EVERYDAY ELECTRONICS

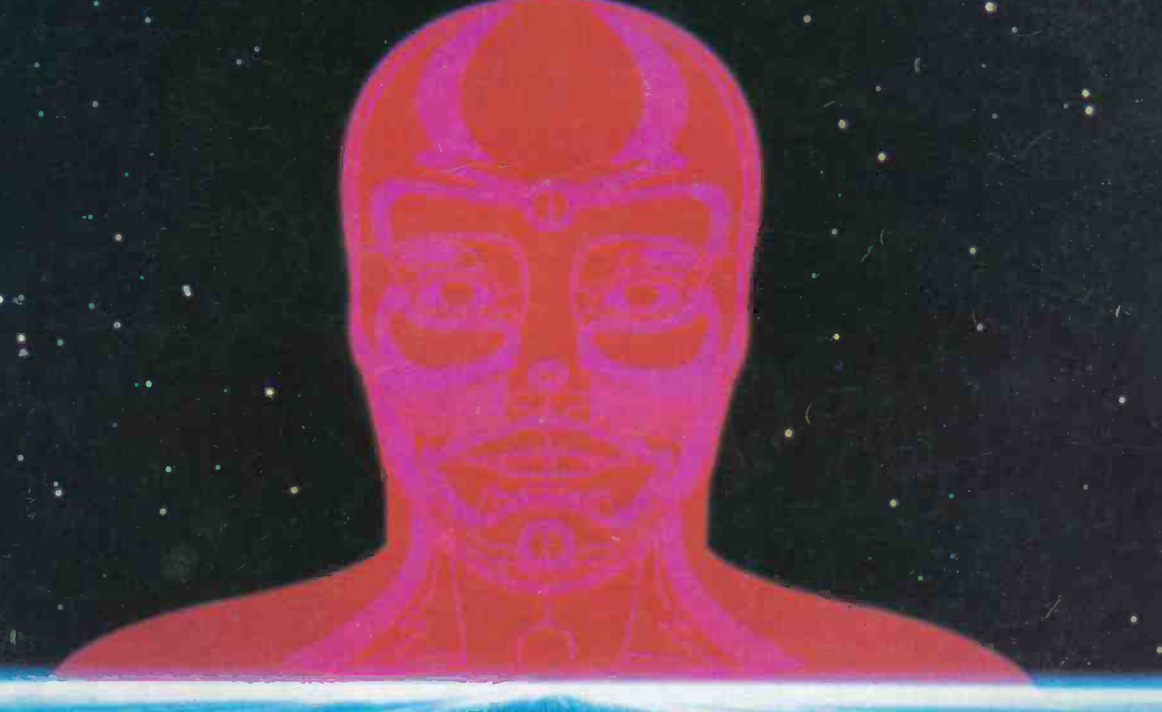
JULY 1989

INCORPORATING ELECTRONICS MONTHLY

£1.40

POWER SUPPLY DESIGN PART 1

PIR INTRUDER DETECTOR



POCKET MONEY PROJECTS
SNAP SWITCH – RAIN ALARM

PROGRAMMABLE POCKET TIMER

The Magazine for Electronic & Computer Projects

No. 1 LIST BAKERS DOZEN PACKS

All packs are £1 each, if you order 12 then you are entitled to another free. Please state which one you want. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

- BD2 5 13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
- BD7 4 In flex switches with neon on/off lights, saves leaving things switched on.
- BD9 2 6V 1A mains transformers uorioht mountino with fixing clamps.
- BD11 1 6½in speaker cabinet ideal for extensions, takes our speaker. Ref BD137.
- BD13 12 30 watt reed switches, it's surprising what you can make with these—burglar alarms, secret switches, relay, etc., etc.
- BD22 2 25 watt loudspeaker two unit crossovers.
- BD29 1 B.O.A.C. stereo unit is wonderful breakdown value.
- BD30 2 Nicad constant current chargers adapt to charge almost any nicad battery.
- BD32 2 Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
- BD42 5 13A rocker switch three tags so on/off, or change over with centre off.
- BD45 1 24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. original cost £40 each.
- BD49 10 Neon valves, with series resistor, these make good night lights.
- BD56 1 Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
- BD59 2 Flat solenoids—you could make your multi-tester read AC amps with this.
- BD67 1 Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
- BD91 1 Mains operated motors with gearbox. Final speed 16 rpm, 2 watt rated.
- BD103A 1 6V 750mA power supply, nicely cased with mains input and 6V output leads.
- BD120 2 Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
- BD122 10m Twin screened flex with white pvc cover.
- BD128 10 Very fine drills for pcb boards etc. Normal cost about 80p each.
- BD132 2 Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
- BD134 10 Motors for model aeroplanes, spin to start so needs no switch.
- BD139 6 Microphone inserts—magnetic 400 ohm also act as speakers.
- BD148 4 Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
- BD149 6 Safety cover for 13A sockets—prevent those inquisitive little fingers getting nasty shocks.
- BD180 6 Neon indicators in panel mounting holders with lens.
- BD193 6 5 amp 3 pin flush mounting sockets make a low cost disco panel.
- BD196 1 in flex simmerstat—keeps your soldering iron etc. always at the ready.
- BD199 1 Mains solenoid, very powerful, has 1in pull or could push if modified.
- BD201 8 Keyboard switches—made for computers but have many other applications.
- BD210 4 Transistors type 2N3055, probably the most useful power transistor.
- BD211 1 Electric clock, mains operated, put this in a box and you need never be late.
- BD221 5 12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
- BD242 2 6in x 4in speakers, 4 ohm made from Radiomobile so very good quality.
- BD252 1 Panostat, controls output of boiling ring from simmer up boil.
- BD259 50 Leads with push-on ¼in tags—a must for hook-ups—mains connections etc.
- BD263 2 Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
- BD268 1 Mini 1 watt amp for record player. Will also change speed of record player motor.
- BD283 3 Mild steel boxes approx 3in x 3in x 1in deep—standard electrical.
- BD293 50 Mixed silicon diodes.
- BD305 1 Tubular dynamic mic with optional table rest.

CAMERAS. Three cameras, all by famous makers, Kodak, etc. One disc, one 35mm and one instamatic. All in first class condition, believed to be in perfect working order, but sold as untested. You can have the three for £10 including VAT, which must be a bargain—if only for the lenses, flash gear, etc. Our ref 10P58.

675 VOLT MAINS TRANSFORMER PCB mounting, 20VA. A very well made (British) transformer. Ideal for laser power supply, etc. Price £4. our ref 4P38.

EXTRA SPECIAL CROC CLIPS Medium size, just right for most hook-ups. Normally sell for around 10p to 15p each. These are insulated and have a length of spring rod connected to them but this is very easy to snip off if you do not need it. 20 for £1. Our ref BD117A.

COPPER CLAD PANEL for making PCB. Size approx 12in long×8½in wide. Double-sided on fibreglass middle which is quite thick (about 1/16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD683.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder—a complete mains operated kit, case included. £12.50+£2 P&P. Our ref 12P5/1.

ORGAN MASTER Is a three octave musical keyboard. It is beautifully made, has full size (piano size) keys, has gold plated contacts and is complete with ribbon cable and edge connector. Can be used with many computers. We can supply information sheet. Brand new, only £15 plus £3 postage. Our ref 15P15.

MIDI SPEAKERS Stereo pair, made by the famous Bush Radio Company. One way BASS reflex system, using a full range 4in driver of 4ohms impedance. Mounted in very nicely made black fronted walnut finish cabinets. Cabinet size approx 8½in wide, 14in high and 3½in deep. Fitted with a good length of speaker flex and terminating with a normal audio plug. Price £5 the pair plus £1 post. Our ref 5P141.

