OCTOBER 1995

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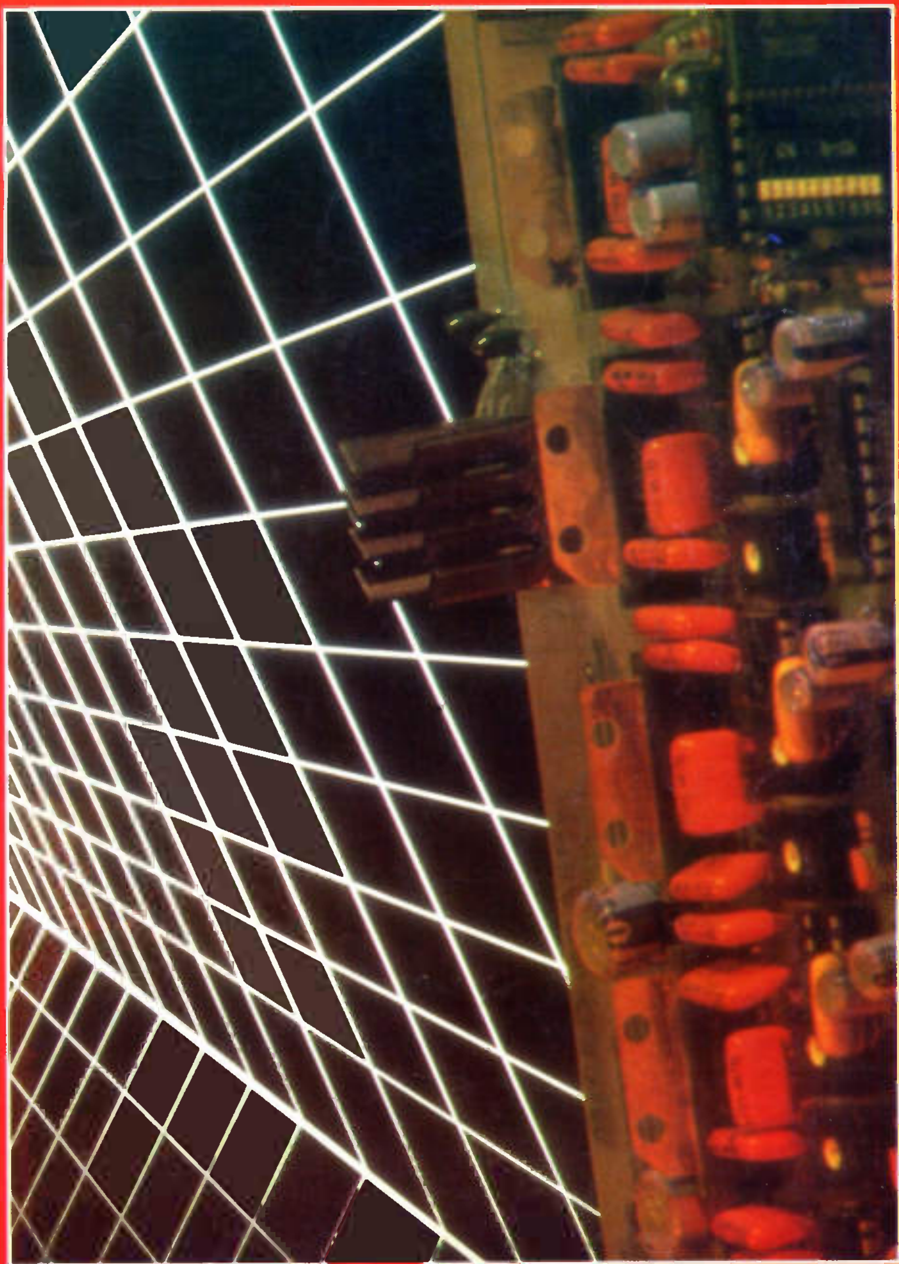

THE NO. 1 INDEPENDENT MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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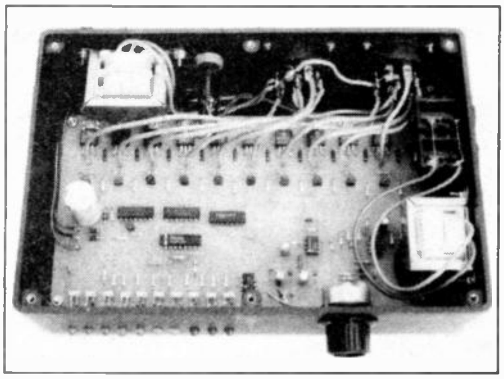
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

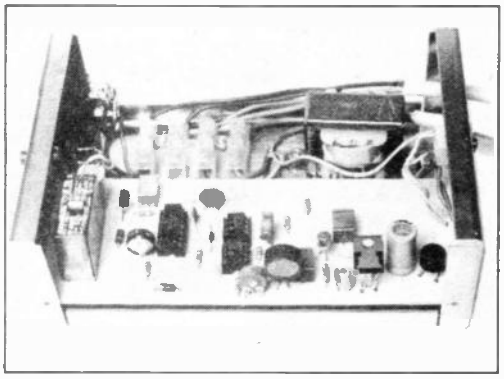
VOL. 24 No. 10 OCTOBER 1995

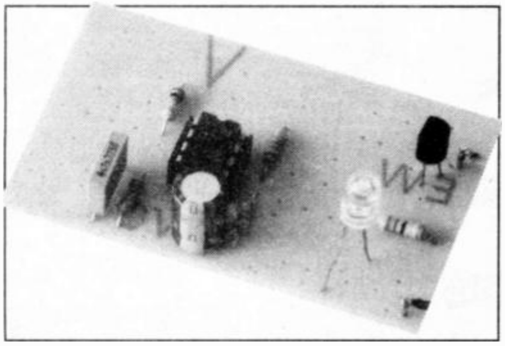
EVERYDAY With PRACTICAL ELECTRONICS

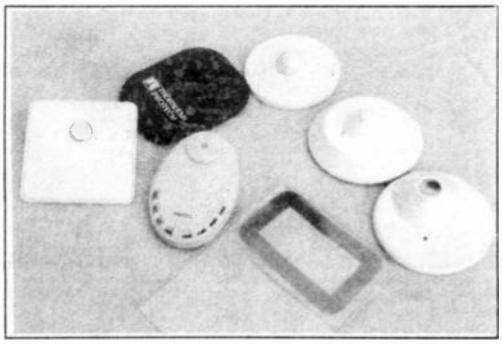
INCORPORATING ELECTRONICS MONTHLY

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects









Projects

Series

Features

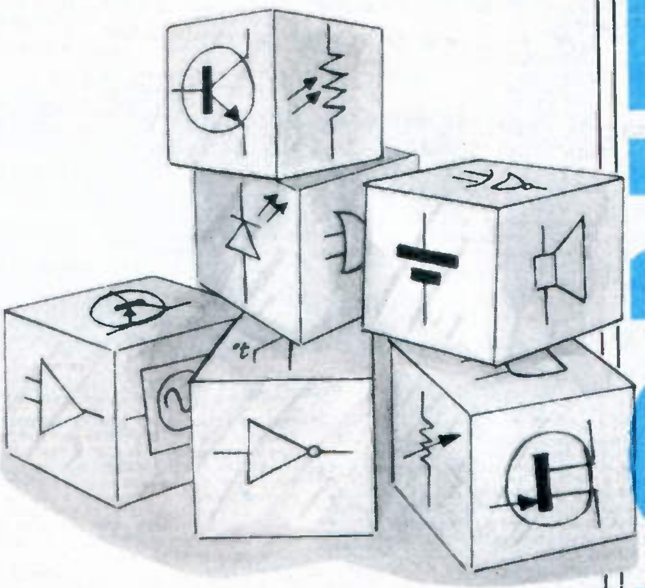
Our November '95 issue will be published on Friday, 6 October 1995. See page 743 for details.

Don't miss the start of

TEACH-IN '96

Our regular Teach-In series is now highly respected for its straightforward, lively and informative approach to the study of electronics. Teach-In has been a regular feature of the magazine every other year since 1971. The new series, subtitled A Guide To Modular Circuit Design *has been written by Max Horsey and is aimed at hobbyists and GCSE electronics and technology students, it will also appeal to AS and A Level students and those taking relevant City & Guilds and BTEC courses. Max is Head of Electronics at Radley College, he previously taught electronics and technology at GCSE and A level in state schools for many years.*

The monthly ten part series will detail over fifty design modules and each month we will also publish a complete project made up from some of the modules. Part One is published next month. If you want to be able to design and build your own projects then this series is for you.



PLUS

THREE MORE *FREE* PCB PROJECTS

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CURRENT TRACER

Each of these projects is designed to fit on the FREE Multiproject PCB cover mounted on this issue.

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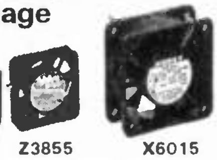

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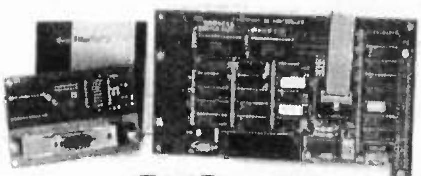
Z3855 Smallest fan we've seen! 42x42 by just 10mm thick. Made by Nitev. Model TA150DC. Rated 12V dc 0.11A **Normally £3.00**

X6015 Papst (mostly) 612L 60x60x25mm 12V dc (6-15V) 0.7W fan. List is £27.47 **Normally £3.00**

ETHERPORT FOR MACINTOSH



X9012 Shiva EtherPort SE. This brand new boxed set of parts from Novell for networking Apple Macintosh computers is fantastic value. You get the Etherport SE Controller Board, the Etherport SE Access Board, the software on a 3.5" disk, an Installation Guide and a User's Guide. Wonder what the original cost was? **Normally £14.95**

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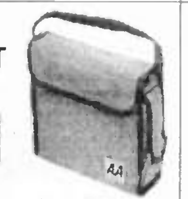

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M3800

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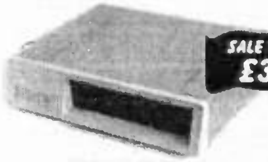

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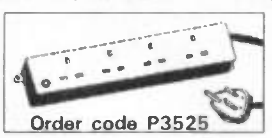

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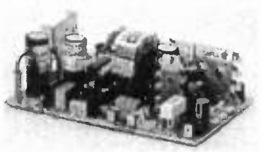

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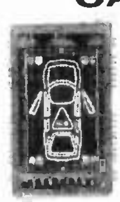

Z3100 Car VFD. This shows the plan view of a saloon and indicates whether doors are shut, lights are on etc. With data sheet. **Normally £2.00**

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NK1004	10µF 400V	25x13	5mm	**51p**
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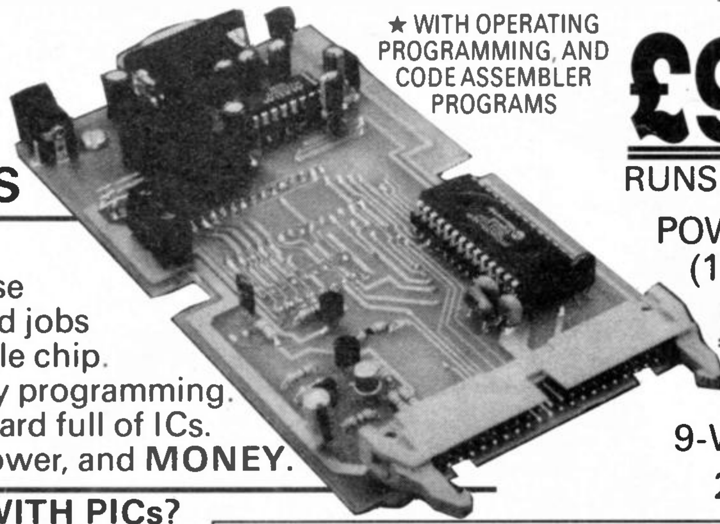

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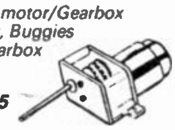

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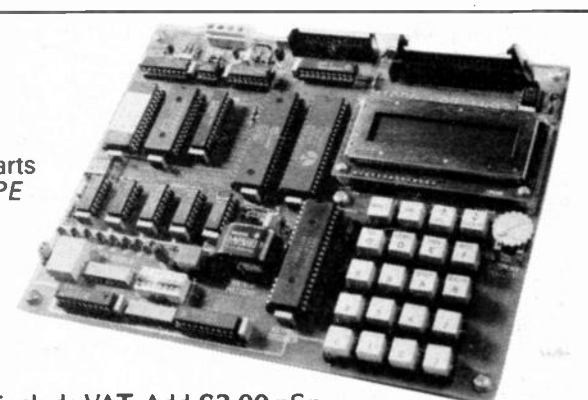

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INCORPORATING ELECTRONICS MONTHLY

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HERE WE GO AGAIN

Every other year since 1971 *EPE* has published a *Teach-In* series. Right from the very first Teach-In the series has established itself as a high quality distance learning course, it is now highly respected around the world and has often been emulated in other publications. *Teach-In '96* is no exception, it deals – in a lively but straightforward way – with Modular Circuit Design, detailing over fifty versatile design modules and bringing them together to produce ten full constructional projects, thus demonstrating the simple techniques used to design and assemble various items of equipment. The projects range from a *Temperature Warning Device* to an *Automatic Camera Panning System* and a *Motor/Shaft Speed Display*. There are also plenty of other constructional projects; something to interest just about every potential constructor.

HONED

This new series has been written for us by Max Horsey – the name will already be familiar to regular readers. Max is Head of Electronics at Radley College and has been contributing to the magazine since 1980. The information in *Teach-In '96* has been developed and honed over a number of years of teaching GCSE, AS and A Level students. It will, of course, be particularly interesting to teachers and students for both electronics and technology courses, but it also has a much wider appeal to all hobbyists who would like to be able to put together their own project designs without years of study and in-depth design calculations, etc. *Teach-In '96* will run for ten months and starts in next month's issue.

GET IT

Whenever we start a new *Teach-In* the demand for copies is high so, to make sure you do not miss out on this exciting new series, either place an order with your newsagent, who will deliver or shop-save a copy for you, or why not take out a subscription, at just £24 (UK) for a year? With a subscription there is a saving of £3 on the cover price, your issue will be posted to you in time to arrive before the official publication date and you will be insulated from supply problems and cover price increases for a year. It's worth thinking about.

Mike Kenward

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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. Due to the cost we cannot reply to queries by Fax.**

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.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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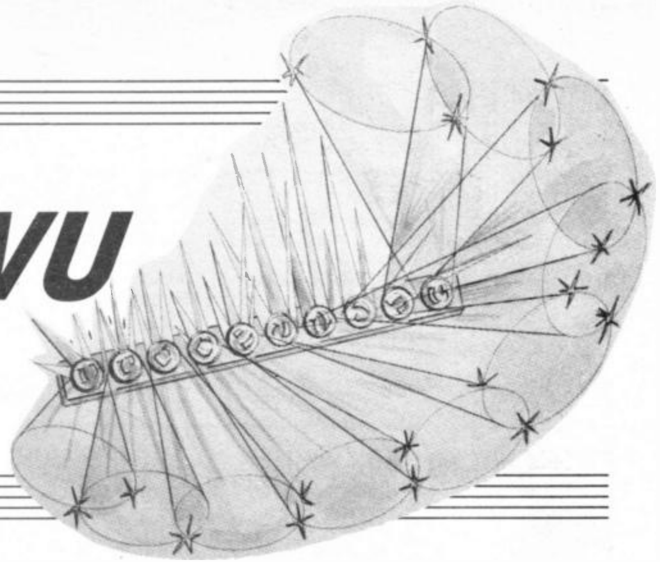
Constructional Project

GINORMOUS VU METER



PAUL STENNING

Add brilliant individuality to your disco display – ten or more lights flashing, ascending, cascading, in harmony with the mood and strength of the music. It's a sight to be seen!

RECENTLY, while rummaging in the loft, the author found the circuit diagram of one of his favourite home-made lighting effects units, a large VU meter. It dated back to when he and a friend ran a small mobile disco. The friend was the DJ, while author dealt with the technical side, building most of their equipment to keep costs down. Feeling prompted to rebuild it, bringing it up-to-date in the process, resulted in this Ginormous VU Meter!

ORIGINALITY

Seven lamps were controlled by the original unit, using individual comparators, whereas the Ginormous VU Meter design controls ten lamps and uses a bargraph driver chip. The effect is emphasized by reducing the difference between the bottom and top lamps, giving a more dramatic effect than a conventional VU meter. In addition, the scaling is linear, rather than the logarithmic scaling normally used.

The Effects potentiometer on the controller sets the level in a similar manner to a recording level control. Normally, this would be set so that the top light comes on at the loudest peaks in the music. However, it may be turned down to give a more romantic atmosphere when playing slower records. Once the desired effect is obtained, it is maintained by an automatic level control circuit, despite variations in volume and music style. This allows the DJ to concentrate on playing the music rather than fiddling with the lighting effects.

Low cost home disco lighting effects use a built-in microphone to pick up the sound. This arrangement is prone to picking up extraneous noises unless it is placed very close to the speakers. This effects unit, though, connects directly to the speaker terminals of an amplifier, eliminating the problem. A transformer is used to isolate the amplifier from mains circuitry.

The input impedance is about one kilohm (1k), which will impose no significant additional load on the amplifier. A high power amplifier is not necessary – by changing one component value the output from a domestic stereo system playing at a sociable volume can be accommodated. Each lamp output can drive up to 250W of lights, giving a total of 2·5kW! In practice, much smaller lamps would be used, 25W per channel being typical. Suggestions for constructing a suitable light box are given later.

Zero crossing control is used to minimize radio frequency interference (RFI). Note that the outputs are only suitable for resistive loads such as normal tungsten lamps. Inductive loads such as pin-spots and similar lights containing transformers are not suitable.

WARNING

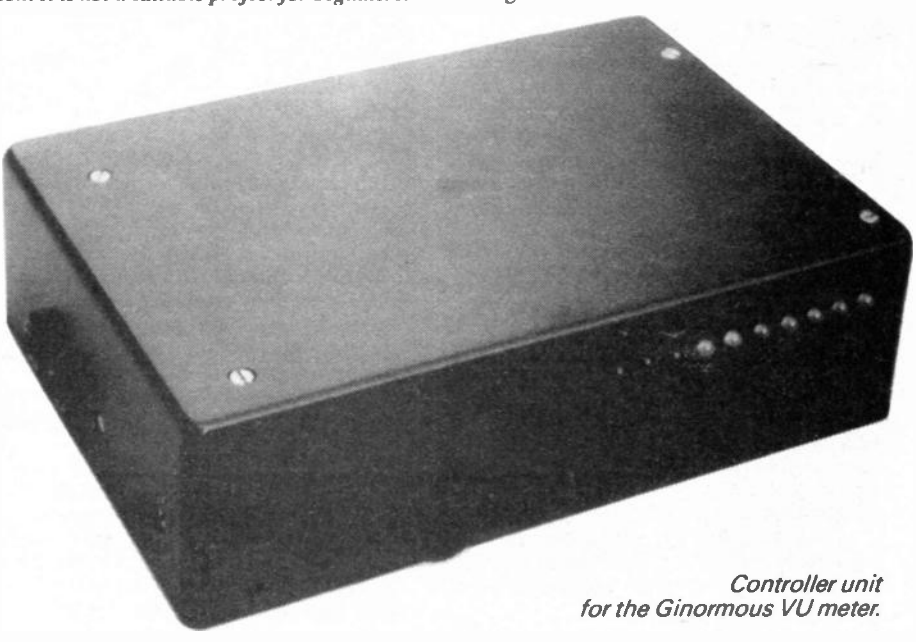
This design operates at lethal mains voltages. If you are in any doubt about your ability to construct it safely, seek assistance from a suitably qualified or experienced person. It is not a suitable project for beginners.

HOW IT WORKS

The circuit diagram for the music level detection and control stages is shown in Fig. 1. Mains transformer T1 is used to isolate the circuit from an audio amplifier. Audio matching transformers are available, but these are not generally designed to isolate mains voltages, and are normally more expensive. Although a mains transformer does not have a particularly flat frequency response, it is good enough for this application. In addition, the transformer reduces the signal to a more manageable level.

The signal from an amplifier delivering hundreds of watts could be about 30V to 60V r.m.s., which is excessive for op.amp circuitry. The transformer used here has a turns ratio of about 10:1, which reduces these voltage levels to a more manageable 3V to 6V. On a domestic stereo amplifier producing maybe between 2V and 10V r.m.s. there will still be between 0·2V and 1V signal level available.

Resistors R1 and R2 form an attenuator to reduce the signal still further, to a level suitable for the input of op.amp IC1. The value of R1 can be adjusted to suit the audio power levels normally encountered. A value of 470k is ideal for domestic use if you wish to remain on speaking terms with the neighbours! If other members of the household do not appreciate your taste in music, it may be better to reduce it to about 220k. On the other hand, 2M2 is about right for use with a 100W power amplifier at high volume.



Controller unit for the Ginormous VU meter.

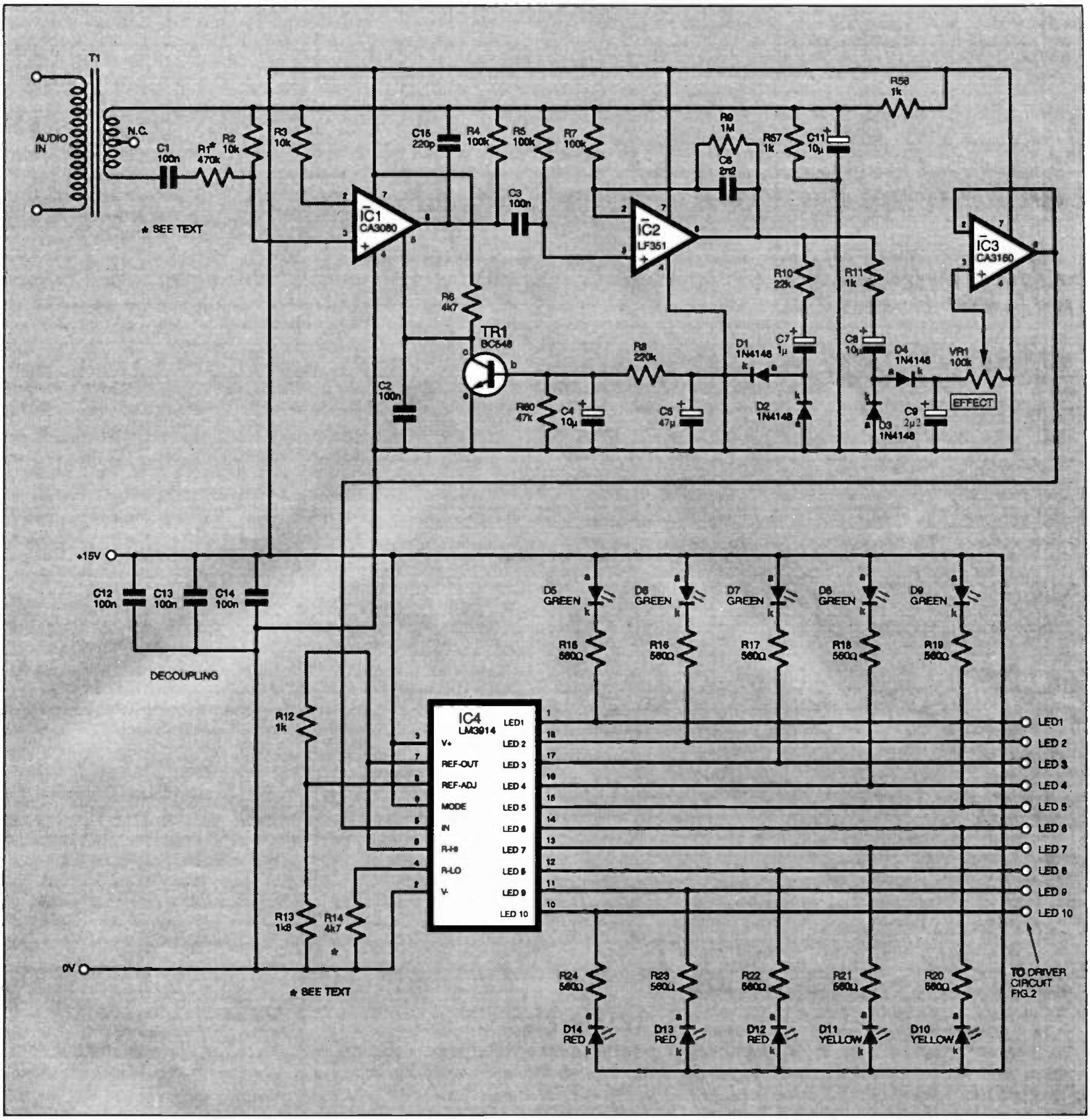


Fig. 1. Music level detection and control stages circuit diagram.

If the value of R1 is too high, there will be insufficient signal for the automatic level control to operate and the effect will vary as the volume is adjusted. If the value is too low, the automatic level control will be saturated and all the l.e.d.s will remain on with virtually no variation. The automatic level control has a wide acceptance range so the precise value is not at all critical.

TRANS-CONDUCTANCE

A transconductance amplifier type CA3080 is used for IC1. The gain of this device is controlled by the current flowing into the control node, pin 5. Resistor R4 is the output load, which converts the output current into a voltage. Capacitor C15 reduces the impedance of the load at higher frequencies, reducing noise and giving some high frequency roll-off. Resistors R2 and R3 bias the two inputs, pins 2 and 3, to the mid-rail supply voltage. Inevitably, there will be some small d.c. offset at the output of IC1, particularly at higher gains. This is blocked by capacitor C3.

If experimenting with the CA3080 device, note that it can easily be damaged by overdriving the control input. The input is connected directly to the base of an internal transistor. Connecting it directly to a low impedance voltage above about 0·6V, or allowing more than about 5mA to pass into it, will destroy the transistor.

A conventional op.amp is used for IC2 and is configured as a non-inverting amplifier with a gain of about ten at lower frequencies. Capacitor C6 progressively reduces the gain at higher frequencies. This is intentional since the effect works better at lower frequencies – in particular the bass beat. The value of C6 may be adjusted to suit individual preferences and music styles.

RECTIFICATION

The output of IC2, pin 6, feeds a rectifier circuit comprising diodes D1 and D2. Capacitor C7 is a d.c. blocking component and C5 is the smoothing capacitor. The latter charges at a rate set by resistor R10 and discharges at the rate set jointly by the paths through R60, R8 and the base of transistor TR1. The component values are arranged to give a gentle attack and slow decay characteristic.

Resistor R6 passes sufficient current to bias IC1 control pin 5 to give maximum gain when transistor TR1 is turned off. If the signal level on the output of IC2 is too great, the output from the rectifier network will rise, causing TR1 to conduct. This diverts current from the control pin of IC1, reducing the gain. This automatic level control circuit will maintain a virtually consistent output level from IC2 despite a large change in audio input level. From measurements taken, a variation of at least 30dB can be accommodated, as proved over many years.

The output of IC2 also drives another rectifier circuit comprising resistor R11, capacitors C8 and C9, and diodes D3

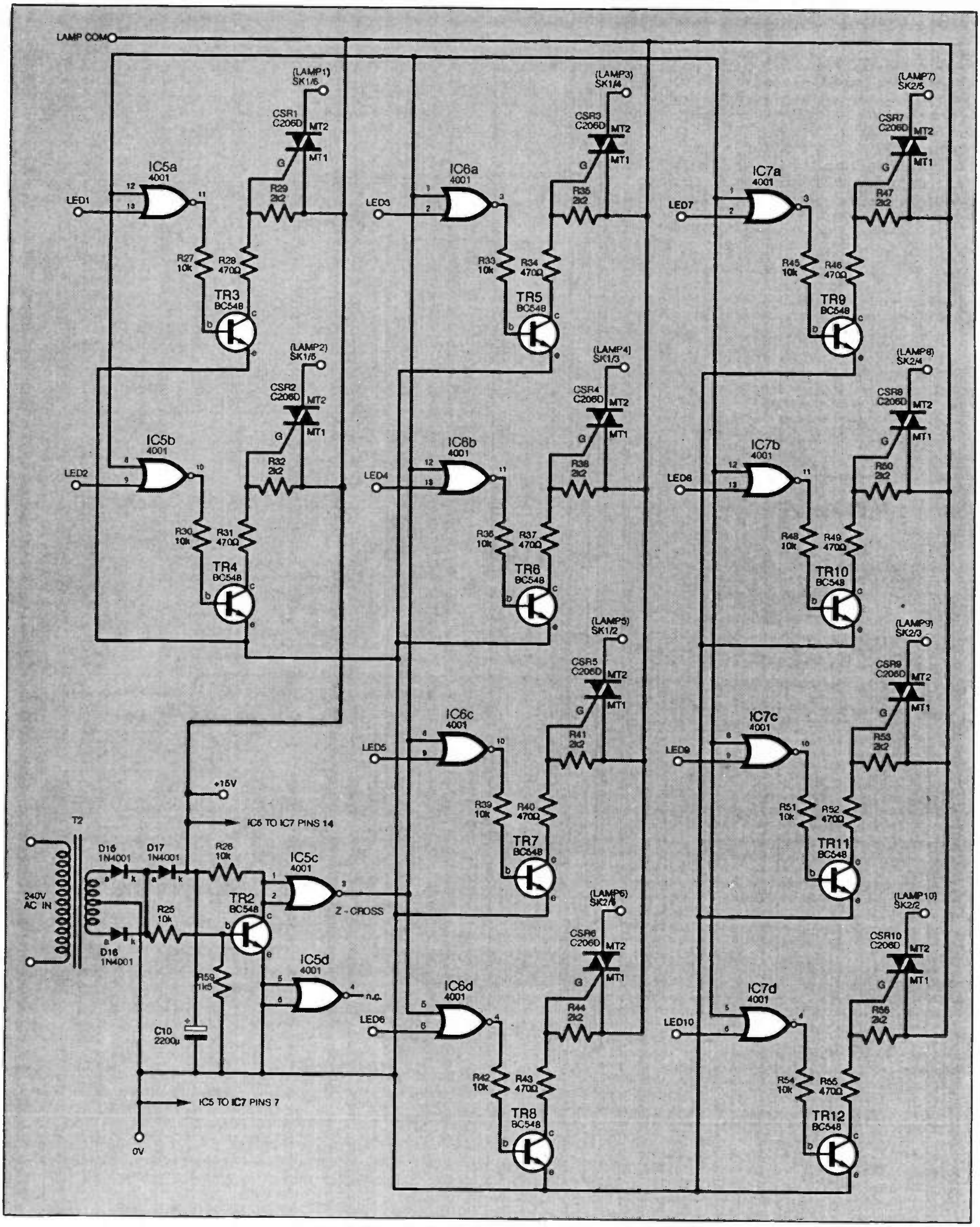


Fig. 2. Circuit diagram for the ten lamp drivers.

and D4. This circuit has a much faster response, due to the low values of R11 and C9. Potentiometer VR1 provides the discharge path for C9. A portion of the d.c. level from this rectifier is tapped off by the wiper of VR1 and buffered by op.amp IC3. A CA3160 op.amp was chosen because its output can be driven to within 0·1V of the positive and negative supply rails.

Mid-supply rail reference voltage for all three op.amps is provided by potential divider R57 and R58, decoupled by C11.

BARGRAPH DRIVER

The output voltage from IC3 is taken to input pin 5 of IC4. This chip is an LM3914 linear 10-channel l.e.d. bargraph driver. A chain of resistors within IC4 provides separate reference voltage levels to 10 comparators. As the input voltage level rises, the comparators are tripped in ascending order, turning on the respective l.e.d.s D5 to D14.

Although current drive to the l.e.d.s is internally regulated, ballast resistors R15 to R24 have also been added in series with the l.e.d.s. If the resistors were omitted the outputs would still drive the l.e.d.s correctly, but the voltage on the output pins would vary from + 14V to + 11V, which is insufficient variation to drive the inputs of the digital chips in the next stage.

The resistors drop an additional 8V approximately, giving a level which is low enough to register as a logic 0, whilst allowing the current regulation to operate. As a bi-product, the resistors also reduce the power dissipation within IC4. An output is low when the appropriate l.e.d. is lit.

The l.e.d. sink current is controlled by the voltage reference circuit and is about ten times the current flowing from the Ref-Out pin into resistor R13. In this case the reference voltage is set to 3·5V and the reference current is 1·3mA, giving an l.e.d. current of about 13mA.

The reference voltage is applied across the internal divider resistor chain. The bottom of the chain is lifted above 0V by the addition of R14. This reduces the dynamic range required, enhancing the effect. The value of R14 may be changed to suit personal preferences and the style of music played. Modern dance music has a low dynamic range for which the value of 4k7 is about right. For music from the 60s or 70s, 1k5 would be more suitable. If a selection of music styles is regularly played, 3k3 would be a good compromise. Alternatively, R14 could be replaced by a 10k potentiometer, adjusting it appropriately.

LAMP DRIVERS

Details of the ten lamp driver circuits are shown in Fig. 2. As the circuits are identical, only one is described in detail, that around IC5a, transistor TR3 and triac CSR1:

When lines LED1 and Z-CROSS are both low, the output of NOR gate IC5a will be high. Via resistor R27, this turns on transistor TR3, which drives the gate of triac CSR1. Since the Z-CROSS line is low for only a brief period as the mains cycle passes through 0V, the triac can only be switched on at this point.

Once the triac is on, it will remain on until the current passing through it drops below a minimum holding value. With a resistive load, this occurs as the mains cycle approaches the next zero crossing point. Thus the load is driven for complete half cycles. No switching occurs at points in the cycle where the switched current would be high.

Because the triac is triggered only momentarily at the zero crossing point, the output is not suitable for driving inductive loads. With an inductive load the current and voltage are out of phase, so this simple triac driving arrangement will not operate correctly. Since the unit is only intended to drive normal lamps, this restriction should not cause any problems.

The Z-CROSS signal is derived from mains transformer T2. Diodes D15 and D16 provide full wave rectification, feeding into smoothing capacitor C10 via diode D17. The positively rectified ripple voltage at the junction of the three diodes is attenuated by the resistor chain R25 and R59 and fed to the base of transistor TR2. The transistor is turned off when the voltage at the junction of the diodes is below about 3V. Resistor R26 is the collector load for TR2 from which the triggered output voltage is inverted by NOR gate IC5c.

NOR gate IC5d is unused and so its input pins 5 and 6 are connected to 0V.

CONSTRUCTION

All components except for the transformers are mounted on a single-sided printed circuit board (p.c.b.) which is available from the *EPE PCB Service*, code 956. Component positioning and track layout details for the board are shown in Fig. 3 and Fig. 4.

Components should be assembled in ascending order of size, or convenience. Use sockets for all the i.c.s., but do not insert the i.c.s until after thoroughly checking the entire assembly. Don't forget to fit the ten wire links. Veropins or similar should be used for all off-board connections.

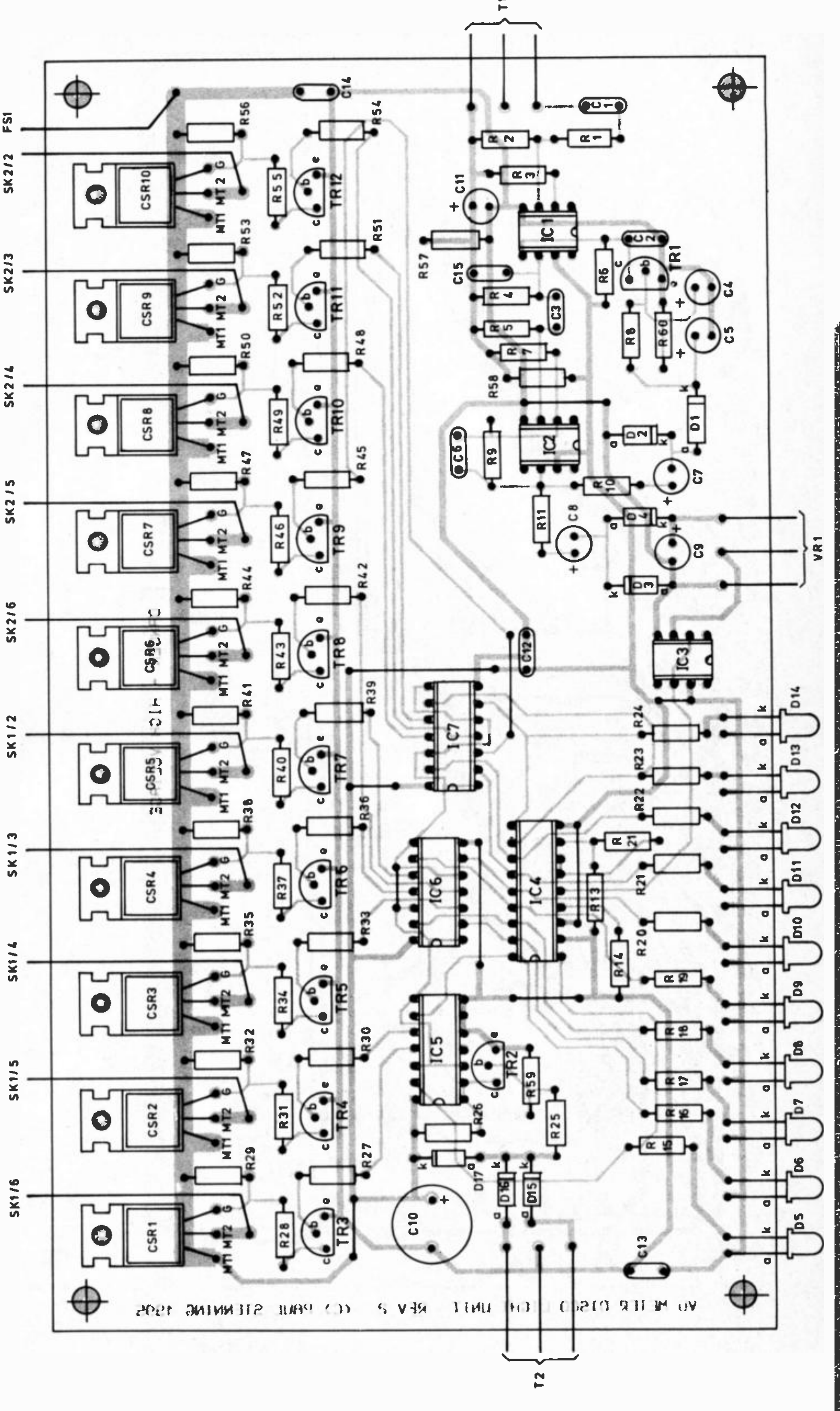


Fig. 3. Component layout for the Gigantic VU Meter p.c.b.

The leads of the l.e.d.s should be left at a suitable length to allow the faces of the components to protrude through holes in the panel of the chosen case. The "k" on the component overlay indicates the cathode of the l.e.d.; usually marked by a flat on the side of the l.e.d.

Potentiometer VR1 may be mounted directly onto the p.c.b. or connected to it by short lengths of insulated wire. On the overlay, the centre pin is the wiper, the left pin is the anti-clockwise end of the track and the right pin is the clockwise end.

Triacs CSR1 to CSR10 should be secured to the p.c.b. with M3 or 6BA nuts and bolts. No heatsinking is required. The heavy mains carrying p.c.b. tracks should be *reinforced* with solder or tinned copper wire of about 20 s.w.g.

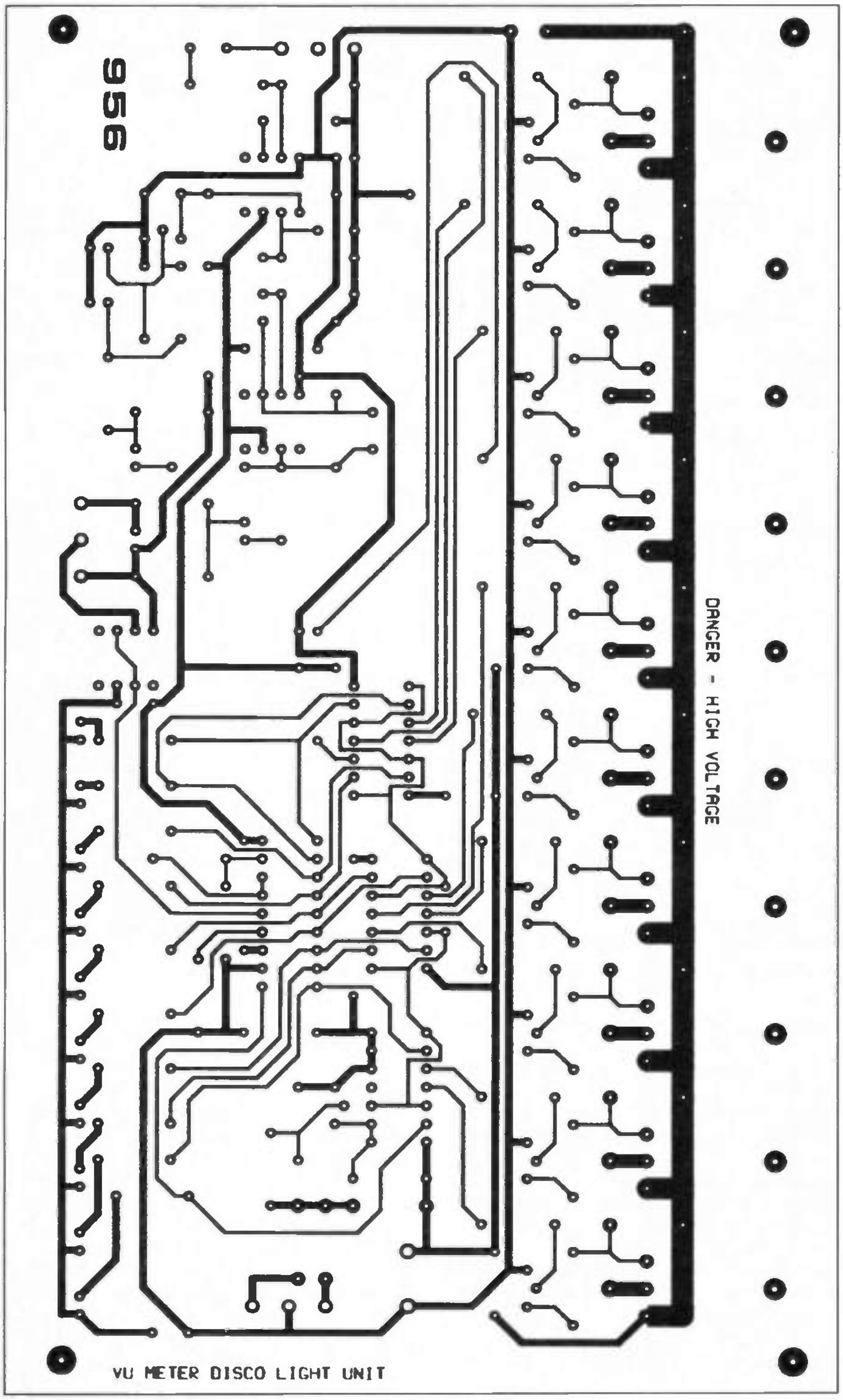


Fig. 4. Full size copper foil track master layout.

When construction is complete, carefully check the entire assembly, especially the area around the triacs, for short circuits and bad joints, etc. Short circuits could cause a nasty mess when the mains is applied!

CASING IT

Once the p.c.b. is finished it should be mounted in a suitable case with the transformers etc. The author's model was housed in a case measuring 221mm × 150mm × 63mm. For professional use, a *sturdy* metal case should be used if the unit is to survive for any length of time – disco equipment leads a rough life! Even for home use, a metal case should be used for safety. Plastic cases are not recommended for this unit. Potentiometer VR1 should have a metal shaft, and a metal knob for strength.

However, a significant amount of money could be saved by building the controller into the light box – saving the cost of a case, some connectors and multicore mains cable.

CONNECTIONS

Interwiring details are shown in Fig. 5. Mains wiring **MUST** be carried out with wire rated at a *minimum* of 6A. The insulated cores stripped out of mains cable will probably be suitable.

Bulgin 8-pin connectors are recommended for the lamps. These are commonly used for disco lighting. Their advantage is that either the plug or socket may be safely Live when de-mated. They are also fairly difficult to break, which is good to know when accidentally dropping a speaker cabinet! Nearly all professional disco controllers and light boxes are fitted with Bulgin P552 sockets.

