you feel confident in stressful situations, and to train yourself to excel at things you're no good at.

Our approved parts set contains case, two PCBs, screening can for bio-amplifier, all components (including three PMI precision amplifiers), leads, brass electrodes and full instructions.

PARTS SET **£36.90** + VAT   ALPHA PLAN BOOK **£2.50**
SILVER SOLUTION (for plating electrodes) **£3.60** + VAT

Parts set available separately. We also have a range of accessories, professional electrodes, books, etc. Please send SAE for lists, or SAE + £2 for lists, construction details and further information (free with parts set).

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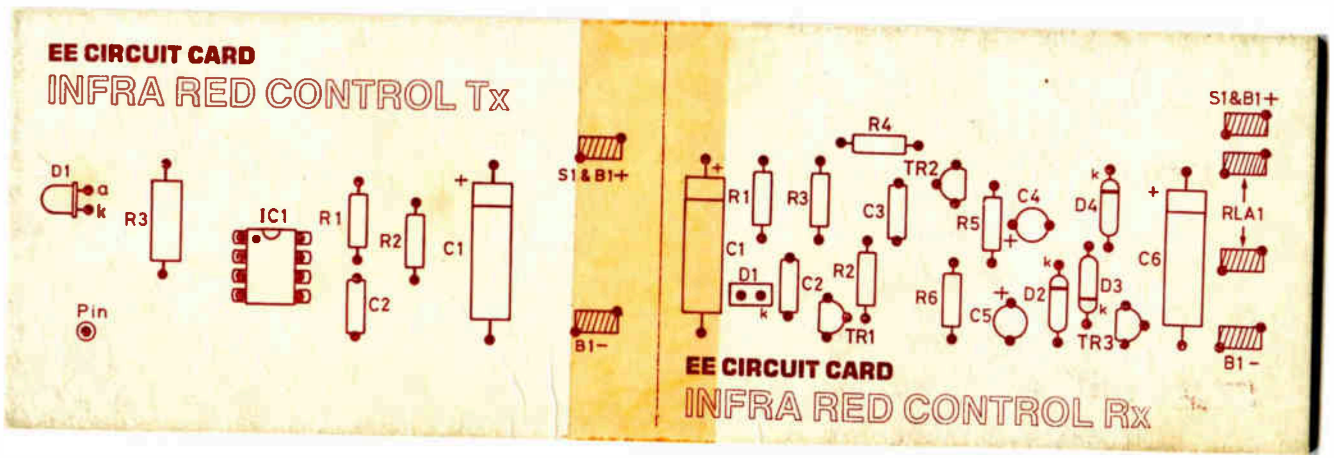
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+
Pin
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INFRA RED CONTROL Rx
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TR2
R1
R3
C3
R5
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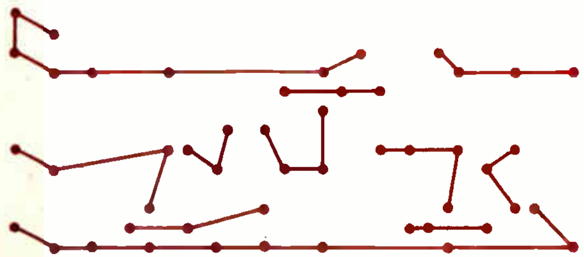

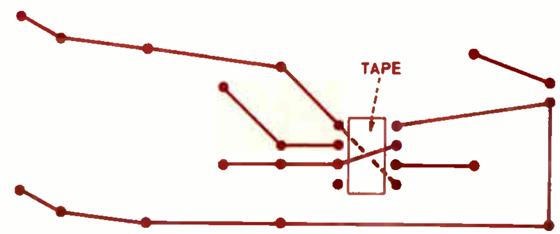
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