CAR SECURITY ALARM. Protect your car against vandals and thieves. Our ultrasonic burglar alarm on the back sheif of your car would sound off with a terrific noise if anyone opened the door, broke a quarter light or opened the boot. Complete equipment comprises the ultrasonic transmitter, receiver and sounder housed in a very neat case, size 7in wide × 2¼in high × 4in deep, and its separate siren. The mains power supply which is included to operate the separate siren would not be required as the 12 volts could be obtained from the car battery. The price is £30. Our ref 30P5.

COMPUTER COMPATIBLE CASSETTE RECORDER For playing games or for listening to music cassettes. It has a built-in condenser microphone and loudspeaker (muted if you use the extension socket). Has the following controls: pause, stop/eject, fast forward, rewind, play and record. Also has built-in tape counter, extension headphone and microphone socket and volume control. Built-in power supply enables it to run from the mains but provision also for battery operation. In 'as new' condition, but customer returns so may have fault. Price only £10 and if you order 4 you get a fifth one free. Our ref 10P65.

3½in FLOPPY DISC DRIVE—DOUBLE SIDED, DOUBLE DENSITY, 80 TRACK Shugart compatible, has 34 way IDC connector and will interface with almost any computer. Made by the famous Japanese NEC Company. Price £59.50 plus £3 insured post.

ATARI 65XE COMPUTER At 64K this is most powerful and suitable for home and business. Complete with PSU, TV lead, owner's manual and six games. Can be yours for only £45 plus £3 insured delivery.

65XE COMPENDIUM Contains: 65XE Computer, its data recorder XC12 and its joystick, with ten games for £62.50 plus £4 insured delivery.

CATHODE RAY TUBE The Philips 9in black and white, makers' reference M24/306W, which in addition to being a high resolution tube is also X-ray and implosion protected. Regular price well over £30, our price £12 plus £2 post, and if you order during May, June and July you will get the deflection coils free. Our ref 12P7.

1/8th HORSEPOWER 12 VOLT MOTOR. Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the ends by means of 2 nuts. A very powerful little motor which revs at 3,000 rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. price £6. Our ref 6P1, discount for quantities of 10 or more.

PHILIPS LASER

This is helium-neon and has a power rating of 1.6mW. Completely safe so long as you do not look directly into the beat when eye damage could result. Brand new, full spec, £30 plus £3 insured delivery. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15. Battery operated P.S.U. now available at £15.

BATTERY DRIVEN LASER POWER SUPPLY This is available in three versions. **First:** is a cased unit which holds the power supply and is fed from a separate 12 volt battery and drives the laser through extension leads. Kit complete with ABS case. Price £15. Our ref 15P22. **Second:** is a metal cased unit which holds the power supply and the laser but is driven from an external 12 volt battery. This unit, in kit form, costs £18. Our ref 18P2. A conversion kit from 15P22 to 18P2 is £6. Our ref 6P14. **Third:** is a metal cased unit which holds the laser, its power supply and 2×6 volt rechargeable batteries which feed it, also the mains driven unit to recharge the batteries. Complete kit is £24. Our ref 24P2.

MONO RADIO CASSETTE RECORDER AM/FM with all the normal controls. In 'as new' condition but customer returns or shop rejects, so may need attention. Price £10. Order 5 of these and get a sixth one free. Our ref 10P66.

PRETTY CASSETTE PLAYER in handy carrying pouch with silk type shoulder cord. Ideal present for a young girl. New, tested and in perfect order. Just needs headphones and batteries. Price £4. Our ref 4P35.

HIGH RESOLUTION MONITOR. 9in black and white, used Philips tube M24/306W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. **£16 plus £5 post.** Our ref 16P1.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape (4½in×4½in×1¾in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each.** Our ref 8P26.

FDD BARGAIN

3½in made by Chinon of Japan. Single sided, 80 track, Shugart compatible interface, interchangeable with most other 3½in and 5¼in drives. Completely cased with 4 pin power lead and 34 pin computer lead £40 plus £3 insured delivery. Our ref 40P1.

OUR ALADDIN'S CAVE. You may be a new reader and now know that we have a shop at 12 Boundary Road, Hove, where you can go and have a browse around at our assortment of 'goodies'. Unfortunately, because of staff shortages, we cannot be open on Saturdays yet, so the hours are 9.30am to 5pm, Monday to Friday. We of course still serve callers at 250 but request that you bring a completed order form as 250 is really the mail order depot.

J & N BULL ELECTRICAL

Dept. E.E., 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT

MAIL ORDER TERMS: Cash, PO or cheque with order. Orders under £20 add £1.50 service charge. Monthly account orders accepted from schools and public companies. Access and B/card orders accepted. —minimum £5. Phone (0273) 734648 or 203500.

POPULAR ITEMS

Some of the many items described in our current list which you will receive if you request it

EHT TRANSFORMER 4kv 2mA Ex-unused equipment. £5. Our ref 5P139

FOIL CAPACITORS Axial ended .33uf 1,000v. 4 for £1. our ref BD672. Many other sizes in stock, send for May newsletter.

4 CORE TINSEL COPPER LEAD As fitted to telephones, terminating with flat BT plug. 2 for £1. Our ref BD639.

EHT TRANSFORMER 8kv 3mA. £10. Our ref 10P56.

DOUBLE MICRODRIVES. We are pleased to advise you that the Double Microdrives which we were offering at about this time last year as being suitable for the 'QL', 'OPD' and several other computers are again available, same price as before namely £5. Our ref 5P113.

SOFTWARE FOR REMAKING. Just arrived. Large quantity of mainly games. All are on normal tape spool in cassette holders and should be suitable for wiping out and re-making into games or programmes of your own design. We offer 5 different for £2 or 100 assorted for £20. Important note: We cannot say which titles you will get nor accept orders for specified titles or 'so many, all different', etc., so only order if you can take them as they come. Order ref 5 for £2 is 2P224, 100 assorted is 20P10.

VERY USEFUL MAGNETS. Flat, about 1in long, ½in wide and ¼in thick. These are polarised on their faces which makes them ideal to operate reed switches in doors and windows or to hold papers or labels, etc., to metal cabinets, or even to keep cupboard doors firmly closed. Very powerful. 6 for £1. Our ref BD274(a).

ACORN COMPUTER DATA RECORDER REF ALF03 Made for the Electron or BBC computers but suitable for most others. Complete with mains adaptor, leads and handbook. £10.00. Ref 10P44.

FREE POWER! Can be yours if you use our solar cells—sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine—they work just as well in bright light. Voltage input is .45—you join in series to get desired voltage—and in parallel for more amps. **Module A** gives 100mA, Price £1, Our ref. BD631. **Module C** gives 400mA, Price £2, Our ref. 2P199. **Module D** gives 700mA. Price £6. Our ref. 6P3

SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £6. Our ref. 6P3.

METAL PROJECT BOX Ideal size for battery charger, power supply, etc.; sprayed grey, size 8in x 4¼in x 4in high, ends are louvred for ventilation other sides are flat and undrilled. Price £2. Order ref. 2P191.

4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core size 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres £2. Our ref. 2P196 or 100 metres coil £8. Order ref. 8P19.

6-CORE FLEX CABLE. Description same as the 4-core above. Price 15 metres for £2. Our ref. 2P197 or 100 metres £9. Our ref. 9P1.

13A PLUGS Pins sleeved for extra safety, parcel of 5 for £2. Order ref. 2P185.

13A ADAPTERS Takes 2 13A plugs, packet of 3 for £2. Order ref. 2P187.

20V-0-20V Mains transformers 2½ amp (100 watt) loading, tapped primary. 200-245 upright mountings £4. Order ref. 4P24.

BURGLAR ALARM BELL—6" gong OK for outside use if protected from rain. 12V battery operated. Price £8. Ref. 8P2.