COMPONENTS

Resistors

R1	470k (see text)
R2, R3, R25 to R27, R30, R33, R36, R39, R42, R45, R48, R51, R54	10k (14 off)
R4, R5, R7	100k (3 off)
R6, R14	4k7 (2 off)
R8	220k
R9	1M
R10	22k
R11, R12, R57, R58	1k (4 off)
R13	1k8
R15 to R24	560Ω (10 off)
R28, R31, R34, R37, R40, R43, R46, R49, R52, R55	470Ω (10 off)
R29, R32, R35, R38, R41, R44, R47, R50, R53, R56	2k2 (10 off)
R59	1k5
R60	47k

See SHOP TALK Page

All 0.25W 5% carbon film or better

Potentiometer

VR1	100k lin. (see text)

Capacitors

C1 to C3, C12 to C14	100n polyester, (6 off)
C4, C8, C11	10µ radial elect. 25V (3 off)
C5	47µ radial elect. 16V
C6	2n2 polyester
C7	1µ radial elect. 63V
C9	2µ2 radial elect. 63V
C10	2200µ radial elect. 16V
C15	220p ceramic plate

Semiconductors

D1 to D4	1N4148 diode (4 off)
D5 to D9	green l.e.d. (5 off)
D10, D11	yellow l.e.d. (2 off)
D12 to D14	red l.e.d. (3 off)
D15 to D17	1N4001 1A rectifier diode (3 off)
TR1 to TR12	BC548 *npn* transistor (12 off)
CSR1 to CSR10	C206D triac (10 off)
IC1	CA3080 op.amp
IC2	LF351 op.amp
IC3	CA3160 op.amp
IC4	LM3914 bargraph driver
IC5 to IC7	4001 quad 2-input NOR gate (3 off)

Miscellaneous

SK1, SK2	8-way Bulgin P552 sockets (2 off)
SK3, SK4	0·25in mono plastic jack sockets (2 off)
T1	12V/0V/12V mains transformer, 100mA
T2	12V/0V/12V mains transformer, 250mA

Printed circuit board, available from the *EPE PCB Service*, code 956; 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket (3 off); 18-pin d.i.l. socket; case (see text); knob; panel mounting 20mm fuse holder; 20mm anti-surge fuse (see text); 3-core mains cable; 3-way mains terminal block; cable clamp; solder tag; nuts, bolts; solder, etc.

Approx cost guidance only **£47**
excl. case and light box

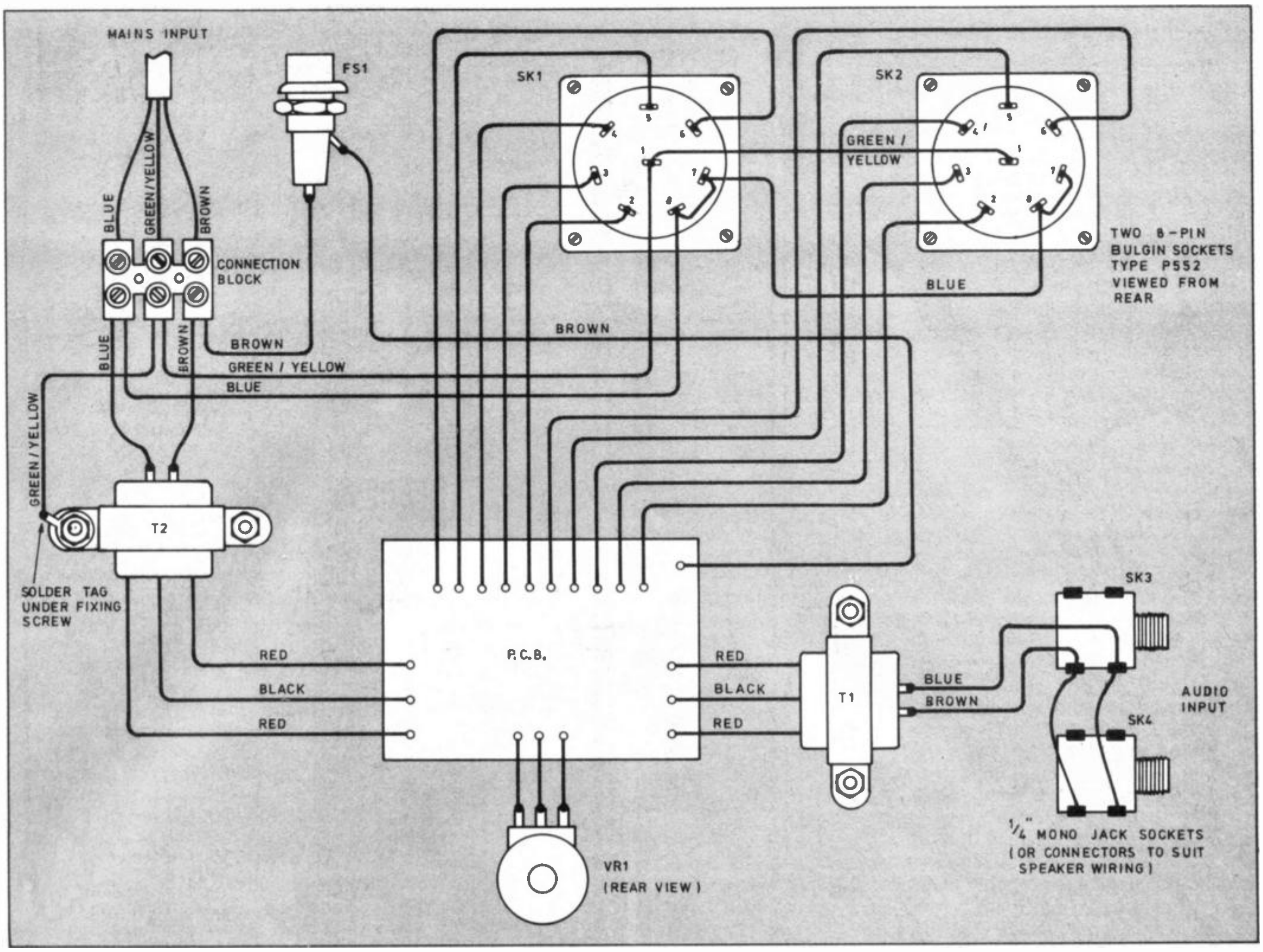


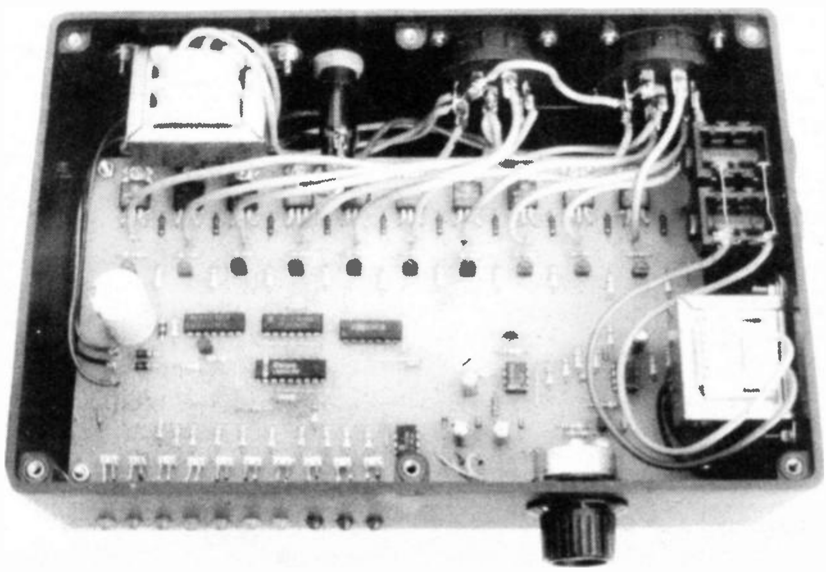
Fig. 5. Interwiring details between the p.c.b. and off-board components.

Connection leads have Bulgin P551 plugs on each end, and are wired for four channels using seven-core cable.

There are normally two sockets on the light boxes (wired in parallel), so a number of light boxes may be connected in a chain, with the controller at one end. This is an extremely flexible method of arranging things, since all the leads are the same, and any controller can be connected to any light box.

The standard wiring for these connectors is pins 7 and 8 for common (Neutral) and pin 1 for Earth. Pins 7 and 8 are linked in every connector, and a single wire is used in the connection leads. For three-channel lighting, pins 3, 4 and 5 are the three Live connections. With four channels, pin 2 is also used. Pin 6 is normally unused or carries a permanent Live feed for motors etc. In this design, pin 6 is used for a further channel so that the ten channels may be carried on two connectors. Although this is slightly non-standard, no harm will be caused if the wrong light is connected to the wrong controller. Standard four-channel leads can be used if they are made up correctly (with pin 6 connected).

An insulating boot should be pushed onto the back of the fuseholder, which should be fitted with an anti-surge fuse. The fuse value should be chosen to suit the total current of all lamps connected, provided that wiring is adquate for the current.

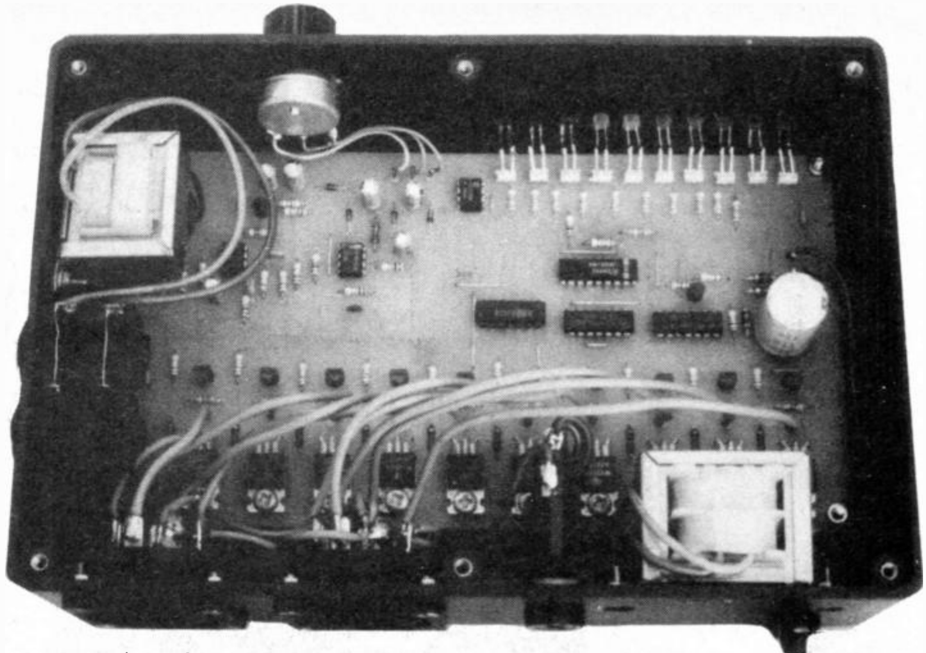


Two standard mono jack sockets are used for the audio input. These **MUST** be the plastic bodied type so that no connection is made between the speaker wiring and the Earthed case (to prevent hum loops or damage to the amplifier). Two sockets are connected in parallel so that the unit may be connected between the amplifier and speakers using two leads. This arrangement is also fairly standard with disco equipment. Use 6A wire for the links between the two sockets as they have to carry the full speaker current. If existing equipment uses a different type of connector for the speaker wiring (such as 3-pin Cannon) these can be fitted instead.

Speaker leads have to handle significant current and should be made using round 2-core 6A mains cable (flat cable kinks too easily). The use of orange cable intended for garden power tools is recommended so that it can be readily distinguished from other audio cables fitted with jack plugs. Use metal jack plugs – the plastic ones break far too easily.

Since all the controllers will normally be stacked up in one place, a number of short speaker leads are useful for linking them together. The above information assumes that this controller is being used with professional disco equipment.

More detail has been given than is strictly necessary to build the controller in the hope that it will be of use to those readers who may be just starting to run a small mobile disco. If this unit is being built solely for home entertainment, any type of connector can be used as long as it is suitably rated for the voltages and currents involved.



TESTING

Initially, the unit should be tested with the lamps disconnected. *Do not fit the fuse in the fuseholder yet.* Set potentiometer VR1 fully clockwise and connect the unit to the mains and amplifier. When playing some music, the l.e.d.s should flash in a manner similar to a VU meter. Reduce the setting of VR1 such that the top l.e.d. lights only occasionally. Now alter the volume on the amplifier. After a second or so (while the automatic level control sorts itself out) the l.e.d.s flashing should revert to the same level.

Switch off and fit the fuse. Connect lamps to the outputs and switch back on. **The whole p.c.b. is now Live, so do not tonch it!** The lamps should flash in time with the l.e.d.s on the appropriate channel. If the light box has not yet been assembled, it may be easier to connect a table lamp to each output in turn **(switching off while changing the connections).**

LIGHT BOX

Construction of the light box depends to a great extent on the resources available and your ability. The suggestions given here may be used as a guide. If a mobile disco is being run, the light box should be made fairly solid. It will get a battering – no matter how gentle its treatment is planned to be. There will be evenings when it is necessary to clear everything up and get out within ten minutes, because the landlord or whoever wants to lock up and go home!

First decide whether a vertical or horizontal light box is wanted. If a disco is being run and a vertical arrangement is chosen, two units will probably be needed to keep the setup symmetrical – which of course costs twice as much. Also bear in mind that vertical boxes could be somewhat unstable and prone to being knocked over, unless they are made fairly wide, deep and heavy. The controller will drive two light boxes without problems.

Alternatively, if the disco is stereo, two controllers could be made (possibly in one case with a dual potentiometer), to drive each light box separately. In this case it may be necessary to reduce the value of capacitor C6 to allow more mid-range through, otherwise the two units will appear to be doing the same thing!

A horizontal light box could be positioned centrally, above or below the disco name sign. The disco name could even be put on the front of the light box, killing two birds with one stone! Make sure the chosen box fits the transporting vehicle!

PERSPECTIVE

Whichever way it is intended to be mounted, basically the need is for a box divided into ten equal rectangular sections. Each division must be large enough to house the lamp without it touching the partitions, or overheating its surroundings. The front of the case is covered with translucent acrylic sheet (Perspex) to diffuse the light and protect the lamps. The Perspex should be at least 40mm away from the lamps for this to be effective. Buy the Perspex first, and hold it near a lamp to establish the best distance.

Translucent Perspex may not be the easiest product to find locally – try looking in *Yellow Pages* under "Plastics – Suppliers" or "Plastics – Film and Sheet". To save money, try to get an off-cut and trim it to size, or make the box to suit.

Perspex can be cut with a normal woodworking saw if GREAT care is taken. Beware that it is prone to cracking if treatment is too heavy-handed. An electric jig-saw works well, if it is fitted with a fine blade. In any event, get a second person to help hold it steady, and progress slowly and gently. The Perspex should be about 2mm undersize on all sides so that it is not under any stress.

If professional lettering of the disco name on the front of the box is wanted, try the "Sign Makers" section of *Yellow Pages*. The service can probably be obtained for about twice the cost of a plain sheet.

CHIPBOARD

The box should be made of solid chipboard, or even blockboard if it needs to be really substantial (and heavy). Corner joints should be made by gluing and screwing the chipboard onto battens. Dividers can be made with plywood, about 6mm thick. This is thick enough to fix into place with glue and small nails. The corner joint battens and the dividers should be recessed about 15mm from the front of the case to allow room for the Perspex to be inset.

Strips of 12mm quarter-round timber or similar can be fixed to the case in front of the Perspex to hold it in place. Use screws from the outside of the case for this, and no glue – the Perspex needs to be removed to change the lamps.

The back of the box should be wide enough to hold the bayonet-cap lamp batten holders, allowing about 15mm each side for ventilation. If the dividers stop about 20mm from the back, this will allow room for the wiring between the lampholders.

Air-flow sockets should be fitted through the back panel wherever there is room, and the rear connections covered with a generous quantity of insulation tape. This prevents an electric shock should someone poke their fingers through the ventilation gap.

Once complete, the box can be painted matt black on the outside, or covered with black vinyl sheet if preferred. A few corner protectors will prevent the chipboard from chipping, and a handle or two in the right place can be very useful. The inside should ideally be painted gloss white.

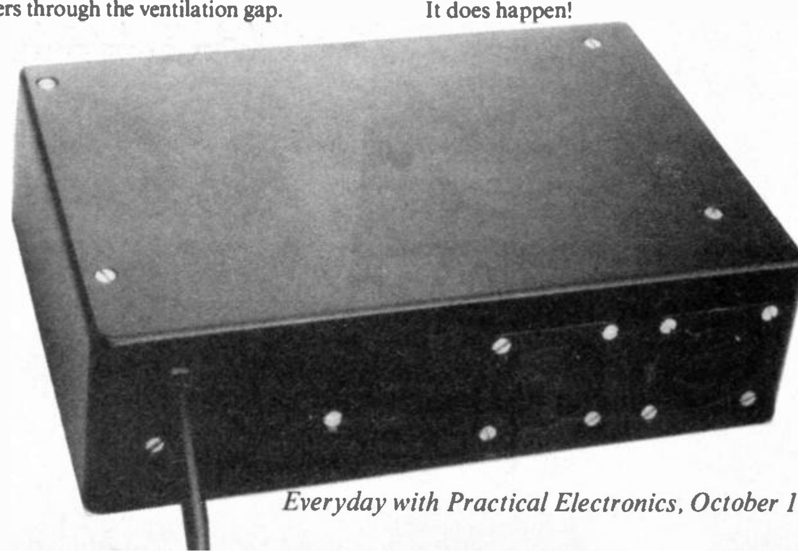
The lamps should be the normal coloured round type, like those used on the larger outdoor Christmas lights. A rating of 25W will generally be suitable, and will not get too hot. Larger lamps such as 40W or 60W could be used if more light is wanted – but there will be more heat too!

Colours could be used that give the impression of a VU meter: five green, two yellow and three red, for example. Or ten randomly coloured lamps could be used. Take spare lamps with you – discos with blown bulbs look most unprofessional!

SUGGESTIONS

A few more suggestions: How about building a horizontal 20-lamp box, with the light effect coming in from the ends or out from the middle? This could look good with a name sign. How about a rectangular box with ten triangular sections each having a corner meeting at the bottom middle, in a fan effect? Or there could just be a row of R60 coloured spot lamps on an overhead gantry. Do something individual and get noticed!

One final suggestion – on a safety matter again. Buy residual current circuit breakers (RCCBs or RCDs) and plug them into the wall sockets where the inevitable multitudes of four-way trailing extension leads are connected. These could prevent an electric shock if some wally smashes a lamp or spills a pint of lager into the equipment. It does happen! □



New Technology Update

Ian Poole reveals that f.e.d.s are seen as the future face of computer display technology

DESPITE the major advances, the majority of computers still use cathode ray tubes (c.r.t.s). These were first thought of at the beginning of this century, and some of the work on them predates the diode valve.

Whilst the c.r.t. uses what is in a sense "old technology", its age means that it is a well developed technology, and it still has viewing, colour and price advantages over other forms of display which are more up to date.

Against this, the c.r.t. is very large. In some cases this is not too much of a disadvantage, but in others, particularly portable applications, it is crucial. Its power consumption is also high, requiring high voltages and appreciable amounts of current. This also makes it totally unsuitable for portable applications which are becoming increasingly common.

Liquid Crystals

Currently, most portable computers use various forms of liquid crystal display (l.c.d.). These do not give the performance of the c.r.t. but have to be used because of their size and power consumption. Over the last few years major advances have been made with active matrix technologies where large amounts of control circuitry are integrated into the structure in the form of thin film transistor circuits, as shown in Fig.1. Now resolutions of 640 x 480 pixels are available in monochrome, and some displays also offer a limited colour capability.

The active matrix l.c.d. offers high definition combined with good contrast, and it eliminates flicker. Despite this, it is unlikely that this form of display can ever become the full answer to all computer display problems. Other technologies which are not as far advanced seem to offer better possibilities of becoming the longer term solution. One of these is called the Field Emitter Display (f.e.d.).

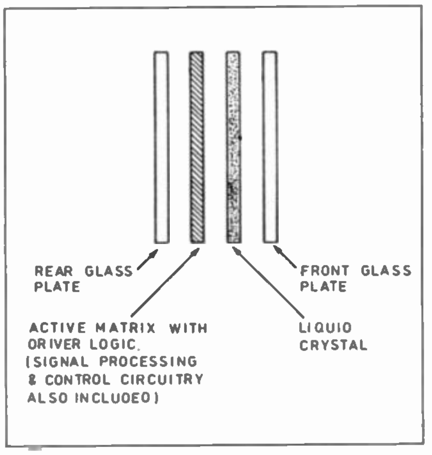


Fig. 1. Expanded view of an active matrix l.c.d.

The F.E.D.

The f.e.d. adopts a fundamentally different approach to all the new types of display which are emerging on the market. Arrays of thousands of minute cathodes acting as electron guns emit electrons which can be accelerated onto phosphor screen coatings causing them to emit light. These phosphors can be coloured to enable colour to be displayed in the same way as a with cathode ray tube.

From Fig. 2 it can be seen that the f.e.d. possesses many similarities to the familiar c.r.t. Where the c.r.t. uses a single electron gun for each colour the f.e.d. uses its array of minute cathodes, each only about one micron in diameter. They emit electrons under the influence of a high electric field from the anode. A gate positioned just above the cathode is used to control the emission.

The anode is contained in the top layer and has a voltage of around 1kV applied to it. This pulls the electrons towards it in the same way that occurs in a c.r.t. The electrons hit the phosphor coatings on the anodes at sufficient velocity to cause them to release light energy.

To enable the images to be created, the cathodes are arranged in an array of rows and columns. These can be controlled by an array of drive circuits using thin film transistor circuits, in much the same way as many l.c.d.s. In this way the f.e.d. appears to borrow solutions from a number of different technologies and manages to improve on them all.

Within the display, the dimensions are microscopic. The distance between the cathode and anode is only about 200 microns. This means that with anode voltages of around a kilovolt problems can be experienced with arcing. Careful design and manufacture is needed to ensure this does not occur.

The overall displays are generally quite thin. Typically, they might be two or three millimetres thick. This makes them ideal for many portable applications.

Further Development

One of the main areas of f.e.d. research is in reducing the voltages required for operation.

Brightness is another important factor. Some experimental f.e.d.s have already produced greater output levels than average c.r.t.s., even though they needed a high anode voltage to achieve this.

The interest in the technology is such that a surprisingly large number of companies are developing them. Major American government organisations can also see their importance and are putting forward funding to help with their development.

Although there are no commercially viable displays available at the moment, a number of demonstration models have been made by various companies. The French company Pixel, which pioneered much of the early f.e.d. work, plans to produce its first six-inch colour displays shortly, and within a year it expects to have a twelve-inch version. Many other manufacturers, including Texas Instruments, Micron Technology and SI Diamond, are also working to produce displays in the near future.

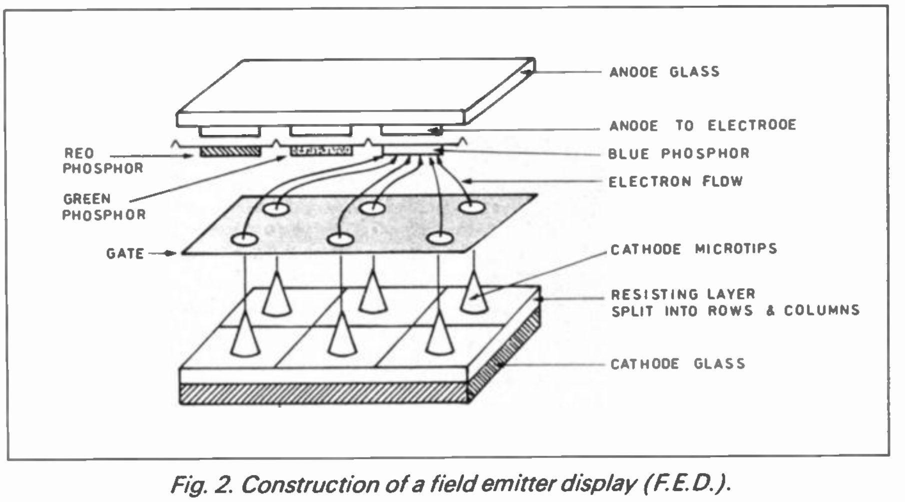


Fig. 2. Construction of a field emitter display (F.E.D.).

Innovations

A roundup of the latest Everyday News from the world of electronics

SEEING THROUGH THE PLOT

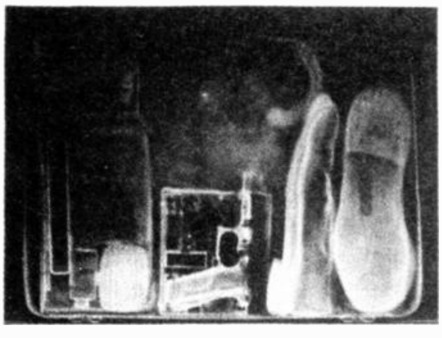
Lasers and new X-ray interface enhance airport security. Plants come under better scrutiny as well – *by Hazel Cavendish*

THE weakest link in airport security remains the luggage inspection process. Airport security officers typically have only a few seconds per bag to spot suspicious objects concealed in carry-on items, and checked luggage and other airline cargo are not routinely examined. Traditional X-ray inspection systems, developed in the 1960s to thwart airline hijackers, are excellent at finding metal handguns and grenades, which are relatively opaque to X-rays, but incapable of detecting hidden non-metallic, organic materials such as plastic explosives and a new generation of plastic firearms. Likewise drugs, cash, gemstones and foodstuffs are relatively transparent.

Now computers are to be linked to X-ray systems to ensure that the tools of a hijacker's trade are instantly detected. The UK's Fairey Group, increasingly involved in industrial electronics and specialist engineering in the USA, Britain and Europe, recently spent over 13 million dollars purchasing an American company called Imaging Technology. The purchased company uses electronic imaging techniques and "frame grabbers" – the name given to a transmission board which acquires images – to improve security measures in airports throughout the world where the threat of terrorism and the smuggling of contraband increases annually.

FLYING SPOT X-RAY

The devices they manufacture for airport security were developed by American Science and Engineering of Cambridge, Massachusetts to detect narcotics and agricultural contraband invisible to traditional X-ray security systems. Aircraft carry-on bags placed on a conveyor belt are passed through a Micro-Dose X-ray security system to seek out plastic explosives and other suspicious organic substances. A "flying spot" of X-rays is scanned rapidly over the bags, and as they are inspected scattered red beams are collected by the "Z R Backscatter" detection system, which uses a laser to bounce beams off different materials to create the image.



Silhouette of a plastic gun would not be seen on conventional X-ray machines.

"The neat thing about this application is that it can detect many different types of plastic bombs concealed in luggage," says Patricia Mansfield, spokeswoman for Imaging Technology. "Most people think of a bomb as being round, but there is one particularly dangerous one made from materials which lay flat and can be spread out in the lining of a case. Our system using the spot-scanning technology of Backscatter can detect it immediately, as well as other forms of plastic explosives and drugs."

Airport staff use side-by-side monitors to watch for either metallic objects or organic materials. Any organic substance appears conspicuously in white on a video monitor, even when camouflaged by metallic or confusing mixed-density backgrounds caused by portable radios or tape recorders.

The system has been developed for a range of different environments, so that luggage can be inspected while being loaded on to an aircraft, furniture analysed as it is moved in and out of high-security buildings and trucks, trailers and sea cargo containers searched automatically for unauthorised goods. The new imaging system is already being used throughout America and the Middle East, as well as many other "hot spots" in the world, and is expected to be adopted internationally.

HORTICULTURAL PLOT

Fairey's Imaging Technology processors are used in quite a different context to speed horticultural practices in Holland. Visser ITE B.V., a leading Dutch manufacturer of horticultural machines, required an automated vision system for their product and the new technology was able to provide the answer.

In the mass production world of Dutch flower-growing, seedlings are cultivated in sectioned trays for easy handling, and are planted from these trays using automatic machines at sites all over the world. Production levels are high, an average greenhouse measuring around eight hectares (20 acres) with an average of 320,000 trays containing 80 million seedlings and plants. Production of any one type of plant is usually over one billion a year.

For economy and efficiency all tray sections, or cells, must be fully filled before they leave the greenhouse. Until recently cells were cleared of soil and refilled manually – a time-consuming and labour-intensive business with up to 300 trays being handled per hour.

Modular Vision computer which relays the X-ray pictures.

The automated vision system adopted by Visser was based on a 486 PC running at 66MHz and capable of inspecting up to 1,000 trays per hour and identifying the coordinates of seedlingless cells. This data was then used to control machinery that blew out the soil or rejected seedlings from the marked cells. Imaging Technology was asked to provide the processors.

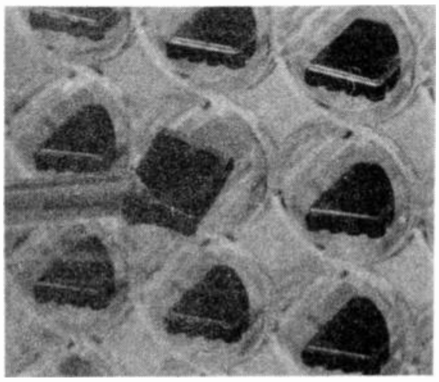
GLEENING THE GREEN

The vision aspect of the project was challenging in the extreme. It was necessary for the system to distinguish between green seedlings and a background that consisted of white tray material, black soil, shiny vermiculite (a water absorber) and possible algae and moss, both of which were green.

Imaging Technology's VISIONplus-AT Modular Frame Grabber was chosen to convert RGB (red, green, blue) colour to HSI (hue saturation intensity) almost instantaneously. By making a histogram analysis after conversion, the system measures the amount of plant material in each cell and rejects or accepts it. Software options change the colour conversion to inspect different sorts and sizes of plant. The use of this inspection system has halved the labour cost of the operation.

APOLOGY

We apologise to Dr Euan Thomson, head of the Norfolk and Norwich Hospital's Radiotherapy Department, for so grossly mispelling his name in last month's *Innovations* column.



IDT's new crystals extend to 80MHz.

FASTER CRYSTAL OSCILLATORS

Extended frequency and temperature ranges are now available with the IXQO-70 series of oscillator chips from UK manufacturer IQD. The frequency range has been extended to cover from 1.8MHz to 80MHz to satisfy increasing demand for higher frequencies. (Readers may recall that the *EPE TV Camera* of March '94 required the use of an 80MHz oscillator based around several components as an 80MHz oscillator chip seemed unavailable at that time.)

The series is capable of driving both HCMOS and LSTTL loads in addition to providing a tri-state output, which provides for an almost instantaneous start up of the oscillator following logic 1 being applied to the enable pin.

Although the series is only available as surface mount devices, since the chips have only eight pins, experienced constructors should find no difficulty using them.

For more information contact Claire Northcott, IQD Ltd., Station Road, Crewkerne, Somerset TA18 7AR. Tel: 01460 77155.

NEWLY BAFFLED

To complement their range of loudspeakers, Infinite Baffle Ltd. have introduced a foldback monitor stage loudspeaker. Its cabinet has been designed so that the user has a choice of angles, 30 degrees or 60 degrees, to suit most applications.

The frequency range has been especially tailored for foldback applications and will extend down to 45Hz and up to 20kHz. The cabinet comes fully flight cased and has a steel grille fitted on the front to protect the 12-inch driver. Compact in size, measuring 590mm x 400mm x 357mm (w × h × d), the unit weighs only 16kg and is competitively priced at £105, including VAT, plus £12.50 carriage.

For more information contact the sole UK suppliers **B.K. Electronics, Dept. EPE, Unit 1, Comet Way, Southend-on-Sea, Essex SS3 9NR. Tel: 01702 527572.**

GOVERNORS SURF THE NET

British Telecom is to provide £25,000 of support to set up The National Governors Council communication and information system NGC-Online and get it onto the Internet. The soon-to-be-launched system will be open to all school governors whose governing bodies belong to NGC member associations.

Governors will be able to access the system either directly or via their schools subscription to Campus World. Initially the service will provide e-mail, information about NGC's activities and newsgroups to discuss live issues and feed views to those who represent them. There will be a section devoted to the education market-place where local NGC groups and education authorities may publish information. There are also plans to provide a database of governor information and support resources.

For information from BT please contact Richard Hamer on 0171 356 5638.

For more information from NGC, contact Jeremy Dodd NGC EMail doddj@jezd.demon.co.uk

DON'T GET LOST

Whether you are walking, climbing, fishing, cycling or simply lost, the new Global Position System (GPS) receiver from Magellan Systems Corporation will give your precise position, direct you to a predetermined landmark or show you the way home, for less than £200.

With its compact size, ease of use and comparatively inexpensive price, the Magellan GPS 2000 can be used anywhere in the world. By keying-in the landmark or places you want to reach, you are shown the information needed for the route, including destination distance, travelling speed and how long it will take to get there. It even shows whether to head left or right.

Even when the weather closes in you can still find your way back. The receiver automatically stores your position every ten minutes, so you can simply select the backtrack facility and it will guide you back the way you came.

About the size of a mobile telephone, the Magellan GPS 2000 locates its position from data transmitted by a constellation of 21 satellites orbiting at a height of 11,000 miles. Originally conceived as a military defence system, the GPS satellites provide navigation information to users of GPS receivers without subscription or charge.

For more information, contact UK distributor Next Destination Ltd., 7 Barnack Business Centre, Blakey Road, Salisbury, Wilts SP1 2LP. Tel: 01722 410800.

Conjunctions astronomical, not astrological, help devine your destiny.

TELECOP

Whether or not local communities like the idea, some police stations are not open for 24 hours a day. In some cases, telephone links are provided outside closed stations allowing callers to speak directly to Divisional Headquarters. Conscious that to many people a voice-only link is too impersonal, Surrey Police are trying out a new video link service in the Byfleet area.

Situated in a secure office, this unique telephone video link is open 24 hours and effectively extends the front counter service available at Woking Divisional Police Station out into the Byfleet area. If successful, the service could become the way forward in improving and maintaining police standards throughout the country.

The system under review is an advanced access control system called TelGuard, manufactured by CommTel. TelGuard is BABT Approved and operates via the existing BT network, or PABX, offering many features and capabilities beyond those of more conventional systems. It can access up to a thousand call points and so has tremendous scope for expansion, with the possibility of future linking with other emergency and local authority services.

Whilst providing Surrey Police a sophisticated yet user-friendly means of being in remote contact with the public, the cost of TelGuard came well below that of any hard-wired alternative system.

For more information, contact TelGuard, P.O. Box 192, Dorking, Surrey RH4 3YJ. Tel: 01306 877889.

Open all hours – a new video link extends the long arm (and view) of the Law.

SOUND SWITCH

TERRY de VAUX-BALBIRNIE

A noise-triggered security switch to deter burglars when a property is unoccupied.

ALTHOUGH we are told that we live in a violent society, most house crime is of the petty or opportunist kind. Most thieves prefer to go about their business in unoccupied premises and only a minority will risk apprehension or the possible need for violent tactics in an occupied house.

It follows that if premises *appear* occupied even when they are not, potential intruders are more likely to leave well alone. A light placed either inside or outside the house has been shown to be a good deterrent.

The Sound Switch is designed to operate a light when noises are "heard" by a sensor. This will give the house an "occupied" appearance. Any lighting up to 3A rating (720W on 240V mains) may be connected. The circuit operates for a preset time which is adjustable from 30 seconds to one hour approximately.

There is also a push-button *cancel* switch which enables the unit to be switched off at any time before the end of the natural timing period. The Sound Switch only works at night – a light sensor inhibits operation during daylight hours.

Since the circuit is mains-operated it may be left switched on continuously at very little cost. The prototype has been used successfully to switch on a garage light when activated by the sound of a car engine. However, in tests it has been shown better at detecting noises such as footsteps – particularly on gravel and similar surfaces.

REMOTE SENSOR

The circuit has been designed to operate using a *remote* sound sensor. This means that it may be used over a long range and not necessarily in clear line of sight with the house. The sensor could, for example, be sited at the end of a pathway.

It must not be mounted inside the main unit or placed close to it. The chief reason for this is that the click from the relay is sufficient to trigger the circuit. Also, it tends to pick up hum from the mains transformer and this can result in repeated triggering.

FALSE ALARM

It must be understood that some false triggering is inevitable. The unit will operate occasionally if electrical "noise" is picked up, possibly along the mains power line.

One possible cause is the operation of electric motors such as those found in washing machines. Another possibility is when a fluorescent light is switched on or off, although it does seem that some of these give much less trouble than others.

Due to the possibility of false triggering, it is not advisable to use the unit to operate a fluorescent light – only standard tungsten filament lamps should be connected. From the security point of view, some false triggering is not thought to be important and its random nature may be a positive advantage. Note that false triggering signals have no effect during daylight hours when the light sensor inhibits operation.

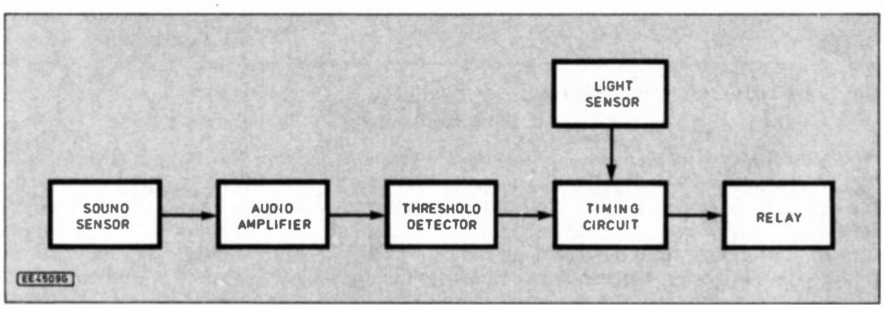


Fig. 1. Block diagram for the Sound Switch.

CIRCUIT DESCRIPTION

The block diagram for the Sound Switch is illustrated in Fig. 1, from which it will be seen that the circuit comprises six main sections. These are: the Sound Sensor; Audio Amplifier; Threshold Detector; Timing Circuit; Relay and the Light Sensor which inhibits operation during the daytime.

The complete circuit diagram is shown in Fig. 2. The low-voltage supply needed to operate the system is derived from the conventional arrangement of mains transformer T1, bridge rectifier REC1 and smoothing capacitor C1. Fuse FS2 provides protection in the event of a fault developing in the secondary circuit.

Voltage regulator IC1 provides a precise 12V d.c. output and this helps to achieve stable operation of the rest of the circuit. Capacitors C2 and C3 additionally help the stabilisation process.

The sound sensor used is a miniature loudspeaker, LS1. This is connected using a miniature audio-type jack plug and socket, PL1 and SK1. The speaker is used as a microphone and converts the sound impinging on its diaphragm into a weak a.c. electrical signal.

The use of a loudspeaker here provides good sensitivity by picking up sound over the large area of its cone. It may be used instead of a conventional microphone because, in this application, faithful sound reproduction is not required.

Signals derived from the sound sensor are applied to the base (b) of high-gain transistor TR1 via coupling capacitor C4. An amplified signal then appears at the collector (c). Resistor R1 provides base bias while R2 is the load resistor. Note that, for best results, a transistor with suffix "C" as specified (that is, the highest gain group) should be used.

The amplified signal is coupled to the non-inverting input (pin 3) of operational amplifier (op.amp) IC2, via capacitor C5. At the same time, this input receives a fixed bias voltage equal to one-half that of the supply by the potential divider action of equal-value resistors R3 and R4.

The inverting input of IC2, pin 2, is similarly biased but this time the voltage is adjustable by means of preset potentiometer VR1. This forms a potential divider in conjunction with resistors R5 and R6. These resistors limit the range of adjustment by VR1 and so facilitate setting-up later.

The threshold voltage level at IC2 pin 2 will be set a little below the normally steady one existing at the non-inverting input pin 3. Consequently, the output of IC2, pin 6, will therefore be *high* (close to the positive supply voltage). This is blocked by diode D1 and has no further effect.

When sound is detected by LS1, the voltage at the non-inverting input of IC2 will fluctuate and fall momentarily below that at the inverting input on each half-cycle. This will cause op.amp output pin 6 to briefly go *low*.

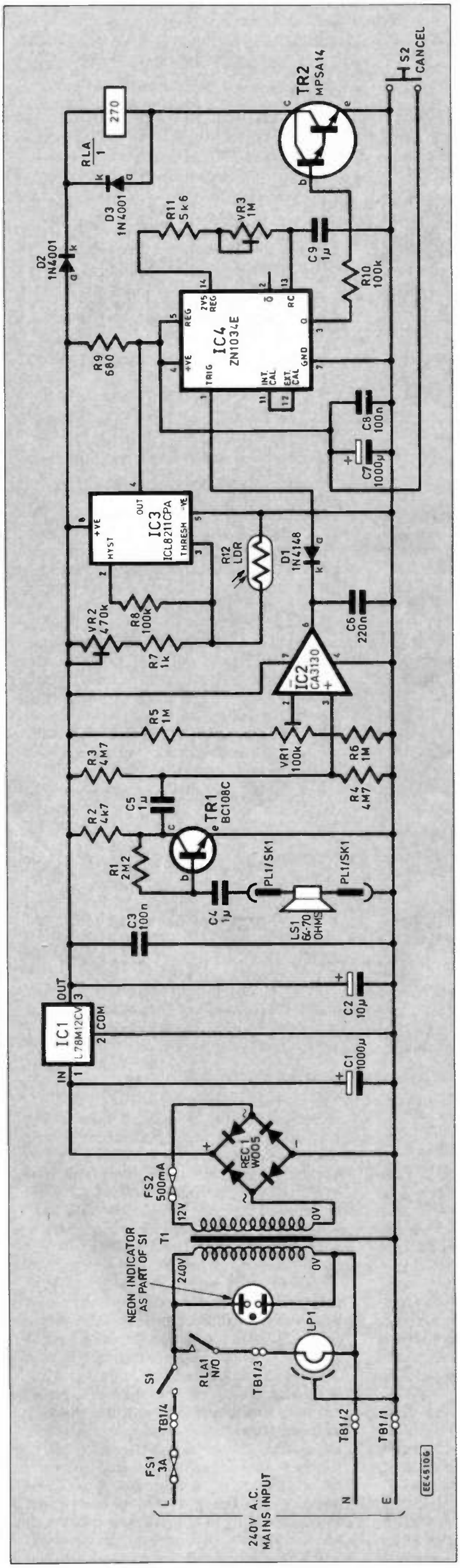


Fig. 2. Complete circuit diagram for the Sound Switch security unit.

COMPONENTS

Resistors

R1	2M2	R8, R10	100k (2 off)
R2	4k7	R9	680
R3, R4	4M7 (2 off)	R11	5k6
R5, R6	1M (2 off)	R12	ORP12 or similar light-dependent resistor (see text).
R7	1k		

All 0·6W 1% metal film, except R12.

Potentiometers

VR1 100k sub-min. enclosed preset, vertical
VR2 470k sub-min enclosed preset, vertical
VR3 1M sub-min enclosed preset, vertical

Capacitors

C1, C7 1000µ radial elect. 16V (2 off)
C2 10µ radial elect.16V
C3, C8 100n ceramic (2 off)
C4, C5, C9 1µ polyester layer (3 off)
C6 220n ceramic

See SHOP TALK Page

Semiconductors

REC1 W005 50V 1·5A bridge rectifier
D1 1N4148 signal diode
D2, D3 1N4001 1A 50V rectifier diode (2 off)
TR1 BC108C *npn* transistor
TR2 MPSA14 *npn* Darlington transistor
IC1 L78M12CV 12V 500mA voltage regulator
IC2 CA3130 CMOS op.amp
IC3 ICL8211CPA voltage detector (see text)
IC4 ZN1034E precision timer

Miscellaneous

T1 miniature mains transformer with 240V primary and 12V 500mA secondary (6VA rating)
LS1 miniature loudspeaker with 64 to 70Ω coil. Diameter 66mm approx.
PL1/SK1 3·5mm mono jack plug and socket
S1 mains rocker switch with inbuilt neon indicator and 3A minimum "make" contacts (see text)
S2 miniature push-to-make switch
RLA miniature relay with 12V 270 ohm coil and "make" contacts rated at 240V 5A minimum
FS1 3A 20mm fuse and chassis fuse/holder
FS2 500mA 20mm fuse and chassis fuseholder

Printed circuit board available from the *EPE PCB Service*, code 915; aluminium box size 152mm × 114mm × 76mm approx.; plastic box for sound sensor – see text; 5A screw terminal block – 4 sections required; 8-pin d.i.l. sockets (2 off); 14-pin d.i.l. socket; stranded connecting wire; light-duty single screened wire; stand-off insulators; small fixings; solder, etc.