VERY RELIABLE CAPACITOR 4.7µ 400v not electrolytic so not polarised, potted in ali can, size 1¾x¾x1½in high. A top grade capacitor made for high class instrument work. Ideal for PCB mounting. 2 for £1. Our ref BD667.

CAPACITOR BARGAIN—axial ended, 4700µF at 25V. Jap made, normally 50p each, you get 4 for £1. Our ref. 613.

SINGLE SCREENED FLEX 7.02 copper conductors, pvc insulated then with copper screen, finally outer insulation. In fact quite normal screened flex. 10m for £1. Our ref BD668.

M.E.S. BULB HOLDERS Circular base batten type fitting. 4 for £1. Our ref BD127a.

SPRING LOADED TEST PRODS—Heavy duty, made by the famous Bulgin company, very good quality. Price 4 for £1. Ref. BO597.

3-CORE FLEX BARGAIN No. 1—Core size 5mm so ideal for long extension leads carrying up to 5 amps or short leads up to 10 amps. 15mm for £2. ref. 2P189.

3-CORE FLEX BARGAIN No. 2—Core size 1.25mm so suitable for long extension leads carrying up to 13 amps, or short leads up to 25A. 10m for £2. Ref. 2P190.

ALPHA-NUMERIC KEYBOARD—This keyboard has 73 keys giving trouble free life and no contact bounce. The keys are arranged in two groups, the main area is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" x 4"—brand new but offered at only a fraction of its cost, namely £3, plus £1 post. Ref. 3P27.

WIRE BARGAIN—500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 plus £1 post. Ref. 3P31—that's well under 1p per metre, and this wire is ideal for push on connections.

1/8th HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which revs at 3,000rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. Price £6. Our ref 6P1, discount for quantities of 10 or more.

3 VOLT MOTOR Very low current so should be very suitable for working with solar cells. £1 each. Our ref BD681.

MINI SPEAKERS to use instead of headphones with your personal stereo—simply plug in to earphone socket. Excellent sound quality, only £4 per pair. Our ref 4P34.

SEALED LEAD ACID BATTERIES Japanese made re-chargeable and maintenance-free. Leak-proof construction, so could be used in any position. Long life expectancy—usually four to five years. 12V 2.6Ah, £10 each. Our ref 10P59. 6V 1Ah, £5 each. Our ref 5P135.

INNER EAR STEREO HEADPHONES Ideal for lady listeners as they will not mess up your hair do! Come complete in a neat carrying case. Price £3. Our ref 3P56.

STEREO HEADPHONE AMPLIFIER Very sensitive. A magnetic cartridge or tape head will drive it. Has volume control and socket for stereo headphones. 3V battery operated. £1 each. Our ref BD680.

FET CAPACITOR MICROPHONE EAGLE CI.200 Output equivalent to a high class dynamic microphone while retaining the characteristics of a capacitor microphone. Price £1. Our ref BD646.

SUB-MIN TOGGLE SWITCH Body size 8mm×4mm×7mm SBDT with chrome dolly fixing nuts. 4 for £1. Our ref BD649.

SUB-MIN PUSH SWITCH DPDT. Single hole fixing by hexagonal nut. 3 for £1. Our ref BD650.

DISPLAY 16 CHARACTER 2 LINE As used in telephone answering and similar machines. Screen size 85mm×36mm×9.3mm. Alpha-numeric, dot matrix module with integral CMOS micro processor, LCD display. Made by the EPSON Company, reference 16027AR. Price £10. Our ref 10P50.

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ABC

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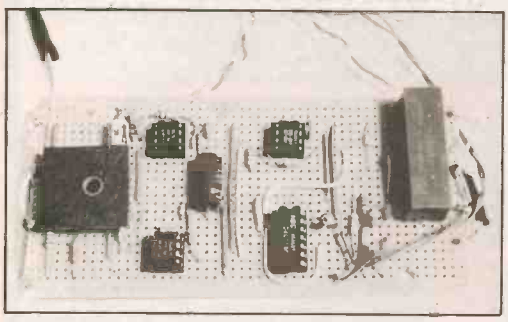
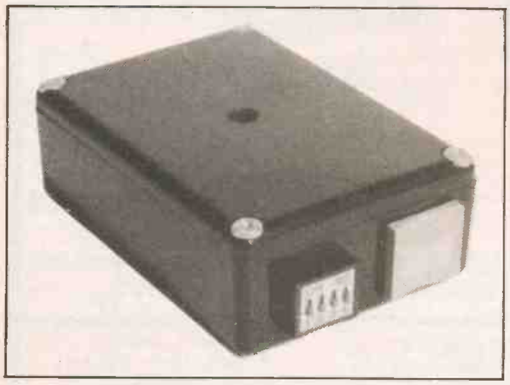
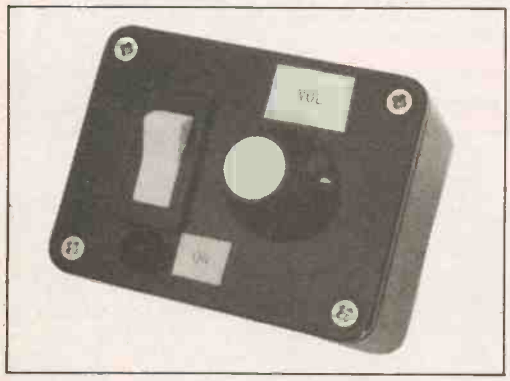
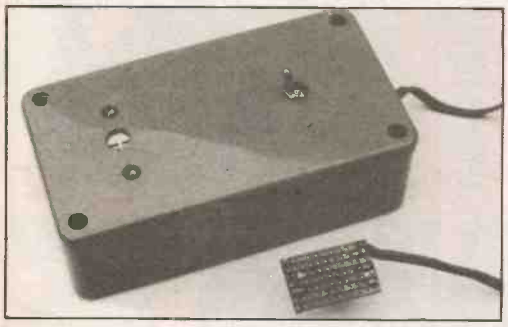
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Projects

Series

Features

Our August '89 Issue will be published on Friday, 7 July 1989. See page 419 for details.

MAGENTA ELECTRONICS Ltd.

A SELECTION OF OUR BEST PROJECT KITS

As usual these kits come complete with printed circuit boards, cases, all components, nuts, screws, wire etc. All have been tested by our engineers (many of them are our own designs) to ensure that you get excellent results.

INSULATION TESTER

An electronic High Voltage tester for mains appliances and wiring. An inverter circuit produces 500 volts from a PP3 battery and applies it to the circuit under test. Reads insulation up to 100 Megohms. Completely safe in use.

OUR KIT REF 444 £19.58

EQUALISER' IONISER

KIT REF 707 £15.53

A mains powered Ioniser that produces a breeze of negative ions in the air. A compact, safe, simple unit that uses a negligible amount of electricity.

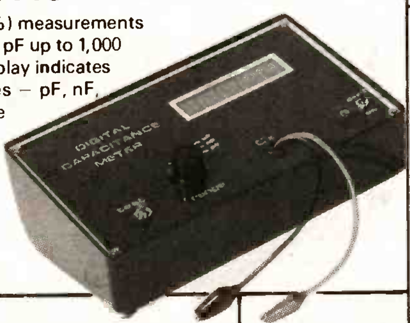
3 BAND SHORTWAVE RADIO

OUR KIT REF 718 £26.53

Covers 1.6-30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

DIGITAL CAPACITANCE METER

Simple and accurate (1%) measurements of capacitors from a few pF up to 1,000 uF. Clear 5 digit LED display indicates exact value. Three ranges – pF, nF, and uF. Just connect the capacitor, press the button and read the value.



£41.55 OUR KIT REF 493

ULTRASONIC PET SCARER

Produces high power ultrasound pulses. L.E.D. flashes to indicate power output and level. Battery powered (9V-12V or via *Mains Adaptor).

KIT REF 812 £13.80
***Mains Adaptor £1.98**

VISUAL GUITAR TUNER

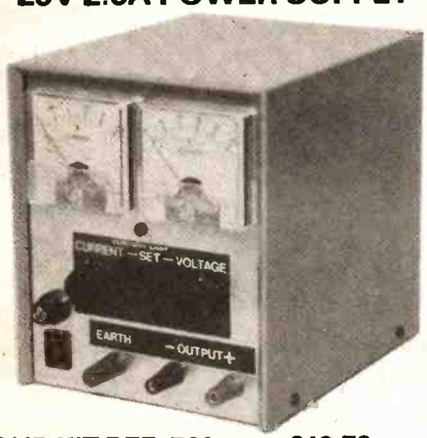
Crystal controlled, with a super rotating LED display. Indicates high, low, and exact degree of mistuning. Use with pick-up or mic. Also has audible output.

KIT REF E711 £21.99

COMPONENTS, KITS, BOOKS, TOOLS, MOTORS, GEARS, PULLEYS, OPTICAL FIBRES, ROBOTICS, AND MUCH MUCH MORE–IN OUR CATALOGUE £1.00

MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY

TOP KITS



OUR KIT REF. 769 £49.73

A superb design giving 0-25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V.
Current-Limit control allows Constant Current charging of NICAD batteries, and protects circuits from overload. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

DIGITAL FREQUENCY 200 MHz METER

KIT REF 563 £62.98

An 8 digit meter reading from A.F. up to 200 MHz in two ranges. Large 0.5" Red LED display. Ideal for AF and RF measurements. Amateur and C.B. frequencies.

PROJECT KITS FOR E.E.

(Just a selection more in our catalogue)

Magenta supply Full Kits: Including PCB's (or Stripboard), Hardware, Components, and Cases (unless stated). Please state Kit Reference Number, Kit Title, and Price, when ordering.
REPRINTS: If you do not have the issue of E.E. which includes the project, you will need to order the instruction reprint as an extra: 80p each. Reprints are also available separately–Send £1 in stamps.

REF NO.	KIT-TITLE	PRICE
814	BAT DETECTOR Jun 89	£19.98
812	ULTRASONIC PET SCARER May 89	£13.80
811	MIDI PEDAL Mar 89	£39.98
810	MIDI MERGE Mar 89	£11.59
809	CALL ALERT Mar 89	£13.51
807	MINI PSU Feb 89	£22.71
806	CONTINUITY TESTER Feb 89	£10.28
505	4 CHANNEL LIGHT DIMMER Feb 89	£37.99
803	REACTION TIMER Dec. 88	£29.98
802	PHASOR (Light Controller) Dec 88	£25.61
801	DOWNBEAT METRONOME Dec 88	£17.57
800	SPECTRUM EPROM PROGRAMMER Dec 88	£26.97
796	SEASHELL SYNTHESISER Nov 88	£24.99
795	I.R. OBJECT COUNTER Nov 88	£29.63
790	EPROM ERASER Oct 88	£24.95
786	UNIVERSAL NICAD CHARGER July 88	£6.99
780	CABLE & PIPE LOCATOR April 88	£15.35
775	ENVELOPE SHAPER Mar 88	£14.99
769	VARIABLE 25V-2A BENCH POWER SUPPLY Feb 88	£49.73
	CAR LAMP CHECKING SYST. Feb 88	£7.10
763	AUDIO SIGNAL GENERATOR Dec 87	£13.64
739	ACCENTED BEAT METRONOME Nov 87	£20.95
740	ACOUSTIC PROBE Nov 87 (less bolt & probe)	£16.26
744	VIDEO CONTROLLER Oct 87	£29.14
745	TRANSTEST Oct 87	£9.70
734	AUTOMATIC PORCH LIGHT Oct 87	£17.17
736	STATIC MONITOR Oct 87	£8.66
723	ELECTRONIC MULTIMETER Sept 87	£46.96
728	PERSONAL STEREO AMP Sept 87	£14.31
730	BURST-FIRE MAINS CONTROLLER Sept 87	£13.57
724	SUPER SOUND ADAPTOR Aug 87	£38.39
718	3 BAND 1.6-300MHz RADIO Aug 87	£26.53
719	BUCCANEER I.B. METAL DETECTOR inc. coils and case, less handle and hardware July 87	£26.45
720	DIGITAL COUNTER/FREQ METER (10MHz) inc. case July 87	£67.07
722	FERMOSTAT July 87	£12.14
711	VISUAL GUITAR TUNER Jun 87	£22.99
715	MINI DISCO LIGHT Jun 87	£12.59
707	EQUALIZER (IONISER) May 87	£15.53
700	ACTIVE I/R BURGLAR ALARM Mar 87	£35.65

REF NO.	KIT-TITLE	PRICE
581	VIDEO GUARD Feb 87	£8.39
584	SPECTRUM SPEECH SYNTH. (no case) Feb 87	£20.92
578	SPECTRUM I/O PORT less case Feb 87	£9.44
569	CAR ALARM Dec 86	£12.47
563	200MHz DIG. FREQUENCY METER Nov 86	£62.98
561	LIGHT RIDER LAPEL BADGE Oct 86	£10.20
560	LIGHT RIDER DISCO VERSION	£19.62
559	LIGHT RIDER 16 LED VERSION	£13.64
556	INFRA-RED BEAM ALARM Sept 86	£28.35
544	TILT ALARM July 86	£7.82
542	PERSONAL RADIO June 86	£11.53
528	PA AMPLIFIER May 86	£26.95
523	STEREO REVERB Apr 86	£26.44
513	BBC MIDI INTERFACE Mar 86	£27.94
512	MAINS TESTER & FUSE FINDER Mar 86	£8.82
497	MUSICAL DOOR BELL Jan 86	£18.72
493	DIGITAL CAPACITANCE METER Dec 85	£41.55
481	SOLDERING IRON CONTROLLER Oct 85	£5.47
464	STEPPER MOTOR INTERFACE FOR THE BBC COMPUTER less case Aug 85	£11.68
	1D35STEPPER MOTOR EXTRA	£14.50
	OPTIONAL POWER SUPPLY PARTS	£5.14
461	CONTINUITY TESTER July 85	£6.20
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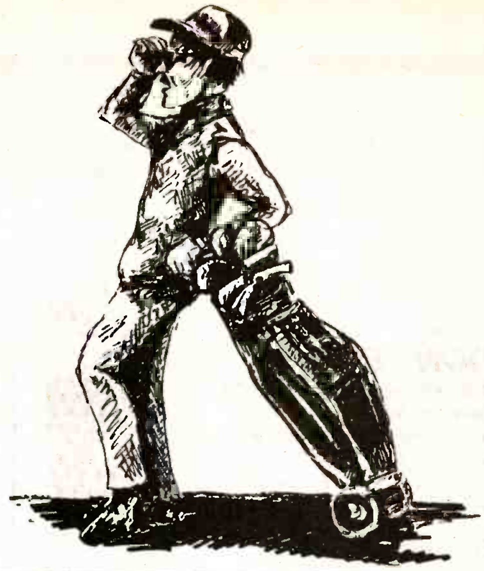


This article describes a means of electronically measuring, calibrating and displaying the distance travelled by a wheel. A golf trolley wheel has been used in the prototype but the principle of operation could be applied to any application where distance measurement of a wheel is required.

Golfers among the readership will appreciate the importance of knowing how far a ball has been hit, in order to calculate the distance to the green, and hence choose the right club for the next shot.

TWO LED FLASHER

It is surprising how useful a simple multivibrator design can be. This educational project will find many uses ranging from a visual warning device to model railway crossing light.