Approx cost guidance only **£37**

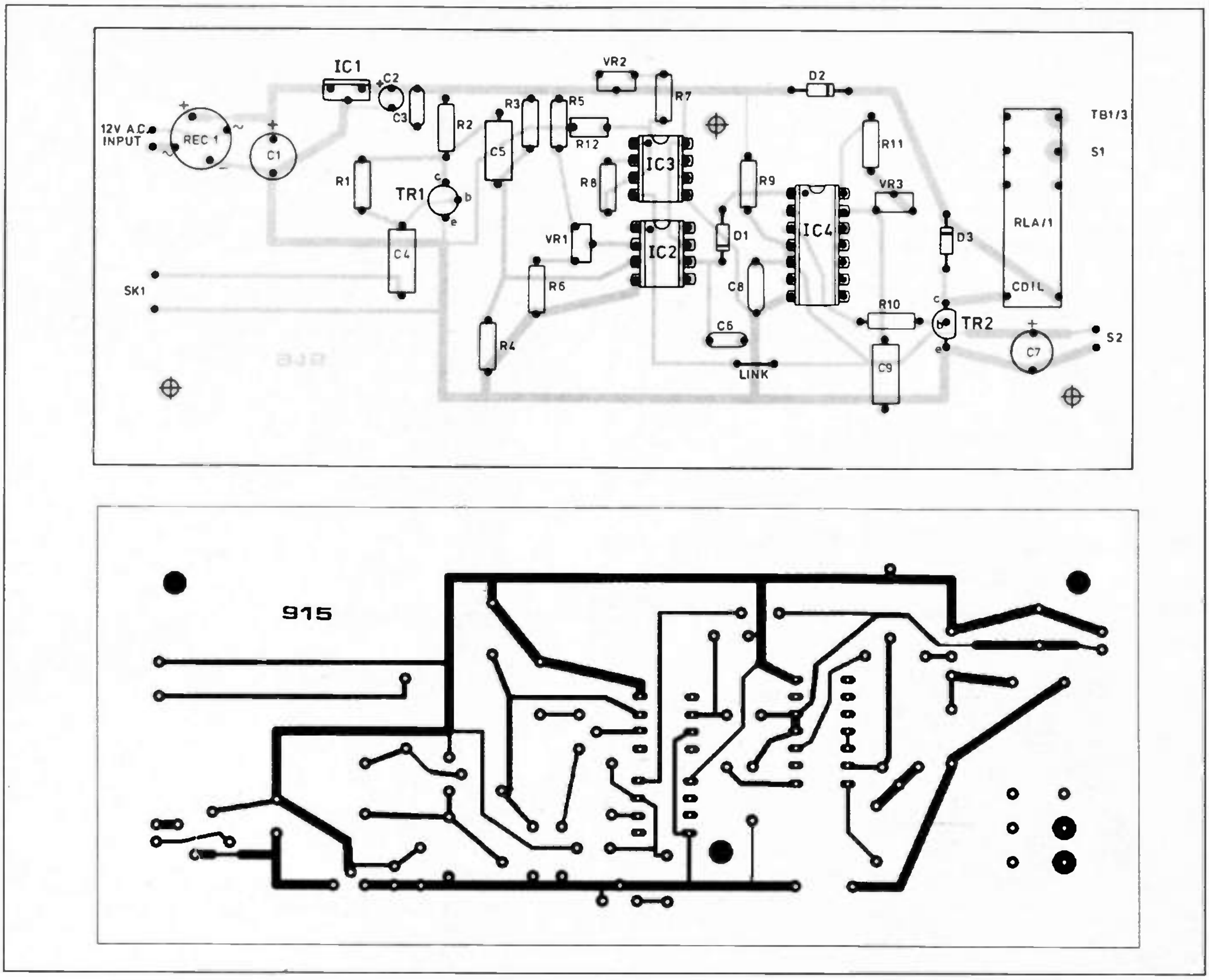


Fig. 3. Printed circuit board component layout and full-size copper foil track master.

This activates the precision timer IC4 by applying a low pulse to its trigger input pin 1 via diode D1. Further trigger signals have no effect during the course of timing. Since IC4 pin 1 is internally biased an external resistor is not needed on the anode of diode D1.

TIMING CYCLE

When timer IC4 is triggered, its twin outputs, Q and $\overline{Q}$ switch state – that is, output Q which is normally *high* goes *low*, and output $\overline{Q}$ which is normally *low* goes *high*. However, in this application only output Q is used and when it is high, Darlington transistor TR2 is turned on by the base current entering through current-limiting resistor R10.

The relay coil, RLA, in the collector path of TR2 is now energized and the normally-open (n.o.) contacts close to complete the circuit from the mains Live connection to the lamp. At the end of the timing cycle, IC4 output Q reverts low, transistor TR2 is turned off and with it so too are the relay and lamp.

The operating period is dependent on the values of resistor R11, preset potentiometer VR3 and capacitor C9. With the values specified and with VR3 set to minimum, the timing is less than 30 seconds. When set to maximum it is approximately one hour.

To cut the timing short – that is, before the end of the natural cycle, push-to-make switch S2 (Cancel) is operated momentarily. This takes IC4 pins 4 and 5 *low* so interrupting the supply and resetting the timer. Resistor R9 prevents a direct short-circuit – it is needed anyway for the correct operation of IC4's internal voltage regulator.

Capacitor C7 provides a soft starting action when S2 is released. This happens because the voltage across C7 and hence at IC3 pins 4 and 5 rises relatively slowly as it charges through R9. This prevents possible false triggering.

DIGITAL TIMER

Precision timer IC4 uses digital techniques to provide a relatively long time interval without the need for a high value timing capacitor. This, in practice, means that an electrolytic capacitor is avoided so resulting in greater reliability.

The timer operates in the following way. When triggered, capacitor C9 charges from a precision 2·5V on-chip reference provided at pin 14 through resistor R11 and preset VR3. Thus, the voltage across it rises and when it reaches a certain value an internal counter registers a count of one. The capacitor is then discharged to begin a further cycle. When 4095 such charge/discharge cycles have been counted, IC4 pin 3 goes low and the i.c. reverts to its initial state.

SEEING THE LIGHT

To inhibit operation under bright light conditions, light-dependent resistor (LDR) R12, precision voltage detector IC3 and associated components are called into play. When the voltage applied to IC3 threshold pin 3 exceeds 1·15V (an internally-set reference) the output, pin 4, has no effect. When the voltage falls below this value, pin 4 provides a *sink* – that is, it becomes *low* with current able to flow into it.

When the amount of light falling on R12 rises, its resistance falls and the voltage across it will similarly fall. The LDR forms the lower arm of a potential divider with resistor R7 and preset potentiometer VR2 comprising the upper arm. Thus, with increasing light levels the voltage applied to IC3 pin 3 will, at some point, fall below the threshold and pin 4 will go low. The exact level at which this happens is adjustable using VR2.

This low output state is applied to IC4 pins 4 and 5. It has a similar effect to operating switch S2 and resets the chip. IC4 will not become active again until the voltage at IC3 pin 3 rises once more above the critical level – that is, when the LDR is sufficiently unilliminated.

Resistor R8, connected between IC3 pin 2 (*hysteresis*) and pin 3 (*threshold*), builds a little backlash into the operation. Thus, when the light level rises to the point required for the output to go low, it will need to go rather darker than this to switch off again. This prevents excessive on-off operation at the critical point. The resistor value stated gave good results in the prototype but could be the subject for reader's experiment.

ELECTRICAL SAFETY

Important Safety Notes: ***Constructing this circuit involves making mains connections. Any reader who is unsure of being able to make a safe job, must seek the help of a qualified electrician. If fixed wiring is needed – for example, for connecting exterior lighting, expert help is strongly recommended.***

The unit must be built in an **Earthed metal box** and situated in a **dry indoor** location. There must be a fuse and a switch fitted in the Live mains input and a neon indicator (which may be separate or part of the switch as in the prototype unit) to show the *on* state.

All external wiring should be of 5A rating minimum and the input protected using a 3A fuse. A fuse must also be included in the transformer secondary circuit. Input and output wires must be firmly gripped at the unit end using strain relief bushes.

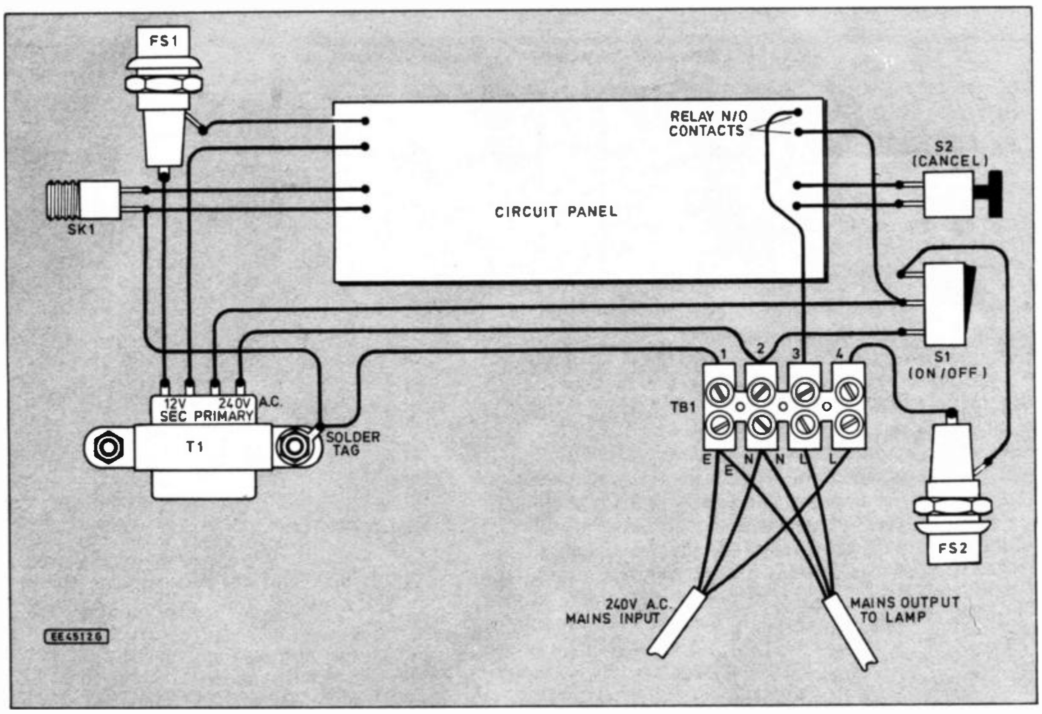


Fig. 4. Details of interwiring between components and the p.c.b.

For fixed wiring applications, the mains input and output cables must terminate in a double-pole switched and fused wall outlet. The unit should then be wall mounted adjacent to this.

To operate a portable appliance such a reading lamp, the input lead should be plugged into a nearby wall socket. The output cable may have a standard trailing socket fitted so that the lamp may be plugged into this.

It is essential to use a generously-rated mains transformer (see components list). Not only will this remain cool during long periods of use but will promote stable operation of the circuit.

CONSTRUCTION

Construction of the Sound Switch is based on a single-sided p.c.b. (printed circuit board) whose component layout and full size copper foil master track pattern is shown in Fig. 3. This board is available from the *EPE PCB Service*, code **915**.

Begin by drilling the three mounting holes in the positions indicated. Follow with the soldered on-board components in the following order. Firstly the i.c. sockets then all resistors, flat with the board, and capacitors taking care over the polarity of C1, C2 and C7 since these are electrolytic capacitors and therefore polarity-sensitive.

Observing their polarity, follow with the voltage regulator, transistors, diodes and bridge rectifier – this latter component has lettering on top which indicates the correct orientation. The regulator does not need a separate heatsink – the metal tab is sufficient because the current drawn, 100mA maximum, is only a fraction of its rated 500mA.

The transistors and bridge rectifier should be soldered so that they stand approximately 3mm clear of the circuit board. Sleeve the leads of LDR and solder this component into position. Bend the leads at right angles as shown in the photograph. Complete construction of the circuit board by soldering the relay into position.

Solder 15cm pieces of light-duty stranded connecting wire to the p.c.b. pads marked "12V a.c. in", "LS1" and "S2". Solder pieces of *mains-type* wire of 5A rating minimum *direct* to the relay normally-open contacts as shown.

Check carefully that these wires are secure so that they cannot dislodge in service. There must be no possibility of them making contact with the metal case.

Prepare the case by drilling holes for the circuit board and transformer mounting. Drill holes also for fuseholders FS1, FS2, switches S1 and S2, socket SK1 and screw terminal block TB1. Drill the holes to be used later to accommodate the strain relief bushes on the mains input and output wires.

Drill a 10mm diameter hole directly above the LDR position and a further small one through which preset potentiometer VR2 may be adjusted using a miniature screwdriver or trimming tool. Make brackets to mount the unit on a wall if required and secure these to the case.

Mount the circuit panel on 5mm plastic stand-off insulators. ***Check carefully that the mains connections at the relay "make" contacts have several millimetres clearance from the base of the box.*** A piece of thick cardboard or insulating tape may be used as an additional precaution.

TRANSFORMER MOUNTING

Mount the transformer using a solder tag on one of its fixings. ***This is used to earth the case and transformer core and is essential for safety reasons.*** Referring to Fig. 4, mount all remaining components and complete the internal wiring. Note that the connections to switch S1 as shown are for a switch having an inbuilt neon indicator. If a standard switch is used, the neutral connection is not required.

The *sleeved* terminal of the Sound Sensor socket must be the one connected to the circuit panel *negative* track – that is, *not* the one leading to capacitor C4. The sleeved terminal must also be connected to the solder tag as shown.

Check that when the top section of the case is fitted temporarily, no wires are trapped and no short-circuits formed. Make a temporary mains input lead and connect a table lamp to the output for later testing purposes.

Decide whether a waterproof enclosure will be needed for the sound sensor – it is essential to protect the loudspeaker from rain. Drill the matrix of holes in the lid for the sound to pass through and mount the loudspeaker. If a waterproof box is used, secure a waterproof gland or tight-fitting grommet in the hole where the wire will pass through.

Connect the loudspeaker to a few metres of light-duty single *screened* wire. Solder the 3·5mm jack plug temporarily to the other end with the screening connected to the *sleeved* terminal of the plug. However, do not plug it in yet.

Before plugging the unit into the mains, make insulating shields so that it is absolutely impossible to touch any of the mains connections. Plug in and switch on. When powered-up it is usual for the unit to self-trigger – cancel this by pressing switch S2. The unit must now be left for several minutes to thermally-stabilise.

ADJUSTMENT AND TESTING

While testing, place a piece of Blu-Tak on the LDR window to prevent light from reaching it.

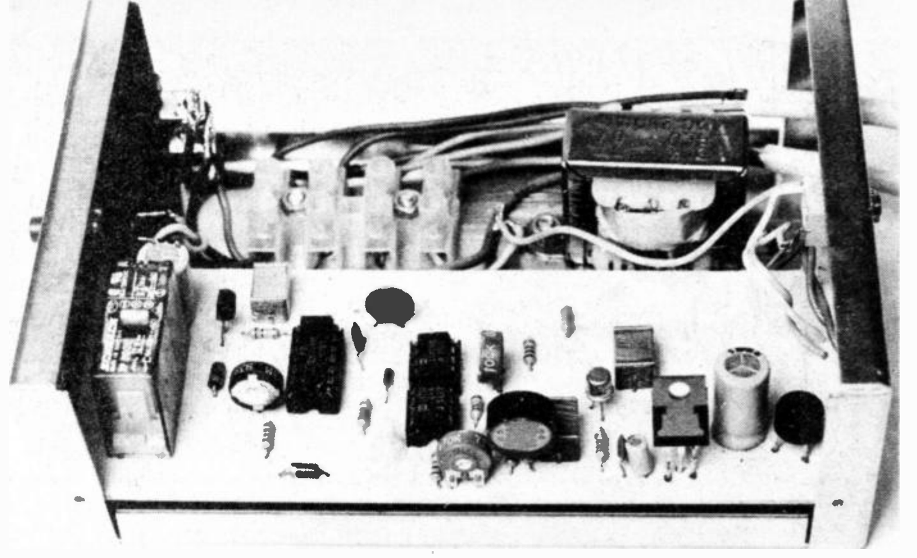
Adjust preset VR1 slowly clockwise until triggering occurs. Rotate VR1 slightly anti-clockwise again and cancel using switch S2. Find the position where the circuit remains off. If there is instablility (repeated operation) this indicates that the setting is too high. It is best to err on the low side.

Place the sensor several metres away from the main unit and plug it in. Doing this will probably cause the circuit to trigger again – cancel using switch S2. Test operation by making a sound close to the sensor. The circuit should operate and the lamp come on for about 30 seconds. The final adjustment can only be found over a trial period under real conditions.

Check the maximum timing by rotating preset VR3 fully anti-clockwise. The lamp should now operate for one hour or thereabouts. Return VR3 to its clockwise position.

Rotate preset VR2 to mid-track position and uncover the LDR. Under normal daylight conditions the circuit should now be inhibited. Accurate adjustment to the operating level cannot be made until the unit is in its final position and the case assembled.

Decide on the best positions for the unit and sensor. Note that light-duty *screened* wire must be used for the interconnection. If a waterproof box has been used for the speaker, the holes drilled for the sound to enter *must face downwards.* At the same time, remember that the sound of rain drops on the box is likely to trigger the unit so it is better to shelter it. Some shielding



may also be necessary to protect it from wind noise.

The unit should be sited so that no light from any lamps controlled by it reaches the LDR or erratic operation may result. Over a period of trial, the best orientation for the sensor should be found, the timing set and final adjustments made. □

Ohm Sweet Ohm

Max Fidling

Smoke Signals

September! By now, the barbecue season is at its peak at the *Fidling Ranch*, as we take every opportunity we can to scoff charred offerings before the autumnal weather rains us off! (Probably no bad thing since I'm a rotten Chef; I can solder the tiniest joint with split-second accuracy but I can't barbecue a burger to save my life.)

With my gardening chores gradually diminishing I can put my feet up a bit and indulge myself by pottering in the workshop, whilst contemplating my latest project. One balmy evening I lit our oversized barbecue ceremoniously for one final fling, slapped some sausages on it, opened a bottle of methylated *vin du table* to breathe, and then wandered into the workshop a few yards away, followed by Piddles the cat (who always perks up at the prospect of food, no matter how burnt).

At a recent summer sale, browsing around my local DIY store, I'd spotted a bin full of smoke alarms, being sold at a knock-down price! I couldn't resist buying one type in particular, which had a small torch beam built in. This illuminated when the smoke alarm activated, thus lighting a suitable escape route.

I'd gleefully bought a couple of these. They had lain on the bench ever since, waiting for a suitable opportunity for me to experiment further with the loot.

Eyeball-to-Eyeball

So my eyes happened upon the smoke alarms. With Piddles, my trusty moggie, nosing around in the workshop in ritual search of meeces, I opened the packaging and swiftly fitted the batteries supplied (for once) with the alarms. Pressing the "test" button produced a beam of light which Thomas Edison would have been proud of, followed seconds later by a very feeble bleep from the internal piezo sounder!

This made Piddles look up briefly, not in the least worried because he was conditioned to this sort of thing by now. Indeed I could swear the cat was rolling his eyes ceiling-wards!

Of course, the first thing I want to do when I buy any gadget, is to take it apart and see how it works! I don't always manage to put it back together in quite the same way (as my toaster will testify), but it did occur to me that there was maybe scope for improving the smoke alarms to enhance their effectiveness.

Steering clear of the worrisome radioactive-looking bits, I checked around the lamp section of one of the smoke alarms and wondered if I could take an output from this and use it to drive something else – perhaps a louder alarm unit to supplement its own ineffective internal offering?

In the Spirit

I had a mini 6V siren in the workshop which I had been saving for a special occasion. Its time had come: I hooked it into one of the alarms across the lamp output, and stabbed the "test" button once again. It worked a treat!

I decided that an in-situ test was called for back at the house, so at this point the workshop was abandoned as we quickly scuttled house-wards in search of a suitable spot to test my idea further. The alarm was soon screwed into the hallway ceiling, just outside the kitchen, with its Cyclops-like lamp reflector peering down at myself and Piddles, by my side. The mini siren which I'd appended to the alarm was stuck on with a sticky-pad, rather incongruously.

Suitably pleased with myself at this latest notion, I ambled out of the workshop in the general direction of the barbecue to see what was cooking. A plume of dense woody smoke was spiralling upwards and generally engulfing the garden. Piddles nosed around near the *Hibachi*, ever hopeful of a tasty morsel.

The sausages were somewhat crispy black one side, and I nimbly turned them over and prodded the charcoal thoughtfully, for good measure. I knew that the Boss was in the kitchen preparing more yummy grub and overall, things were looking rosy! I could hear the clattering of cutlery and general activity through the open kitchen window.

Time for some wine! The barbecue appeared to be heading for thermo-nuclear meltdown as I slapped more grub onto the sizzling blackened grille. By now I was starting to warm to the task (literally!) in my happy haze as plumes of pungent smoke drifted housewards.

As more fiery fumes pirouetted into the air, a shrill scream was suddenly heard from the kitchen! Dashing inside, I heard the mini siren wailing angrily and I saw the smoke alarm lamp shining angrily, pointing like an accusing finger at myself standing below it!

In installing my latest brainchild alarm system, in my enthusiasm I had failed to warn the Boss! The smoke alarm had indeed done its job, encouraged by the carbonaceous fall-out from the barbecue outside, and putting the fear of God in the Boss at the same time!

I was thus evicted from the kitchen and consigned to tending the charcoal, in disgrace. Except that Piddles had tucked into the grub I'd managed to salvage from certain ruin on the glowing embers.

Special Feature

SECURITY TAGGING

PETER NUTT

You may not spot them, but electronic tags are attached to ever increasing types of merchandise in most High Street stores. The detection techniques used are ingenious.

TWENTY years ago the "Alligator" style plastic tags were first starting to dangle from the clothing in a few High Street stores. "Electronic Article Surveillance" (E.A.S.) had come to Britain.

The need for retailers to put a halt to losses from shoplifting had them looking to the electronics industry for answers. Cameras were the early solution, but with video recorders still rare and expensive, to be effective someone had to watch the monitor all day, and what if the camera was pointing the wrong way? Much better if the stock could look after itself!

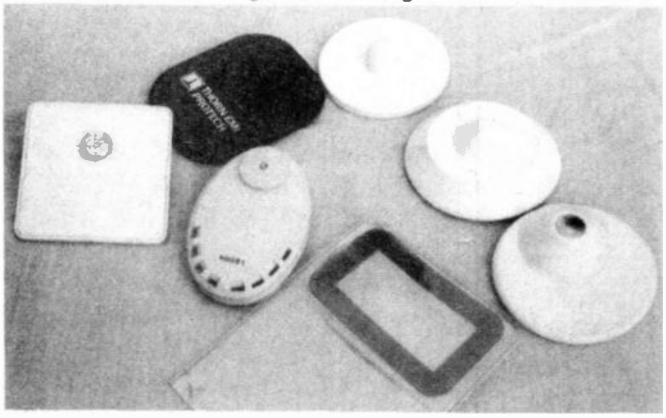
Engineers out in the field are frequently confronted by the inquisitive public. "How does that work: like those airport metal detectors, or does it use laser beams?", are questions frequently put forward. Thankfully not the latter, receiving an eyeful of laser light from some Star Trekean beam sounds rather painful.

Precise constructional details of the "targets" (tags) that are fixed to the garments and the circuits that detect them are heavily patented and jealously guarded secrets by the companies concerned. However, the reality is that it is all based on some standard electronic principles. Two types of technology are used: radio frequency (r.f.) based systems (the ones commonly encountered in stores) and magnetic systems (found only in libraries in the early days but now spreading into the High Street).

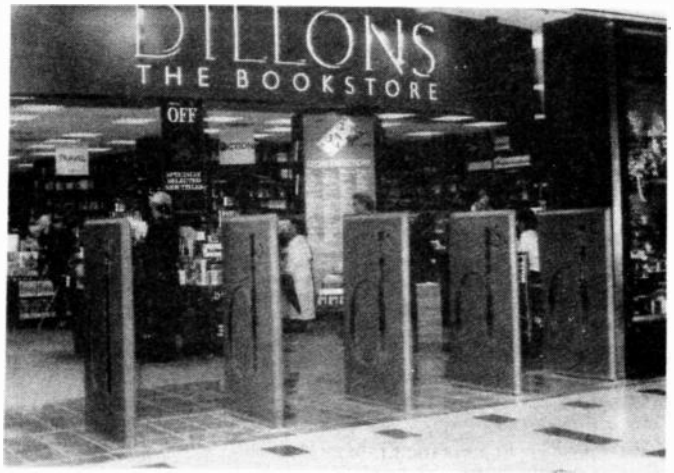
Radio based systems can be subdivided into two categories: low frequency (l.f.) and high frequency (h.f.) systems – sometimes inaccurately referred to in the industry as microwave systems. The different radio systems can be identified to some extent by the shape and size of the tags. In general, long thin tags belong to the h.f. family, and round or square tags to the l.f. The two types each offer a variety of advantages.

LOW FREQUENCY SYSTEMS

Over the years, manufacturers have explored various avenues in search of the ultimate solution. One manufacturer's answer was the "active" or "live" tag, where the target itself was in essence a miniature battery operated transponder whose signal was picked up by a receiver at the doorway. This method had some problems, the biggest one being the power source. The life of the tag was determined by its battery life. Even if use could have been made of today's CMOS technology, the shelf-life of the battery (about two or three years then) was too limiting a factor.



A selection of low frequency r.f. security tags.



Customised detectors at the exit of a major store.

There might be more success today with Lithium cells etc. but the biggest problem now, as then, is cost. These tags could not compete with the simpler passive ones that were developed, which cost much less to manufacture and never run flat!

Modern l.f. tags are all passive devices that use one of two methods for producing a detectable "signature". These devices use a variety of frequencies, depending upon the manufacturer and sometimes also on the application intended, ranging from several kilohertz with some methods, to several megahertz in the mid h.f. bands (short-wave) for others.

The l.f. systems are easily identified. They are normally slim stand-alone units, positioned one each side of the doorway or, if the doorway is wide, positioned in multiples, about two metres apart (approximately the limit in field strength for this type of system). One of the most popular, and a typical system of this type, is the familiar slim "stepped double loop" pattern of Knogo U.K.'s l.f. system evident in most High Streets.

RINGING METHOD

As with most developing electronic products, the price of these devices has fallen and cost effective systems have been developed for even small corner shops. These tend to be single antenna systems with single circuit board "transceiver style" electronics. Although simpler than the traditional systems, they also can be linked to cover larger areas. Both the Transmitter/Receiver and Transceiver based systems use the same targets.

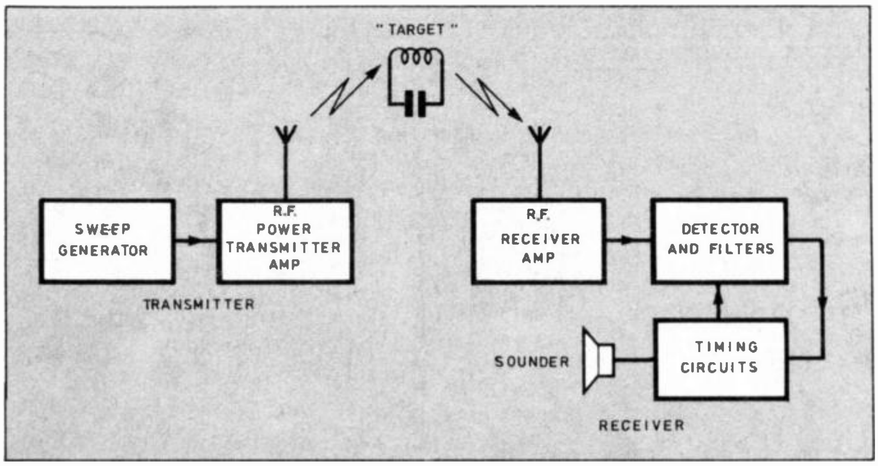


Fig. 1. A typical low frequency r.f. system.

By far the most popular method used is to make the target resonate, or ring. In this method, the target is a tuned circuit with special characteristics. As the target approaches the store exit, it is energised by a transmitter which is situated on one side of the doorway with a corresponding receiver on the other.

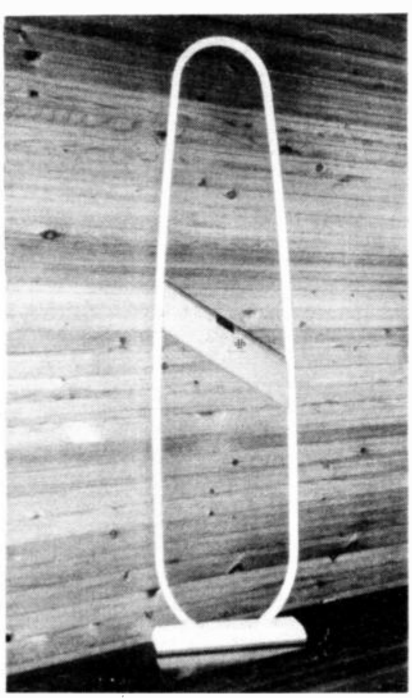
The electronics is either housed in a small briefcase sized base unit onto which the antenna is mounted or, with some manufacturers, remotely housed in a small cabinet. The actual configuration of the antennas is something else that manufacturers keep close to their chest. They need good directional properties, good spurious noise rejection and must still be able to detect the very small return signal from the target.

When the target is within the field it is "rung" by the swept r.f. signal from the transmitter (see Fig.1). The target resonates and "falls off" at the same period. The receiver amplifies the weak return signal, filters off the fundamental and then processes it.

Signal processing is the real hush-hush part of the system, manufacturers are very sensitive about their receiver technology, occasionally accusing others of transgressions over patents in this area. Filters and accurate timing circuits are the order of the day here, to ensure the vast array of innocent objects carried daily through stores are ignored. The output circuitry then drives the sounder and lamps that get your pulse jumping when you browse too close to the doorway.

FREQUENCY CHANGING

With the frequency changing method the target is more complex. When the target enters the r.f. field the energy is received from the transmitter, as in the previous method, but is used to generate a different frequency to return for detection. The extra complexity of the target, and therefore construction cost, is balanced by the fact that a simpler antenna system can be employed. In practice, the transmitter is normally a loop around the doorway, with the receiver antennas placed in small pods around the door frame. Although the return signal is small, being of a different frequency to the transmitted signal has certain processing advantages. Yet again filtering and timing circuits are the key.

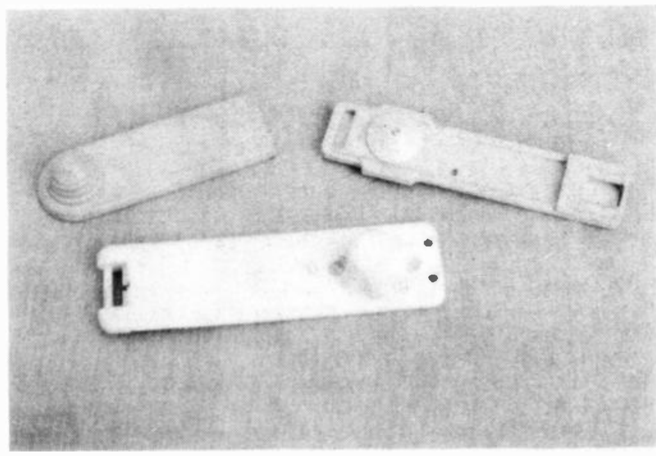


Slim-line r.f. transceiving detector.

Recent advances in material technology are producing ferrite based targets that are proving to be as cost effective as the "ringing" targets.

HIGH FREQUENCY SYSTEMS

Unlike l.f. systems, the principle of h.f. system operation remains broadly the same across the different manufacturers. The targets that belong to this family of systems are easy to identify, normally being long and slim,



Three typical high frequency r.f. tags.

benefitting from the fact that only a fairly simple arrangement is needed inside. All h.f. targets are passive devices. They are small "antennas" used in connection with a non-linear semiconductor.

Two frequencies are transmitted, mixed in the target and the radiated product is detected by the receiver. They tend to use primary frequencies up near 1GHz. This has advantages in the antenna department, making them small without directional problems, and a variety of system layouts is possible.

The white wooden box on both sides of the door virtually became a trademark for Sensormatic's h.f. system in the early days and many of these units are still operating. The slimmer more modern looking unit is essentially the same in principle. One of the advantages of the latter type of system is the fact that the equipment does not need to be shown at the doorway, and customising

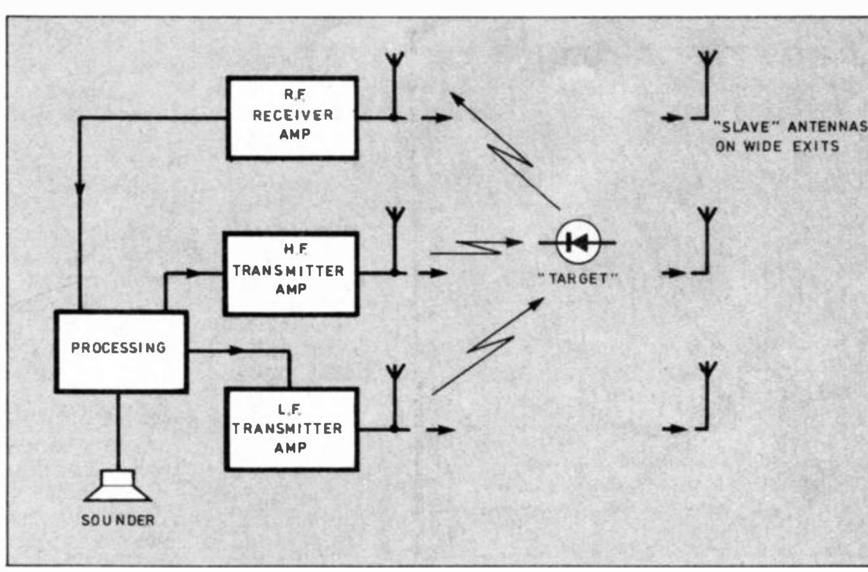


Fig. 2. A typical high frequency r.f. system.

becomes easy. It is possible to install them in the floor or in the ceiling, keeping the architecture of the doorway intact.

With a setup like this, the only way to tell if a store has an E.A.S. system is by the tags on the clothing. This is not to everyone's taste, though, as the deterrence factor is lost to some extent.

Regardless of installation or manufacturer's preference, all h.f. systems have two transmitters operating at two different frequencies (see Fig.2). However, the two major manufacturers choose to do it slightly differently, with one preferring to use one h.f. transmitter and one l.f., the other using two h.f. transmitters.

The signals are transmitted from either helical or "slab" antennas. At the target, the signals are mixed and then the re-radiated product is detected by the receiver. Signal processing is more simple than in the l.f. systems, helped by there being much less man-made spurious radiation at the h.f. frequencies used. Some systems also send a "pilot tone" as a means of double checking the validity of an alarm signal.

This all sounds so good you may wonder why anybody might bother with the l.f. units. The h.f. systems are very popular but there are a few disadvantages. The "bleed" area (how much the detection field intrudes into the store) tends to be larger than with l.f. units. Even though manufacturers have improved on this since the early systems, it can be a problem in small stores.

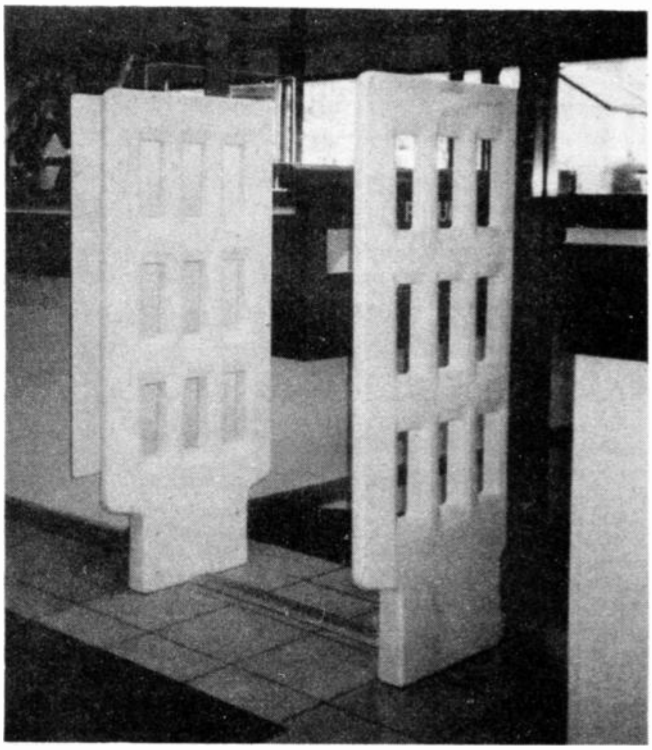
The other main disadvantage is lack of "aisle identification", as it is called: if the whole of a wide doorway is covered by one system it will be difficult to spot the culprit in a crowd.

TAGS AND DETACHERS

How the various targets are attached is also interesting. They all use a fine pin with a large head, with the exception of some early h.f. tags that were of the hinged "alligator" type. Two methods are used:

The most popular is a small spring-loaded set of "teeth" fixed into the centre of the tag. These grab the pin when inserted, and then have an effect similar to the "Chinese finger grip", the teeth biting harder the more you pull on the pin. The device for detaching the pins uses magnets in a very clever way. The tag must be presented to the "decoupler" which has an annular polar magnet arrangement that pulls the teeth clear allowing the pin to be withdrawn.

Would-be shoplifters about to sprint off down the High Street with a magnet in their pocket can save themselves the trip, though. The strength, balance and relative position of the magnetic arrangement are critical and the materials to construct a magnet of the necessary power are difficult to obtain. In fact, this was difficult for the manufacturers to achieve in the early days and electromagnets were used.



Typical magnetic detectors either side of a store exit.

The other method, although less "hi-tech", is just as effective. It is used almost exclusively by one manufacturer. Imagine a piece of thin spring steel with a slit in it held under tension. This is the basis of the receiver mechanism in the tag. When the grooved pin is inserted into the slit, it is gripped hard. Pulling to try to remove it has the same "Chinese finger grip" effect again. To legitimately remove the pin a "gripper" style device that fits precisely relieves the tension in the metal, allowing the pin to be removed.

MAGNETIC SYSTEMS

Magnetic systems, surprisingly, were the earliest E.A.S. systems to appear, they first appeared in libraries in the United States in the 1960s. Installed by Knogo Corporation, those early systems were enormous compared to today's and had to be literally "part of the furniture". As the concept became better understood and electronics marched ever onward, the systems became smaller and, more importantly, affordable. The principles employed are completely different to those in the radio systems.

The target is a small piece of metal alloy and a magnetic field is set up at the point of detection (i.e. check-out or doorway). As the target passes through the magnetic field, the alloy becomes saturated and the array of harmonics generated is picked up by receiving antennas and processed.

If only it was that simple in practice! The detected alloy is chosen for its specific properties, it has an almost unique harmonic "signature", making it an ideal target. There are very few materials, natural or manufactured, that exhibit the required properties and the chance of them unwittingly being carried on a shopping expedition makes accidental triggering of the system improbable.

Manufacturers have continued to refine the material, enabling the size of the target to be reduced. It is now possible to have the targets built into labels, tickets and price-guns, etc. One manufacturer even produced a system using a thread of the material about the same diameter as five-amp fuse-wire, virtually undetectable when inserted into the item to be detected. Target alloy can also be encapsulated in plastic and fitted with the pin clasp mechanism, making it suitable for clothing, just as with the r.f. systems.

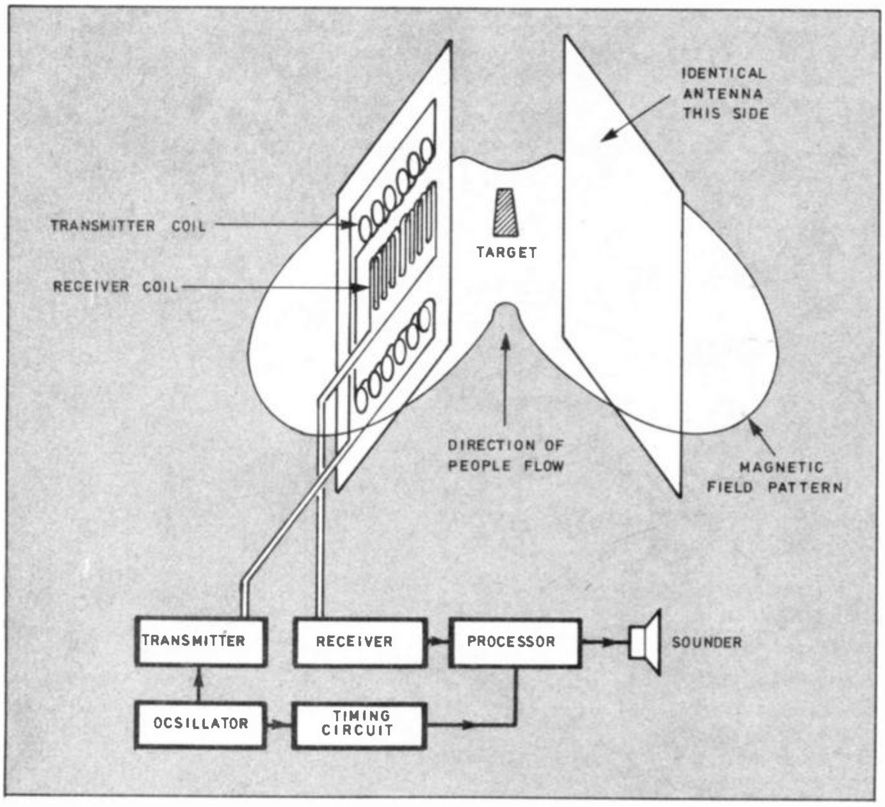
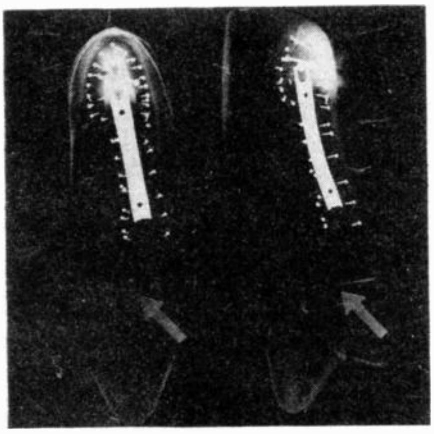


Fig. 3. A typical magnetic detection system.

The latest innovation from the industry is the move towards "source protection", this involves the target being inserted during manufacture, making life simpler for the retailer. It also makes the target tamper-proof. Applications for these systems are enormous, ranging from libraries, the original users, to supermarkets, bookshops and D.I.Y. stores. The technology has reached the point where sales of magnetic systems will probably outstrip radio systems over the coming years.



"Source protected" shoes with the targets manufactured into the soles (see arrows).

HOW THEY WORK

A simple analogy that the author often uses to explain the magnetic systems is as follows: Think of the construction of a conventional transformer. The primary coil is the equivalent of the transmitter antenna, being energised by a low frequency source (see Fig.3). The secondary coil represents the receiver antenna, picking up the fundamental frequency from the primary through induction.

Now introduce a metal object, the target, into the field, acting as the "former" in the transformer analogy. The current induced into the secondary coil is still mainly at the fundamental frequency, but with the addition of low level harmonics generated by the target. What is interesting is that the harmonics are particular to the target metal concerned. After filtering out the fundamental frequency, there remains the "signature " of the introduced metal.

This is, of course, a much simplified version of events. As with their radio based products, manufacturers understandably protect their many years of research and investment with secrecy and patents. However, as with the radio products, the principle of operation lies in basic physics.

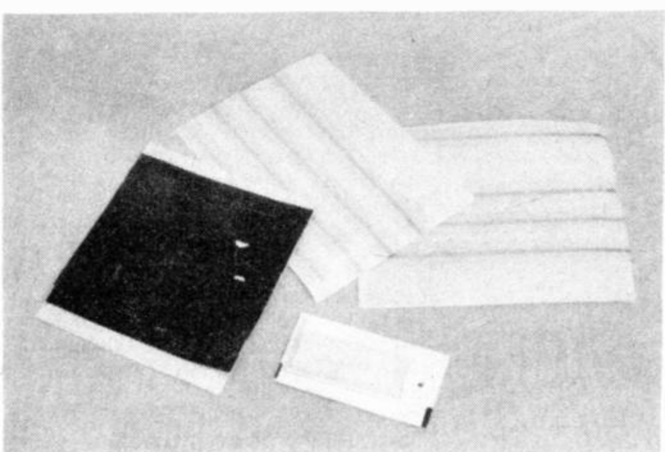
The antenna systems tend to be on the heavy side, as fairly large diameter turns of copper wire are required to produce the very high Q factor necessary for the transmitter coil. The receiving antenna tends to be much lighter. Layout of the antennas varies with design, and is also kept confidential.