PULSATING ALARM

This project is designed to provide a sound output which pulsates off and on in the same manner as the "WALK" sound indication produced by a "Pelican" pedestrian crossing. It can be used in it's own right or incorporated into other circuits, for example to provide an audible alarm function for a sensor circuit.

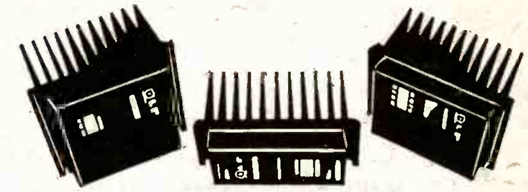
TREASURE HUNTER

Pieces of eight!

A pulse induction type metal locator with a single coil search head that is simple to construct. The unit requires no special equipment to set up, has an audio output, and can be used with the search head immersed in water if required.

EVERYDAY ELECTRONICS

JULY ISSUE ON SALE JUNE 2 1989



EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL. 18 No. 7 July '89

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HOW MUCH?

This month sees the start of an on-going series of projects, grouped by the sub-title *Pocket Money Projects*. They will all be different and we expect to publish two each month for the next year or so. The only thing they have in common is that they are all relatively inexpensive—I suppose it depends how much "pocket money" you have as to just how affordable each one is.

Whilst most of these projects are simple to build, many of them are also very useful and, for this reason, they should be of interest to all readers. Building something very simple that does a useful job has a certain satisfaction — there is a lot to be said for the most simple possible design.

Each design can also be quite educational, both from the theory and practical aspects. The circuits will provide ideas for those who wish to start designing their own projects; those undertaking GCSE courses for instance.

HOW OFTEN?

Sometimes readers complain that some of our projects are repeats of older ones, this is of course quite true, but we do find readers have very long memories! A repeat within a couple of years is unusual and normally only done because of the use of a different design approach, widely different facilities or because of demand for an updated unit.

We are about to publish a new *Treasure Hunter,* the last one—the *'EE Bucaneer*—was presented in May 1987 and p.c.b.s for it are still being sold. This new design is totally different and should provide an interesting alternative to constructors.

But wait; the following month we will publish another metal detector design, the *Probe Pocket Treasure Finder*. Why two designs in two months? Well, the second unit complements the first. The *Treasure Hunter* is a full size metal detector, the Probe is a pocket sized unit for pinpointing the metal in the earth once the Hunter has "found it". Again each design is completely different, each has a particular use and, as I said, they actually complement each other!

Mike Kenward

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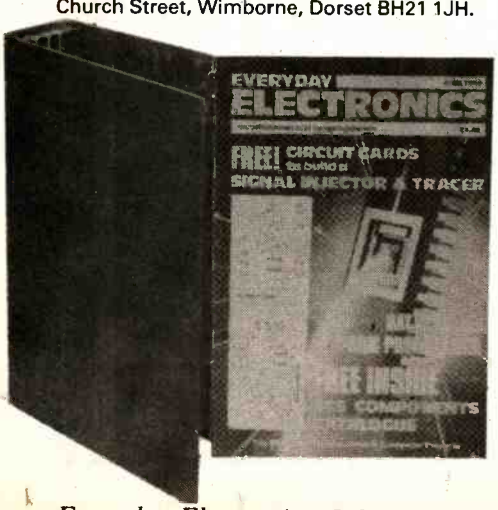

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or 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.**

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.

OLD PROJECTS

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

Constructional Project

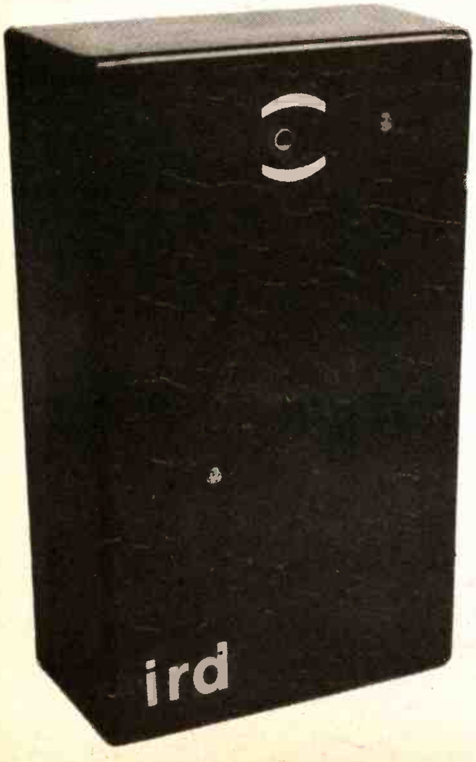
PASSIVE INFRA RED INTRUDER DETECTOR

OWEN N. BISHOP

Get your unwanted intruders to activate floodlights, an alarm or whatever, with this passive detector.

THIS device is designed to detect a person who has already entered the house and is wandering around inside. It is a *passive* system. The sensor waits passively until it detects infra-red coming from the body of the intruder. It then triggers the alarm. Do not imagine that the intruder creeps around your house carrying an illuminated infra-red l.e.d.! All objects warmer than absolute zero (0 Kelvin or −273 degrees C radiate infra-red—the warmer they are, the more infra-red they radiate.

An intruder's body, like yours, is at a temperature of 37 degrees C. Normally the temperature of the walls of the room and the objects inside of the room is less than this. The detector responds to any sudden *change* in the amount of infra-red reaching it. When the intruder enters the room, or comes closer to the detector, the amount of infra-red increases and the alarm is sounded. In September '88 we presented an infra-red intruder detector that relies on a different principle. In that system an infra-red l.e.d. throws a beam of infra-red across the area to be protected and an infra-red sensor monitors the beam. When the body of an intruder breaks the beam, the alarm is sounded. A system of that kind is termed an *active* system.



TWO SYSTEMS

It is worth while comparing the advantages and disadvantages of the two systems. The main advantage of the active system is that its action is robust; it can be positioned so as to detect an intruder at a particular point and to sound the alarm without fail when it does so. If properly installed, it is not likely to give a false alarm. Against this is the fact that the system normally requires wires between the main unit and the infra-red emitting unit. Also it may be difficiult to position the two units conveniently without upsetting the arrangement of the furnishings etc.

The passive system has the advantage that it does not need external wiring, unless you intend to have an external siren, or to operate it in conjunction with an existing security system. It is usually easy to find a convenient position to mount the unit. Also a passive system can cover a much larger area than is normally feasible with an active system.

The main disadvantage of passive detectors is the higher risk of false alarms. As with all security devices that depend on detecting microscopic signals, the more sensitive the device, the more likely it is to respond to the inevitable "noise" present in the environment. A heater suddenly switched on by a thermostat, automatically switched lamps, a rush of warm ducted air, the rising sun, a flapping curtain, as well as roaming pets are all possible sources of infra-red noise. The solution is to compromise; sensitivity is adjusted to suit the general level of noise in the environment. Usually this presents no real problem, and the advantages of the passive system are sufficient to make it attractive, not withstanding.

Passive systems have become very popular in the past few years, and several designs have been marketed. The commercially-built devices usually include two sensors and a specially segmented lens. The more sensitive models can detect an intruder at a range of up to 20 metres. Such devices are comparatively expensive. The design presented here employs only a single sensor, and no lens. It has a range of about three metres and an angle of acceptance about 80 degrees wide. This is ample to protect a room of average size.

PYROELECTRIC SENSOR

At the heart of the passive system is a ceramic material consisting of doped lead zirconate titanate. This produces an electrical charge on its surface whenever it is subjected to a *change* in the amount of infra-red radiation reaching it. The radiation warms the material slightly, causing the charge to appear. An opposite charge is generated if the amount of infra-red is reduced.