The power emitted by these units is relatively modest and, contrary to popular myths about "frying" hearing aids, is in fact about the same as a "beefy" domestic hi-fi. The distance to which such a field can be sustained is limited by the power applied and the size of the antennas. Antennas have to be designed to suit their environment, and so this limits the size. Also, power requirements rise on a square law, thus to extend the range by a small amount would require an unreasonable increase in power.

These factors limit the practical range of magnetic systems to about a metre of aisle width, although this varies slightly with different designs. As with radio systems, they can be linked to cover wider gaps.

As the target material enters the system and moves through the magnetic field, signals appear in the receiver antenna. The first stage is to filter out the fundamental signal. Of the remaining harmonic signals, some may be the result of innocent objects carried into the store, or interference from electrical sources (drills, lighting, radio sources, etc.) and possibly line noise.

A lot of the local noise will be taken care of by the noise cancelling antenna configuration, but because of the low signal levels involved and the wide variety of metal objects carried by shoppers in normal daily life (i.e. watches, pens, spectacles, keys, etc.) quite sophisticated signal processing is necessary.

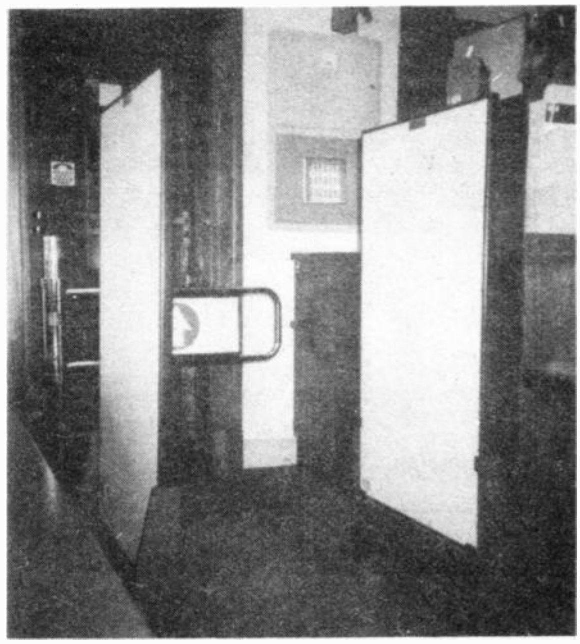


Magnetic system targets, the black ones are for videos, the small one is on the back of a barcode price tag.

Unsurprisingly, the most common metal encountered is steel, or other items with a ferrous content. These tend to produce even harmonics which are detected and filtered off at an early stage in the receiver, to be used for processing at a later stage.

The next step in sorting out a valid signal is handled in several ways. One major manufacturer uses the very effective method of signal averaging. It relies on accurate timing signals, as do most circuits in the E.A.S. business. The signal is applied to two averaging circuits of different periods, these are then sampled at specific times. The theory being that "instantaneous" noise will only be present for one or two samples, whereas the wanted signal will be synchronous. The output from these circuits then joins the "metal" signal for some final processing and then drives the sounders, lamps or even locking gates.

This technology has benefited greatly from the introduction of microprocessors, and the very latest systems available are way ahead of those early library units. The sampling and processing power of the new designs make them more sensitive, versatile and adaptable. The latest system from Knogo even has the capability of having its parameters adjusted by engineers over the phone line.



Magnetic system detectors installed in a library.

TARGET OPERATION

Whether used in a library application or for retail protection there are two possible methods of target operation, full circulation or pass-around. Where the system antennas are mounted onto the check-outs, e.g. at the supermarket, after bar-code price scanning, the goods are normally fed past the back of the antennas by the conveyer belt to where you load them into a trolley. You then walk through the system, collect your purchases and the target goes into the waste bin at home with all the wrapping.

Where the pass-around method is not possible and the full circulation method is required, antennas have to be located at the doorway. It now becomes necessary to "turn off" the target at the point of sale, and in the case of libraries "turn on" the target when the book is returned. These systems have to use a recyclable target.

There are several different ways of making such a target but all use the same principle. The alloy is overlaid with a certain amount of soft iron. At the point of sale the goods are passed over a "desensitiser" plate. This puts a special magnetic pattern on the iron "coating" which causes the normal signature of the alloy to be disguised and not detected at the antennas. When the product is returned, the overlaid magnetic pattern is "cleaned off" with a magnetic eraser and the product returned to the shelf.

As well as permanent and recyclable targets there are a wide variety of other designs. Some are built into bar-code price labels or customised labels that carry the Store's name and logo. Stealthy targets disguised as almost anything are now being used to keep one step ahead of the shoplifter. For stores that have mixed goods, encapsulated targets are available that look similar to the r.f. tags and attach in the same way. The ultimate in tamperproof design is the source-embedded target which will eventually become a standard with some supermarket chains.

OTHER SYSTEMS

When it comes defining things, there is always the one that defies classification. Such is Sensormatic's Ultramax system. This system is somewhat of a hybrid and is proving very popular in the High Street. It uses targets that look similar to the regular magnetic systems but which are energised by l.f. pulse transmissions and then detected in a similar manner to conventional magnetic systems.

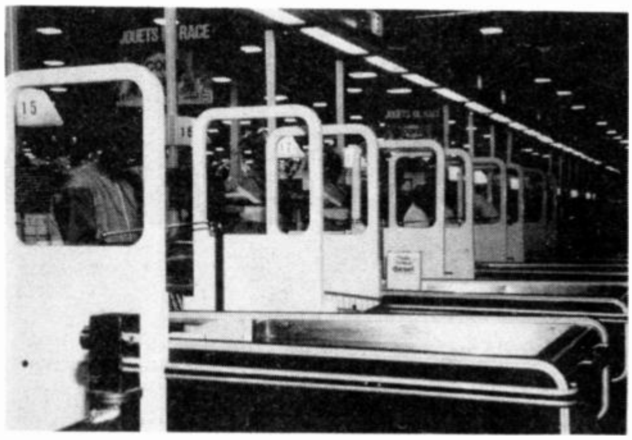
Ultramax is proving very successful in mixed goods retailers (record stores, D.I.Y. etc.) where a self-adhesive target is used. Some of the E.A.S. companies also market what are known as "Colour Tags". These look similar to r.f. tags but no electronics are involved. They contain a permanent brightly coloured dye. The theory being that any tampering would result in the garment being spoilt and useless to the thief.

THE FUTURE

In the not so distant future, retailers without E.A.S. systems will be the exception in the High Street. As the number of systems increases, crime slowly migrates towards the unprotected stores. E.A.S. technologies are developing at astounding rates and the systems currently in development will be easier to use but undetectable by the consumer. All the different technologies in crime prevention/detection are starting to experience convergence. A prototype already exists for a system that links the tagging system, camera system, and all the E.P.O.S. (Electronic Point Of Sale) terminals in the store to a master computer running a specialist Expert System.

When fully developed, an alarm from the doorway antennas would cause the cameras to record the event, and possibly compare the picture with a database of known felons, delivering the information to the security staff in an "evidence ready" format. The same computer system would monitor all the E.P.O.S. positions for unusual activity. It would detect, for example, an incident that came to light recently: a check-out assistant when cashing up sales for a friend, passed a large expensive joint of meat along the counter, while at the same time passing the bar-code from a tin of beans across the scanner.

All this monitoring could take place without the need of an operator, just alerting staff when necessary. It sounds a little like "Big Brother" watching over us all, but as with other electronic revolutions we quickly become used to them and soon don't even notice their presence. With the cost of electronic assemblies falling rapidly, in real terms it cannot be long until everyone in the High Street joins in.



Multiple detectors line the exits of a French superstore.

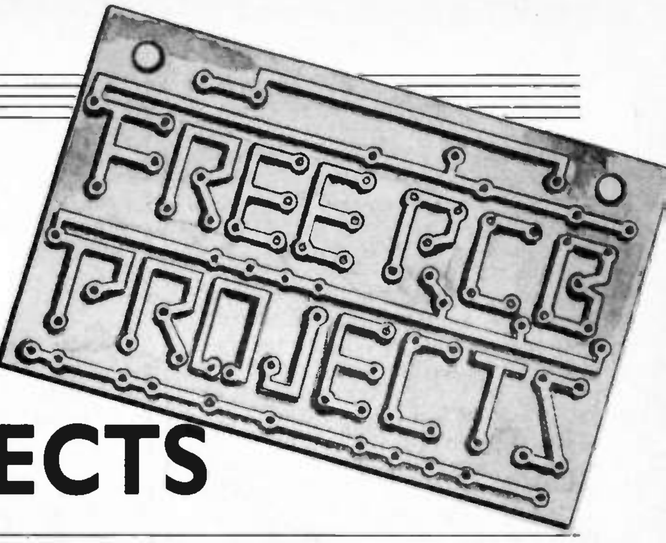
ADDITIONAL INFORMATION

Companies involved in the E.A.S. industry in the UK. In approximate order of size.

SENSORMATIC (including Knogo and Securitag),
Tel: 01442 251120
KNOGO
CHECKPOINT (including ID systems)
SECURITAG
ACTRON Owned by ADT
I.D. SYSTEMS
3M Only marketing magnetic systems
ESSELTE METO
ANTINSON Owned by Group 4 (Swedish)
2M
NEDAP

Peter Nutt has worked for Knogo (now owned by Sensormatic) in various engineering capacities since 1980. □

ABOUT YOUR FREE PCB MULTI-PCB PROJECTS



A SELECTION of "Pick and Mix" projects that can *all* be built on the FREE, cover mounted, printed circuit board attached to this issue.

This month we present three projects: **Audio Sinewave Generator ★ Treble Booster ★ Infra-Red Controller/Alarm** (two p.c.b.s). Next month's three projects will be: **Video Enhancer ★ Distortion Effects Unit ★ Current Tracer.**

Like the first six projects in the *March and *April issues, these simple projects cover a wide range of applications, but they are all based on the same printed circuit design. This is exactly the same design that was used for the original set of six projects. Any of this second batch of circuits can be built on the original *FREE* p.c.b., and any of the original batch of circuits can be built on the new *FREE* p.c.b.

If you wish to build all these "mini board" projects, then extra p.c.b.s will be needed and can be purchased from the *EPE PCB Service*, code 932, for the sum of £3 each (including VAT and postage). Alternatively, you can purchase extra copies of the October '95 issue from your ***Newsagent,*** whilst it is still on sale, and make a small saving on each additional p.c.b.

March '95 – (Back issues available)
★ Sound Activated Switch ★ Audio Amplifier
★ Light Beam Communicator (two p.c.b.s).
April '95 – (Back Issues available)
★ Light Activated Switch ★ Switch On/Off Timer
★ Continuity Tester.

Circuit Board

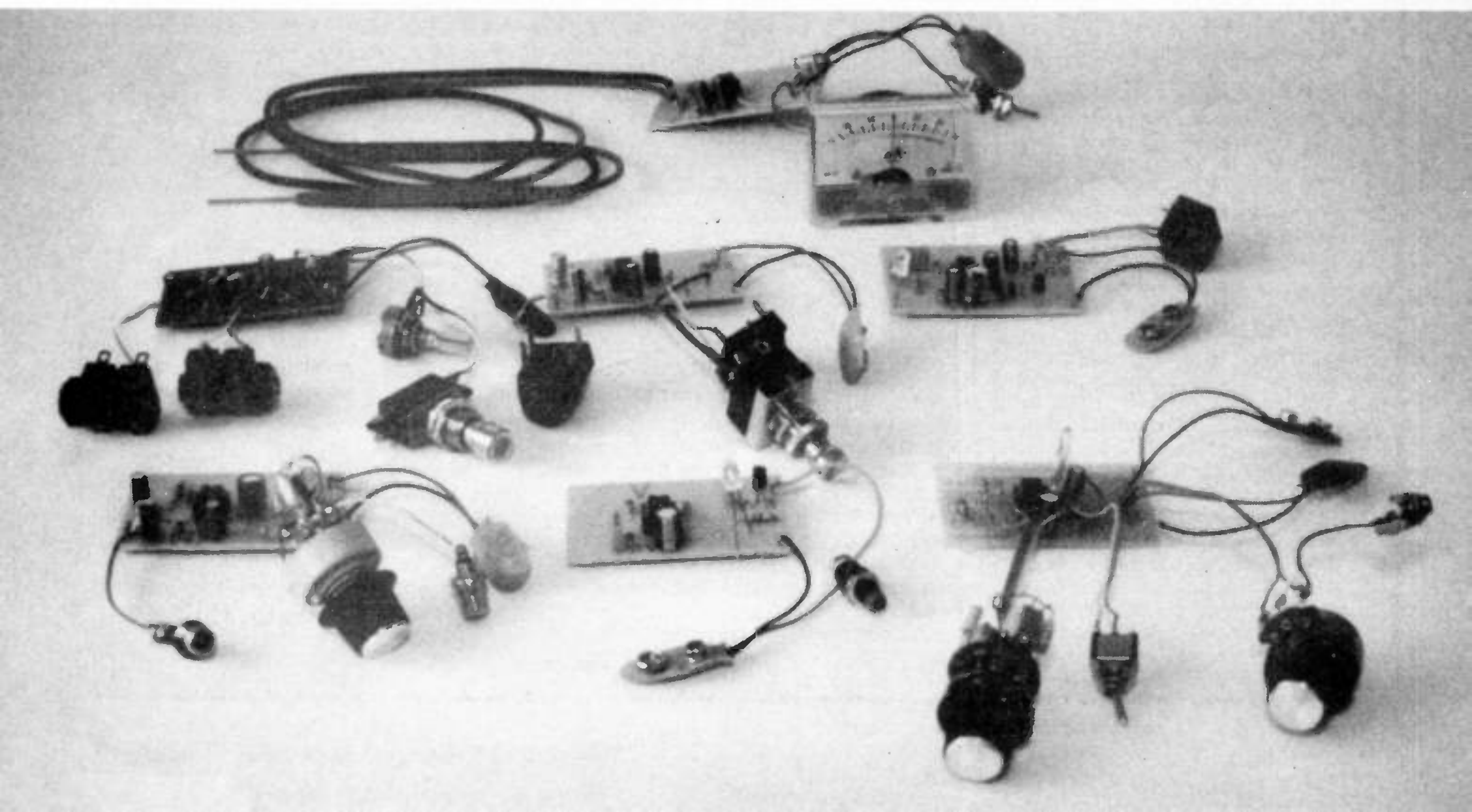
The board is designed to take a single operational amplifier having an 8-pin d.i.l. encapsulation and the standard 741 style pinout arrangement. The operational amplifier can be used in the inverting and non-inverting amplifier modes, as a voltage comparator, or as a trigger. At least two types of oscillator can also be accommodated. The board has provision for discrete relay driver and complementary class B output stages.

While the restriction of a single operational amplifier clearly limits the complexity of projects based on this board, using modern operational amplifiers it is still possible to accommodate a wide range of projects within its confines. This second set of six projects demonstrates the use of high quality audio, precision d.c., a wide bandwidth/high slew-rate operational amplifiers.

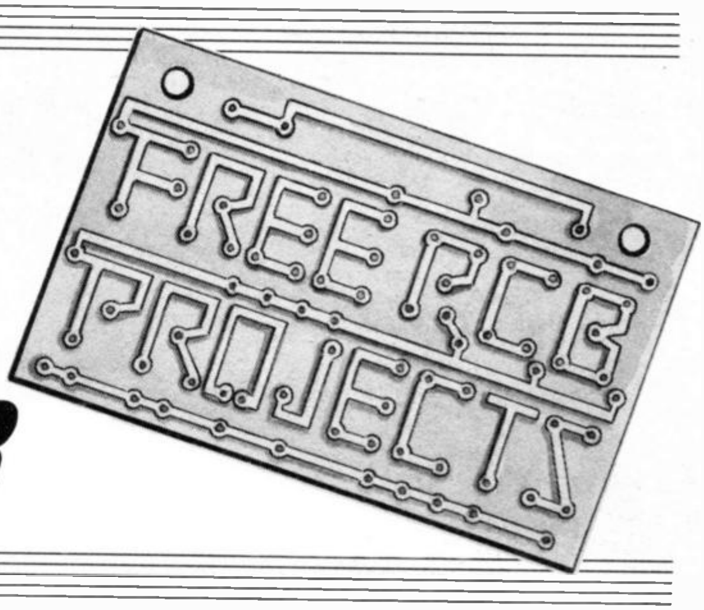
Pad Carefully

Using the board is reasonably straightforward, but it does require slightly more care than when using a custom printed circuit board. None of the projects utilize all the pads, and in most cases more than 50 percent of the holes in the board are left vacant. This makes it essential to take a little more care when fitting the components, and to double-check the positioning of each one. Apart from this, using the Multi-PCB should be as easy as project building on a custom board.

The Multi-PCB Projects (left to right, top to bottom): Current Meter – Treble Booster – Distortion Unit – IR Receiver – Video Enhancer – IR Transmitter – Audio Sinewave Generator.



Constructional Project



AUDIO SINEWAVE GENERATOR

ROBERT PENFOLD

Use your FREE cover-mounted p.c.b. to build this simple, switched range audio sinewave generator. Output Frequencies: 100Hz • 1kHz • 10kHz •

An audio signal source of some kind is an essential piece of test gear for anyone involved in constructing and testing hi-fi amplifiers, or any other type of audio equipment. These signal sources range from simple signal injectors to up-market signal generators which cover a wide frequency range, and have two or three very high quality output waveforms to choose from.

This device falls somewhere between these two extremes. It only provides a single output waveform, but this is an extremely high quality sinewave type.

The output frequency is not variable, but three output frequencies of 100Hz, 1kHz, and 10kHz are available. This enables tests to be made at a *low*, *middle*, or *high* audio frequency.

The output level is continuously adjustable from zero to approximately 10 volts peak-to-peak. There is also a −20dB switch that can be used to attenuate the output by a factor of ten. The output voltage range is then zero to one volt peak-to-peak, which makes it easier to set low output levels.

WIEN OSCILLATOR

There are many oscillator configurations that can provide a good quality sinewave signal, but the Wien oscillator is the most popular choice. This is reasonably simple, but can provide very good results provided oscillation is properly regulated. The basic circuit diagram for a Wien oscillator, using an integrated circuit, is shown in Fig. 1.

A non-inverting amplifier forms the basis of the circuit. The amplifier can be a discrete type, but modern designs are invariably based on an operational amplifier i.c.

The Wien network is formed by resistors R1, R2 and capacitors C1, C2, and its purpose is to provide frequency selective positive feedback. At a certain frequency the phase-shift through the Wien network is zero, and at this frequency positive feedback is applied to the amplifier. The zero phase-shift frequency is equal to 1/6·283CR Hertz. It is assumed here that R1 equals R2, and that C1 equals C2, which is normally the case in practical designs.

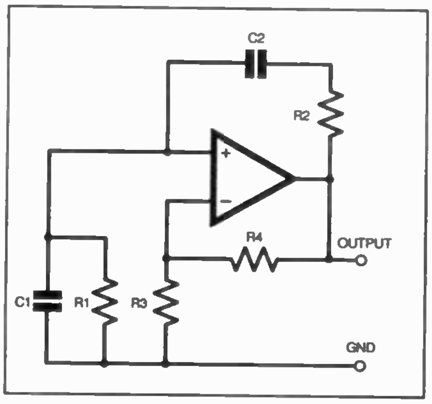


Fig. 1. The Wien oscillator configuration.

GAIN

Provided the voltage gain of the amplifier is at least a little higher than the losses through the Wien circuit, the circuit will oscillate at the zero phase-shift frequency. In order to sustain oscillation the voltage gain of the amplifier needs to be at least three times.

The closed-loop voltage gain of the amplifier is set by resistors R3 and R4, which form a conventional negative feedback circuit. The voltage gain is equal to (R3 + R4)/R3.

In practice it is not good enough to merely set the voltage gain of the amplifier at a little over three times. This would provide oscillation, but the circuit would oscillate so strongly that the output would become severely clipped. This would give an output waveform more like a low quality squarewave than a pure sinewave signal. Even if the gain was carefully adjusted to just the right level, it would only require a small change in the loading on the output of the amplifier to either quench oscillation, or to allow it to run out of control.

STABILISATION

In order to obtain really good results it is necessary to incorporate an automatic gain control (a.g.c.) circuit. This automatically adjusts the gain of the amplifier so that the output level is maintained at a suitable level.

The exact output level is not too important, and anything that gives a reasonably strong but non-clipped output signal will suffice. The two normal types of automatic gain control have either a field effect transistor (f.e.t.) or a thermistor as one element of the negative feedback network.

THERMISTOR

The thermistor method is probably the more popular, as it generally gives lower distortion, and is a much more simple arrangment. Its only real drawback is that the special thermistors for this application are relatively expensive.

The audio generator featured here uses a conventional thermistor stabilised design. The thermistor used is basically just a standard negative temperature coefficient type (increased temperature gives reduced resistance), but it is self-heating.

In other words, it is not designed to respond to the ambient temperature, and it is actually contained within an evacuated glass envelope which helps to minimise the influence of the outside world. The thermistor is designed to heat up when it passes a small current. The higher the current, the hotter it becomes, and the lower its resistance.

It is resistor R4, in Fig. 1, that is replaced by the thermistor. At switch-on the thermistor is cool. It therefore exhibits a high resistance, which in turn gives the amplifier a high voltage gain. This causes strong oscillation, and a large current flow through the thermistor.

This results in the thermistor heating up, giving greatly reduced resistance, much lower voltage gain, and weak oscillation.

With weaker oscillation there is reduced current flow through the thermistor, which therefore cools down and gives stronger oscillation.

The strength of the oscillations fluctuates momentarily, but the circuit soon settles down with a moderately strong output signal. If loading on the output produces a reduction in the output level, the current through the thermistor decreases, and it provides stronger oscillation.

Similarly, if a reduction in loading produces a stronger output signal, the current through the thermistor increases, thus decreasing the oscillator strength. The thermistor therefore sets the amplitude of the output signal at a suitable level initially, and then maintains it at that level with reasonable variations in loading, etc.

CIRCUIT DESCRIPTION

The full circuit diagram for the Audio Sinewave Generator is shown in Fig. 2. Resistors R1 and R2 bias the non-inverting (pin 3) input of IC1, and their parallel resistance forms one element of the Wien network. They are the equivalent of R1 in Fig.1. The other resistor in the Wien network is R5.

Three switched pairs of capacitors (C2 to C7) provide the unit with its three different output frequencies. C4 and C7 provide the 100Hz signal, C3 and C6 provide the 1kHz signal, and C2 plus C5 produce the 10kHz output signal.

Resistors R3 and R4 bias the inverting (pin 2) input of IC1, and their parallel resistance also acts as one element of the negative feedback network. They are the equivalent of R3 in Fig.1.

Thermistor R7 is the other section of the negative feedback circuit. An RA53 thermistor is the normal choice for this application, but due to its lower cost an RA54 is used in this circuit.

The RA54 is very similar to the RA53, but it has a higher operating resistance. This means that it works at a slightly lower current than the RA53, but with a slightly higher operating voltage.

What this means in practice is that the output level from the oscillator is higher than would be obtained using an RA53. The peak-to-peak output voltage is about 10 volts, whereas a circuit based on an RA53 normally has an output level of about three volts peak-to-peak.

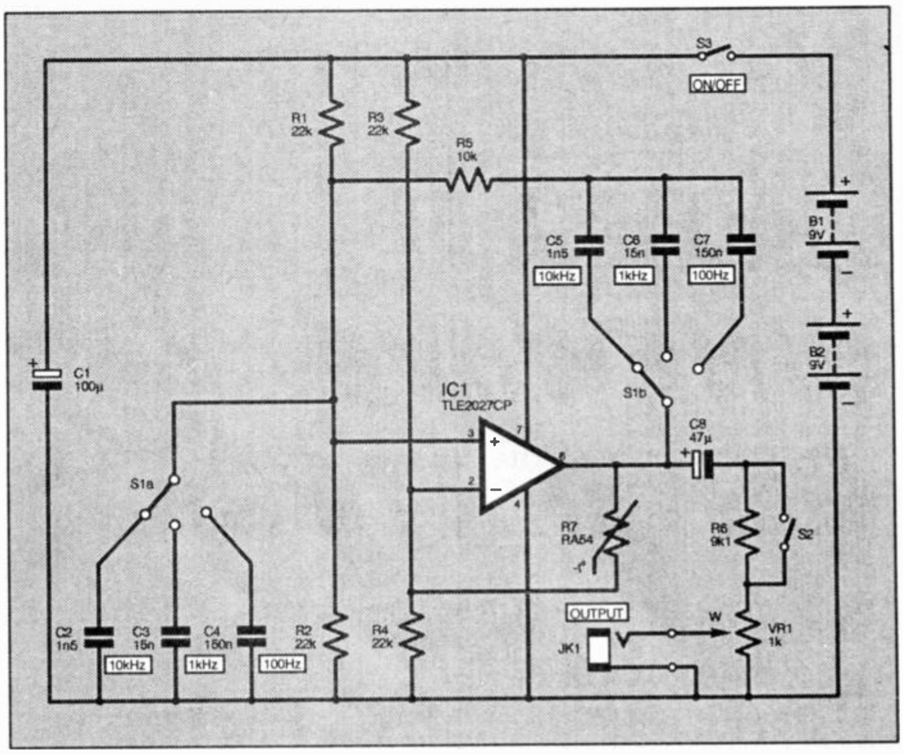
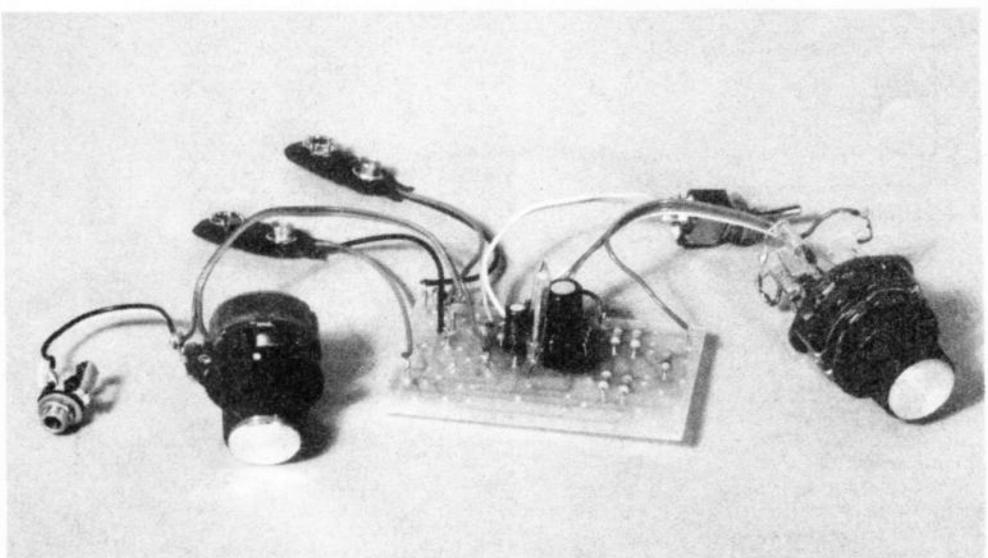


Fig. 2. The complete circuit diagram for the Audio Sinewave Generator.

Potentiometer VR1 is the variable output attenuator. Opening switch S2 introduces losses through resistor R6 that reduce the output by about 20dB. Use a value of 100 kilohms for R6 if a reduction by about 40dB is preferred.

The 10 volt output level of the circuit precludes the use of a single 9V battery. The circuit is therefore powered from two small 9V batteries wired in series. This gives an 18V supply, and plenty of "headroom". The current consumption is approximately 5·5mA from each battery.

Although a very high quality operational amplifier is specified for IC1, the circuit will work using practically any type which has internal compensation. Using a very low noise and distortion component such as the TLE2027CP it is possible to obtain a very high quality output signal, which enables the unit to be used in demanding applications such as distortion measurement. However, for simple signal tracing or gain testing a less expensive type such as an LF351N or µA741C is perfectly satisfactory.



The completed Sinewave Generator awaiting a suitably sized case. Note the capacitors soldered directly on the rotary switch tags and the glass thermistor mounted on the p.c.b.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R3, R4	22k (4 off)
R5	10k
R6	9k1 (see text)
R7	RA54 glass-encapsulated NTC bead thermistor

All 0·25W 5% carbon film, except R7

Potentiometer

VR1	1k rotary carbon, lin.

Capacitor

C1	100µ radial elect. 25V
C2, C5	1n5 polyester (2 off)
C3, C6	15n polyester (2 off)
C4, C7	150n polyester (2 off)
C8	47µ radial elect. 25V

Semiconductor

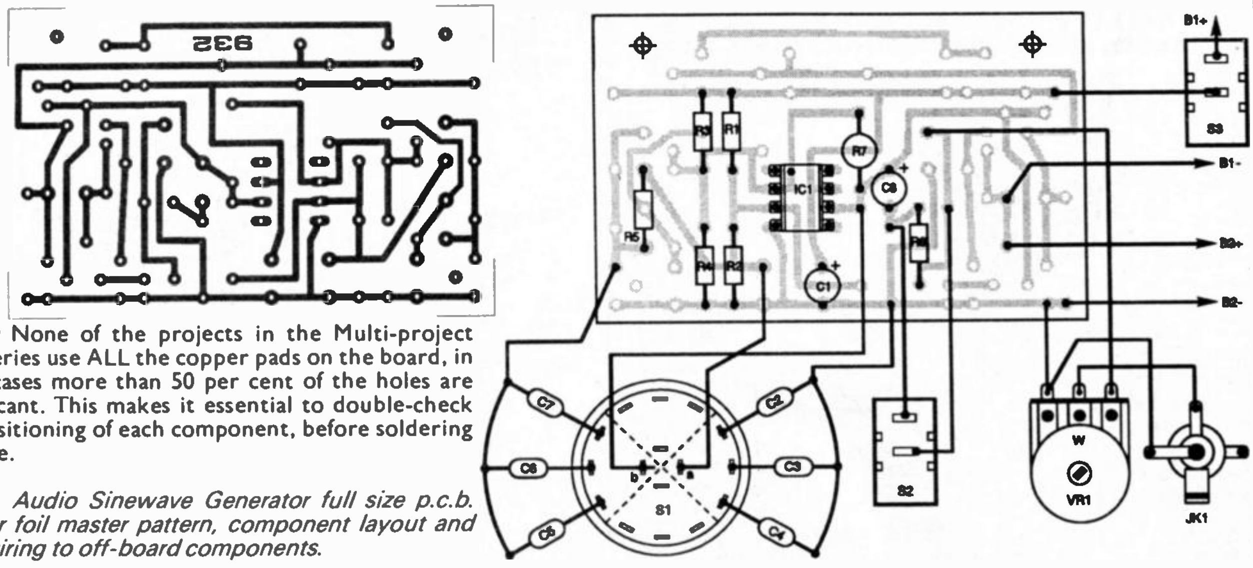
IC1	TLE 2027CP low-noise op.amp

Miscellaneous

JK1	3·5mm mono jack socket
S1	3-way 4-pole rotary (only two poles used)
S2	s.p.s.t. min. toggle switch
S3	s.p.s.t. min. toggle switch
B1, B2	9V battery, with clips (PP3 size, 2 off)

Printed circuit board, one *FREE* cover-mounted (or additional boards available from the *EPE PCB SERVICE*, code 932); small instrument case, size to choice; 8-pin d.i.l. socket; PP3 type battery clip (2 off); control knob (2 off); multistrand connecting wire, solder, etc.

Approx cost guidance only **£19** *excluding Batts.*



Note: None of the projects in the Multi-project PCB series use ALL the copper pads on the board, in most cases more than 50 per cent of the holes are left vacant. This makes it essential to double-check the positioning of each component, before soldering in place.

Fig. 3. Audio Sinewave Generator full size p.c.b. copper foil master pattern, component layout and interwiring to off-board components.

CONSTRUCTION

This simple circuit can be bulit on the *FREE* printed circuit board (p.c.b.) attached to the front cover of this magazine. (If you intend to build all the designs using this p.c.b., you can obtain extra boards from the *EPE PCB Service*, code 932, for the sum of £3 each. Alternatively, you can, of course, purchase extra copies of this issue from your *Newsagent* and make a small saving on the cost of the p.c.b. (the extra copies could be passed to a friend).

The generator circuit will just about fit onto the *EPE Free* printed circuit board, but capacitor C2 to C7 must be mounted on the tags of rotary switch S1 rather than on the board itself. The topside component layout and full size underside copper foil master pattern is shown in Fig. 3.

Also included in the diagram is the interwiring to off-board components. There are a number of connections from the board to controls, etc., and single-sided solder pins should be fitted to the board at the appropriate places.

The TLE2027CP is not a static-sensitive device, but it is not particularly cheap either. It is therefore a good idea to use a holder for this component. In fact it is advisable to use a holder even if a cheaper device is used for IC1.

The thermistor is fairly costly and has a glass encapsulation. It should obviously be treated with due respect. The thermistor can be fitted to the board either way round.

A three-way four-pole rotary switch is used for S1, but in this case only two poles are used, and eight tags are left unused. There should be little difficulty in fitting the six capacitors onto S1 provided the tags and the ends of the leadout wires are generously tinned with solder beforehand.

There is a fair amount of hard wiring for such a small project, so be especially careful to avoid crossed-over connections. Be particularly careful when wiring up switch S3 and the two battery clips. JK1 is a 3·5 millimetre jack socket on the prototype, but this can be a higher quality socket (such as a BNC type) if preferred.

TESTING

If an oscilloscope is available, this can be used to check that the unit is producing "clean" output signals at the appropriate frequencies, and at the correct maximum amplitude. The amplitude of the output signal will stabilise quite quickly when using the two higher output frequencies, but it might take a few seconds to fully settle down after switching S1 to the "100Hz" position.

In the absense of suitable test gear, a *crystal* earphone can be connected to socket JK1 and used to monitor the output signal. Other types of earphone are not suitable incidentally.

Check that adjustment of switch S1 provides *low*, *middle*, and *high* tones, and that the volume of the signal can be controlled properly using S2 and rotary control VR1. A sinewave signal contains just one frequency component, and has an unmistakable "pure" sound which should be readily apparent when listening to the 100Hz and 1kHz output signals.

IN USE

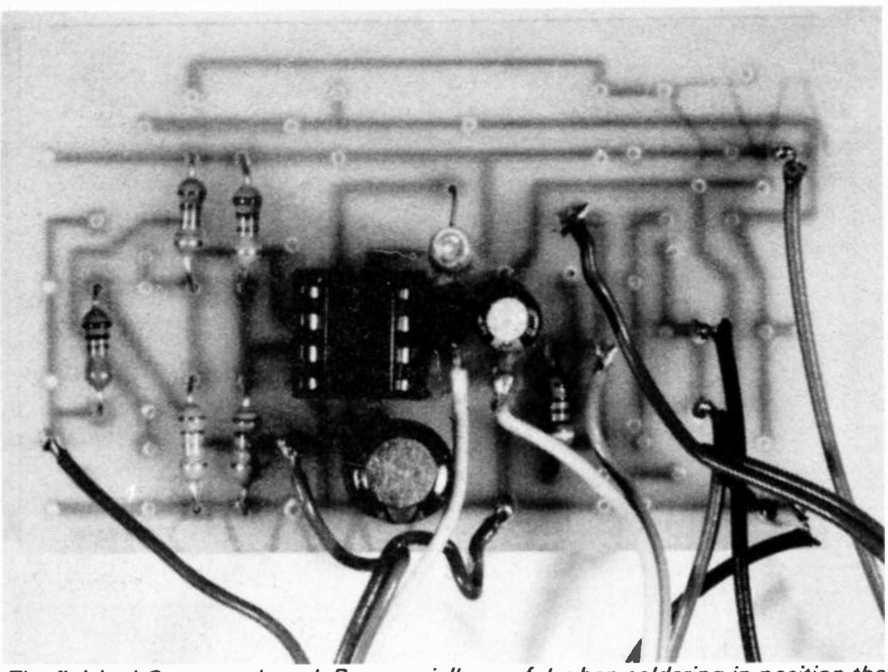
There are many ways of using a unit of this type, and a detailed description of its use goes beyond the scope of this article. The most simple way of using the unit is as a signal injector when trying to locate a fault in an audio amplifier.

The output of the Audio Sinewave Generator is connected to the input of the amplifier, and the generator is set for a suitable output level. For high level inputs (tape, tuner, etc.) results will usually be satisfactory with VR1 at a middle setting and S2 set to the "−20dB" position. For general testing the 1kHz output frequency should be selected.

A signal tracer, which can be something as basic as a crystal earphone and a set of test leads, is then used to check for the signal at various points along the signal path. At some point the signal will be too low in level, badly distorted, or whatever. The fault is then at that point in the amplifier, or immediately prior to it.

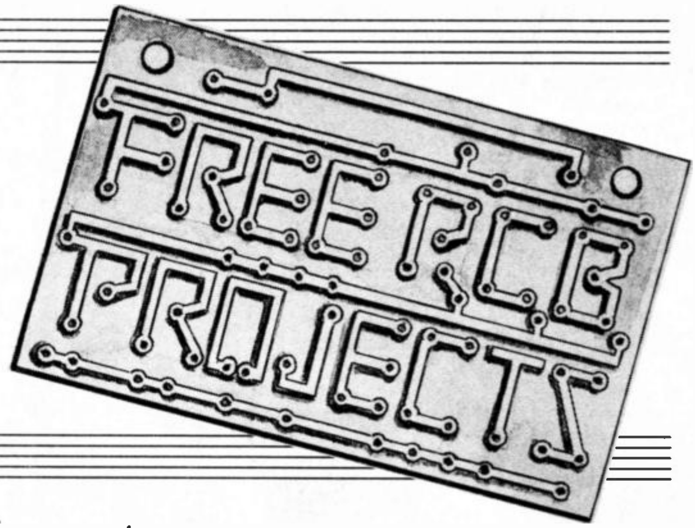
An advantage of using a high quality sinewave test signal is that practically any imperfection imposed on the signal is clearly audible, or easily seen on an oscilloscope display.

The normal safety precautions MUST be taken when making tests on mains powered equipment. Those of limited experience should only use the Sinewave Generator to make tests on battery powered equipment. □



The finished Generator board. Be especially careful when soldering in position the glass bead thermistor and use a d.i.l. socket to take the op.amp i.c.

TREBLE BOOSTER



ROBERT PENFOLD

Give your performance a boost with this popular sound effects unit. Can be built on the FREE p.c.b. attached to this issue.

THE MOST simple means of altering the sound of an electronic instrument is to use some frequency selective filtering. This is the method used in guitar treble boosters, which simply boost the higher audio frequencies.

In general, this means that the fundamental frequency of each note is left unaltered, but the harmonics are boosted. In particular, the higher harmonics are substantially boosted. This is said to give a much "brighter" and "livelier" sound.

The Treble Booster described here is really a form of treble tone control, and it can be used to provide a variable degree of boost or cut. It has a flat response with the tone control at a central setting. The frequency response graph of Fig.1 shows the responses of the unit when set for maximum boost and cut.

There is about 6dB of boost/cut at 1kHz, rising to around 15dB to 17dB of boost/cut at frequencies of about 4kHz to 10kHz. The response is tamed slightly at the highest audio frequencies and beyond, in order to reduce the risk of problems with instability.

When set for maximum boost the circuit provides a response which is comparable to a conventional tone booster. It is useful to be able to back-off the boost slightly if desired, so that a more subtle effect is obtained.

Using treble cut has the opposite effect to using boost, with the fundamental frequencies left largely untouched, and the harmonics severely attenuated. This gives a less shrill and more mellow sound, which could be useful for certain types of music.

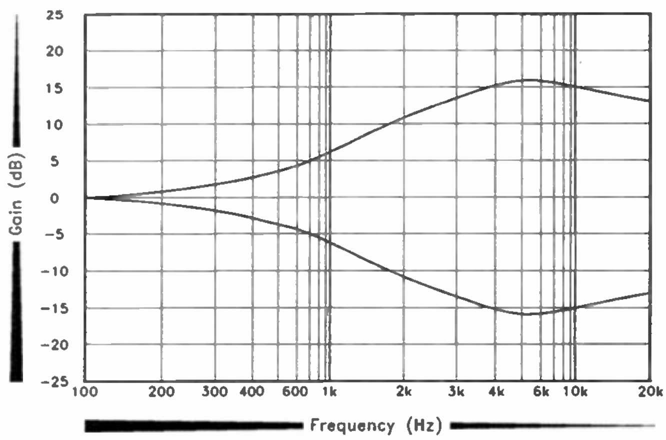


Fig. 1. Frequency responses with maximum boost and cut.

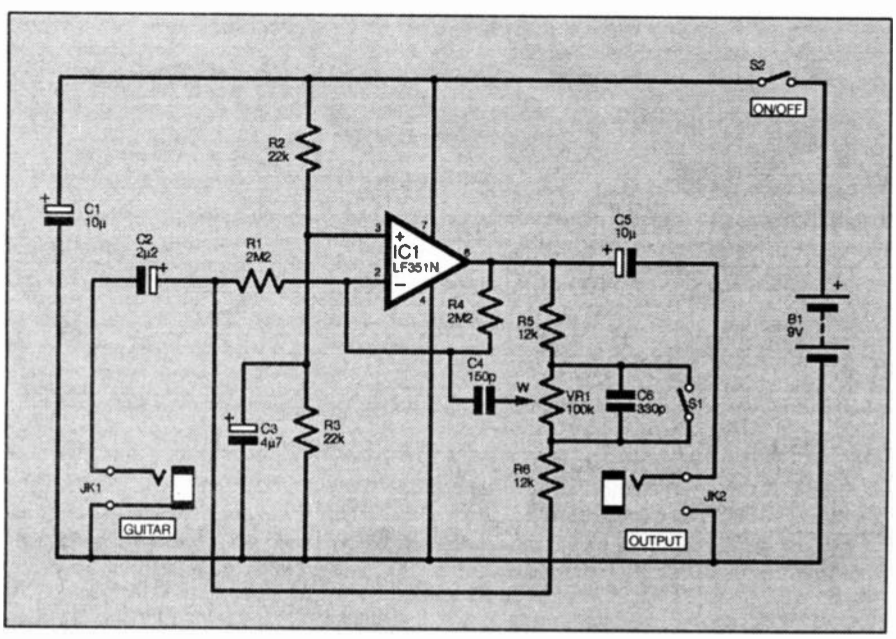


Fig. 2. Complete circuit diagram for the Treble Booster.

CIRCUIT OPERATION

The complete circuit diagram for the Treble Booster is shown in Fig.2. The circuit is basically just a non-inverting mode amplifier. Resistors R2 and R3 bias IC1's non-inverting input (pin 3), and R1 plus R4 act as a negative feedback network that set the closed-loop voltage gain of IC1 at unity.

However, R1 and R4 are only used to set the operating conditions of IC1 at d.c. and low to middle audio frequencies. The *high* frequency voltage gain is governed by a more complex negative feedback network which is comprised of resistors R5, R6, potentiometer VR1 and capacitors C4, C6.

If we ignore capacitor C6 for the moment, R5, VR1, and R6 form a conventional negative feedback network which enables the voltage gain of the circuit to be varied. With the wiper (w) of VR1 towards the top end of its track the circuit provides losses of nearly 20dB. Taking VR1's wiper to the middle of its track gives unity voltage gain, and moving it down to the bottom of the track gives almost 20dB of gain.

If the wiper of VR1 was connected direct to the inverting input (pin 2) of IC1, this cut and boost would be provided at *all* frequencies. Instead, it is coupled to the inverting input via capacitor C4, which has quite a low value. Consequently, C4 only provides an efficient coupling at high frequencies.

At middle and bass frequencies capacitor C4 has a very high impedance, and provides only a loose coupling to IC1's inverting input. Therefore, control VR1 is ineffective at these lower frequencies, where the voltage gain of the circuit is largely governed by resistors R1 and R4. This permits the required boost and cut to be obtained at high frequencies, but keeps the gain at about unity at middle and low frequencies.

Capacitor C6 "tames" the boost at the highest audio frequencies. This is not essential to the effect, but it helps to avoid problems with instability and excessive high frequency "hiss". It effectively places a short circuit across the track of VR1 at very high frequencies, rendering it impotent.

The "bypass" switch S1 can be used to place a short circuit across VR1's track at all frequencies, and this provides a simple means of switching the effect in and out. The current consumption of the circuit is only about 2mA, which gives a very long battery life.

CONSTRUCTION

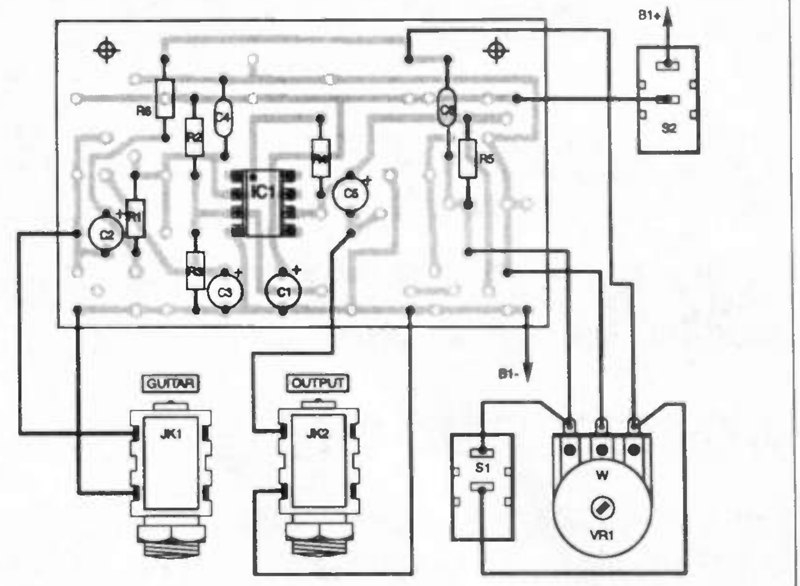
Using the *FREE* printed circuit board from this issue makes construction of the Treble Booster fairly trouble-free. The full size copper foil pattern, component layout, and interwiring for the Treble Booster are shown in Fig.3. The LF351N used for IC1 is not a static sensitive device, but it is as well to use an i.c. holder for it anyway.

As IC1 operates at less than unity voltage gain at some frequencies when VR1 is set to provide treble cut, this can cause instability in some internally compensated operational amplifiers; which are only guaranteed to remain stable at voltage gains of more than unity. The LF351N was found to be stable in this circuit, but other operational amplifiers might have a tendency to oscillate at a high frequency.

Be careful to fit IC1 and the four electrolytic capacitors the right way round. Capacitors C4 and C6 do not need to be close tolerance (one per cent) polystyrene capacitors, and ordinary five per cent types will suffice.

Fit single-sided solder pins to the board at the points where leads from the off-board components will need to be made. To ease soldering, "tin" the tops of the pins with plenty of solder.

There is no need to use "screened" leads for any of the wiring provided the leads are kept reasonably short. Insulated, plastic bodied, jack sockets are used for JK1 and JK2 on the prototype. These are equipped with single break contacts which are not needed in this case. Hence two tags of each socket are left unconnected. Of course, open style jacks can be used if preferred.



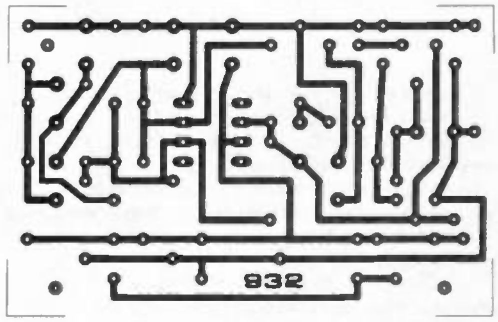


Fig. 3. Treble Booster printed circuit board (p.c.b.) component layout, full size copper foil master and wiring to off-board components.

Note: None of the projects in the Multi-Project PCB series use ALL the copper pads on the board, in most cases more than 50 per cent of the holes are left vacant. This makes it essential to double-check the positioning of each component, before soldering in place.

COMPONENTS

Resistors

R1, R4	2M2 (2 off)
R2, R3	22k (2 off)
R5, R6	12k (2 off)

All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometer

VR1	100k rotary carbon, lin

Capacitors

C1, C5	10μ radial elect. 25V (2 off)
C2	2μ2 radial elect. 50V
C3	4μ7 radial elect. 50V
C4	150p polystyrene
C6	330p polystyrene

Semiconductor

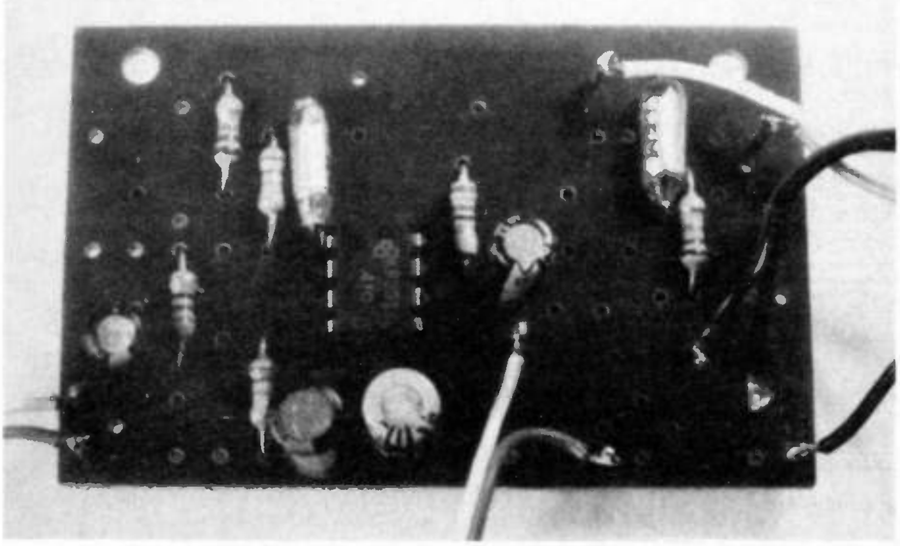
IC1	LF351N J-f.e.t. op.amp

Miscellaneous

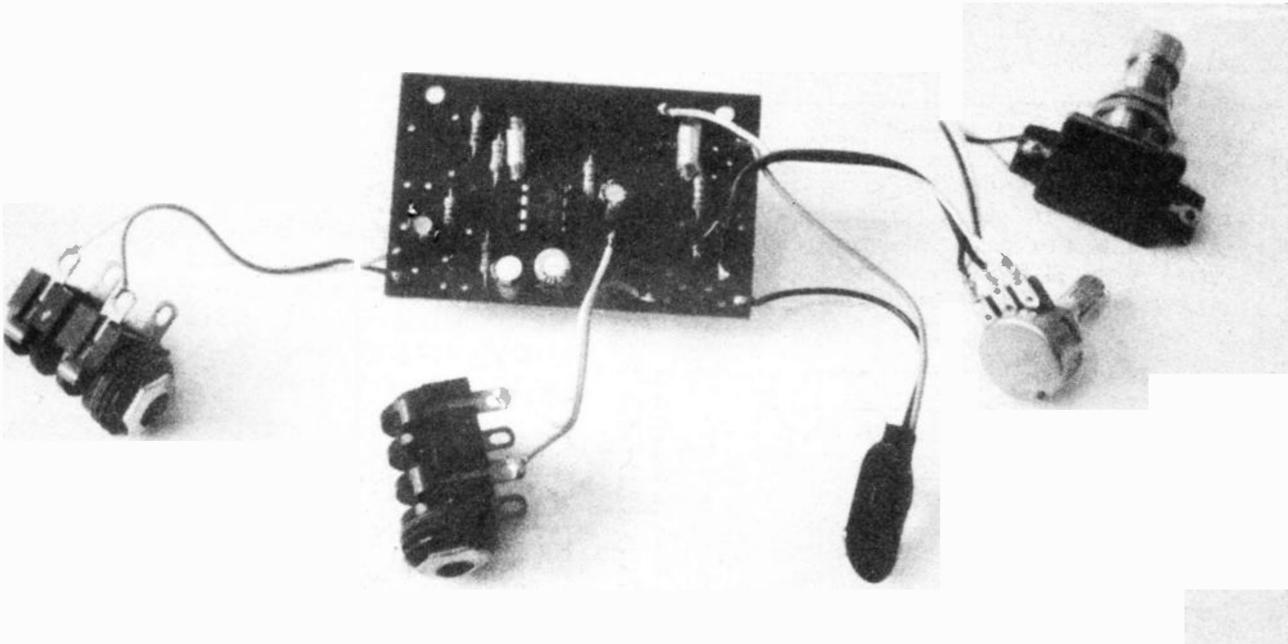
JK1, JK2	Standard, plastic-bodied, mono jack socket (2 off)
S1	s.p.s.t. heavy-duty pushbutton switch (see text)
S2	s.p.s.t. min. toggle switch
B1	9V battery (PP3 size)

Printed circuit board, *FREE* (cover-mounted) with this issue or additional boards from *EPE PCB Service*, code 932; case, metal (size to choice): control knob; 8-pin d.i.l. socket, PP3 type battery clip, multistrand connecting wire, solder, etc.

Approx cost guidance only **£10** *excluding Batt.*



Component layout on the completed printed circuit board.



*The completed Treble Booster p.c.b. showing the two plastic-bodied jack sockets and, top right, the robust heavy-duty "foot-operated" pushbutton switch. These components should all be mounted in a strong **metal** case.*

FOOT CONTROL

A heavy-duty pushbutton switch (S1) is mounted on the top panel of the case so that it can be operated by foot. The normal choice is a successive operation switch. This type of switch is activated once to switch in the effect, a second time to switch it out again, and so on.

It might be difficult to obtain a s.p.s.t. switch of this type. If necessary, the appropriate pair of contacts on a d.p.s.t. or d.p.d.t. switch can be used.

Some users prefer to use a simple push-to-make, release-to-break pushbutton switch. Using an ordinary push-to-make switch, this results in the effect being activated when the switch is released, and switched out when it is pressed. A push-to-break switch has the opposite effect, with the treble boost being switched in when the switch is operated. This second method is probably the most convenient in use.

A small and inexpensive pushbutton switch is not really suitable for an application such as this. It would be difficult to operate at all, and would almost certainly break before too long. The switch must be one of the larger and tougher pushbutton types.

Obviously the case for this project must also be quite tough. A metal case is definitely preferable to a plastic type. Apart from strength considerations, a metal case will provide some screening of the wiring, which will help to minimise stray pick-up of mains "hum" and other electrical noise.

Diecast aluminium boxes are extremely tough, and are a popular choice for guitar effects units. Unfortunately, they are also relatively expensive. A good quality folded aluminium box provides an inexpensive alternative to a diecast type.

IN USE

The guitar is connected to the input socket JK1 on the Treble Booster using an ordinary screened jack lead. A lead of the same type is used to connect the output from JK2 to the input of the guitar amplifier.

With the footswitch S1 closed, the circuit should act as a simple unity gain buffer stage, and the system should work much the same as normal. With S1 opened, the effect of adjusting VR1 should be readily apparent.

If the guitar has a built-in tone control, this should normally be set for maximum treble. Of course, when the Treble Booster is actually used to provide treble cut, it might be better to turn back the guitar's tone control. It is really just a matter of experimenting with various control combinations to find the effects you like best.

Bear in mind that this unit is adding gain into the signal path when it is used to provide boost. As there is no significant increase in gain at low frequencies this should not give increased problems with "hum" pick up. It could increase the risk of problems with feedback though, and it might be necessary to take a little more care in order to avoid such problems. □

INFRA-RED CONTROLLER/ ALARM

FREE PCB PROJECTS

ROBERT PENFOLD

Use your FREE p.c.b., plus one extra board, to build a simple infra-red transmitter and receiver.

Designed to be useful in a number of applications, such as a remote control camera trigger or a "broken beam detector" type alarm

THIS SYSTEM consists of a basic infra-red transmitter and receiver. It can be used as a simple remote control unit, to trigger a camera for example, or as a broken beam type detector for a burglar alarm system. The circuits are essentially the same for both applications.

The range of the system depends on the particular photocells used, but is generally about three to four metres. If the system is used as a broken beam alarm it is possible to obtain a much greater range using one or two lenses.

MODULATED BEAM

The block diagram of Fig. 1 shows the basic arrangement used for this system. The Transmitter uses a special l.e.d. to generate the infra-red signal.

The "light" output from the infra-red l.e.d. is just off the end of the visible red part of the spectrum, at wavelengths of around 900nm. Consequently there is no visible light output, which is obviously important in security applications where the alarm must be heard but not seen.

The output level from the l.e.d. is not very high, which makes it difficult to obtain a useful operating range. At long ranges the output from the l.e.d. tends to be lost in the ambient infra-red level. Matters are made easier by using a pulsed beam, which is easily distinguished from the background infra-red signal, which changes at a relatively slow rate.

The infra-red l.e.d. is driven from an oscillator via a buffer stage that can provide the relatively high drive current needed to give a good operating range. A pulse frequency of a little over 1kHz is used, but the exact operating frequency of the transmitter is unimportant.

A phototransistor at the Receiver turns the pulses of infra-red "light" into small electrical pulses. These are then fed to a high gain a.c. amplifier which boosts them by a factor of more than two hundred. This gives an output voltage swing of a few volts peak-to-peak at the output of the amplifier.

A rectifier and smoothing circuit converts this into a strong d.c. signal that is used to operate a relay driver. The latter in turn switches on the relay, which is basically just a conventional switch operated by an electro-magnet. The relay contacts are used to activate the camera, alarm system, or whatever.

When used in an application such as a remote camera trigger, the transmitter is normally switched off. The output from the amplifier is then just noise, which is inadequate to operate the relay driver and relay. The relay contacts are therefore open under standby conditions, but will close when the transmitter is operated.

If the system is used as a broken beam alarm sensor, the transmitter is switched on continuously, and the relay contacts are normally closed. Someone passing between the transmitter and the receiver will briefly cut off the infra-red signal to the receiver, causing the relay contacts to momentarily open. This momentary change is sufficient to trigger the main alarm circuit.

TRANSMITTER CIRCUIT

The circuit diagram for the Infra-Red Transmitter appears in Fig. 2. The oscillator uses IC1 in what is really a form of relaxation oscillator. Resistors R1 and R2 bias the non-inverting input (pin 3) of IC1, and R3 provides positive feedback over IC1. This gives an inverting trigger action from IC1's inverting input (pin 2) to its output.

If the inverting input, pin 2, is taken slightly above half the supply voltage the output goes low. Taking the inverting input a little below half the supply voltage then results in the output of IC1 switching high again.

Capacitor C2 and resistor R4 are the timing components, and they are connected between the output of IC1 and its inverting input (pin 2). Initially there is no charge on C2, which results in the output of IC1 going high. C2 then charges via R4

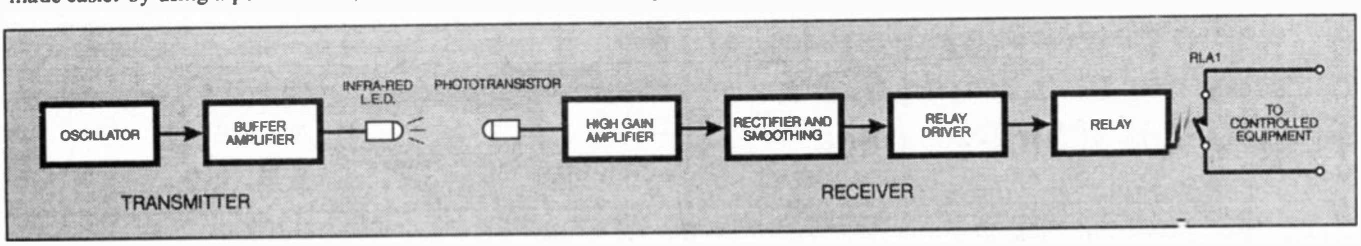


Fig. 1. The block diagram for the Infra-Red Controller/Alarm.

until the charge potential reaches slightly more than half the supply voltage. The output of IC1 then triggers to the low state, and C2 discharges via R4.

This continues until the charge voltage goes slightly below half the supply voltage. IC1's output then triggers to the high state again, and C2 starts to charge via R4 once more. This charge-discharge action continues indefinitely, with a roughly squarewave signal being generated at pin 6, the output of IC1.

This signal is used to drive the infra-red l.e.d. D1, via the emitter follower buffer stage transistor TR1, and current limiter resistor R5. The specified value for R5 sets the l.e.d. current at nearly 100 milliamps, but as the l.e.d. is switched off for about 50 per cent of the time, the average l.e.d. current is a little under 50 milliamps. This is the maximum acceptable drive current for most normal infra-red l.e.d.s.

If used in a Remote Control System, the Transmitter circuit is powered from a 9V battery. Even though the supply current will only be drawn briefly and very intermittently, an ordinary PP3 is not really adequate to power the unit. A "high power" PP3 size battery is suitable, or six HP7 size cells in a holder can be used.

Battery power is not practical if the unit is used in a Burglar Alarm System, and a mains power supply unit must then be used.

RECEIVER CIRCUIT

The full circuit diagram for the Infra-Red Receiver is given in Fig. 3. TR1 is a phototransistor, and it is used in what is almost a standard common emitter amplifier. However, no bias current is fed to the base (b) terminal of TR1.

The collector (c) current is governed by the light level received by TR1. The higher the received light level, the higher the current flow. The pulses of infra-red from the Transmitter therefore produce pulses of leakage current through TR1, which give small negative pulses at TR1's collector.

The output signal from TR1 collector is coupled by capacitor C2 to a high gain inverting amplifier based on IC1. Resistors R2 and R5 are the negative feedback network, and these set the closed-loop voltage gain of IC1 at 220 times.

Capacitor C4 couples the amplified output signal from IC1 pin 6 to a conventional half-wave rectifier and smoothing circuit (D1, D2 and C5). Germanium rather than silicon diodes are used in the rectifier, because germanium types have a lower forward voltage drop. This gives slightly improved sensitivity.

The positive d.c. signal developed across capacitor C5 drives the base of TR2, which is a simple common emitter switch that controls the relay RLA coil. D3 is the usual relay protection diode, and this suppresses the high reverse voltage spike which would otherwise be produced across the highly inductive relay coil each time it was switched off.

A supply current of about 4·5mA to 5mA is drawn when the relay RLA is switched off. The current consumption is much higher while the relay is activated. The exact increase depends on the coil resistance of the relay, but it is generally around 35mA to 40mA.

Battery operation is possible in a remote control application, where the relay will be switched off for the majority of the time. It would still be advisable to use a fairly

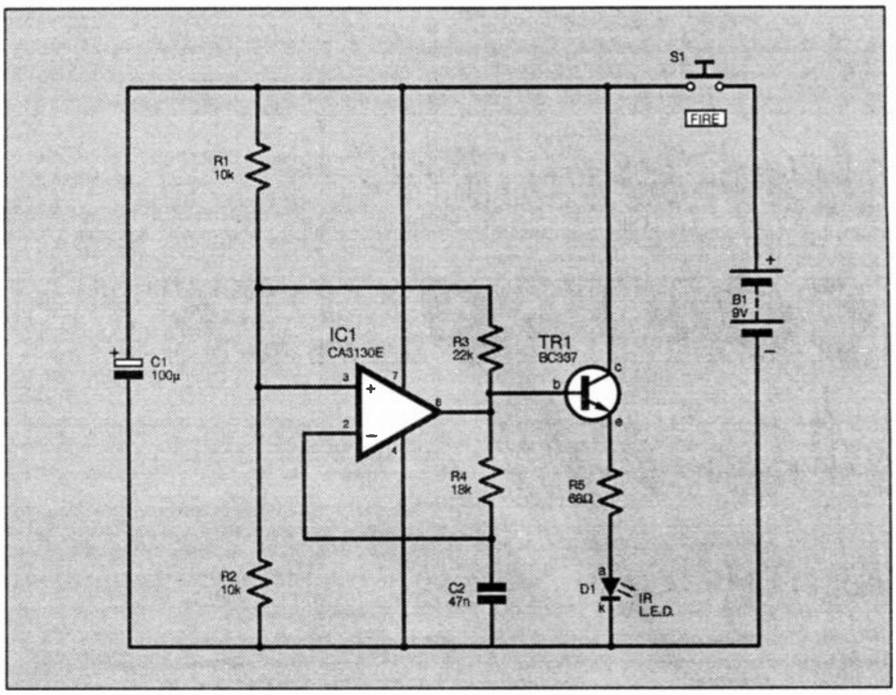
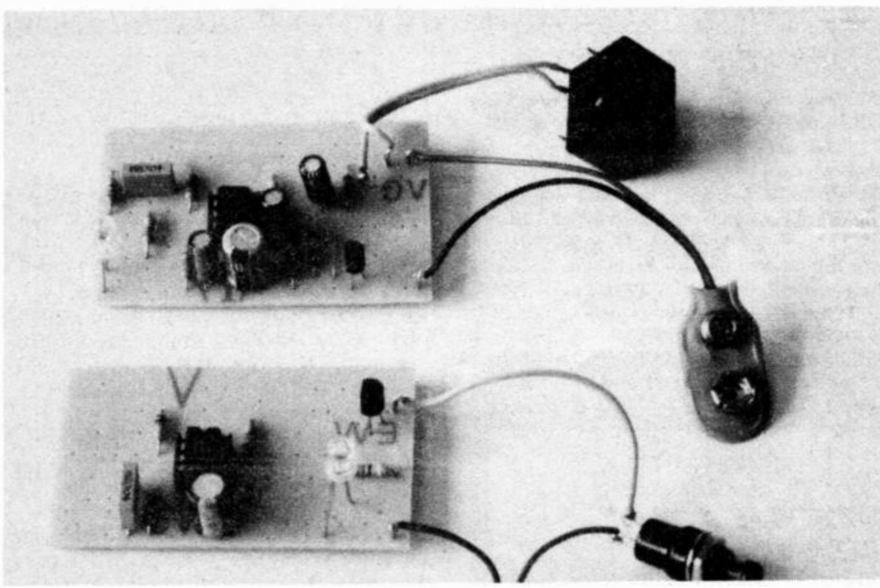


Fig. 2. Complete circuit diagram for the Infra-Red Transmitter.



The completed Transmitter and Receiver (top) p.c.b.s.

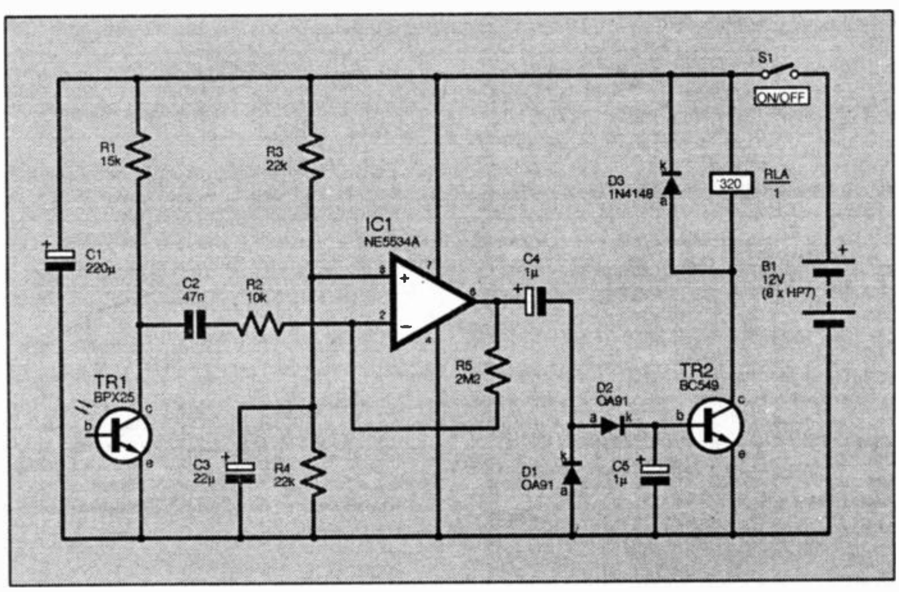


Fig. 3. Circuit diagram for the Infra-Red Receiver. The relay contacts are not shown.

high capacity battery, such as eight HP7 size cells in a holder.

Battery operation is not practical in an alarm application, where the relay will be switched on for long periods of time. A mains power supply must then be used.

CONSTRUCTION

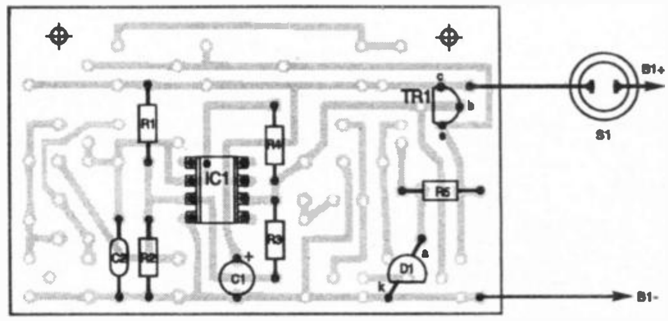
The Infra-Red Controller/Alarm system can be built on the *FREE* cover mounted printed circuit board, but two boards are needed in order to accommodate both ends of the system. Extra boards can be purchased from the *EPE PCB Service* for the sum of £3 each; code 923. (you could, of course, purchase an extra copy from your Newsagent and make a small saving).

The topside component layouts, actual size coper foil master and interwiring for the Transmitter and Receiver are shown in Fig. 4 and Fig. 5. Starting with the Transmitter, the CA3130E used for IC1 is a CMOS device, and it consequently requires the usual anti-static handling precautions.

Use an 8-pin d.i.l. socket for this component, but do not fit it into place until the unit is finished in all other respects. Until then it should be left in its anti-static packing. When fitting IC1 into place handle the device as little as possible.

Commence construction of the Transmitter p.c.b. by inserting and soldering in place the two single-sided pins for the pushbutton and battery negative leads. These should be followed by the resistors, capacitors and semiconductors. Note the polarities of the electrolytic capacitor C1, TR1, l.e.d. D1 and IC1.

Almost any five millimetre diameter infra-red l.e.d. of the type sold for use in remote control systems, etc., can be used for D1. L.E.D.s of this type generally seem to be sold simply as "infra-red l.e.d.s" rather than under a particular type number.



Note: None of the projects in the Multi-Project PCB series use ALL the copper pads on the board, in most cases more than 50 per cent of the holes are left vacant. This makes it essential to double-check the positioning of each component, before soldering in place.

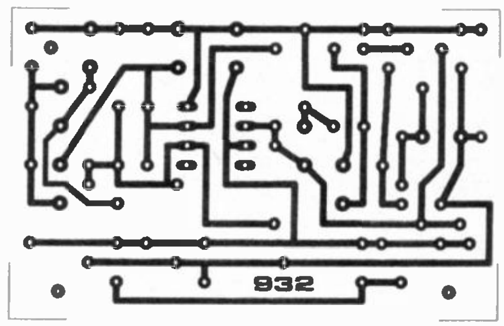


Fig. 4. Transmitter printed circuit board component layout and full size underside copper foil master pattern.

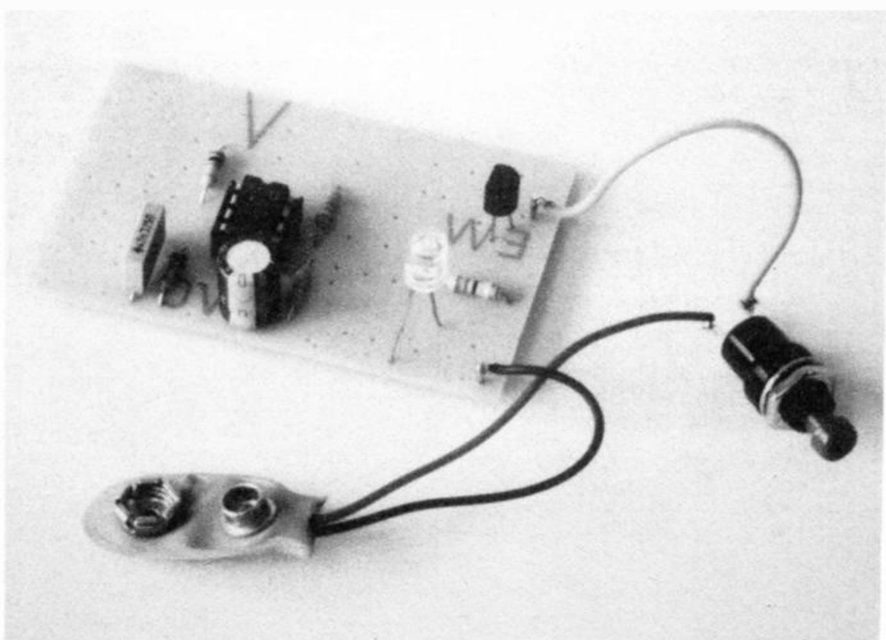
Some of these l.e.d.s have quite a narrow beam, which gives good range, but in a remote control application this can make it a little tricky to get the Transmitter aimed accurately enough. A normal infra-red l.e.d. is probably the better choice if the system will be used as a remote control.

Although D1 is shown as being mounted on the circuit board, in practice it may be better to mount it off-board in a panel-holder, and hard wire it to the board. Alternatively, it can be mounted on the circuit board, with its leadout wires bent through right angles so that it can be pushed into a small hole drilled in one end of the case.

The pushbutton switch S1 is not needed if the system is used as an alarm sensor. The 9V supply is instead fed straight to the circuit board. In an alarm application it might be more convenient to use a 12V supply. This is acceptable, *but only if the value of resistor R5 is raised to 82 ohms.*

RECEIVER

The NE5534A low-noise op.amp i.c. used in the Receiver is not static sensitive, but it is still worthwhile using a holder for this component. D1 and D2 are germanium diodes, and are more vulnerable to heat damage than silicon types.



Layout of components on the Transmitter board. It may be best to mount the infra-red emitting diode off-board in a suitable cutout in the case.

COMPONENTS

TRANSMITTER

See SHOP TALK Page

Resistors
- R1, R2 — 10k (2 off)
- R3 — 22k
- R4 — 18k
- R5 — 68Ω

All 0·25W 5% carbon film

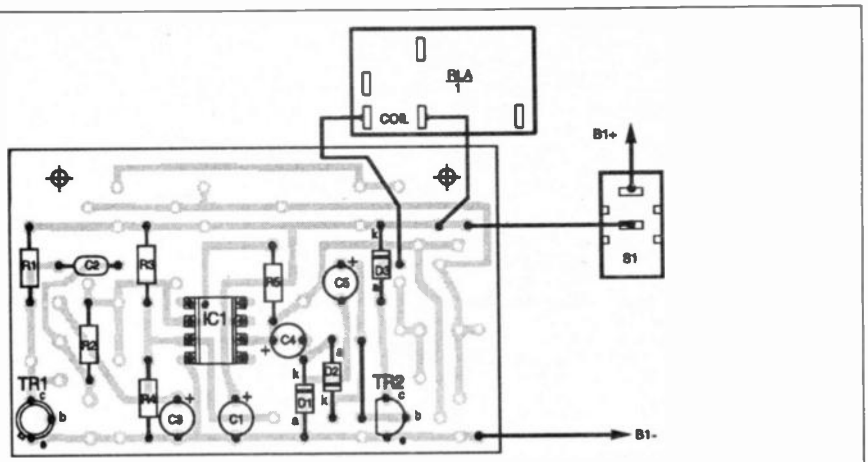
Capacitors
- C1 — 100μ radial elect. 16V
- C2 — 47n polyester

Semiconductors
- D1 — 5mm infra-red light emitting diode
- TR1 — BC337 *npn* silicon transistor
- IC1 — CA3130E CMOS op.amp

Miscellaneous
- B1 — 9V (6 x HP7 cells in holder)
- S1 — Pushbutton switch, push-to-make, release-to-break

Printed circuit board, *FREE* with this issue (plus one extra board for Receiver – available from *EPE PCB Service*, code 932); plastic case, size to suit; 8-pin d.i.l. socket; PP3 type battery clip; multistrand connecting wire; single-ended solder pin (2 off); solder, etc.

Approx cost guidance only **£6** excluding Batts.



Note: None of the projects in the Multi-Project PCB series use ALL the copper pads on the board, in most cases more than 50 per cent of the holes are left vacant. This makes it essential to double-check the positioning of each component, before soldering in place.

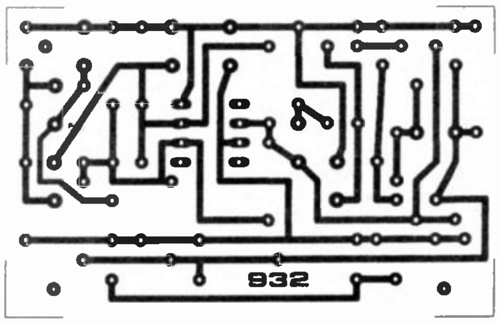


Fig. 5. Receiver p.c.b. component layout, interwiring to relay and switch, and full size underside copper foil master.

It should not be necessary to use a heat-shunt when fitting these two diodes, but the iron should be applied to each joint for no longer than is really necessary. Do not overlook the link-wire just to the right of D2.

Although a BPX25 phototransistor is specified for TR1, virtually any silicon *npn* phototransistor will work well in this circuit. This includes lower cost types, such as the TIL81 and BPY62.

The circuit also seems to work well with l.e.d.-like devices such as the RS/Electromail BP103B. These do not have a base leadout wire, but the base terminal is not used in this circuit anyway. The shorter lead is the collector (c) terminal. Photodiodes are not suitable for use in this circuit, because they give inadequate sensitivity.

RELAY

The relay RLA has to be mounted off-board as there is insufficient space for the relay on the circuit board. Any relay having a 12V coil with a resistance of about 250 ohms or more, plus suitable contacts of adequate rating, is suitable for this project.

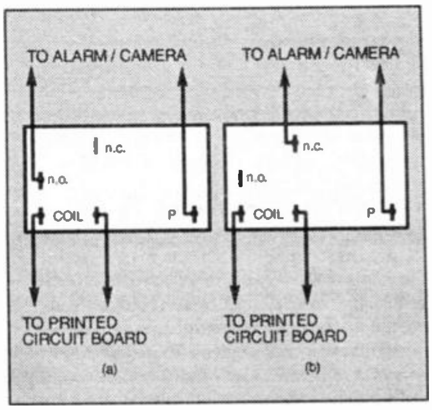
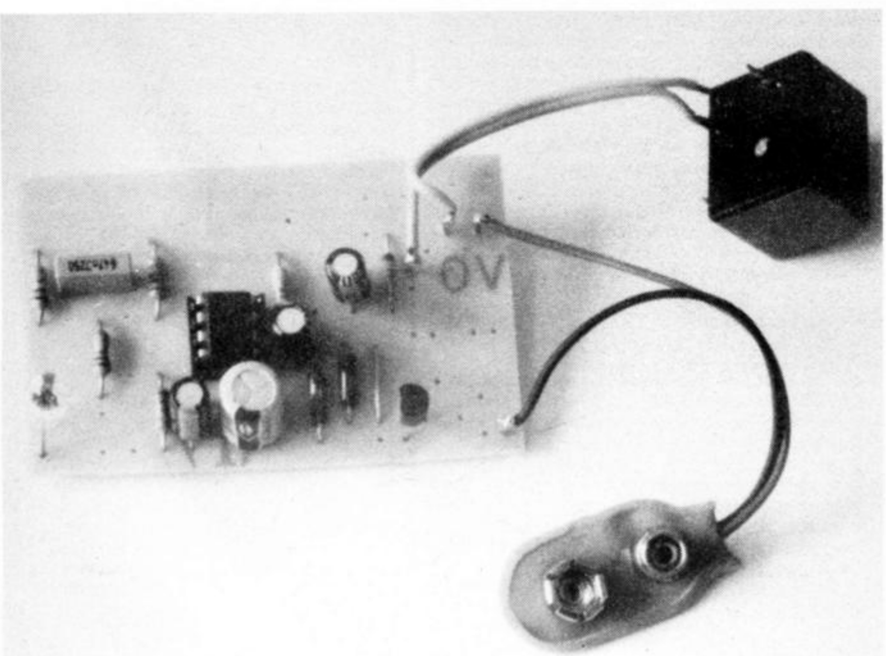


Fig. 6. Using the relay to provide normally open (a) and normally closed (b) contacts.

Modern relays do not usually have provision for any form of chassis mounting. However, there should be no difficulty in gluing the relay to the inside of a plastic or metal case. Use a good quality adhesive such as a "Super Glue" or an epoxy resin type.

The specified relay has changeover contacts, but in an alarm or remote control application the pole (p) and normally open (n.o.) contacts are used, with the normally closed (n.c.) tag being left unconnected, see Fig. 6a. In some applications it might be necessary to have a set of normally closed contacts. For example, if a camera must be triggered when the beam is broken, and the relay switches off. The connections to the relay if normally closed contacts are required is depicted in Fig. 6b.



Component layout and wiring for the Receiver board. The relay will need to be glued in position in the case.

COMPONENTS

RECEIVER

See SHOP TALK Page

Resistors

R1	15k
R2	10k
R3, R4	22k (2 off)
R5	2M2

All 0·25W 5% carbon film

Capacitors

C1	220µ radial elect. 16V
C2	47n polyester
C3	22µ radial elect. 16V
C4, C5	1µ radial elect. 50V (2 off)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
D3	1N4148 silicon diode
TR1	BPX25 *npn* phototransistor (see text)
TR2	BC549 *npn* silicon transistor
IC1	NE5534A low-noise op.amp

Miscellaneous

S1	s.p.s.t. min toggle switch
B1	12V battery pack (8 x HP7 size cells in holder)
RLA	12V 320 ohm coil, with s.p.d.t. contacts rated according to application (see text)

Printed circuit board, (extra) available from *EPE PCB Service*, code 932; case, size to suit; 8-pin d.i.l. socket; multistrand connecting wire; PP3 type battery clip; solder pin (4 off); solder, etc.

Approx cost guidance only **£11** excluding Batts.

OPTICS

For most purposes the system will have sufficient range using just the built-in lenses of the photocells. In an alarm application where a large operating range is required it may be necessary to resort to one or two additional lenses.

Positive (convex) lenses having a diameter of about 25mm to 50mm and a focal length of around 50mm to 100mm are required. The lens at the Transmitter focuses the infra-red signal into a tight beam. The lens at the Receiver gathers up infra-red "light" over a relatively large area, and concentrates it onto the phototransistor.

It is not necessary to use high quality lenses, and the inexpensive plastic types available from electronic component retailers are perfectly suitable. These have an overall diameter of about 37mm, a lens diameter of 30mm, and a focal length of 80mm. The 3·5mm rim around each lens enables it to be glued in position using any good general purpose adhesive.

The basic arrangement used with a twin lens system is shown in Fig. 7. The distance between each photocell and its lens is equal to the focal length of the lens. The specified distance of 80mm will probably need to be altered if you use something other than the lenses mentioned above.

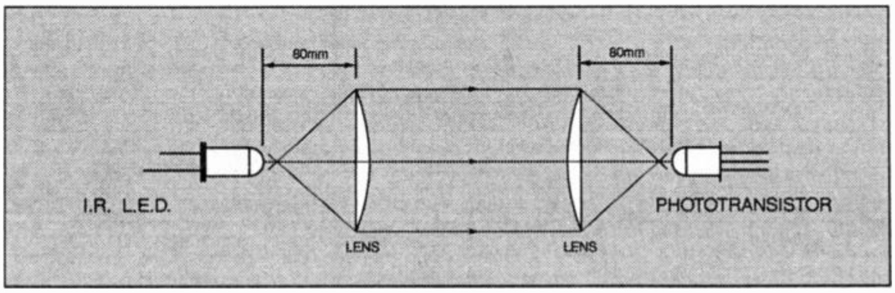


Fig. 7. Using a simple optical system to give increased range.

Adding the lenses greatly boosts the range of the system, and a maximum range as great as 40 to 50 metres might be achievable. For a more modest increase in range (about 10 metres) it is only necessary to use a lens at one end of the system.

Adding a lens to either unit makes it extremely directional. The aim of the unit then needs to be extremely good if the system is to work, even over short distances.

With a lens used at each end of the system, both units must be aimed very accurately. Getting everything set up correctly is made more difficult by the invisible nature of the "light" from the transmitter.

Getting the system operating properly over a long range can take a lot of trial and error. Because of this increased directivity, it is not practical to use a lens or lenses to give increased range in a remote control application.

TESTING

Initially it is best to try the system over a short range of about one metre, omitting any optical system. If all is well, gradually try the system over a greater range to establish its maximum usable range, and where appropriate, add in the lenses and try to get everything set up correctly.

In use, try to avoid having the equipment set up in a fashion that results in the receiver "looking" at strong light sources. In particular, avoid having the receiver "look" at modulated light sources, such as mains lighting. Strong light sources could reduce the sensitivity of the receiver, and modulated light sources could hold the receiver with the relay switched on. □

SHOP TALK
with David Barrington

Ginormous VU Meter

The transconductance op.amp i.c., type CA3080, used in the *Ginormous VU Meter* project is a fairly popular device and should be generally available. However, it is the 8-pin d.i.l. version that we are after here and the suffix E (denoting d.i.l. package) should be quoted after the type number.

As "disco" equipment usually leads a very robust lifestyle, the finished VU Meter should be housed in a strong metal box. Also, provided the unit is well "earthed," potentiometer VR1 should have a metal shaft and be fitted with a metal knob for strength.

The 8-way Bulgin P552 sockets and matching plugs should be available from most of our component supplier advertisers. They should also be able to offer suitable "mains" transformers. The ones used in the prototype model came from the **Maplin** wire-ended range.

The large printed circuit board is available from the *EPE PCB Service*, code 956. Don't forget to reinforce the mains carrying p.c.b. tracks with additional "runs" of solder and/or extra tinned copper wire. All mains carrying wiring ***MUST*** be 6A minimum rating.

Sound Switch

The main points to watch out for when constructing the *Sound Switch* project are: the presence of "mains" voltages; to use properly rated, about 5A to 6A minimum, wiring were indicated and, most importantly, to use a well Earthed *metal* case.

The relay used in the prototype appears to be the **Maplin** "Miniature Double-pole Mains Relay" (code YX98G), with contacts rated at 5A 240V a.c. and a coil rating of 200 ohms. This is a fairly standard rating for a mains relay and other similar rated types can be used, but check first that it will sit on the circuit board or be prepared to "hard-wire" it to the p.c.b. Make sure the relay connecting tags are covered with insulating sleeving.

The 8211 voltage reference chip is currently listed by **Cricklewood Electronics** and **Maplin**. The small 66m dia. louspeaker used as the sensor transducer should be available from most of our component advertisers. The ZN1034E precision timer should also be generally available.

The Sound Switch p. c.b. is available from the *EPE PCB Service*, code 915.

Capacitor Check

Selecting the resistors for the range selector switch in the *Capacitor Check* project may prove quite a problem as we progress around the switch to the higher megohm values. The table in the article helps by showing the "ideal" value together with the actual make up or grouping of resistors to find the best compromise.

Once you reach the lowest capacitor range you require a resistor above the 100 megohm value. Resistors greater than even 10 megohms do not appear to be that readily available and multiple resistors connected in series will be needed.

The 47MΩ and 33MΩ resistors used in the prototype are listed by **Maplin** as "high voltage", metal film resistors. An alternative would be to used resistors from the "high ohmic" range supplied by **Electromail** (☎ *01536 204555*). Two would be required one of 100MΩ and one of 33MΩ

The single-pole 12-way, make-before-break, rotary switch will be found to have only 11 positions instead of the 12 required. The answer is to remove the brass nut and discard the tab washer which acts as the limit stop. The Rotary switch in the model is a Lorlin type and came from Maplin (code FH42V). Note it must be a "make-before-break" type.

The printed circuit board is available from the *EPE PCB Service*, code 955.

Audio Sinewave Generator

Some readers may find difficulty in locating the precision low-noise op.amp type TLE2027CP for the *Audio Sinewave Generator*, Free p.c.b. project. This was purchased from Maplin, code CP86T.

The RA53 is usually the normal choice of thermistor in this type of circuit, but due to its lower cost an RA54 has been selected for this circuit. Although, to be honest, it was found that prices did not vary too much from one device to another, according to where the purchase was made. In fact, **Cricklewood** (☎ *0181 450 0995*) list both devices at £9 whereas Maplin only list the RA53 at £12.99.

Infra-Red Controller/Alarm

The 5mm infra-red light emitting diode used in the Transmitter circuit of the *Infra-red Controller/Alarm, Free* p.c.b. project should be readily available from advertisers.

Turning now to the Receiver all components seem straightforward and should not present any sourcing difficulties. Most of our component advertisers should stock the BPX25 phototransistor or its equivalent. This includes the TIL81 and the BPY62 types.

Any relay having a 12V coil with a resistance of about 250 ohms or more, plus suitable contacts of adequate rating, is suitable for this project. The one used here is from the Maplin "Ultra Miniature High Power Mains Relay, code YX97F. This can control currents up to 10A and can be used to control 240V a.c. equipment.

The lenses used in this sytem do not have to be high quality types. The ones used in the models are the red plastic type sold by Maplin, code FA95D, and have a focal length of 80mm, an overall diameter of 37mm, and a lens diameter of 30mm.