This material is used in the F001P infra-red detector (Fig. 1), which also includes a field effect transistor and resistors (Fig. 2). When a charge appears on the ceramic element a potential develops across the gate resistance R_g. The f.e.t. and R_s are wired as a source follower, so a potential appears across R_s too. The source follower gives an increased output impedance to the device, allowing a useful amount of current to be drawn from it without any significant drop in potential.

The RPY96 is a similar device in a T05 can, with a rather larger element for greater sensitivity.

CIRCUIT DESIGN

The system diagram is shown in Fig. 3. If the IR sensor is operated on +3V, as in this circuit, the output voltage at its source ter-

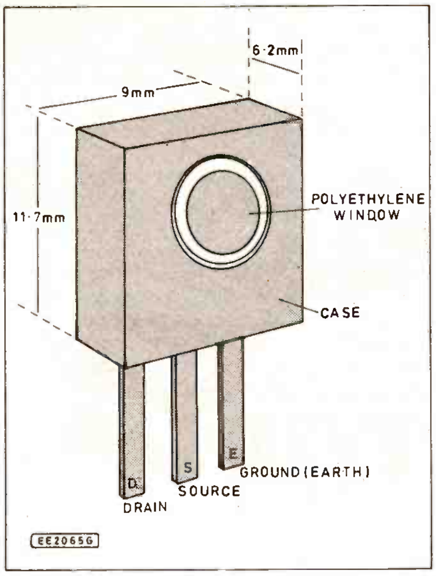


Fig. 1. The F001P infra-red detector.

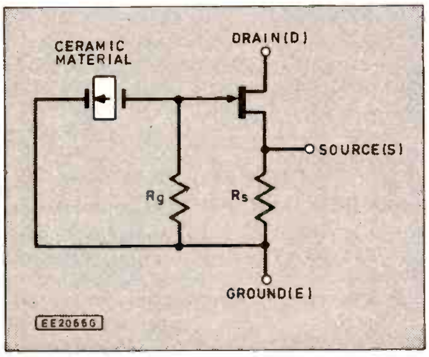


Fig. 2. Circuit of the F001P.

minal is approximately 0.45V. This rises by a few tens of millivolts for a fraction of a second when a warm object enters the field of view of the sensor, and then returns to 0.45V. If the object departs, there is a corresponding fall in voltage.

The output from the sensor is amplified by an operational amplifier connected in the inverting mode. To keep current requirements low, we use a CMOS op.amp. (a 7611) here and in the other stages. The output from this amplifier is normally 0V, falling when an object is detected, and rising when it departs. The output from this amplifier surges slowly up and down, owing to infra-noise, but shows rapid changes when a warm object moves across the field of view. To reduce the effect of the slow surges, the next stage is a high-pass filter (C2 and R5, Fig. 4), with cut-off frequency of 0.1Hz.

The signal is further amplified by a second inverting amplifier, with high gain. The output of this amplifier normally hovers around 0V but rises sharply, often swinging fully to 3V, when a warm object is detected.

To detect the upward swings of the amplifier output, we use a comparator. We employ a third 7611 op.amp. for this. The reference voltage V_{ref} is provided by a variable resistor VR1. The comparator is connected with positive feedback (R10) so that it has a more definite "snap" action when V_{ref} is exceeded. The output from the comparator is normally +3V and falls close to −3V when a warm object is detected. These values are quoted relative to the 0V rail. Relative to the −3V rail they are +6V and 0V respectively. Thus they are acceptable as logic "1" and "0" inputs by the CMOS bistable stage, which is connected betwen the +3V and −3V rails.

The bistable is a conventional one constructed from two NAND gates. Both inputs are normally high, the set input coming from the comparator, and the reset input being connected to the +3V rail through a resistor (R11). The bistable is reset by pressing a push-button, S1. Its output is then low.

When a warm object is detected, the output of the comparator falls to logical low, so setting the bistable. The bistable output goes high, feeding base current to two transistors. One of the transistors switches the l.e.d. indicator lamp and the other transistor switches the relay which operates the siren. The design specifies a reed relay of a type intended for circuit-board mounting, with a single pole single throw contact, but any other 6V type with a coil resistance of a few hundred ohms can be used instead.

POWER SUPPLIES

The circuit requires 6V d.c. The amount of current required by the op.amps. is reduced to only 100μA each by connecting the quiescent current control input (pin 8) of each op.amp. to the 0V rail. The whole circuit takes only 5mA when quiescent. A battery made from four pen-cells (AA) should last about 30 hours, running continuously. This could be adequate for occasional use.

A case of the recommended size has room for a battery box holding four type 'D' cells. Rechargeable cells of this size supply about four ampere hours, so would last for over a month of continuous running, or about two months operating only at nights. If you have already installed the security system that was the subject of our earlier series, you will already have a 12V supply. This can be dropped to 6V using a potential divider (Fig. 5), alternatively almost any 6V d.c. supply can be used.

The circuit uses a reed relay to control

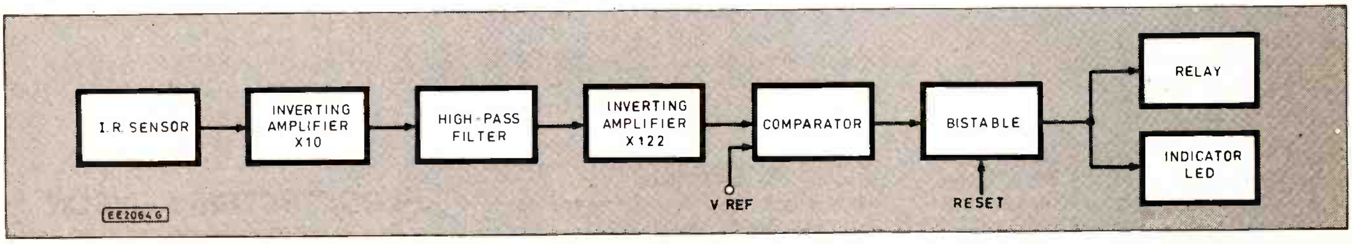
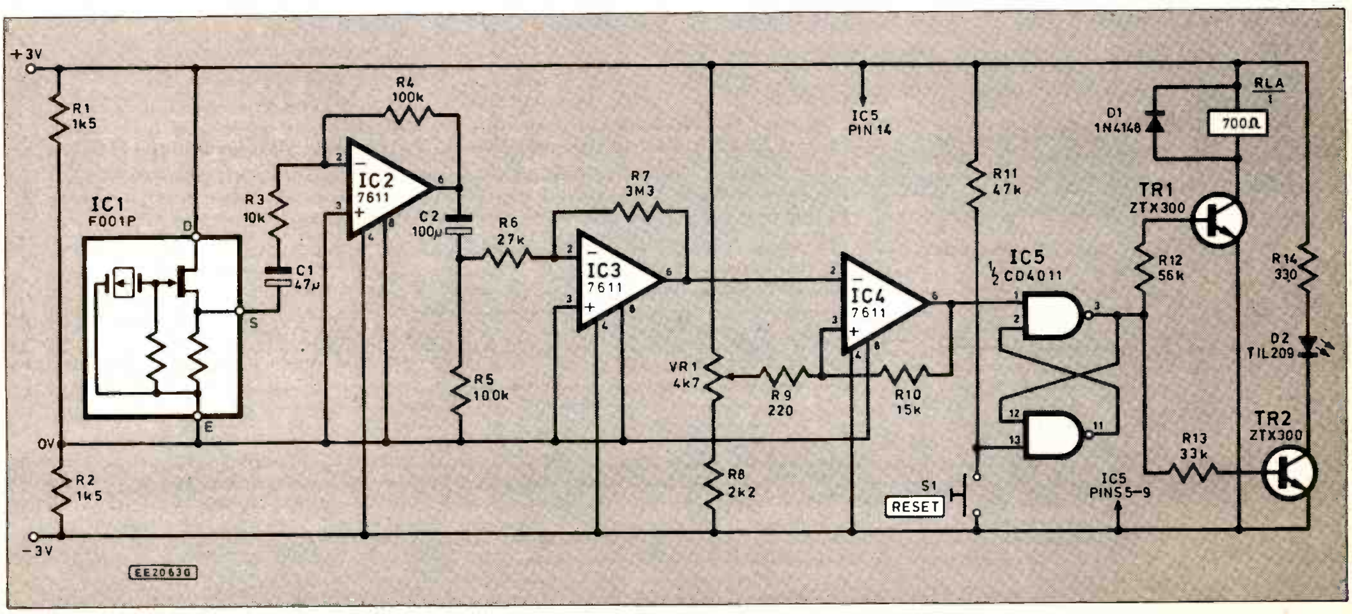


Fig. 3 (above). Block diagram of the Intruder Detector.