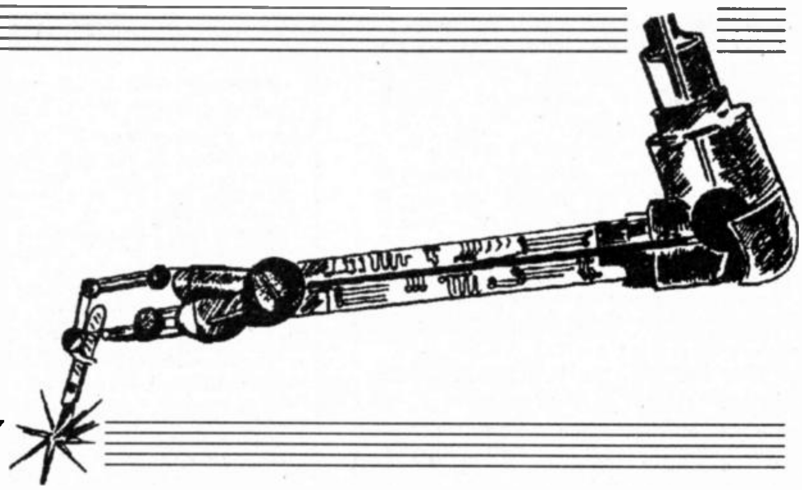
Treble Booster

The only item that needs to be chosen with care when building the *Treble Booster*, a Free p.c.b. project, is the robust, heavy-duty footswitch. It is difficult to find a s.p.s.t. type and the one used in our model came from **Maplin**, code FH92A, and is a s.p.d.t. type; the centre tag being the common one. These switches are fairly expensive and advertisers such as **Bull Electrical**, **Greenweld** and **J&N Factors** often have them on "special offer".

Extra printed circuit boards for all this month's and next month's "Multi-PCB" projects are available from the *EPE PCB Service*, code 932 (see page 822).

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

Welcome aboard to our regular roundup of readers' queries. We look at those mysterious IP numbers describing enclosures, several simple circuits are offered for l.e.d. flashers for cyclists and modelmakers, and we've a brief roundup of major semiconductor sites available on the World Wide Web. We also ask – how do you dispose of used p.c.b. etchant?

LET'S kick off straight away with a question on using heavy duty boxes for projects which are likely to have to withstand some rough treatment.

Boxing Clever

My young son and I enjoy metal detecting. However we have succeeded twice in ruining one of my cherished metal detectors – both by severe impact and also by drowning in seawater!

This raises the questions of how one may best protect electronic equipment against impact and moisture. Could you help? Kind regards from ***Rev. Thomas Scarborough****, Cape Town 8001, South Africa.*

If you're referring to home-made equipment, then there are several things that can be done when buying parts which will help your project to survive a tough environment. For instance, certain switches (notably larger toggle types) can sometimes be fitted with a specially-made waterproof "boot" over the toggle of the switch, this will completely seal the switch and prevent water entering.

Potentiometers are a bit trickier, but I've seen silicone rubber waterproof seals which fasten down over a standard ¼in. shaft ("Hexseals" Order Code 146-839, from **Farnell Electronic Components Ltd.**, (☎ *0113 263 6311*) and they prevent the ingress of salt water, etc. into the electronics within the casing – but only if the shaft is circular and doesn't have a "flat" all the way down. Miniature hermetically sealed potentiometers with integral control knob can be bought, too. One manufacturer is Vishay (again, distributed by Farnell, Order Code 350-618 et al.).

If your metal detector has a loudspeaker output, then a mylar (polyester) cone type could be used as these, unlike ordinary paper cones, are waterproof. Presenting much more of a problem are components such as jack sockets, slide switches, meters etc. I don't know of any realistic and reliable way of "weatherproofing" them, and so they represent a potential troublespot if you decide to dunk your treasure hunter into the briny!

Also consider the use of aerosol spray varnishes to cover printed circuit boards fully, provided that no moving parts are interfered with. Ultimately, plastic embedding compounds can be used to "pot" the entire board and make it completely weatherproof, but impossible to repair into the bargain!

IP Ratings

By manufacturing them to a tighter tolerance and by using suitable gaskets etc., plastic and metal boxes are available which are specially designed to be waterproof and dustproof. You'll often see an "IP" Rating for such enclosures given in the more up-market catalogues.

The table below summarises the IP system, as defined in BS EN 60529:1992 *Specification for degrees of protection provided by enclosures.* You'll see that the higher the IP number, the more dust- and waterproof they become (and consequently they become increasingly expensive).

Shock Proof

A limited degree of entry by water may be allowed under this system, providing the amount is deemed insignificant. An enclosure rated IP65 would probably be adequate for most weather-sensitive applications, or IP67 for extreme conditions – if you can afford it!

Table 1: IP Ratings

Digit	*First Digit (Protection against entry by solid objects)*	*Second Digit (Protection against entry by liquids)*
0	Nil protection	Nil protection
1	Protected against solid objects >50mm diameter	Protected against dripping water
2	Protected against solid objects >12mm diameter	Protected against spray entry up to 15 degrees from vertical
3	Protected against solid objects > 2·5mm diameter	Protected against spray entry up to 60 degrees from vertical
4	Protected against solid objects > 1·0mm diameter	Protected against water splashing from any direction
5	Limited protection against entry by dust particles	Protected from low pressure water jets
6	Fully protected against dust entry.	Protected against heavy sea spray
7		Protected when immersed between 15cm to 1m depth
8		Protected when fully submerged for long periods.

As far as mechanical shock protection goes, any printed circuit boards which are made of fibreglass can be considered virtually indestructible (not withstanding hole-density weaknesses). Paxolin boards are susceptible to damage and shouldn't really be used in such applications. The same goes for stripboard, which by its very nature, breaks extremely easily. Any large, bulky components which are p.c.b. mounted are best secured down on the board using hot melt glue for instance, to guard against impact and vibration damage.

Obviously, select an enclosure which is strong enough to withstand some abuse. Polystyrene will shatter and isn't suitable, high-impact styrene, polypropylene or ABS (Acrylonitrile Butadiene Styrene) housings are better, otherwise go for an aluminium-alloy diecast type, choosing a suitable IP rating. Also, very many plastics become brittle at low temperatures and are more likely to crack through impact when it's cold.

Cycle L.E.D. Flasher

John. O. Allen in Navan County, Meath, Ireland, pedalled along with the following question:

"I was wondering if you have a circuit for blinking l.e.d.s. for the rear of push bikes, it's the "in-thing" today. Hope you can help!"

The fact that light emitting diodes (l.e.d.s) are compact and use minimal current means that they've really caught on as flashing beacons for bicycles. Horseriders use them as well. Red flashers are used for the rear whilst green or yellow l.e.d.s may often be seen facing on-coming traffic.

In the UK, though, it is not yet legal to use these as the main cycle light, but the law is currently under review. The British Standard BS6102 Part 3 – against which current legislation cross refers – *does not* in its present form allow l.e.d. lamps to be fitted, so they're technically illegal when used as the *sole* light source.

However, when riding at night, although cyclists must have lamps and reflectors which comply with the Standards, they can fit *additional* lighting within certain constraints – notably that lights at the front should be white, and red to the rear and technically they should *not* flash. Nonetheless, flashing lamps are now widely available and UK law is expected to change soon to permit them to be used, says the Bicycle Association. It's up to you whether you decide to use one or not. Personally, I think their merits far outweigh any arguments against.

A suitable bipolar integrated circuit which was specially designed for flashing l.e.d.s efficiently, is the National LM3909. In theory this can drive a 2V l.e.d. just from one 1·5V cell, however I find it more effective to use two batteries.

A suitable "flasher" circuit, using the LM3909, which could be used to supplement existing traditional filament lighting is shown in Fig. 1. Note the low component count, it powers one l.e.d.

I suggest that a high intensity l.e.d. is used, which although superbright has a relatively narrow viewing angle which could perhaps be enhanced with the use of l.e.d. reflectors. I can point readers in the direction of **ElectroValue Ltd.** (☎ ***01784 442253***) who uniquely list in their catalogue, 12mm diameter plastic reflectors which push-fit onto 3mm and 5mm devices.

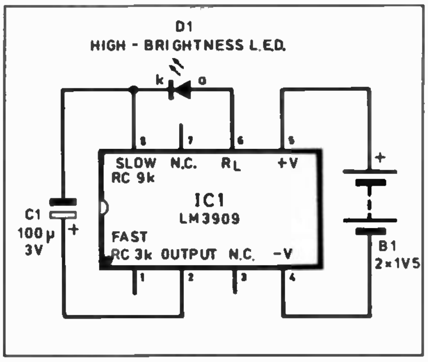


Fig. 1. Circuit diagram for a single L.E.D. Flasher, with low component count.

How multiple light emitting diodes could be driven from one chip, still using the LM3909, is given in the circuit diagram of Fig. 2. Try the circuit with one or two 1·5V cells, and experiment with the component values.

One point to observe is the use of individual series resistors with each l.e.d. This may seem over-elaborate, but there is a reason: light-emitting diodes each have a forward voltage (V_f, typically 1·8V) which may differ from that of its neighbours.

If one l.e.d. has an unusually low forward voltage, it would shunt all the other l.e.d.s. which would then all be dimmed undesirably. Using a series resistor enables each l.e.d. to "settle" to its own inherent forward voltage, any error voltage appearing across the resistor – so none of the l.e.d.s. forward voltages will affect the performance of any of the others.

The intensity of l.e.d.s is measured in mcd's – milliCandelas. Ordinary l.e.d.s may have an intensity of just a few mcds, but superbright high intensity lamps are made, notably by Hewlett Packard, which output several Candelas (2000 – 3000 mcds).

The down-side is that the viewing angle of high brightness types may be restricted to just a few degrees. Check through the current crop of catalogues and compare specifications (and price!).

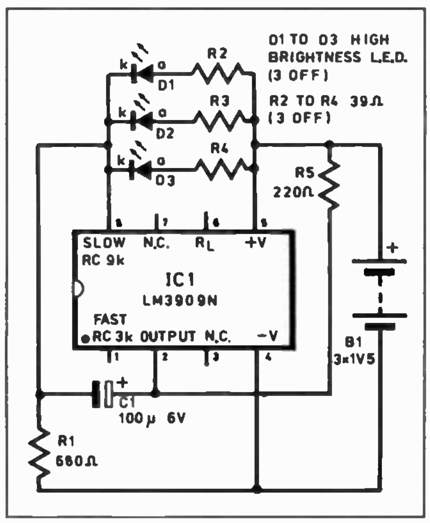


Fig. 2. Circuit diagram for driving multiple l.e.d.s from a single LM3909 "flasher" chip.

Etchant Disposal – How?

One question which crops up time and again, and which causes concern amongst readers, relates to the safe and proper disposal of ferric chloride etchant. Is there an environmentally-friendly way?

One thing I'd never do is tip it down a kitchen sink or a lavatory. The product stains everything it touches and can ruin domestic kitchen surrounds if splashed or spilt.

Some will say that it should be taken to a rubbish dump – but in my locality at least, local authorities will not accept ferric chloride solution or any other such substances at a household refuse site. A minor dilemma is that it's unrealistic to expect people to travel vast distances to find a properly licensed chemical waste site, but it's also clearly irresponsible to tip any used etchant onto soil or bury it.

At least one product, the Seno "Etch-In-A-Bag" system includes a neutraliser powder which when added to the etchant, will solidify it and render it harmless. The resulting solid mass can then be thrown away in a dustbin when it will eventually finish up at a landfill site.

One suggestion I've seen somewhere on the Internet is to neutralise the product with caustic or sodium carbonate and mix it with a concrete or mortar mix. The etchant is converted to an immobile form which can safely go to landfill.

Any more views? Write in!

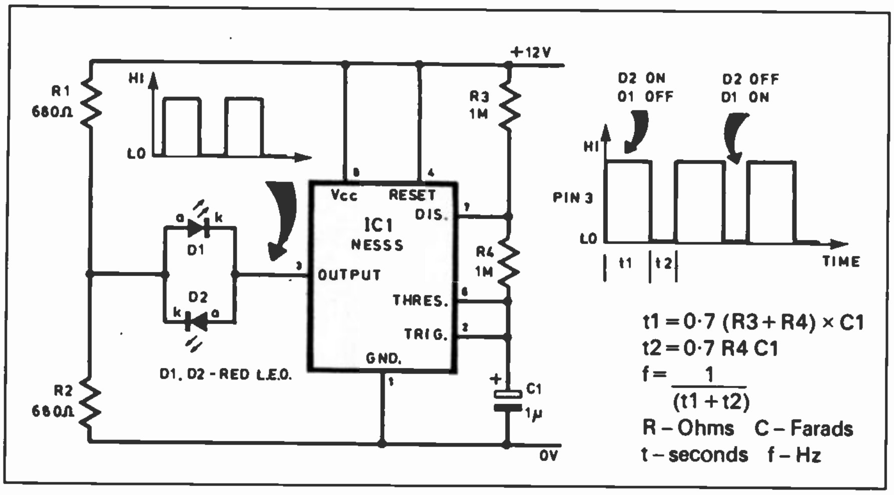


Fig. 3. Circuit diagram of an L.E.D. Flasher, suitable for 12V operation. The timing formulae are also shown.

Aerial Combat

A couple of questions more on l.e.d. flasher circuits. One from ***Mr. T. J. Angell*** of Cwmaman, Mid Glamorgan:

"I hope you can help me with what must be a very simple device! How can I make two l.e.d.s. flash alternately at about one cycle per second (not critical) using a 12V supply?"

Also from ***Philip Wheeler*** of Sanderstead, Surrey (via CompuServe):

"At a model show I recently attended, I saw an interesting electronics circuit to simulate "guns" on an aircraft. It used two ultrabright red l.e.d.s. for each wing. They flashed at a rate of about 3Hz to 4Hz to simulate automatic fire, and were activated by a servomotor. Could you help with a circuit?"

Probably the easiest way is to use an ordinary 555 timer chip, connected as an astable multivibrator. In the case of Mr. Angell's requirement for an alternating flasher, in Fig. 3 the output section is slightly unusual in that the square wave output toggles between high and low which causes the appropriate l.e.d.s. to illuminate alternately although it's impossible to obtain a perfect 1:1 mark:space ratio. This will function from 12V d.c. without any problem. I've also shown the formulae for calculating the timing.

To fit the modelmaker's application, Fig. 4 is suggested. I'm not sure how tight space will be, the circuit will run from 4·5V upwards, so I suggest a supply of 9V d.c. derived from a PP3 battery. A small lever-operated microswitch could be used for S1 which could be closed by a servo cam. I'll leave the aerospace mechanics up to you!

The maximum output of the bipolar NE555V is 200mA – twice that of the CMOS version whose output tends to fall when the output current rises. The downside is that the NE555V draws a higher quiescent current – but I think an alkaline battery (e.g. MN1604) would be fine, otherwise you may be able to use the aircraft's existing supply.

Semiconductor WWW Sites

Finishing with what's happening on the Internet, many semiconductor manufacturers now have their own presence on the World Wide Web, and some of them let you gain access to product information and data sheets on-line. For example, you could try:

Harris Semiconductor:
http://www.harris.com (under construction; or try www.semi.harris.com/datasheets)
Intel: http://www.intel.com
Motorola: http://www.motorola.com
National Semiconductor:
http://www.nsc.com:8080/ds/ds.html
Philips Semiconductors:
http://www.semiconductors.philips.com/ps/
Texas Instruments: http://www.ti.com

The URL's (Universal Resource Locator) shown above were accurate at the time of writing. Be warned that some Data Sheets, when available, may only be available in Adobe or Postscript format – the Harris WWW site looks like it will give you Adobe Acrobat (1.5Mb), free of charge, but I haven't tried it. If anyone knows of any other interesting sites, either WWW or vanilla ftp, please Email me and I'll share them with everyone!

One topical site which did catch my eye – anyone who has built our *Simple Theremin* project will be interested in the Theremin Home Page maintained by Vanderbilt University School of Engineering, Nashville, Tennessee:-
http://www.vuse.vanderbilt.edu/~jbbarile/wwwfiles/theremin.html

This American World Wide Web page is dedicated to the inventor of the Theremin, its use and construction. It gives a history of the invention plus a list of bands using the Theremin, and more!

Finally – for all budding scientists, try the URL
http://www.eskimo.com/~billb/amasci.html which is a link to the American "Information for the Science Hobbyist" Home Page. Must see, lots of really cool and exciting things to do and see! (It says here.)

Education Service

It's that time again! *Our Circuit Surgery Education Service* is designed to support the teaching of GCSE and Advanced Level electronics, helping teachers as well as students. If you have any particular questions, feel free to drop us a line and we'll do our best to help!

Please *don't* ask us for circuit diagrams for your chosen project – we won't do it! But we'll be happy to offer pointers, advice and subtle tips wherever possible, especially if you're stuck with your current project work or would like another opinion. *If you do not wish your query to be published, please state this clearly.*

Two-way Clinic

Circuit Surgery is our "two-way" page devoted to helping readers with questions and queries, and generally passing on hot hints and tips. If you have any topical comments or puzzling problems in the field of hobby or educational electronics which you'd like us to investigate, please write to: Alan Winstanley, Circuit Surgery, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. Email **alan@epemag.demon.co.uk.**

We can't guarantee an individual reply unless we intend to use it in the column, but you'll find we'll generally come up with something! Next month is the turn of *Ingenuity Unlimited* once again – see you soon.

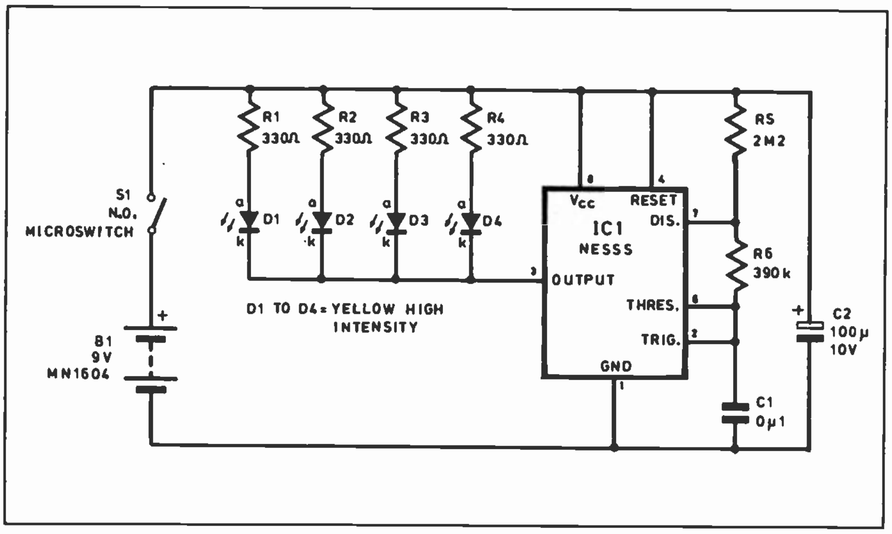


Fig. 4. Experimental circuit diagram for producing an imitation machine-gun effect for model aircraft.

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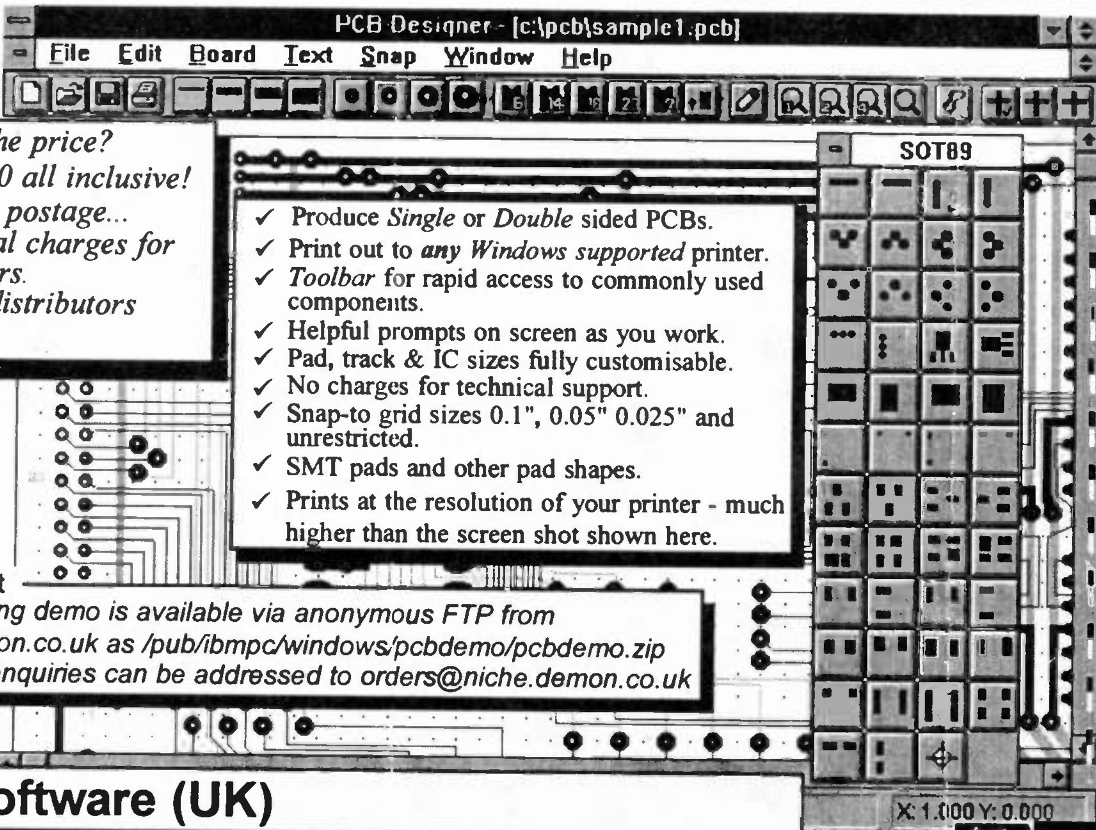

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e-mail enquiries can be addressed to orders@niche.demon.co.uk

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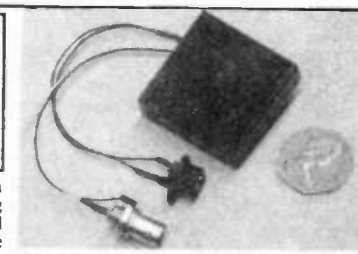

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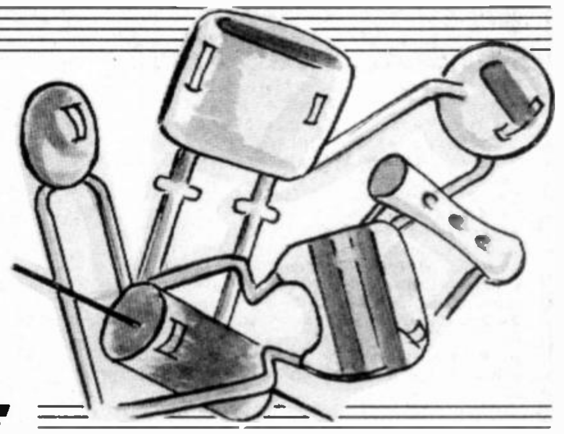
Constructional Project

CAPACITOR CHECK



TERRY de VAUX-BALBIRNIE

A cheap and cheerful capacitance "meter" that will measure values from less than 10nF to 5000µF with an accuracy good enough to confirm the nearest standard value of an "unknown" capacitor.

THERE is often a need to measure or confirm the value of an "unknown" capacitor or one on which the lettering has become obscured. Also, certain components of dubious origin appear to have non-standard markings and this makes them difficult to match up if ever they need to be replaced.

The more up-market digital multimeters are able to measure capacitance in addition to having the familiar voltage, current and resistance ranges. Owning such an instrument is fine where capacitor values need to be measured frequently. However, the "hobby" type of multitester which many amateurs use is not capable of measuring capacitance and there is no point in buying an expensive instrument when this facility would only be used occasionally.

CAPACITOR CHECK

The Capacitor Check to be described is probably the simplest which can be constructed that will find the value of a capacitor with reasonable accuracy. It will measure values from *less than 10nF up to 5,000µF* with an accuracy good enough to determine the nearest standard value of an "unknown" component.

There are twelve ranges: 10nF; 50nF; 100nF; 500nF etc. up to 5000µF. There is also a test facility which may be used to check that the unit is working correctly and that the battery is in good condition.

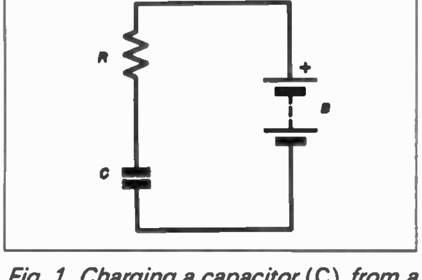


Fig. 1. Charging a capacitor (C) *from a battery* (B) *through a resistor* (R).

The cost of construction could be minimised by using any plastic box of suitable size instead of the more expensive sloping-front instrument case used in the prototype (see photograph).

TIME CONSTANT

The principle upon which the Capacitor Check circuit works is that of *time constant* and since some readers will not be too familiar with this concept, a short description follows.

When an initially uncharged capacitor (*C*) charges from a battery (*B*) through a resistor (*R*), it takes a certain time to do so – see Fig. 1. The charging pattern obtained when a 1µF capacitor charges through a 1MΩ (megohm) resistor from a 9V battery is shown in Fig. 2.

Here, the voltage across the capacitor is measured as time passes. The time taken depends on the values of *C* and *R* – the higher they are, the longer it takes. Thus, the time taken to charge will be greater if either *C* or *R* is increased or, of course, if both are raised in value.

If the voltage of the supply is different, the time scale will be the same, the line simply approaches whatever the supply voltage happens to be. It will be seen that the voltage rises quickly at first but reduces its rate of increase as time passes.

Note that the voltage across the capacitor is proportional to the charge stored and may therefore be used to represent it. In Fig. 2, when the voltage reaches 4·5V the charge will be 50 per cent of maximum (shown by the dotted lines).

MOVE CLOSER

The voltage across a charging capacitor will never reach that of the supply but simply approach it more closely as time goes by. It therefore makes little sense to talk about the time taken to fully charge a capacitor.

A more useful concept is to relate the time to some fraction of the maximum charge. In practice, this fraction is taken to be about 0·63 or 63 per cent – a figure following from some rather deep maths.

The time taken for the voltage across the capacitor to reach this figure (5·7V on a 9V supply) is called the *time constant* and, in the example, is one second. This is marked "1 TC" in Fig. 2.

The rather strange figure in the definition of time constant comes about because it provides a convenient link with the values of *C* and *R*. The time constant may be calculated by multiplying these together – i.e.

$$T = CR$$

where *T* is the time constant in seconds, *C* is the value of the capacitor (in Farads) and *R* is the value of the resistor through which it charges (in ohms).

The 1µF capacitor charging through a 1MΩ resistor will therefore provide a time constant of one second, which is shown in Fig. 2. There is therefore no need to go to the trouble of taking measurements and drawing a graph to determine the time constant.

When one time constant is reached, there will be 37 per cent of charge still to be delivered. During the next time constant, this will be topped up by 63 per cent of itself. Since 37% of 63% gives a further 23

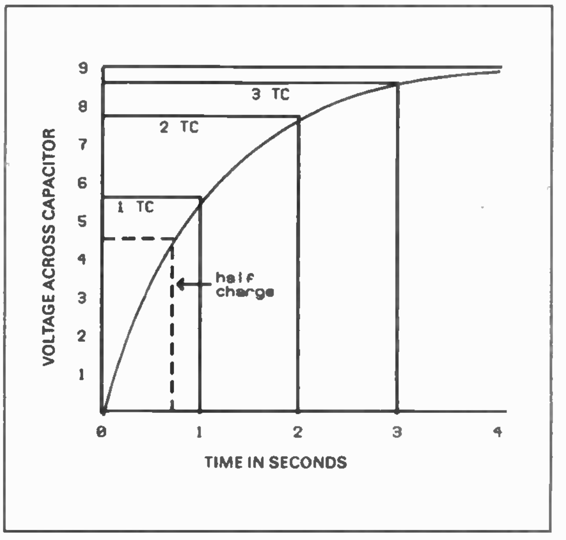


Fig. 2. Charging graph using a 1µF capacitor through a one megohm resistor from a 9V battery.

per cent, and since there is already 63% of the total charge held by the capacitor, the percentage of supply voltage appearing across the capacitor after two time constants will be 86 per cent. For a 9V supply this corresponds to about 7·7V (marked "2 TC" in Fig. 2).

After three time constants, the 14% of charge still to be given is itself topped up by 63% giving a total of almost 95 per cent or about 8·5V (marked "3 TC"). Many electronic engineers use *the three time constants* criterion to regard a capacitor as "fully charged".

This circuit works by measuring the time taken for a capacitor to charge by two time constants i.e. to the 86 per cent level through a resistor of known value. The time taken to do this is *2CR* and, by measuring this time, the capacitance may be found.

CIRCUIT DESCRIPTION

The complete circuit for the Capacitor Check is shown in Fig. 3. Switch S4 performs the on-off function. Light emitting diode D4 is an On/Off indicator with resistor R10 limiting the operating current. Switch S2 is used to select "Measure" (M) or "Test" (T) mode as required. Assume for the moment that it is in the M position as shown.

Operational amplifier IC1 is configured as a *voltage comparator*. If the voltage at its non-inverting (+) input, pin 3, exceeds that at the inverting (−) one, pin 2, the output at pin 6 will be *high*. In other cases it will be *low*.

Resistors R3 and R4 form a potential divider connected across the nominal 9V supply. The values of these resistors have been chosen to provide 86 per cent (actually it is nearer 87%) of the supply voltage to the non-inverting input, pin 3.

Meanwhile, the capacitor being measured, C_t, charges through resistor, R1, so the voltage across it rises and follows the form shown in Fig. 2. R1 is selected from a chain of resistors using the rotary Range switch, S1 (inset in Fig. 3).

The value of "R1" in the chain will be such that, with a capacitor at the top of the range selected (i.e. a 100nF capacitor on the 100nF range), the time constant will be 1·66 seconds. The values of "R1" required to provide this time constant on the various ranges are shown in Table 1. In practice, the resistors are connected cumulatively and the third column shows the actual resistors used in the prototype.

Assuming the "test" capacitor C_t is discharged to begin with, the voltage across it will initially be zero and so the inverting input voltage will lie below the non-inverting one. The op.amp will therefore be on with output pin 6 high. After two time constants have elapsed, the voltage across the capacitor will rise above 86 per cent of the supply. The op.amp input conditions will now be reversed and it switches off with pin 6 becoming low.

RAPID PULSE

Being configured as an *astable* means that IC2's output, pin 3, switches repeatedly between high and low states providing there is a supply connected and pin 4 (Reset input) is high. This allows the red light-emitting diode D3 to flash with the operating current limited by resistor R7.

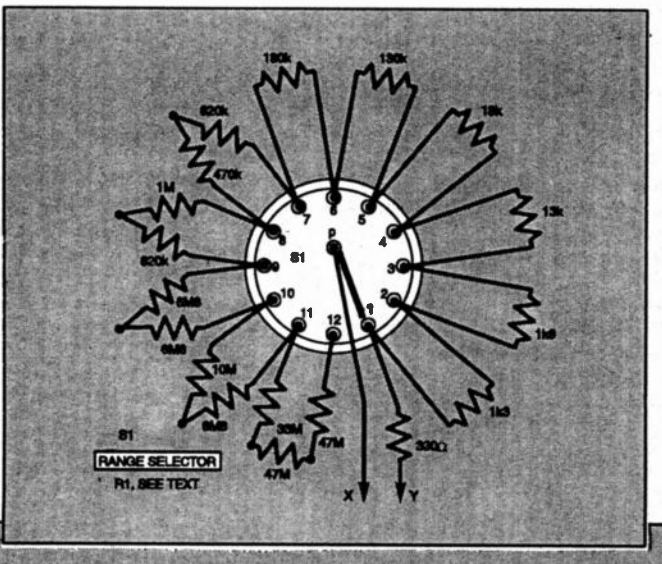
While IC1 pin 6 is high (during the initial stages of C_t charging), IC2 pin 4 is maintained in a high state and this enables the i.c. When the capacitor charges through two time constants, IC1 pin 6 becomes low, IC2 is disabled and the flashing stops.

The nominally "low" state of IC1 output would still be high enough to enable IC2 if connected direct and the two diodes, D1 and D2, correct this. Since approximately 0·7V appears across a forward-biased silicon diode, the introduction of two diodes in series will reduce the output voltage by about 1·4V. The voltage at IC2 pin 4 will therefore not be sufficient to enable the chip. Resistor R6 maintains IC2 pin 4 *low* in the absence of a *high* state from IC1 output.

The rate at which pulses are produced depends on the values of fixed resistors R8, R9 and preset potentiometer VR2 in con-

Table. 1

Range	Total resistance needed	Resistors used cumulatively
5000µF	333Ω	330Ω
1000µF	1k67	1k3
500µF	3k33	1k8
100µF	16k7	13k
50µF	33k3	18k
10µF	167k	130k
5µF	333k	180k
1µF	1M67	820k + 470k
500nF	3M33	1M + 820k
100nF	16M7	6M8 + 6M8
50nF	33M33	10M + 6M8
10nF	167M	47M + 47M + 33M (or 100M + 33M see Shop Talk)



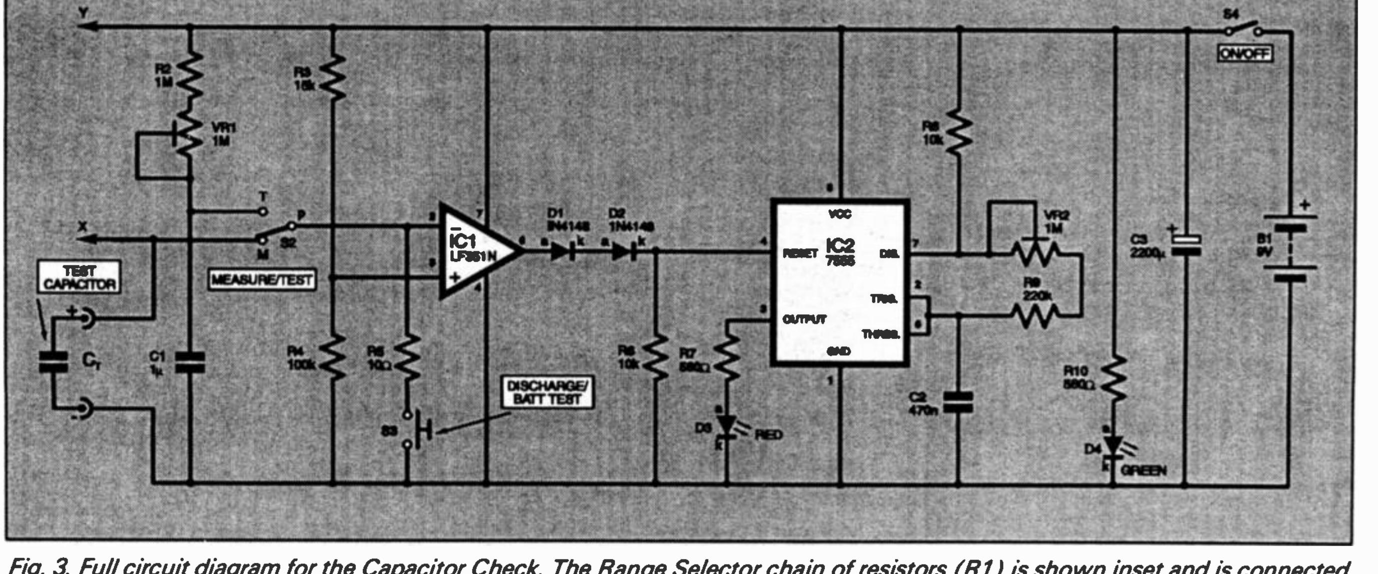


Fig. 3. Full circuit diagram for the Capacitor Check. The Range Selector chain of resistors (R1) is shown inset and is connected to points X and Y in the main circuit.

COMPONENTS

Approx cost guidance only **£17**
excluding batt. & case

Resistors
R1 resistors chain (see also Table. 1)
330Ω, 1k3, 1k8, 13k, 18k, 130k, 180k, 470k, 820k (2 off), 1M, 6M8 (3 off), 10M, 33M, 47M (2 off)

R2	1M		
R3	15k	R6, R8	10k (2 off)
R4	100k	R7, R10	560Ω (2 off)
R5	10Ω	R9	220k

All 0·6W 1% metal film, except 33M and 47M which are 5% metal film.

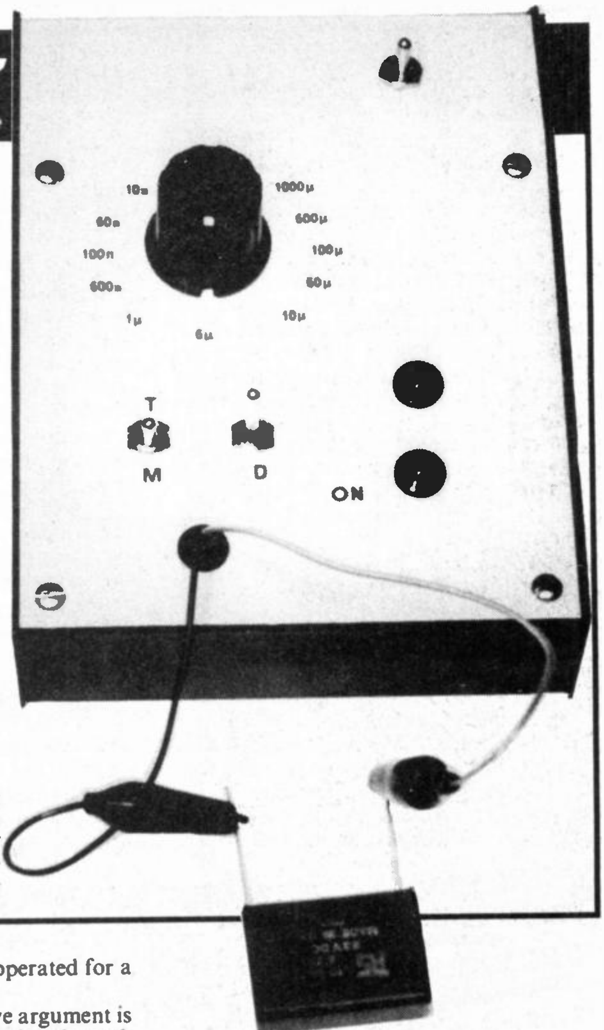
Potentiometers
VR1,VR2 1M sub-min carbon preset, vert. (2 off)

Capacitors
C1 1μ polyester layer
C2 470n polyester layer
C3 2200μ p.c.b. radial elect. 16V

See SHOP TALK Page

Semiconductors
D1, D2 1N4148 signal diode (2 off)
D3 5mm red l.e.d.
D4 5mm green l.e.d.
IC1 LF351N j.f.e.t. op.amp
IC2 ICM7555IPA CMOS timer

Miscellaneous
S1 Single-pole 12-way rotary switch, make-before-break action
S2, S4 Min. s.p.d.t. toggle switch (2 off)
S3 Min. s.p.d.t. biased toggle switch or press-to-make pushbutton switch (see text)
B1 9V battery (PP3)
Printed circuit board available from the *EPE PCB Service*, code 955; ABS plastic or metal box with sloping front panel, size to choice; 8-pin d.i.l. socket (2 off); miniature crocodile clip (2 off); PP3 battery holder and snap connector; control knob; p.c.b. stand-off insulator and mounting bolt; rubber grommet; red and black stranded connecting wire; multi-coloured stranded interconnecting wire; cable ties; solder etc.



junction with capacitor C2. With the values chosen, they will be delivered at between one and 10 per second approximately depending on the adjustment of VR2.

During initial setting-up, the preset VR2 will be adjusted so that exactly *three* flashes per second are provided – this being the maximum rate at which they may be counted without too much difficulty. Ten flashes therefore correspond to 3·33 seconds which is equal to *two time constants* for a capacitor at the limit of the range selected.

VALID ARGUMENT

When switch S2 is in the alternative (T) position, IC1 pin 2 is connected to the arrangement of fixed resistor R2, preset potentiometer VR1 and capacitor C1. Preset VR1 will be adjusted so that exactly ten flashes are given by l.e.d. D3. This may be used to check that the circuit is working correctly.

It also acts as a "battery test" since a battery in poor condition will fail to maintain the charge rate to capacitor C1. This will be indicated by an apparent increase in value of the test capacitor – i.e. more than ten flashes given.

When pressed, switch S3 applies a virtual short-circuit to any capacitor before a measurement is made – this ensures that it is initially discharged. Resistor R5 limits the current through the switch contacts to 1A approximately. If a large-value capacitor were to be discharged with no series resistor, there would be an instantaneous high current and the consequent sparking could possibly damage the switch contacts.

Resistor R5 still has a sufficiently low value to allow the highest-value capacitor on test to be virtually fully discharged in a fraction of a second. This is important because the switch will only be operated for a short time.

It will be clear that the above argument is valid only if all the current flowing through resistor chain R1 actually charges C_t. In practice, this means that none must be diverted into IC1 inverting input. This, in turn, implies that the input resistance of IC1 must be much higher than the maximum value of R1 which is about 167MΩ.

The specified op.amp for IC1 has an input resistance in the region of one 1TΩ (one million megohms) which is many thousands of times greater than this. The effect of the op.amp on any capacitor charging is therefore negligible.

Capacitor C3 is charged from the battery while the circuit is switched on. This provides a reserve of energy which may be needed when testing high-value capacitors since here the value selected from the resistor chain for R1 will be low (see Table 1). In these cases, a high initial current will be drawn from the supply. When the battery is old and its internal resistance high, the initial current would be reduced and this would slow down the charging process. This would increase the timing and apparently increase the value of a capacitor being measured.

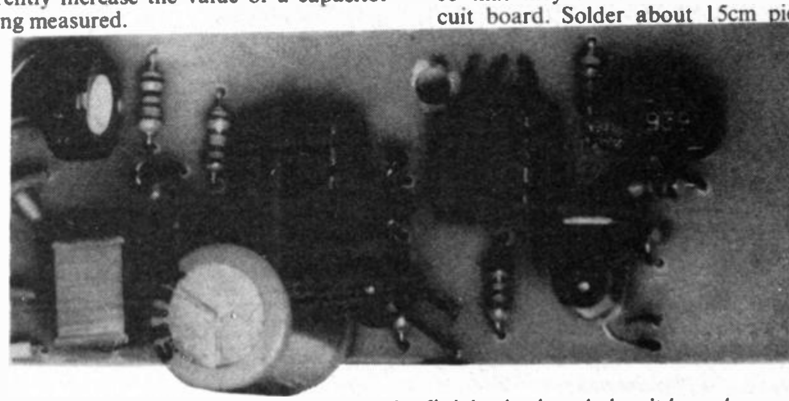
Since the time constant is independent of supply voltage, there will be no adverse effect as the battery ages to a reasonable level and the available voltage falls. The potential divider, R3/R4 will always supply IC1 pin 3 with 86 per cent of the supply voltage whatever this might be.

CONSTRUCTION

Details of the component layout and full-size copper foil master track pattern for the Capacitor Check printed circuit board (p.c.b.) are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 955.

Begin construction by drilling the single mounting hole and soldering the two i.c. sockets into position. Follow with the resistors, preset potentiometers, capacitors and diodes. Pay special attention to the polarities of the diodes, i.c.s and electrolytic capacitor C3.

Solder the two l.e.d.s in position using most of the length of their connecting leads so that they stand 15mm above the circuit board. Solder about 15cm pieces of



Layout of components on the finished printed circuit board.

stranded connecting wire to the points labelled: S4; S2 (T) (2 off); S2(p); S3 and Batt. –V. Adjust presets VR1 and VR2 to approximately mid-track position.

Note that, in the prototype, switches S2 and S4 were of the miniature s.p.d.t. toggle variety and S3 was a s.p.d.t. *biased* toggle type all chosen from the same range to harmonize with one another. Of course, an ordinary push-to-make pushswitch could be used instead for S3.

RANGE SWITCH

Prepare rotary Range switch S1, by cutting the spindle to a suitable length to accommodate the control knob. As supplied, the switch will be found to have only 11 positions instead of the 12 required. To correct this, remove the brass nut and the tab washer beneath. Discard the tab washer and replace the brass nut. The switch will now have its full complement of positions.

Solder the resistors (R1 chain) shown in Table. 1 around the tags of the rotary switch S1 as shown in Fig. 5. Unfortunately, some of the larger value resistors are not readily available (see *ShopTalk*) and for the low ranges, multiple resistors connected in series will be needed to make up the value. For the lowest range (10nF), *three* resistors were used in the prototype – two 47MΩ and one 33MΩ. The 47MΩ resistors have a rather large body profile but this does not really matter.

The first resistor in the "R1" chain, 330 ohms, used for the highest range (5000μF) is not soldered between rotary switch tags but only to the first one and the other end is left free for the moment. Both its ends should be sleeved using a little insulation stripped from a connecting wire.

CASE PREPERATION

Drill holes in the lid of the box for the l.e.d. clips, the four switches and for the battery holder. Drill a hole to align with that already made in the p.c.b.. Make a hole for the test leads which will pass through from the inside and fit it with a rubber grommet.

Attach the switches, l.e.d. clips and battery holder. Referring to Fig. 6, complete the internal wiring. Insert the i.c.s into their sockets observing the orientation. Note that IC1 is a j.f.e.t. device and needs no special handling precautions. IC2 is a CMOS i.c. and vulnerable to damage by static charge which might exist on the body. To avoid this, touch something which is "earthed" – such as a water tap – first.

Attach the p.c.b. so that the l.e.d.s snap into their clips. Secure it using a single fixing and a 20mm long plastic stand-off insulator on the bolt shank. In this way, everything will be attached to the lid so providing least strain on the connecting wires. Fit self-adhesive plastic feet to the bottom of the box to prevent scratching the work surface.

Make up the test leads using short pieces of light-duty flexible wire with small

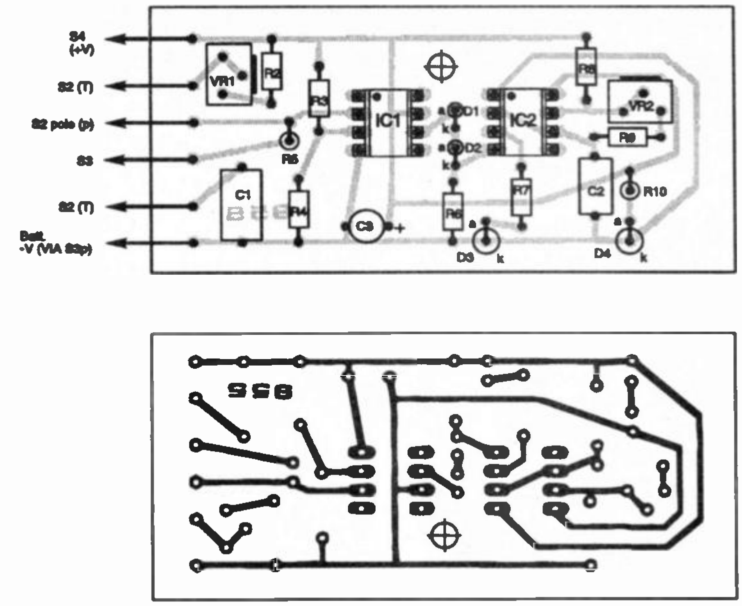
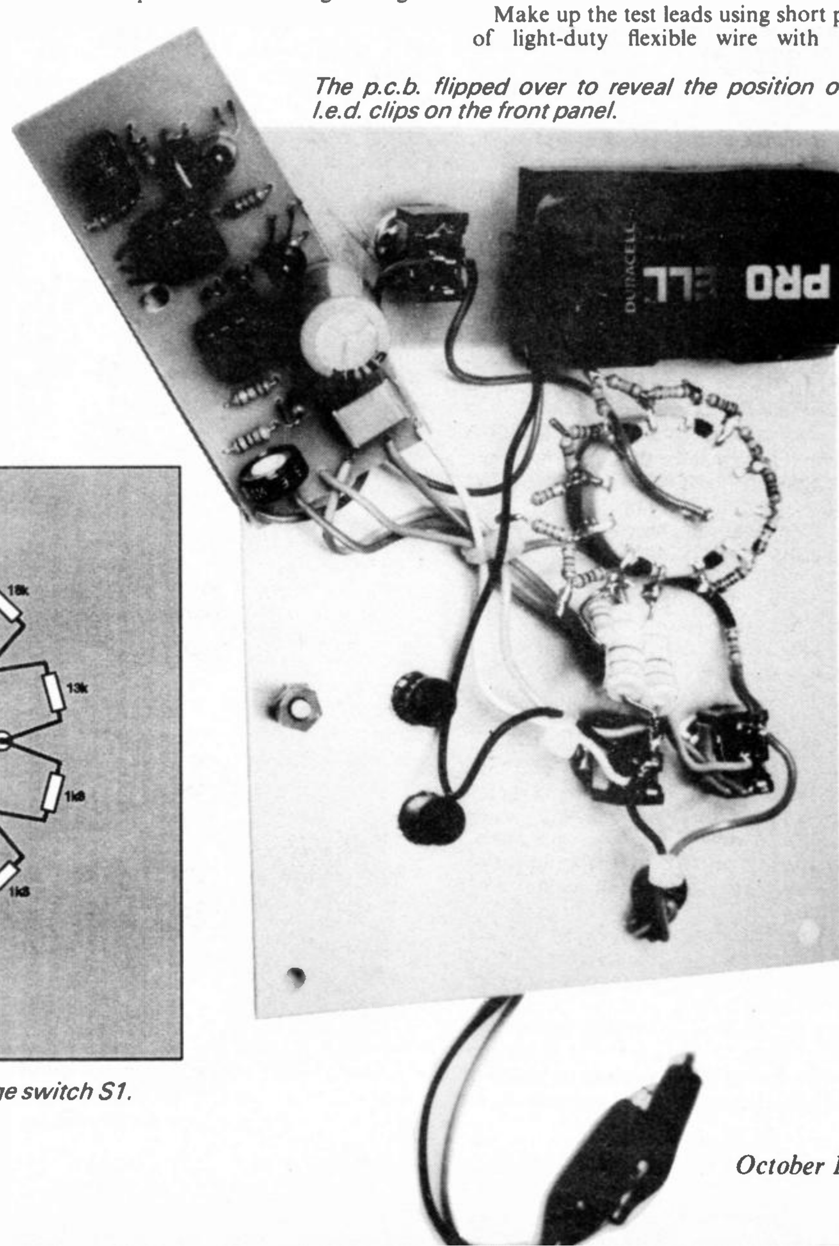


Fig. 4. Printed circuit board component layout and full size underside copper foil master pattern.



The p.c.b. flipped over to reveal the position of the l.e.d. clips on the front panel.

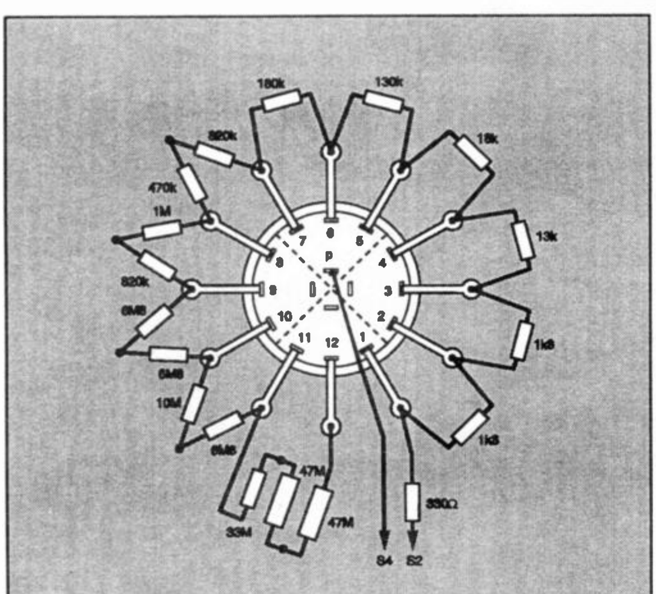


Fig. 5. Resistor chain wired to the Range switch S1.

crocodile clips on the ends. A *red* wire should be used for the positive wire – that is, the one leading to switch S2 (*M*). The other one should be *black*. Pass the ends of the "test" leads through the grommet and, leaving a little slack, attach a cable clamp on the inside to provide strain relief. Switch S4 off and connect the battery. Do not attach the lid yet.

SETTING-UP

Set switch S2 to *measure* (*M*) and switch S4 on. Note that the green l.e.d. glows. The range is unimportant at this stage.

Short-circuit the two crocodile clips together. This should make the red l.e.d. flash continuously. Using a trimming tool or small screwdriver, adjust preset VR2 so that exactly *three* flashes per second are given. Listening to the one-second clicks from an analogue clock and counting in threes is the easiest method.

With S2 set to *test* (*T*), the red l.e.d. may continue to flash for a short while then stop. If capacitor C1 is already charged, it will remain off. Press S3 for an instant and note that it flashes again. On releasing S3, count the number of flashes until they stop. Adjust preset VR1 until *ten* flashes are given and check this a few times.

CHECKING IT OUT

To use the Capacitor Check, rotary switch S1 is first set to the range required. If this is not known, usually a guess can be made from the physical size of the capacitor and the procedure followed by trial and error.

When the "checker" is first switched on the green l.e.d. glows. The red l.e.d. will also flash at the rate of three per second. The "unknown" capacitor is now connected in-circuit, using the pair of crocodile clips, and the momentary-action switch S3 operated.

The number of flashes – nominally up to ten – is now counted until the red l.e.d. goes off. If there is only one flash, none at all, or many more than ten the Range switch S1 will need to be adjusted up or down accordingly.

Taking account of the range setting, the number of flashes indicates the approximate value of the capacitor. For example, suppose the 100μF range is selected and "six" flashes are given. The value of the capacitor will lie between 60μF and 70μF (remember, there could have been a further flash just about to happen).

As a further example, suppose the 50nF range was selected, then "four" flashes would indicate a capacitor value between 20nF and 25nF (one flash here being equivalent to 5nF). It is permissible to allow a few more flashes than the nominal ten. If, in the last example, 13 flashes were given the value would lie between 65nF and 70nF.

MAKING THE TEST

Select the appropriate range and connect the "test capacitor" to be measured between the crocodile clips. If it is an *electrolytic* capacitor, it is important to observe the polarity marked on the body – i.e. connect the negative end to the *black* test lead.

Switch S2 to the *M* position and note that if the capacitor is uncharged the red l.e.d. will begin to flash. Do not wait for it to stop but press S3 and, on releasing it, count the flashes as before. Repeat this once or twice.

Convert this number into a value as explained previously. There should be no be more than one flash difference between readings using the same capacitor. Note that each time a measurement is made, the discharge switch S3 *MUST* be used – never assume that any capacitor is fully discharged to begin with.

Do not hold both capacitor leads between the fingers while testing it. If you do, your body resistance will interfere with the charging action and lead to an apparent increase in its value. There would be little effect when testing high value capacitors but it would make a large difference with small ones.

Electrolytic capacitors tend to deform somewhat in storage. In practice, this means that the value may not settle down until they have been charged and discharged a few times. Also, this type of capacitor is subject to a wider tolerance than other types – typically 20 per cent.

CHECK MATE

Every so often, the circuit should be checked. Set S2 to *Test*, press S3 momentarily and count the number of flashes. This should be *ten* as previously set. If it is more than this, the battery needs to be replaced. □

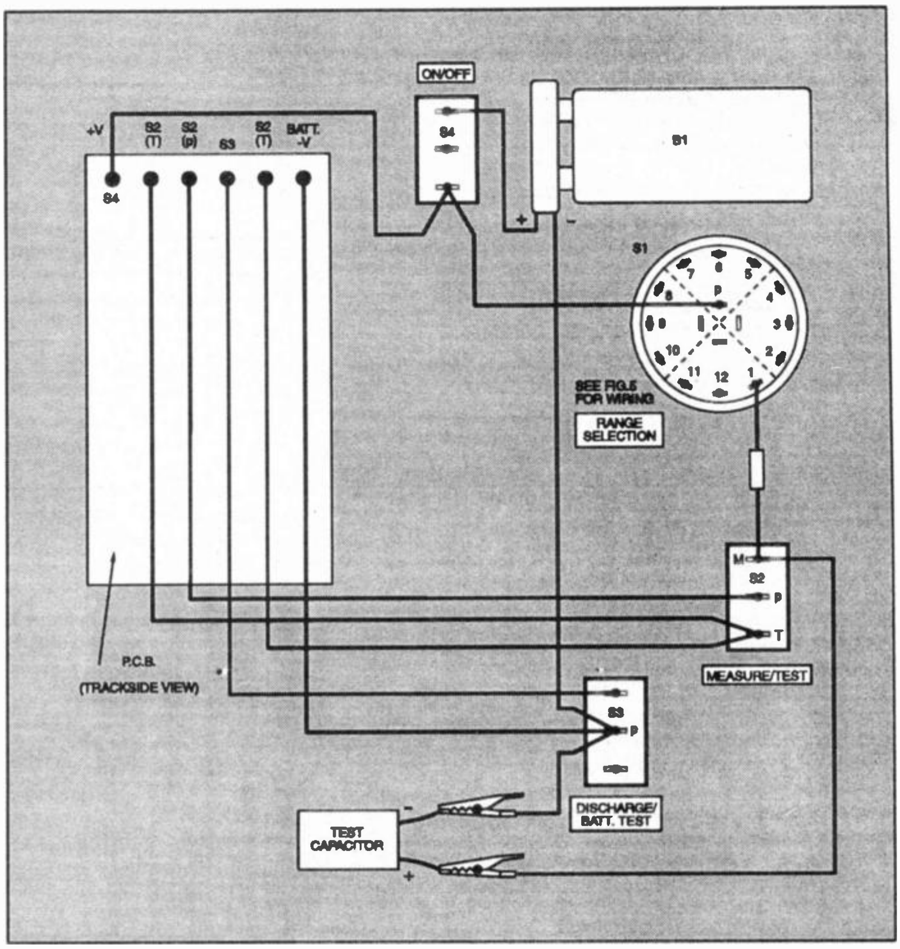
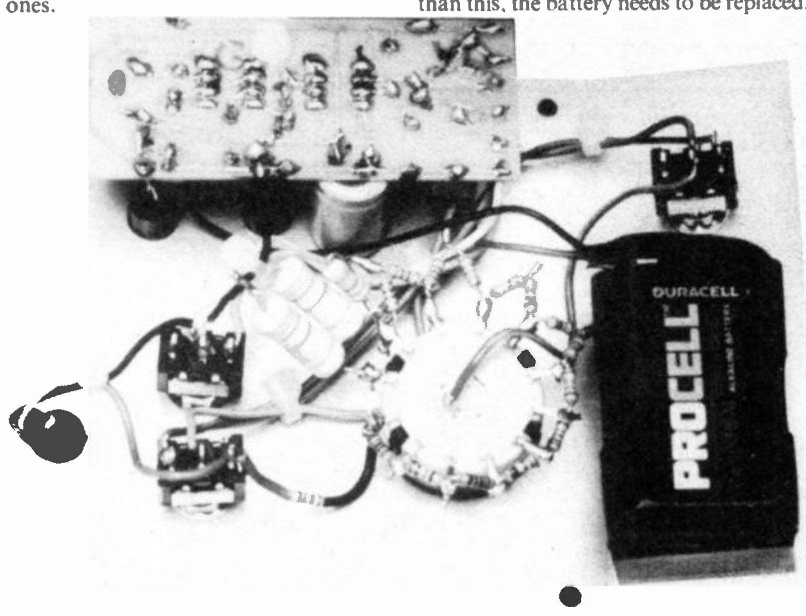


Fig. 6. Interwiring from the p.c.b. to the switches and also wiring between off-board components.



Chain resistors wired directly to the Range switch and the p.c.b. mounted "face-down" on the rear of the front panel.

FOX REPORT

by Barry Fox

Trusting Telerate

I do hope the financial community looks at Telerate Live in action, before signing up for the service. Judging by the way the city suits applauded Telerate's launch party pitch, they are quite likely to sign on the strength of a promise.

This is truly ironical, because the whole thrust of the pitch was that financial professionals need to see politicians and government officials in action, so that they can judge who is telling the truth. That way they avoid ending up like Barings Bank.

Dow Jones, publisher of the *Wall Street Journal,* already runs a service called Telerate. It delivers financial information to office computers. Now DJ is offering Telerate Live, which delivers TV news pictures of important announcments into a Windows workstation.

Trust Me

To ram the message home Telerate showed video clips of George Bush promising no tax rises, Margaret Thatcher promising to "fight on and win" her leadership battle and a corrupt Italian politician pleading innocence. "All broken promises" said the man from Telerate "You need to see their expression to know who to trust".

The news pictures looked clear and crisp, because they were shown from a tape recording on six large screen TV sets. I was waiting for a demonstration of how they look, live, on a computer screen. But as the tape ended the lights went up and the show was over.

I asked Peter Kingsley, Telerate's Director of Marketing, whether we could see a Windows terminal in action. There wasn't one. But Kingsley assured me that the pictures would be as good as those we had seen on the TV screens. "Haven't you heard of the cards that you can add to a PC to display TV pictures?", he asked.

Yes, I have. But these cards take full bandwidth analogue TV signal from an aerial and display them on the PC screen. Depending on the screen resolution and circuit bandwidth, the pictures should be as good as on an ordinary TV set.

Rating the Cards

But the rules of the game change completely when the picture signals are digital, either streaming down a line or off a CD-ROM. Although it is possible to get VHS or better quality pictures from a Video CD with MPEG-1 coding at under 1·5 Mbit/s, considerable care is needed for the coding process. It needs several passes and usually the coding is done off-line, in slow time.

Higher data rates (3 or 4 Mbits/s) are needed to deliver similar quality pictures if they are coded in real time, completely automatically.

It turns out that Telerate has been banking on the launch of Eutelsat's *Hot Bird* satellite, originally scheduled for Christmas and finally launched three months late because of Ariane rocket problems. One of Hot Bird's transponders will carry the European Business News TV station (from which Telerate's news clips are sourced) as an analogue signal, with 27MHz bandwidth. On top of this, the same transponder will carry a 9-Megabit data stream to deliver Telerate's picture, sound and text information.

But this service will not be ready until "later this year" and as a stop gap Telerate will deliver its signals by 2-Megabit optic fibre link into offices. This drastically limits the data rate available for video, and with real time coding the picture quality inevitably suffers.

Game Show

The information pack which Telerate gave guests as they left their party gives the game away. Inside there is a photograph of a computer sceen with four-fifths of the screen area displaying financial text and one-fifth working as a window to display a TV picture. Although the text display is clear and crisp, I'd say that the TV display is sufficiently blurred and fuzzy to let a lying politician go on lying.

Non-Appliance of Science

Recently, one of the main employers in Wales, Panasonic, issued an uncharacteristically blunt warning. This had clearly been timed to coincide with DTI Minister Ian Taylor's launch of Britain's *Science, Engineering and Technology Week*.

While Taylor was telling industrialists, teachers and students that it was "never too early to master the appliance of science", Panasonic's parent Matsushita was warning that serious shortcomings in the British education system will soon stop foreign countries investing in the UK. Matsushita, the largest manufacturer of consumer electronics equipment in the world, also publicly criticised Britain's attitude to engineering.

Panasonic has built factories in Wales which employ 2000 people to make television sets and microwave ovens. Panasonic offers technical apprenticeships and tries to train employees for engineering jobs which must otherwise be done by Japanese employees on secondment from the company's factories in Osaka. But last year when Panasonic advertised for engineering apprentices, the company could only recruit three of the two hundred applicants. Less than ten of the applicants were women.

Other Japanese companies are facing the same difficulties, says Panasonic, and the flow of inward investment by overseas companies "could slow to a trickle unless significant steps are taken to improve technical and engineering skills training".

Training Perception

David Fowler, Panasonic's board member for personnel, told a seminar of 60 technology teachers from all parts of Wales that "Far too many university graduates are opting for degrees in the arts and humanities, where the prospects of finding well paid work are receding by the hour".

Panasonic also wants to change the general perception of the role of an engineer in industry. In most countries, an engineer is respected as a skilled technician. But in the UK engineers are regarded as second-class necessities. I frequently see management and marketing "suits" making fools of themselves at meetings and conferences by talking about technical issues they do not understand. They are too proud to let their engineers do the talking.

"Students really need to be warned of the high price they will have to pay in terms of employment prospects for choosing subjects not related to future opportunities", Fowler told the teachers. "Companies like ours have to dig very deeply indeed to find people with relevant skills for further training. That applies as much to graduates as anyone else, even if they have degrees in technical subjects".

"There appears to be a lack of commitment actively to support and finance the development of courses that satisfy our business needs. At graduate level, for example, we need more people trained in digital electronics".

INTERFACE

Robert Penfold

THIS month we conclude our probe into the "Hamcomm" shareware program, and consider the use of an external tone decoder for RTTY reception. Using a tone decoder gives the potential for improved results on weak signals, or when there is a lot of QRM.

It does not require the use of a particularly complex circuit. In fact the circuit featured here is based on just a couple of dual operational amplifiers.

There is a slight problem when using an RTTY tone decoder, which is simply one of tuning in signals with adequate accuracy. Amateur RTTY uses a frequency shift of only 170Hz, which requires the tuning to be accurate within a few hertz in order to obtain efficient decoding. Simple tuning indicators tend to be awkward to use due to the lopsided nature of most amateur RTTY, with one tone present for a far greater percentage of the time than the other tone.

On the Mark

Using the "Hamcomm" program it is quite easy to switch between the internal and external decoding modes, and this enables the program's built-in tuning aids to be used with an external decoder. It is just a matter of aligning the program's tuning markers with the operating frequencies of the tone decoder, and then tuning received signals so that they match up with the markers.

Once a signal has been tuned correctly, switch to the external decoder mode to copy the station. This method is quite effective, and avoids the need for a complex and expensive hardware tuning indicator.

It is perhaps worth pointing out that the frequency stability of the communications receiver is an important consideration for RTTY reception. Once a signal is tuned in, the tuning accuracy must be maintained if efficient decoding is to be obtained.

This can be very difficult using a receiver that drifts continuously. A modern receiver with synthesised tuning is generally much better in this respect than an older set. On the other hand, a set with synthesised tuning is only usable if it has quite fine resolution (about 25Hz or less), or has a "fine tuning" control that permits the tuning to be varied between synthesised tuning steps.

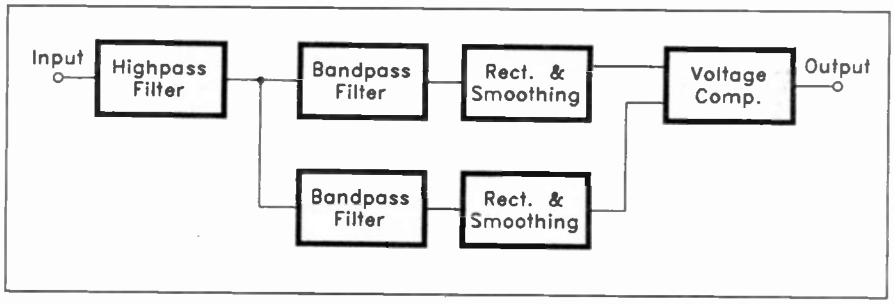


Fig. 1. Block diagram for the RTTY Tone Decoder.

Highs and Lows

When used with an external decoder "Hamcomm" provides the serial to parallel conversion. All the decoder has to do is take the CTS line of the serial port high when one tone is present, and low when the other tone is detected. Fig. 1 shows the block diagram for the RTTY Tone Decoder.

A highpass filter at the input helps to reduce problems with low frequency QRM. This stage drives two bandpass filters which operate at approximately 1·2kHz and just over 1kHz.

In other words, they operate on frequencies that are 170Hz apart, which is the same as the frequency shift of the input signal. In use the receiver is tuned to bring the two tones of the RTTY signal to the centre frequencies of the bandpass filters.

Each bandpass filter drives a rectifier and smoothing circuit. The positive d.c. output voltage from each smoothing circuit is roughly proportional to the strength of the output signal from the relevant bandpass filter.

As the input signal switches from one tone to the other, the output voltages from the smoothing circuits seesaw in sympathy with the input signal. The two voltages are fed to the inputs of a voltage comparator.

The output of the comparator switches fully high or low, depending on which input voltage is at the higher potential. It does not matter which tone gives which output level, but in this case the higher tone sends the output low.

If this gives an output signal of the wrong polarity the software can be switched to the "reverse" mode, and correct decoding should then be obtained. Alternatively, switching from lower sideband to upper sideband (or vice versa) will invert the output signal to one of the right polarity.

Circuit Operation

The full circuit diagram for the RTTY Tone Decoder as shown in Fig. 2. The input filter is based on IC1a, and it is a

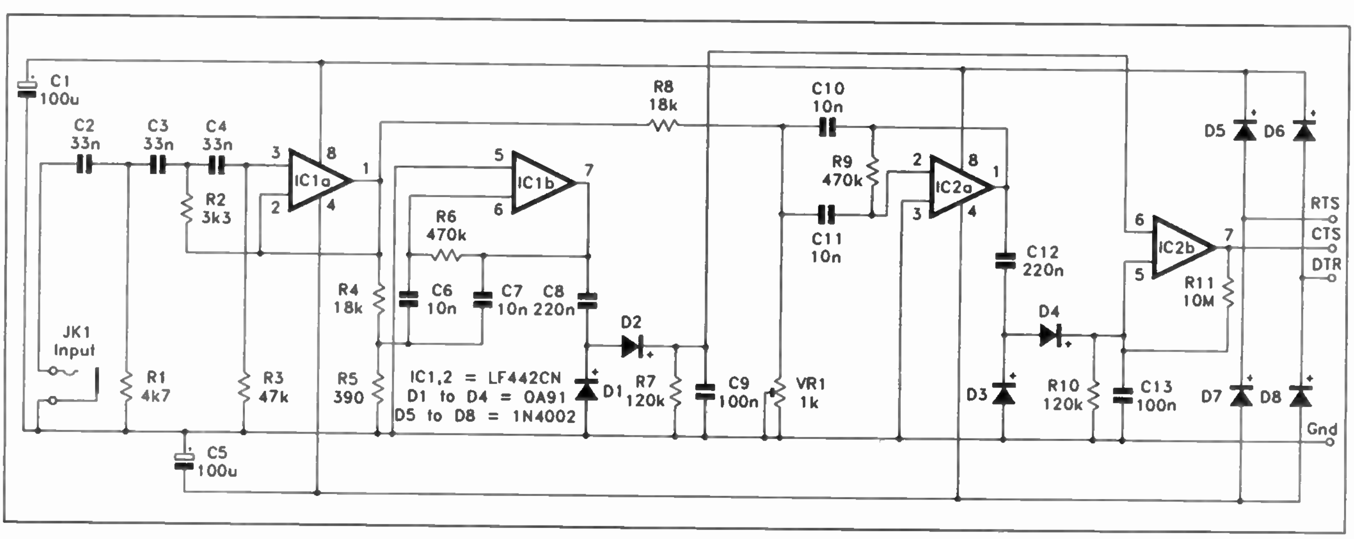


Fig. 2. The RTTY tone decoder circuit diagram.

conventional third order (18dB per octave) highpass type having a cut-off frequency at approximately 750Hz. IC1b is used in the higher frequency bandpass filter, and this uses a conventional configuration.

The parallel resistance of R4 and R5 forms one element of the *C-R* filter network, and these also provide attenuation which counteracts the otherwise excessive gain of the filter. Capacitors C6, C7, and resistor R6 provide the other three elements of the filter network.

Capacitor C8 couples the output of this filter to a conventional half-wave rectifier and smoothing network based on diodes D1 and D2. The time constant of R7 and C9 is long enough to give a well smoothed output signal, but is short enough to permit the unit to respond rapidly as the input signal alternates between one tone to the other.

The second bandpass filter is based on IC2a and is essentially the same as the first, but it has a preset resistor (VR1) as one section of the input attenuator. This enables the centre frequency of the filter to be adjusted over quite a wide frequency range, but in practice it is set 170Hz lower than the centre frequency of the other filter.

If preferred, preset potentiometer VR1 can be set to give a centre frequency 170Hz higher than the other filter. Results seem to be much the same either way. It can also be set for shifts of other than 170Hz.

In fact, it could be replaced by two or three switched presets, giving the option of several shift frequencies. It is advisable to use a multiturn "trimpot" for VR1, since it could be difficult to set an ordinary preset with adequate accuracy.

The output of IC2a (pin 1) feeds into a rectifier and smoothing circuit that is identical to the one used at the output the other filter. The outputs of both the smoothing circuits drive the inputs of IC2b, which acts as the voltage comparator. A small amount of d.c. positive feedback is provided by resistor R11, and this helps to avoid problems with "jitter" at the output when only background noise is present at the input.

Powerful Handshake

In common with the interfaces described previously, power is obtained from two of the otherwise unused handshake outputs of the PC's serial port. Diodes D5 to D8 form a bridge rectifier that ensures the circuit is always provided with a supply of the correct polarity.

Only a milliamp or two can be drawn from the handshake outputs. Accordingly, IC1 and IC2 must be low supply current operational amplifiers.

Using the LF442CN a total current consumption of only about one milliamp is obtained. Most other dual operational amplifiers (LF353N, LM1458C, etc.) will give a very much higher current drain, and might not give usable results unless a proper dual-balanced 12V supply is used.

In Use

This interface requires the same serial port connections as the CW decoder described in last month's article. Also in common with the CW decoder, the simple interface is needed if the built-in tuning aids of "Hamcomm" are to be utilized. Refer to last month's article if you require details of either the serial port connections or the circuit for the simple interface.

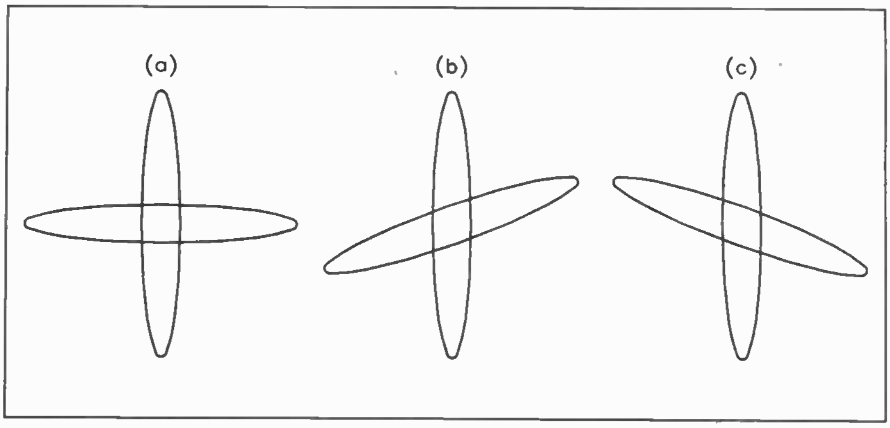


Fig. 3. (a) The correct oscilloscope display; (b and c) the display with incorrect shift.

Obviously, the RTTY Tone Decoder will not work properly until VR1 has been set for the correct frequency shift. If an accurately calibrated sinewave generator and an oscilloscope or audio millivolt meter are available, first determine the centre frequency of the higher frequency filter.

To do this, couple the output of the generator to the input of the Tone Decoder, and use the oscilloscope or millivolt meter to monitor the output level at pin 7 of IC1b. Adjust the signal generator for maximum output, being careful to keep the signal below the clipping level of IC1b.

Next set the audio signal generator 170Hz lower in frequency, and monitor the output level from IC2a pin 1. Adjust VR1 for maximum output from IC2a, again making sure that the signal is kept below the clipping level so that a definite peak is obtained.

The unit should then work quite well, but the oscilloscope can be used to check the setting of preset VR1, provided it has an X-input. Monitor the output from IC1a pin 7 using the X-input, and the output from IC2a pin 1 using the Y-input.

One tone will produce a horizontal ellipse on the oscilloscope's screen, and the other tone will produce a vertical ellipse. As the signal switches rapidly from one tone to the other this will generate a sort of cross shape on the screen. Fig. 3a shows a slightly idealised version of the correct display with an accurately tuned RTTY transmission.

Trail and Error

If the shift of the decoder is not quite right, the two sections of the display will not be at right angles to each other at any setting of the receiver's tuning control. This gives a display of the type shown in Fig. 3b or Fig. 3c, depending on whether the shift is too great or too small.

Try tuning to several stations to check that it is the decoder which is at fault, and not the initial test station. If the decoder is at fault, a little trial and error with the setting of VR1 will soon correct things.

Without the aid of suitable test equipment it can be difficult to get the decoder set up correctly. It can be done using trial and error, but this could be very time consuming, since the shift has to be set very accurately if good results are to be obtained.

Probably the best simple method is to monitor the output from IC1b pin 7 using a crystal earphone. Connect the earphone between IC1 pin 7 and "ground".

If you slowly tune across an RTTY station you should hear the output from the earphone grow quite loud as each of the tones falls within the passband of the filter. Adjust the tuning so that the higher frequency tone produces maximum output from IC1b.

Next, monitor the output from IC2a pin 1, and adjust VR1 for maximum output from the lower frequency tone. Be careful not to peak VR1 on the higher frequency tone. The signal will peak at two settings of VR1, and it is the peak at the higher resistance setting that is the correct one.

Results using the prototype decoder were very good, and seemed to be somewhat better than those obtained using a simple interface and software to provide all the decoding. The system is still not immune to fading though, and something less than 100 per cent copy has to be accepted when band conditions are unfavourable.

"Hamcomm 3.0" is available from the **PDSL, Dept EPE, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL** (Tel. 01892 663298, Fax 01892 667473).

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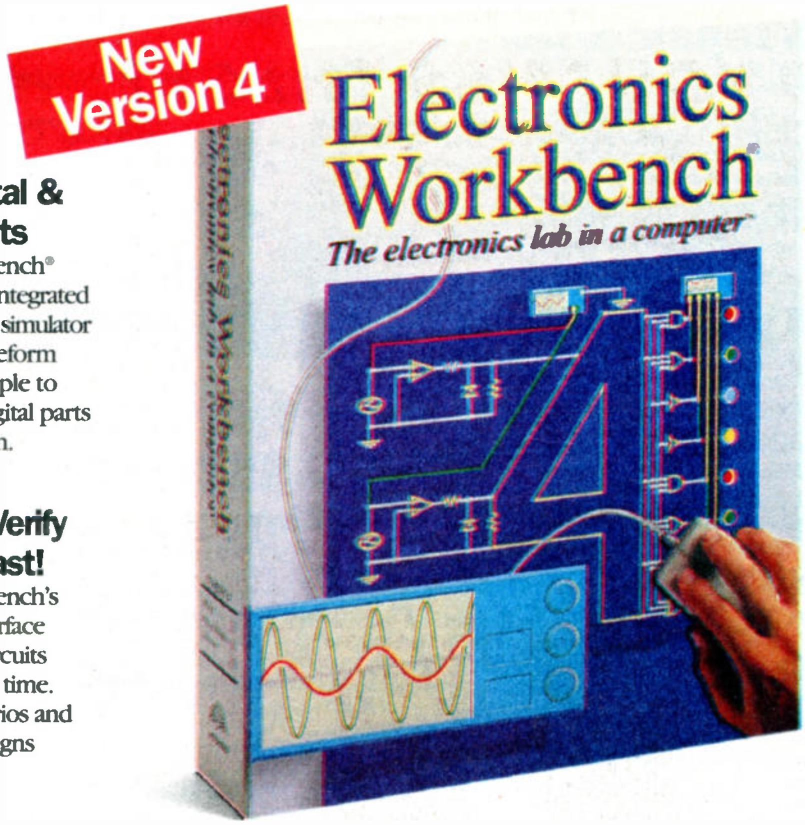

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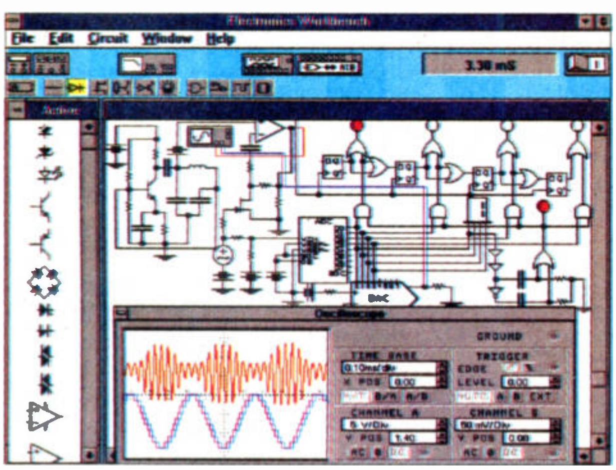

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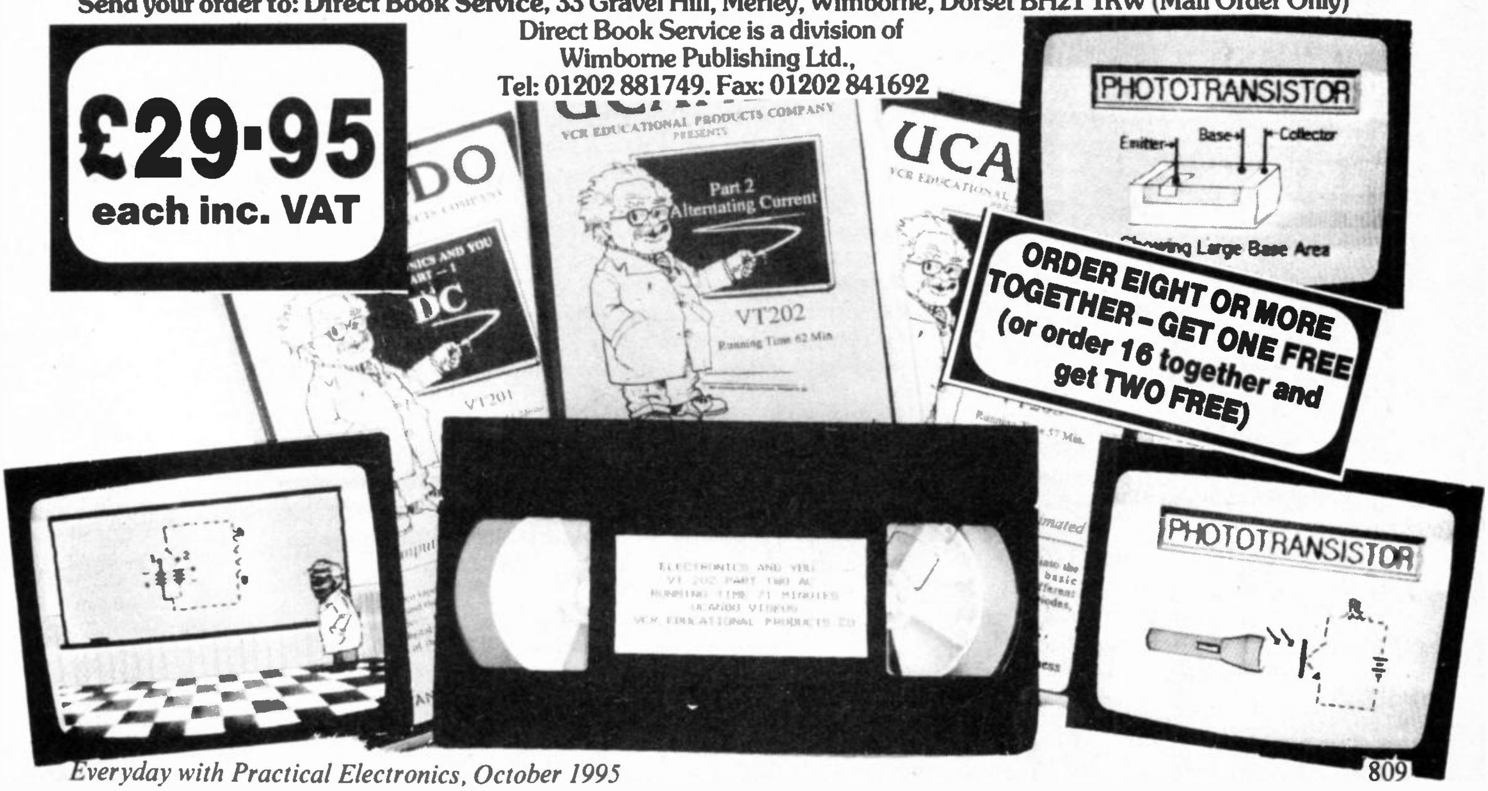
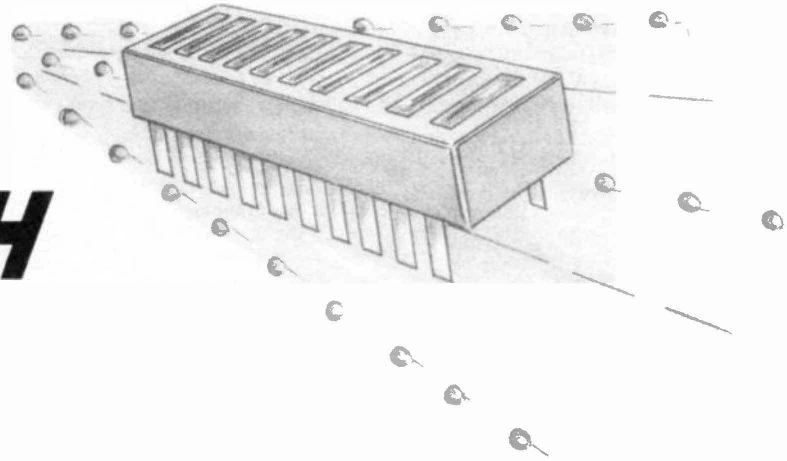




USING BARGRAPH DISPLAYS

ANDY FLIND

An experimental approach to understanding the workings of bargraph displays, and to highlight just how versatile they really are!

THERE are many occasions when an experimenter or circuit designer will wish to convert an analogue signal into a visual display. The traditional way of doing this has always been the moving-coil meter, but since these are relatively large and fragile an alternative method is sometimes welcome.

One modern solution is the l.e.d. bargraph display, often used to indicate amplitude levels on audio equipment. These are small, rugged, low in cost and easy to read, with a very fast response to input changes. They also look impressive!

It might be thought that the driving of a whole string of l.e.d.s in accurate sequence would require a complex circuit. It does, but thanks to some inexpensive "bargraph driver" i.c.s the designer doesn't have to worry about this.

Using these drivers, "dot" or "bar" style displays can easily be made to track input voltages accurately. For increased resolution displays may be cascaded, and there is even a choice of linear, log or "VU" response. The log version is particularly useful where a wide signal input range is to be covered.

Power supplies range from just three up to eighteen volts so they are well suited to battery operation. All this flexibility, however, requires less effort from the designer than simply controlling the brilliance of a single l.e.d. with a discrete circuit, and this article will explain exactly how it is done together with some practical experiments.

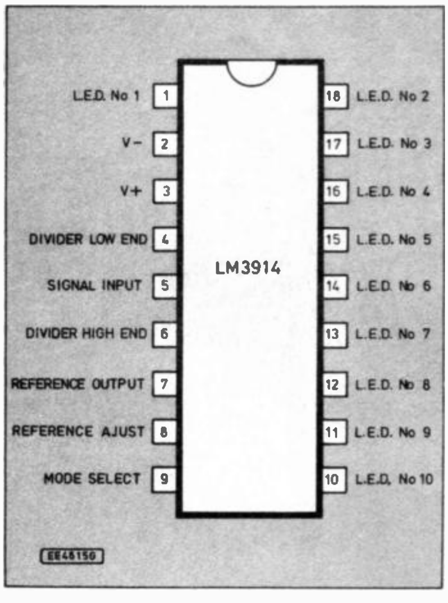
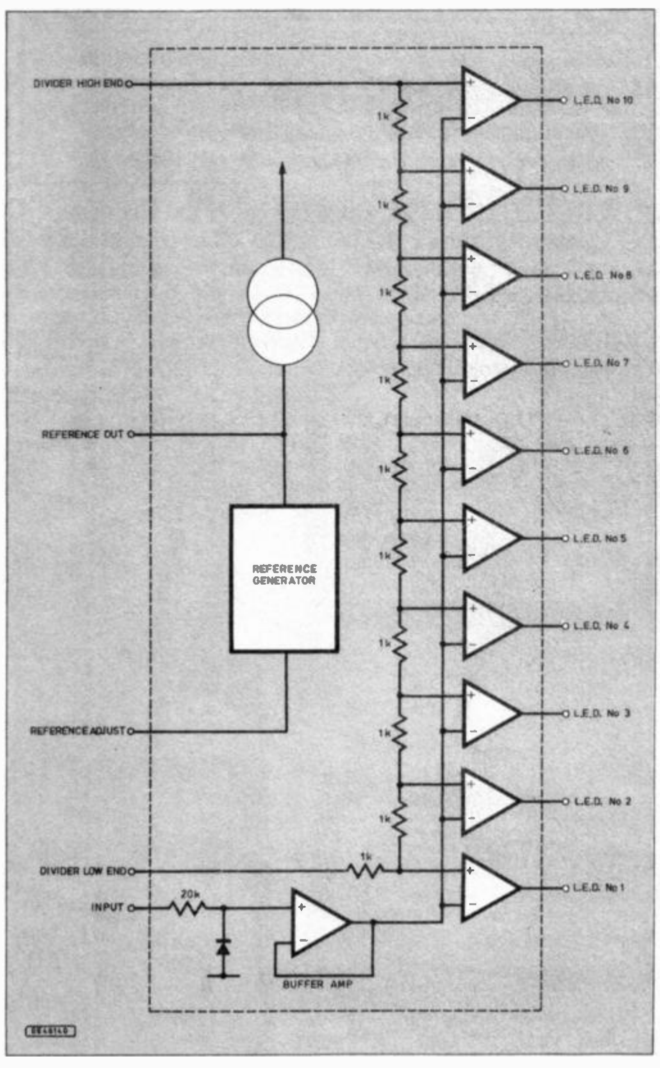


Fig. 2. (left). The pinout line-up and functions for the bargraph driver i.c.