Fig. 4 (below). Circuit diagram of the Intruder Detector.



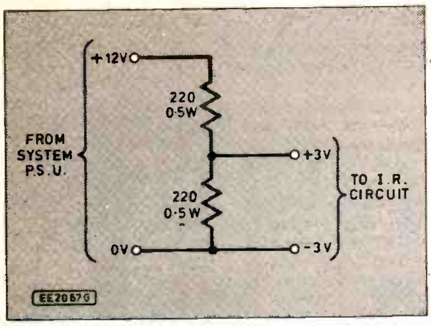


Fig. 5. Potential divider for power supply.

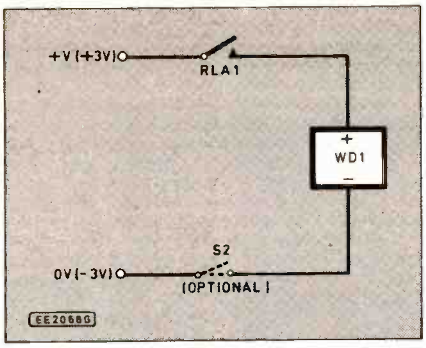


Fig. 6. A siren driven by the relay.

the siren (Fig. 6). This allows you to switch a wide range of warning devices, including solid-state devices, electric bells and buzzers, lamps etc. These can be driven by an external power supply. The relay specified has contacts rated up to 500mA, 200V d.c. If you have already installed our security system, this relay may be wired in parallel with the pressure mats.

Audible warning devices of surprisingly large sound outputs (over 100dB at one metre) with low current consumption (20mA) are available and are very suitable for use with this detector. If rated for 6V operation, such devices may be driven directly from the same battery as the detector.

CONSTRUCTION

The stripboard layout is shown in Fig. 7. Note that some of the strips beneath IC5 are not cut as they are being used to connect pins on opposite sides of the i.c. There are no special constructional problems but, since there is a sequence of stages in the system, it is best to construct and test each stage before proceeding to the next.

The sensor is soldered in place, after which it is bent back on its leads to lie flat on the board. **Take care not to touch the window of the sensor,** as this is likely to impair its performance.

A voltmeter or oscilloscope may be used to monitor the output of each stage. The voltages to be obtained were described earlier. When testing, position the circuit board so that the sensor is directed away from you (and from anyone else in the room). Waving your hand in front of the sensor, about 40cm from it, produces an easily measurable response. Or you can try moving your whole body across its field of view at a greater distance, up to three metres. Remember that it is designed to respond only to *changes* in the amount of radiation it receives. It is possible by moving *very* slowly indeed to approach the circuit without producing a significant response.

When testing the comparator stage, set VR1 to about half-way along its track to begin with. You should be able to find a position in which the output of IC3 is normally high (+3V) but falls low (−3V) when the sensor is stimulated. If you are using a relay with a built-in protective diode, omit D1.

The off-board connections are shown in Fig. 8. Use thin multi-stranded wire for these. The prototype has two sockets for use with an externally powered siren. You may prefer to use a low-power audible warning device contained within the case or mounted on or beside it. The l.e.d. has its leads cut short and bent into small loops before soldering the connections to the board (use a heat-shunt). Test the circuit for correct operation before proceeding to fit it into its case.

HOUSING

The prototype was fitted into a medium-sized a.b.s. box as shown in Fig. 9. A smaller box could be used if an external power supply is being employed.

A circular aperture is cut in the bottom of the box, located so that the sensor window is concentric with this when the circuit board is mounted on its two bolts. The off-board components are mounted in a group on one side of the box. It is important that

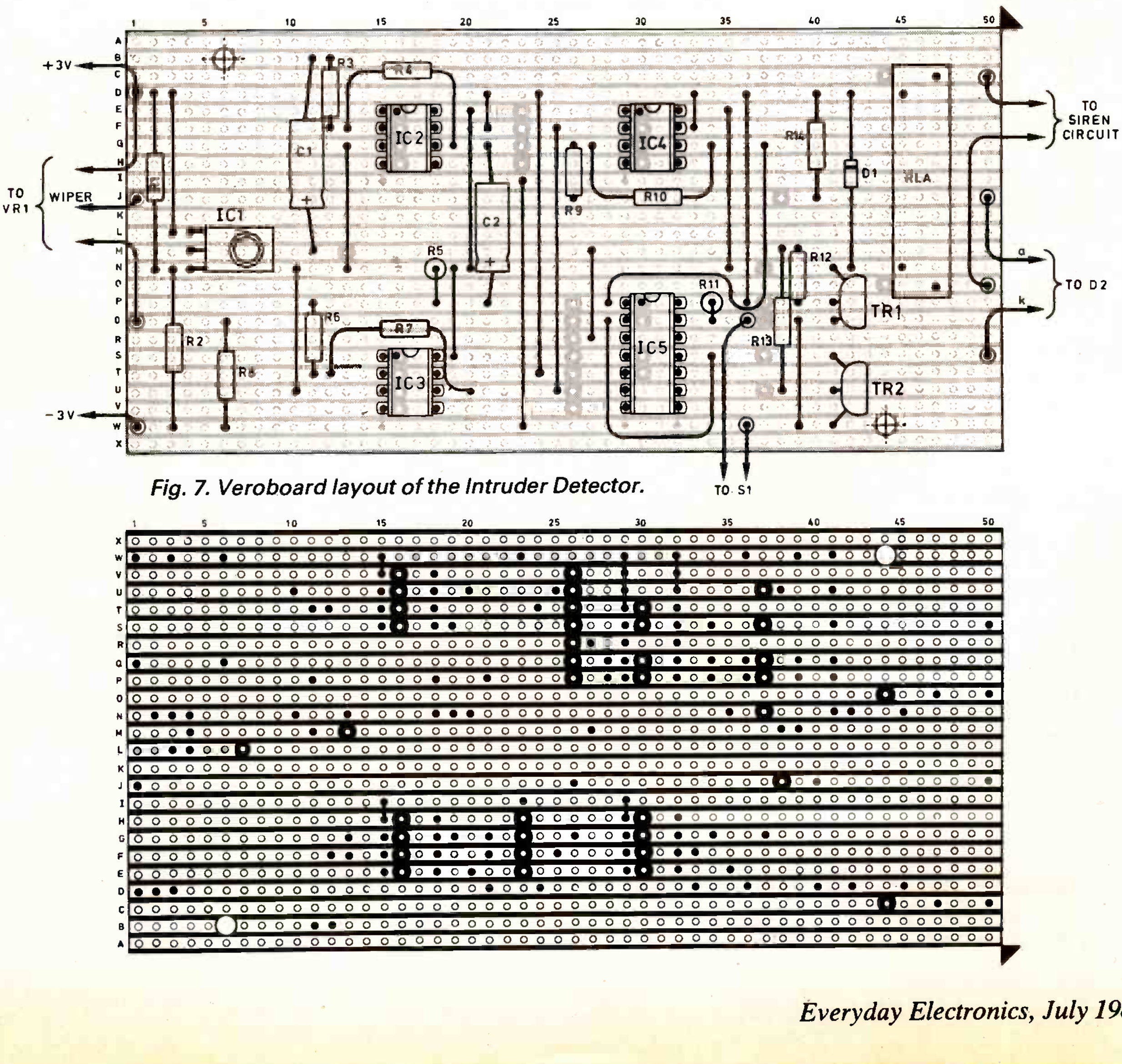


Fig. 7. Veroboard layout of the Intruder Detector.

they are on the side as it is impossible to adjust sensitivity and to reset the system if one is standing directly in front of the sensor. Indeed this is a point that must be considered when deciding where in the room to site the completed project. There must be a line of retreat by which a person, having reset the device, can escape without triggering it.