Fig. 1. (right). Internal structure of the LM3914 bargraph display driver i.c.



CHAIN GANG

The drivers to be described are the LM3914/LM3916 series, intended for use with 10-segment l.e.d. displays. Apart from the log, linear, or VU response characteristics they are internally similar so a suitable place to start is with a brief description of their internal structure.

A simplified diagram of the internal structure of the display drivers appears in Fig. 1, together with the pin positions and functions in Fig. 2. The heart of the device is a ten-stage "divider chain" of resistors, to which a reference voltage can be connected. This reference may be derived either from an external source or from one supplied within the chip.

Each divider stage is connected to one input of an associated comparator, and the other inputs of all ten comparators are driven by a buffer amplifier to which the signal input is connected. As the input voltage rises, the comparators switch in sequence to drive the display l.e.d.s.

ON THE BUFFER

The buffer and comparators have some useful properties which make them exceptionally easy to design with. They can operate with input voltages down to the negative supply, so single supply circuit design is simple.

The buffer input impedance is very high, so it may be connected directly to high-impedance sources. It can withstand up to thirty-five volts both above and below negative supply, so additional protection will usually be unnecessary.

The comparator outputs are open-circuit in the "off" state. When "on", they become constant-current sinks so the l.e.d.s can be connected directly to them without current limiting resistors, and the display brightness does not change with supply voltage variations. The l.e.d. drive current is set by the user with the value of a single external resistor.

Two operating modes, "Bar" and "Dot", are available, selected by a single pin connection. "Dot" is better for battery operation as only one l.e.d. is normally alight, whilst "Bar" may be preferred for some mains-operated applications. In both modes, with a few extra connections two or more driver chips and their displays may be cascaded for greater resolution.

EXPERIMENTER'S TEST BOARD

The simple "Test Bed" stripboard component layout of Fig. 4 will enable constructors to experiment with these displays. The circuit diagram for the Experimenter's Test Board is shown in Fig. 3, consisting of the driver IC1, the ten-segment display IC2, and a decoupling capacitor C1. This is a tantalum bead type, recommended by the

COMPONENTS

EXPERIMENTER'S TEST BOARD

Capacitors
C1 2μ2 tantalum bead, 35V

See SHOP TALK Page

Semiconductors
IC1 LM3914 (linear), LM3915 (log) or LM3916 (VU) bargraph display driver
IC2 10-segment l.e.d. bargraph array, red

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Stripboard, 0·1in. matrix, 13 strips x 23 holes; 18-pin d.i.l. socket; 20-pin d.i.l. socket; single-core link wire; multi-strand connecting wire; solder pins (13 off); solder etc.

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EXPERIMENTER'S BARGRAPH TEST BOARD

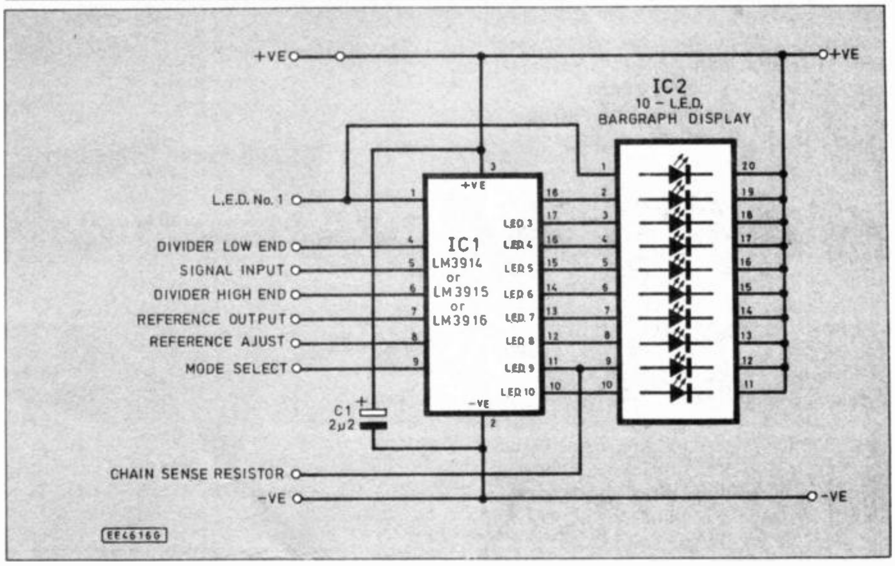


Fig. 3. Circuit diagram for the Experimenter's Bargraph Test Board.

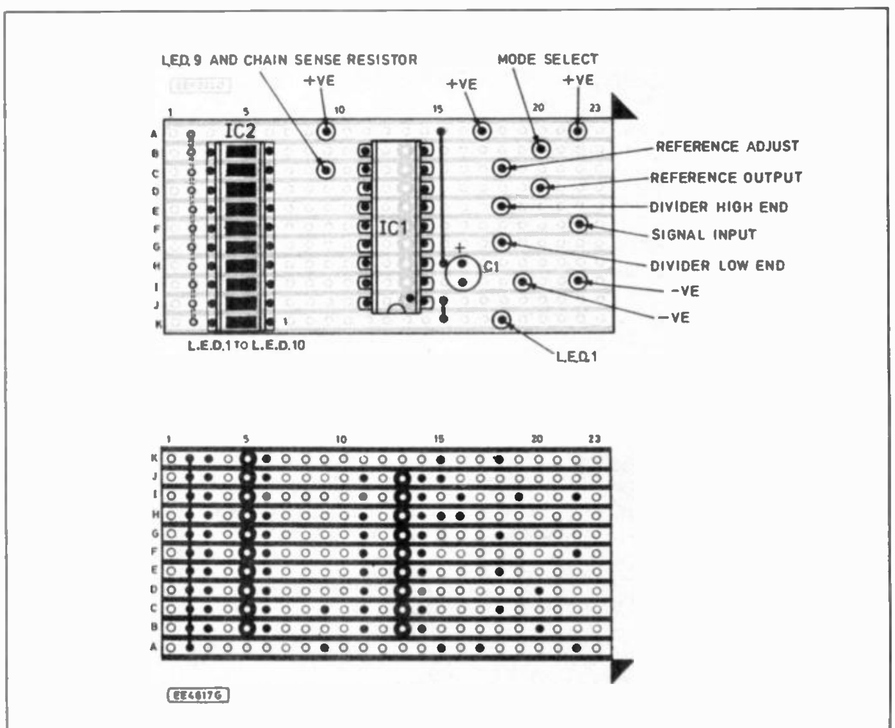
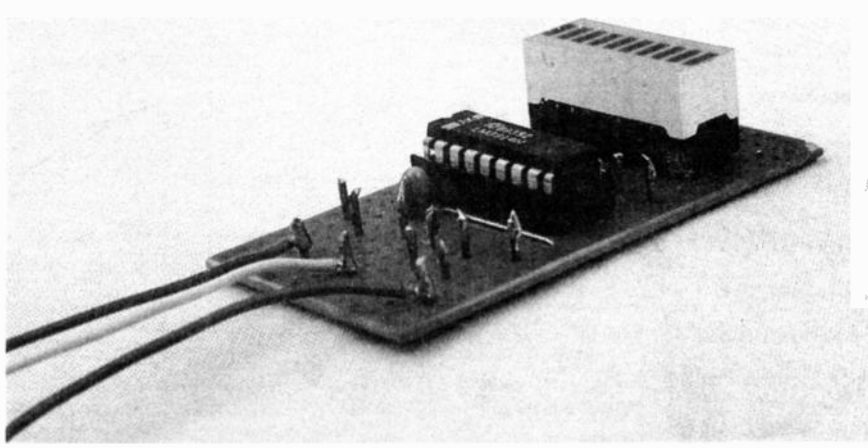


Fig. 4. Stripboard topside component layout, solder pin function details and underside view showing copper track breaks and links across tracks at points A2 to K2.



manufacturers to eliminate any possibility of spurious oscillation.

Connection points for configuring various circuits are readily accessible on the stripboard. The use of solder pins, available from board suppliers, for these is recommended here. The Experimenter's board has 13 strips of 23 holes.

Construction involves making nineteen breaks in the underside copper tracks as shown (Fig. 4), then fitting two topside wire links, three components, a third wire link on the underside and the thirteen solder pin connection points. The link on the copper track side is soldered to *every* strip across the left end, at points *A2* down to *K2*, to make the common connection of the l.e.d. anodes (a); it's position can be seen in Fig. 3.

Sockets are advised for the driver i.c. and the l.e.d. display so that if the circuit is later transferred to a p.c.b., these components can be re-used. Also, comparisons between log, linear and VU displays can be made by simply plugging in the appropriate chips and, if by some mischance an i.c. becomes damaged, it may be easily replaced.

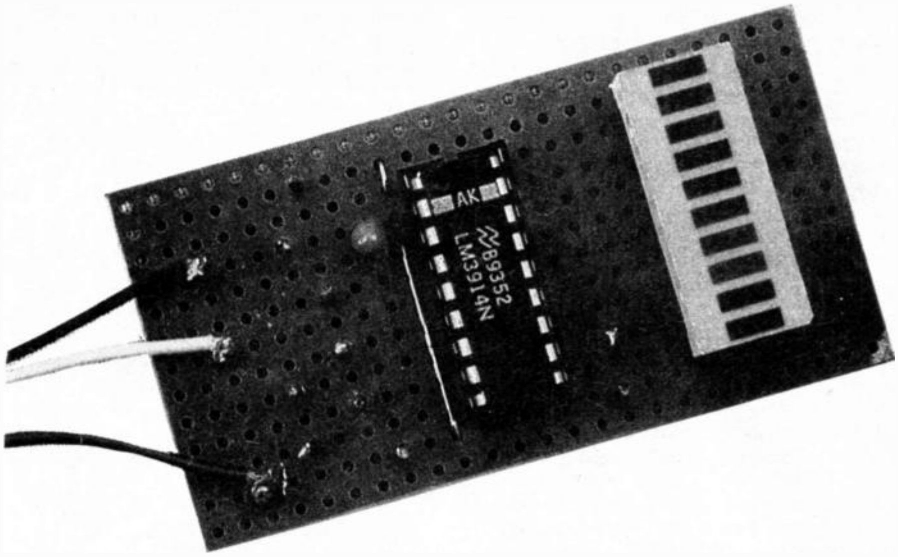
Capacitor C1 is a tantalum bead type, care should be taken with the polarity of this as the markings are often difficult to read. The position of IC1, with pin one at bottom right, should be observed.

TEST CIRCUIT

Following construction, experiments with the bargraph can be carried out. The pin functions of the various solder pin connections are also shown in Fig. 4. The simplest circuit arrangement is that of Fig. 5, where the bottom of the divider chain and the "reference adjust" are connected to negative supply whilst "reference output" is connected to the top of the divider chain, with a one kilohm resistor R2 to negative.

A variable input of about 0V to 1·6V, is supplied by VR1. The other connections are simply left unused. The voltage supplied by the "reference output" is about 1·25V, so when this simple circuit is powered VR1 should cover the full range of the display, which will be "Dot" mode.

Resistor R2 sets the l.e.d. drive current. The current supplied to each illuminated l.e.d. is about ten times the current drawn



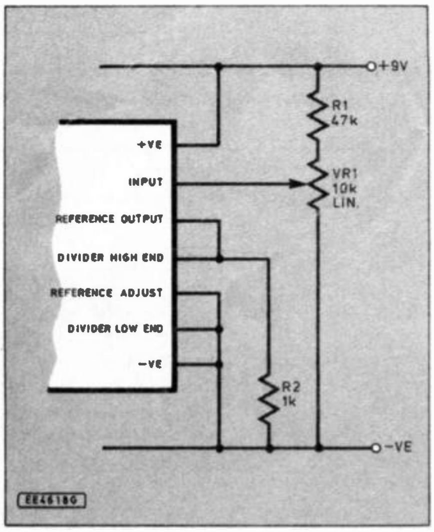


Fig. 5. Simplest form of test circuit arrangement.

from the reference output pin, so in this case, with 1·25V across one kilohm, it will be about 12·5mA.

For many battery-powered applications, this simple circuit will be all that is required. One chip, one l.e.d. array, two passive components and the circuit is complete! It will operate down to three volts, so three 1·5V cells are adequate to operate it, though anything up to 18V can be used.

However, it's worth exploring the capabilities of these i.c.s in more depth. If "mode select" (pin 9) is connected to the positive supply the display will change to "Bar" mode. This uses more current, but may be preferred for some applications. Heat generation within the chip can cause problems in this mode but a simple remedy for this will be explained later.

FURTHER REFERENCE

Meanwhile, some alternative methods of providing the reference for the divider chain can be described. Fig. 6a and Fig. 6b show two ways of using the internal reference to obtain full scales of 1V and 0·5V respectively, whilst maintaining the l.e.d. drive current at about 12mA. Both can be trimmed by about ± 25 per cent.

The "reference adjust" pin (8) can be used in the same way as the "adjust" terminal on some 3-pin regulators, with a resistor to negative supply raising the

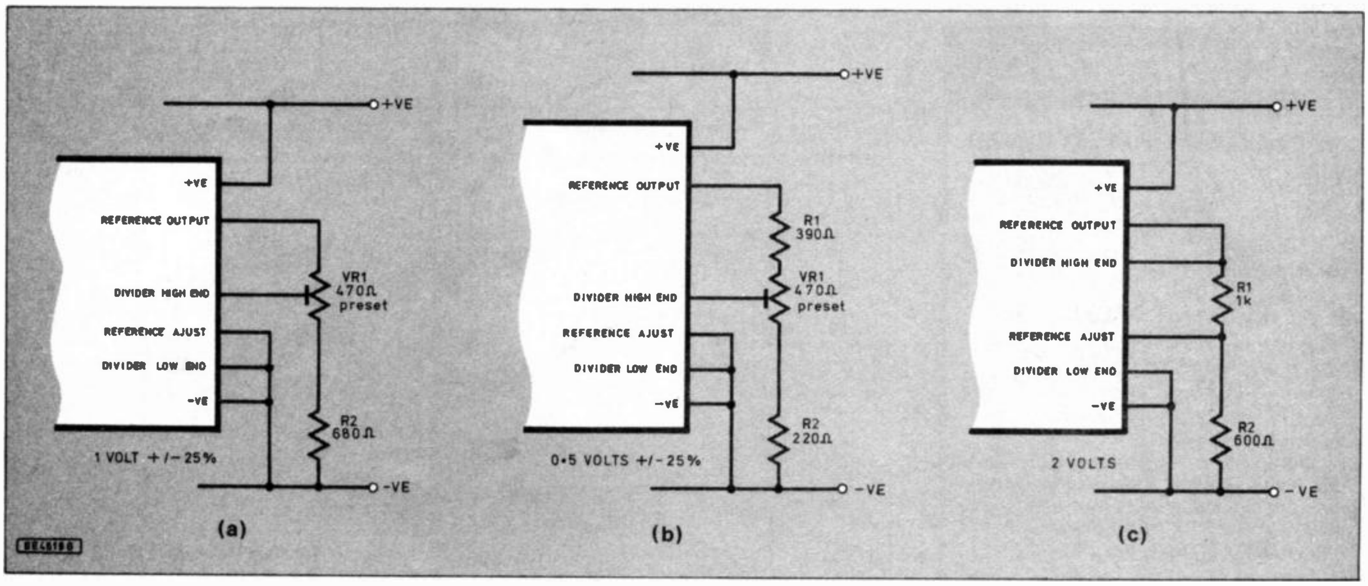


Fig. 6. Varying the reference with the internal generator of the bargraph driver chip. (a) and (b) show two ways of using the "internal reference" to obtain full-scales of 1V and 0·5V respectively. (c) using the "reference adjust" and internal reference to produce 2V.

voltage as shown in Fig. 6c. The internal reference of 1·25V appears between the "reference out" and "reference adjust" pins so the current flowing through resistor R1 flows to ground through the additional resistor R2, in this case adding another 0·75V to give a total of 2V.

The value of R2 for any voltage can be calculated from R2 = (V_{out} − 1·25) × R1/1·25, remembering that the value of R1 will be determined by the l.e.d. drive current required. A small current, about 125μA, flows out of "reference adjust" and will add a little to this voltage, but in most cases this will be too small to be of significance.

EXTERNAL INFLUENCE

Use of the internal reference is not essential, of course. So long as the l.e.d. drive has been set by connecting "reference adjust" and "reference out" to negative, the latter with a suitable resistor, the divider reference can be supplied from anywhere.

An adjustable 2V reference taken from a 5V regulated supply rail is shown in Fig. 7a. The bottom of the divider doesn't have to be connected to negative, either. Fig. 7b shows an arrangement which will give about 3V full-scale, starting from +2V.

In these arrangements the resistance of the divider chain must taken into account. In the case of the LM3914 linear driver this is about 10kilohms which, in parallel with the middle resistor, makes the scale 1V instead of about 1·6V.

CASCADE

For greater resolution, drivers and their displays may be cascaded. In "Bar" mode this is simple. All that is necessary is to connect the "mode select" pin of each chip to positive to select "bar" display, set the "reference out" current of each for the required display brilliance, then connect the divider chains in series and apply the reference across them all. These connections, for two i.c.s, are shown in Fig. 8a.

Things get a little more complicated where the mode is to be "dot". The l.e.d. current and divider chain connections are the same, but as the first l.e.d. of each successive chip turns on, it is necessary to extinguish the last l.e.d. of the previous one.

Special circuitry is provided in the chips to achieve this. To use it, the "mode select" pin (9) of each i.c. in the circuit should be connected to pin 1 ("l.e.d. 1") of the following i.c. The "mode select" of the last chip can be left unconnected.

All chips except the last should also have a 22 kilohm resistor in parallel with l.e.d. 9 (between pin 11 and +Ve). Three i.c.s connected in this manner are shown in Fig. 8b.

TAKING PRECAUTIONS

A couple of basic precautions are necessary when using these i.c.s. The first, already mentioned, is the use of a 2·2μF tantalum bead decoupling capacitor close to the supply pins to prevent possible oscillation.

A second and more serious consideration concerns power dissipation when used in "Bar" mode. Let's say a chip is programmed to supply 18mA to each l.e.d., with a 680 ohm load resistor connected to the reference. With all ten l.e.d.'s lit, the drain will be about 180mA.

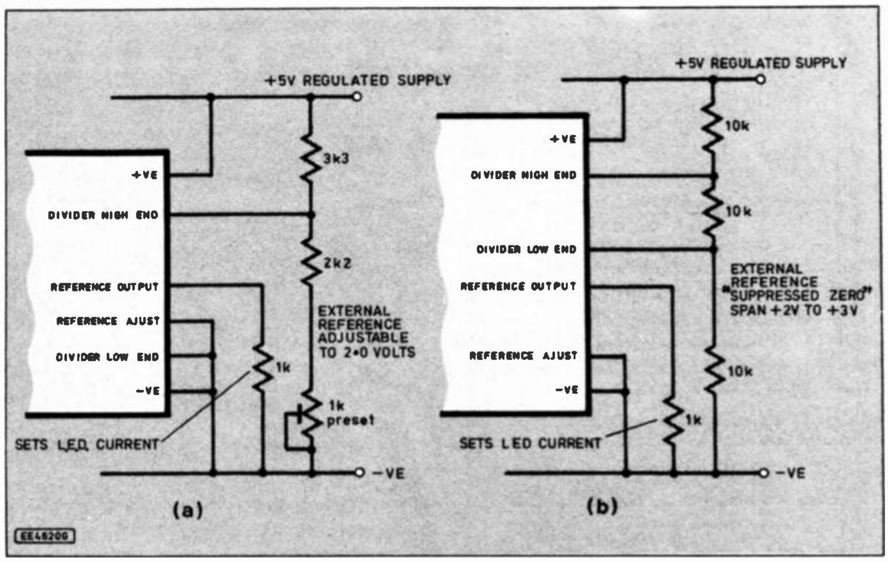


Fig. 7. Using external reference sources, (a) to produce an adjustable 2V and (b) up to +3V starting from +2V.

If the supply voltage is 9V, the l.e.d.s will drop about 1·75V of this and the remainder, some 7·25V, will appear across the current sinking outputs of the chip, giving rise to an internal dissipation of about 1·3W. The snag is that the i.c. is only rated for a total dissipation of 600mW so this would fry the chip faster than your local chippie!

The simple solution is to incorporate a resistor in series with the positive supply to the l.e.d. anodes, chosen to reduce the voltage to about 3V when the maximum current is drawn. In the example above a value of 33 ohms would be about right.

This would reduce the supply to 3V, of which about 1·3V would appear across the drivers in the chip, producing a dissipation of about 230mW which is well within the safe area. The resistor would dissipate about a watt of course, so a *suitably-rated* type would be required.

For mains-driven circuits incorporating a number of bargraph displays a good starting point would be a separate regulated 5V supply of suitable current rating. Series resistors would still be required, but their value would be reduced to 10 ohms with a 0·4W rating, and the overall amount of heat to be dissipated would be much reduced.

To try this with the "Experimenter's Test Board" stripboard an extra break will be required in the positive supply strip, with an extra connection point to make a *separate* supply connection to the l.e.d. array. □

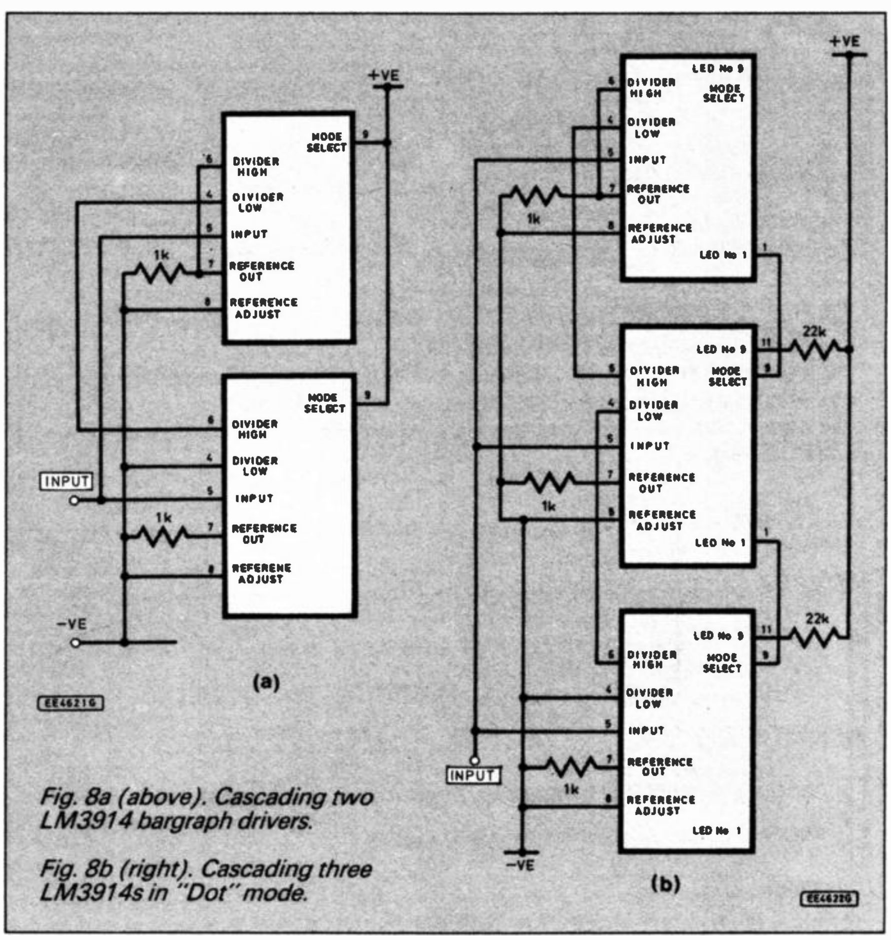


Fig. 8a (above). Cascading two LM3914 bargraph drivers.

Fig. 8b (right). Cascading three LM3914s in "Dot" mode.

Techniques

ACTUALLY DOING IT!

by Robert Penfold

ELECTRONICS is a hobby that can be pursued more or less as a craft, with projects being constructed by people who have little or no idea of how everything works. At the other extreme it is possible to read and learn about the theory of electronics without ever bothering to build a single project. Virtually all electronic hobbyists steer a course somewhere between these two limits, learning a fair amount about both the practical and theoretical sides of the hobby.

Even if you wish to pursue electronics largely for the pleasure of constructing projects, there are still some technicalities which you will need to tackle. An understanding of circuit diagrams is something you will probably want to master at a fairly early stage.

INGENUITY

An ability to read circuit diagrams is not needed in order to tackle a constructional project featured in *EPE* since a printed circuit or stripboard design is provided for every project. You basically just have to follow the drawings, which use physical representations of the components rather than symbols which often have little in common with the physical appearance of the components.

There are numerous circuits published in books, and in magazine features such as *Ingenuity Unlimited* and *Circuit Surgery*. Many of these are quite simple but useful, and before too long you will probably wish to try your hand at building one.

With this type of thing you normally have no help other than the circuit diagram, and you must design your own circuit layouts. You must obviously learn to read circuit diagrams before you can progress to the component layout. Fortunately, reading most circuit diagrams is very straightforward.

SYMBOLISM

A selection of common circuit symbols is given in Fig. 1. When dealing with circuit diagrams it is important to realise that there are variations in a given symbol from one circuit diagram to another.

In a few cases this is due to the fact that there are old and new versions of the symbol. The obvious example is the resistor, which has the old zigzag style symbol, and the box style symbol which is the current British standard.

Although it is officially obsolete, the zigzag resistor symbol remains popular, and is still used a great deal. It is, of course, the resistor symbol used in circuit diagrams that appear in this magazine.

In a similar vein, circuit symbols do not seem to be internationally standardised. Publications that have their origins outside the UK often have circuit symbols that are significantly different to the British standard set.

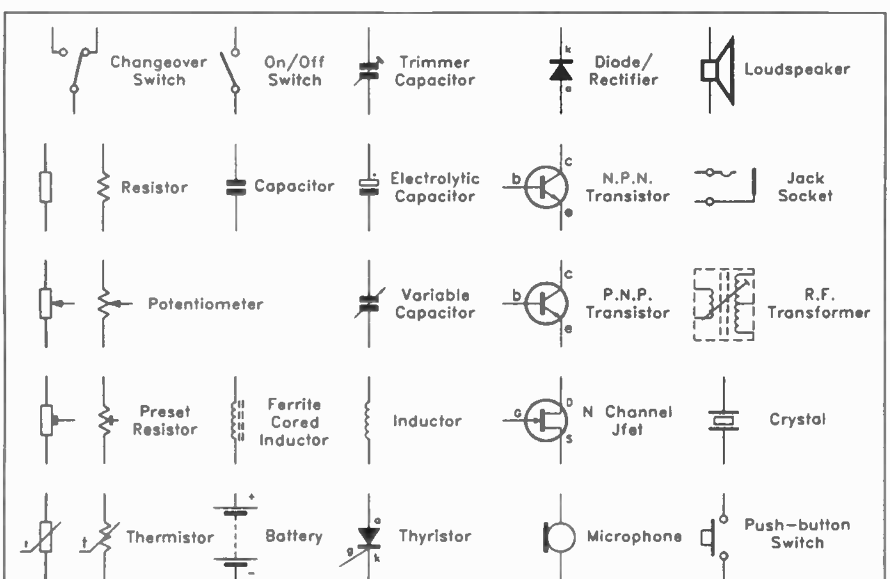


Fig. 1. A selection of common circuit symbols. The styles in which they can be drawn vary greatly.

Perhaps the most common examples are the American capacitor symbols. In an American capacitor symbol one line is curved, whereas both lines are straight in the British version.

The other reason for differences between supposedly identical circuit symbols is simply differences in drawing style from one symbol designer to another. These usually produce relatively minor variations, and should not give any major difficulties.

There is actually a style of circuit diagram which has virtually all two terminal components represented by a rectangle, like the box style resistor symbol. This type of circuit diagram has not been used much in publications aimed at amateurs, but is used a great deal in service manuals, etc.

Table 1: Component Identification

Letter(s)	Component
B	Battery
BY	Battery
C	Capacitor (any fixed value type)
CH	Chassis
CRT	Cathode ray tube
CSR	Thyristor or triac (controlled silicon rectifier)
D	Diode (any type, including photodiodes, l.e.d.s, and rectifiers)
E	Earth
FL	Filter (usually a ceramic, mechanical, or crystal type)
FS	Fuse
JK	Jack socket
IC	Integrated circuit
IFT	Intermediate frequency transformer
L	Inductor
LP	Lamp (neon or filament, but not an l.e.d.)
LS	Loudspeaker
M	Motor
ME	Meter
Mic	Microphone
PCC	Photo conductive cell (photoresistor, usually a cadmium sulphide type)
PL	Plug (any type)
Q	Transistor
R	Resistor (fixed value)
RL	Relay (coil or contacts)
RV	Variable resistor or potentiometer
S	Switch
SK	Socket (any type, but jack sockets are often given "JK" identification letters)
SW	Switch
T	Transformer (any type including r.f.)
TC	Trimmer capacitor (preset variable capacitor)
Th	Thermistor
TL	Earphone or headphones
Tr	Transistor
TR	Transistor
V	Valve (any type except c.r.t.)
VC	Variable capacitor
VR	Variable resistor or potentiometer
WD	Warning device (horn, bell, buzzer, etc.)
X	Crystal (also used where other letters inapplicable)

If in doubt about a circuit symbol, the letter in the component number should enable you to identify the type of component the symbol is meant to represent. With the circuit diagrams that use rectangles for most types of component, this is the only means of telling whether a component is a resistor, a capacitor, or an inductor.

There are a few minor variations in the letters used in component numbers. For example, transistors are normally TR1, TR2, etc, but can be Tr1, Tr2, etc., or Q1, Q2, etc. The list of component identification letters compiled in Table 1 should help to clarify matters.

BETWEEN THE LINES

On circuit diagrams, symbols are used to represent the components, and lines are used to represent the wires connecting one component to the next. Fig. 2 shows a simple "dummy" circuit diagram. Sometimes things are very straightforward, and in this example resistor R4 simply connects between pin 6 of IC1 (integrated circuit) and the base (b) terminal of TR1 (transistor).

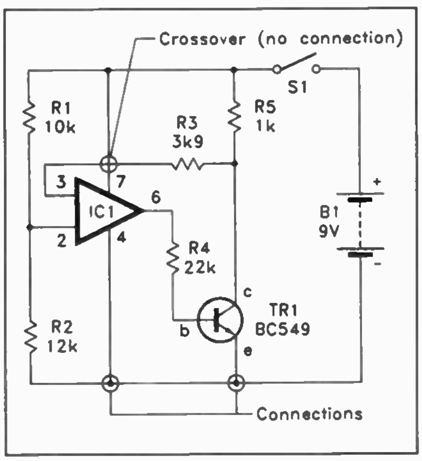


Fig. 2. Circuit diagram example showing connections and a crossover.

Often though, a lead or pin of a component will connect to more than one other component. For example, pin 2 of IC1 connects to both R1 and R2. This inevitably leads to some "T" junctions where three leads meet, and the "dot" circuit symbol is then used to indicate that there is a connection between all three leads. If one lead crosses over another but there is no connection between them, no dot symbol is used at the intersection of the two lines. Thus, in this example circuit there is no connection between pins 3 and 7 of IC1.

POLARITY

Most of the two-terminal components can be connected either way round. This includes resistors, non-polarised capacitors, inductors, and crystals. Electrolytic capacitors, and other polarised types such as tantalum capacitors, however, must be connected with the right polarity. There is no difficulty here since the positive terminal is marked with a "+" sign on circuit diagrams, and the actual components are marked with "+" and (or) "−" signs. Also, "axial" electrolytic capacitors usually have an indentation around the body next to the positive leadout wire.

Diodes of any type (rectifiers, photodiodes, l.e.d.s, etc.) must also be connected the right way round. On the circuit diagram the bar part of the symbol denotes the cathode ("**k**" or "+") terminal of a diode or rectifier.

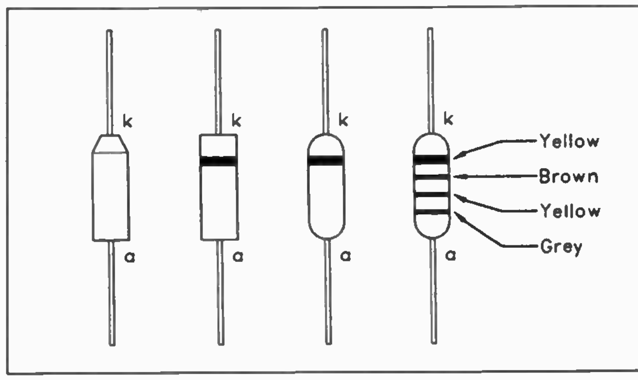


Fig. 3. Common methods of indicating the polarity of diodes and rectifiers.

On most diodes and small rectifiers the cathode terminal is indicated by a band around the appropriate end of the body, see Fig. 3. With some of the larger rectifiers the cathode is indicated by a thinning of the body at the cathode end.

The 1N4148 is a popular general purpose silicon diode, and this sometimes has four bands around the body. These indicate the "4148" part of the type number using a method of coding based on resistor colour codes. The first yellow band is the one next to the cathode leadout, and this band should be slightly wider than the other three.

With the more exotic diodes, such as photodiodes and l.e.d.s, the retailer's catalogue will usually provide connection details. One of the reasons I frequently advise buying at least a couple of the larger component catalogues is that they provide a massive amount of useful data. This often includes leadout data for all the semiconductors included in the catalogue.

Obviously great care needs to be taken in order to get three lead semiconductors (transistors, triacs, etc.) connected the right way round. Again, the larger component catalogues provide leadout information for all the three terminal semiconductors you are likely to use.

Note that it is the convention for the leadout diagrams for transistor, triacs, and the like to be ***base views.*** In other words, they show the components viewed with the leadout wires pointing towards you.

INTEGRATED CIRCUITS

There are specific circuit symbols for logic gates, and for operational amplifiers (op.amps), but for other integrated circuits (i.c.s) a rectangle is used. In the present context the symbol used is not important. All you need to worry about are the component *identification numbers* which enable you to distinguish between one integrated circuit and another, and the *pin numbers* for each device.

These days, most integrated circuits are housed in d.i.l. (dual in-line) plastic encapsulations. These either have pin one indicated by a small dimple in the case, or the pin 1/14 end of the component is indicated by a notch or line at that end of the case, see Fig. 4.

Many actual components seem to use two of these methods, as in the fourth example of Fig. 4. Always look carefully at d.i.l. integrated circuits as there are often moulding marks that can look rather like the notch, but are actually at the other end of the case.

Only 14-pin devices are shown in Fig. 4, but the method of numbering is the same regardless of the number of pins. The pins are numbered in a counter-clockwise direction with the device ***viewed from the top*** (with the pins pointing away from you). Note that the convention is for i.c. pinout diagrams to be top views, which is the opposite to the convention for transistors and physically similar semiconductor devices. With the more exotic integrated circuits, such as some of the power types, the all-important component catalogues should be able to provide pinout details.

PRACTICE MAKES PERFECT

Ultimately there is only one way to get to grips with reading circuit diagrams, and that is to try your hand at it, starting with a few simple circuits and progressing to more complex ones as you advance your skills. Start by looking at some of the simpler projects in *EPE*, and compare the theoretical circuit with the circuit board and wiring diagrams. This will teach you a great deal about laying out circuit boards as well as improving your proficiency at reading circuit diagrams.

Alternatively, you could "sign-on" for the new ***Teach-In '96*** series starting next month. This exciting series will be combining both the theoretical and practical sides of electronics – *Most of the emphasis being on the "PRACTICAL" – Ed.*

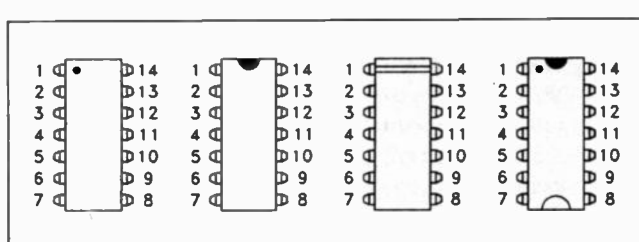


Fig. 4. Polarity indications and pin numbering for typical d.i.l. integrated circuits.

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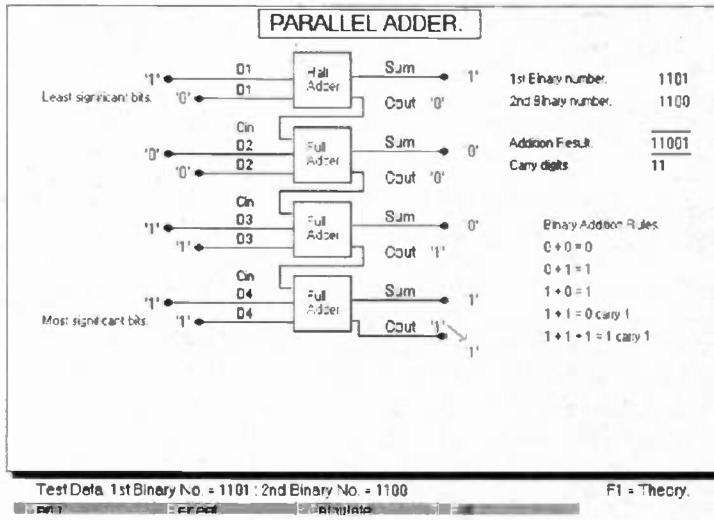

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This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can be confusing.
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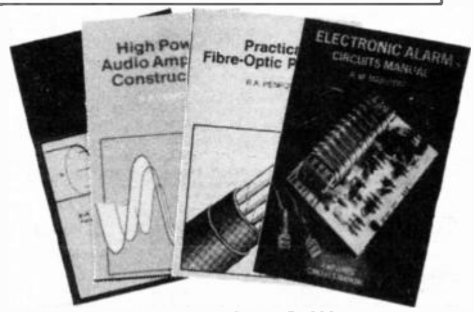

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The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
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The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
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I. D. Poole
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R. A. Penfold
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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
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A. Pickford
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There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
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P. Shore
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

NOVICE ENTRY

Last month I explained how to become a radio amateur, by taking the "full" Radio Amateurs' Examination (RAE). This time I'm looking at the Novice Radio Licence which is designed to encourage people of all ages, but particularly the young, to take up amateur radio.

Courses for the Novice Radio Amateurs' Examination (NRAE) are run by the Radio Society of Great Britain at locations throughout the UK. Local instructors who are also radio amateurs run the courses. These last for about 30 hours over 12 weeks, and the exams are held four times a year.

Candidates must successfully complete the course before taking the examination. Encouragingly, the courses achieve very good results as can be seen from the following statistics. In the three years up to September 1994, 3,603 candidates took the exam and 2898 passed, a success rate of 80 per cent.

EXAMINATION

The 75-minute examination is set by the City & Guilds of London Institute and has 45 multiple choice questions.

The subjects covered are: Receivers and receiving techniques; components, applications and units; measurements; propagation and antennas; transmitters and transmitting techniques; operating techniques; station layout; construction; safety; and licensing conditions.

A candidate passing only one paper can carry forward that pass indefinitely, needing only to pass the remaining paper in a future examination. As in the case of the RAE, special arrangements can be made for disabled or housebound candidates. Subject to receipt of satisfactory evidence, extra time may be allowed, or the examination may be taken at home or in hospital.

TWO TYPES OF LICENCE

Once you have passed the examination there are two types of Novice licence available. Class A requires a Morse test to be passed at five words per minute, and Class B can be obtained without the need to take a Morse test.

Unlike the holders of the "full" Class A and Class B licences, Novice licensees have restricted frequencies available to them, and must use low power when transmitting. Class A Novices have some access to the HF bands (using mainly Morse with some telephony) and to the VHF/UHF bands (with several modes, including voice, Morse, and use of computers). Class B Novices have limited access as above only to the VHF/UHF bands.

Despite these limitations, Novice operators are able to experience many aspects of amateur radio at first hand, and many go on to take the RAE to become "full" A or B licensees.

HOW TO START

Information about Novice training courses, including details of where they are held in your locality, can be obtained from the *Radio Society of Great Britain, Dept EPE, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE*. The Society has several publications specially written for Novice students.

Additionally, as mentioned last month, the Radiocommunications Agency has a free booklet, *How to Become a Radio Amateur*, obtainable by 'phoning 0171 215 2352. Copies of the NRAE examination syllabus (price £2 post free), plus free sample questions, can be obtained from *The City & Guilds of London Institute, Dept EPE, 46 Britannia Street, London WC1X 9RG*. The subject number to be quoted is 773.

Next month I will finish this review of the ways to become a radio amateur by looking at the two different types of Morse test, and various methods of learning the code.

RSGB MEMBERSHIP CHANGES

The RSGB has just announced a new membership category for young people under 18 called the "HamClub". For £10 a year members receive a special Junior Membership pack and a free annual subscription to *D-i-Y Radio* magazine.

At the other end of the scale, veteran Home Corporate members with 50 years continuous membership will receive a 50 per cent discount on their fees, and those with 60 years membership will be given free life membership.

As from September, the Home Corporate membership fee increased from £32 to £34 p.a. The rate for senior citizens is unchanged at £27. Full-time students and family members' fees are reduced.

Details of the new categories and changed rates are in the August issue of *Radio Communication*. Copies of this issue are available to non-members by sending an A4 s.a.e. with 43p in stamps to: "John Davies, August RadCom", at the RSGB address above.

FREE DX BOOKLET

A useful free booklet for SWLs, *Radio Propagation For Beginners* is available from radio station KNLS in Alaska. This is written by Carl Mann, a radio news reporter in Omaha, Nebraska, himself an enthusiastic shortwave listener.

Intended to help listeners improve their reception during the low end of the 11-year propagation cycle, its chapters cover: An Introduction to Propagation; Groundwave, Skywave and the Ionosphere; The Radio Spectrum; The Solar Cycle; and Understanding and Using Propagation Knowledge.

There are four appendices, providing definitions of the geophysical alerts broadcast at 18 minutes past the hour by WWV (the standard frequency and time signal station); information about the current state of solar cycle 22, which is forecast to end in mid-1996; a frequency/wavelength conversion chart covering the shortwave broadcast bands; and details of a simple long wire antenna suitable for shortwave reception.

The booklet is free of charge, but two international reply coupons should be sent to cover postage. Write to *DX Propagation for Beginners, c/o Station KNLS, Anchor Point, Alaska 99556, USA*. Please mention that you read about the booklet in this magazine.

AUSTRALIAN FEE REDUCED

In May, I reported that Australia's Spectrum Management Agency (SMA) had imposed a 92 per cent increase on its amateur licence fees, including a new "Spectrum Access Tax".

After receiving a barrage of protest from amateurs around Australia, the SMA has compromised by reducing the new licence fee from the proposed A$71 to A$51, a final increase over the old fee of just under 38 per cent.

The Wireless Institute of Australia (WIA) is continuing its fight against any increase at all, and is currently seeking to make the government more aware of the true value of amateur radio in the hope that it will set a more appropriate (lower) licence fee.

SUPERHET RADIO HANDBOOK

A new book by Ian Poole, G3YWX, a regular contributor to *EPE*, looks at the operation of the superhet radio. He says: "It has formed the basis for most radios since the 1920's. Now over seventy years later there are no other ideas even on the horizon which might replace it."

During this period, valves have been replaced by transistors, which in turn have been replaced by integrated circuits. Although the superhet principle has remained the same, today's circuits are more complicated than those of the past, and provide more facilities with greatly improved performance.

This book takes the reader through every stage of the superhet circuit, from basic principles to modern refinements. If you want to understand what radio is all about, you can make a good start with this small handy volume. Whether you are interested in communications equipment, worldband radios, scanners or domestic broadcast receivers, it will help you understand how they work, and what to look for when in the market for a new receiver.

The Superhet Radio Handbook, by I.D. Poole, is published by Bernard Babani (publishing) Ltd, price £4.95. It is available from the *EPE Direct Book Service*.

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