The aperture is large enough to allow for the 80 degree angle of view of the sensor. Consequently, the area of circuit board immediately adjacent to the sensor shows through the aperture. To hide this, cut a piece of matt black card about 25mm square. Or use white card and black it with a thick felt-tip pen. Punch a circular hole 6mm in diameter in the centre of the card. This is to fit snugly around the rim surrounding the window. A standard paper perforator of the type used for punching loose-leaf paper should give a hole of exactly the right diameter. Place a small drop of glue on the rear of the card and push it gently over the rim around the sensor window. The card adheres to the sensor case and obscures the surrounding circuit board.

If you are using an external siren, situated at a distance from the detector, it is useful to fit a manual switch (S2, Fig. 6). This allows you to switch in the siren *after* setting the detector, or to switch it out *before* you approach the detector to turn it off. If you are using an internal audible warning device, S2 can be mounted on the case or at a distance away.

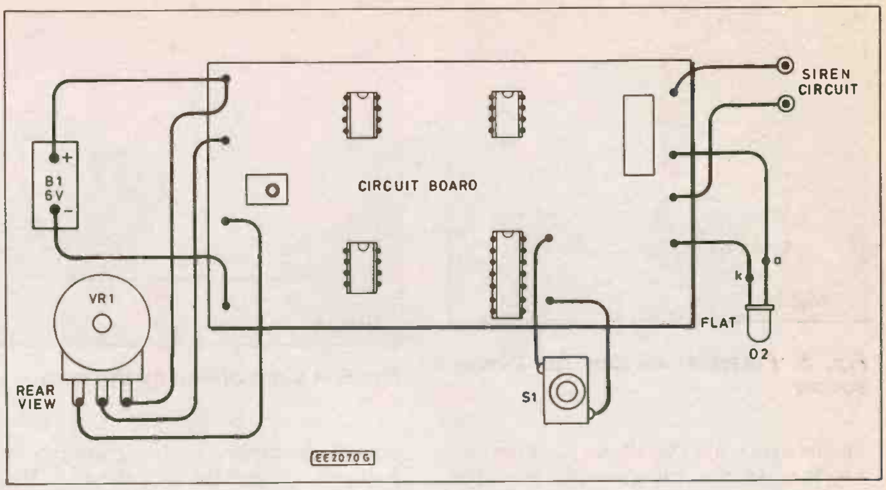


Fig. 8. Interconnections to the Veroboard.

COMPONENTS

See page 445

Resistors
- R1, R2 1k5 (2 off)
- R3 10k
- R4, R5 100k (2 off)
- R6 27k
- R7 3M3
- R8 2k2
- R9 220
- R10 15k
- R11 47k
- R12 56k
- R13 33k
- R14 330

All carbon, 0.25W, 5% or metal film 0.6W.

Potentiometer
- VR1 4k7 lin.

Capacitors
- C1 47μ axial elect. 10V
- C2 100μ axial elect. 10V

Semiconductors
- D1 1N4148 signal diode
- D2 TIL209 or similar light-emitting diode
- TR1, TR2 ZTX300 *npn* transistor (2 off)
- IC1 F001P pyroelectric infra-red sensor
- IC2-IC4 7611 CMOS operational amplifier (3 off)
- IC5 4011 CMOS quadruple 2-input NAND gate

Miscellaneous
- RLA1 reed relay, circuit-board mounting, s.p.s.t., normally open contacts, 700 ohm coil 6V-9V d.c. (Electromail type 348-970)
- S1 push-to-make push-button
- S2 s.p.s.t. switch (optional)
- B1 battery holder for four D-type cells (if required);

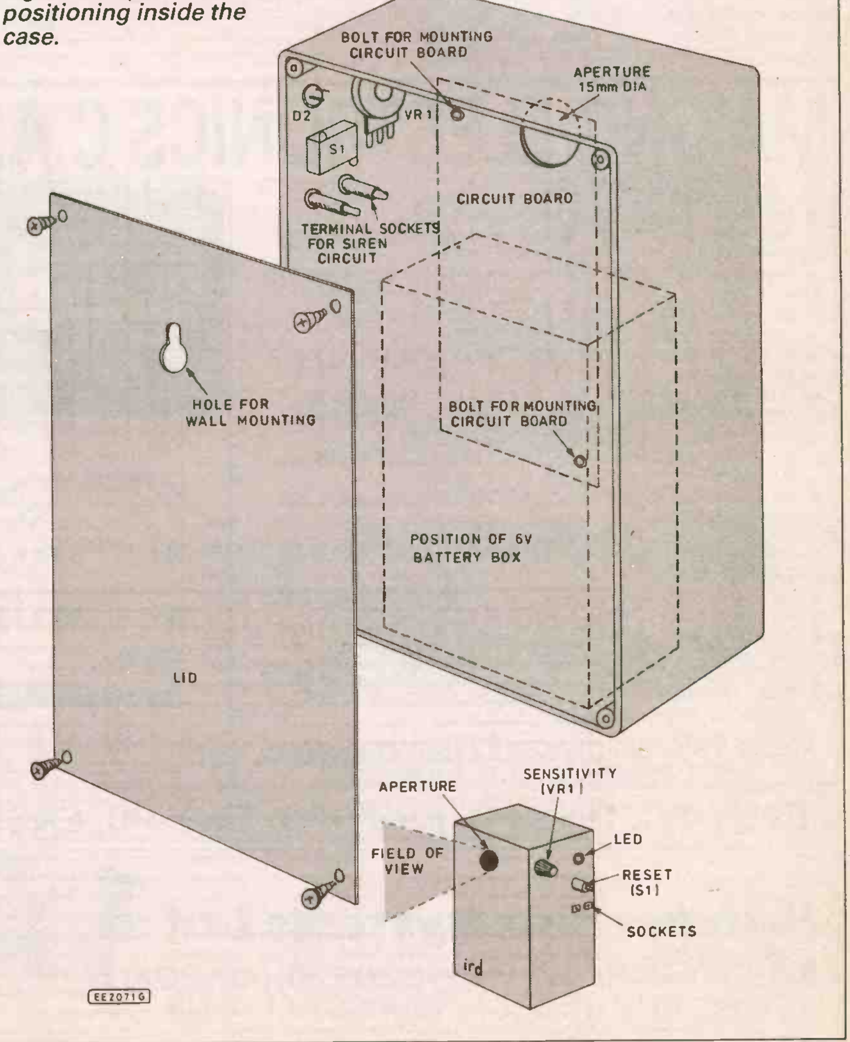
Audible warning device, of any preferred type—see text; battery connector (if required); stripboard 127mm×24mm (23 strips by 50 holes); 1mm terminal pins (10 off); a.b.s. case approx 195mm×114mm×60mm; 2mm plug and socket (2 off), or other suitable connectors; knob for VR1; bolts, 16mm, M4 (2 off); nuts, M4 (4 off).

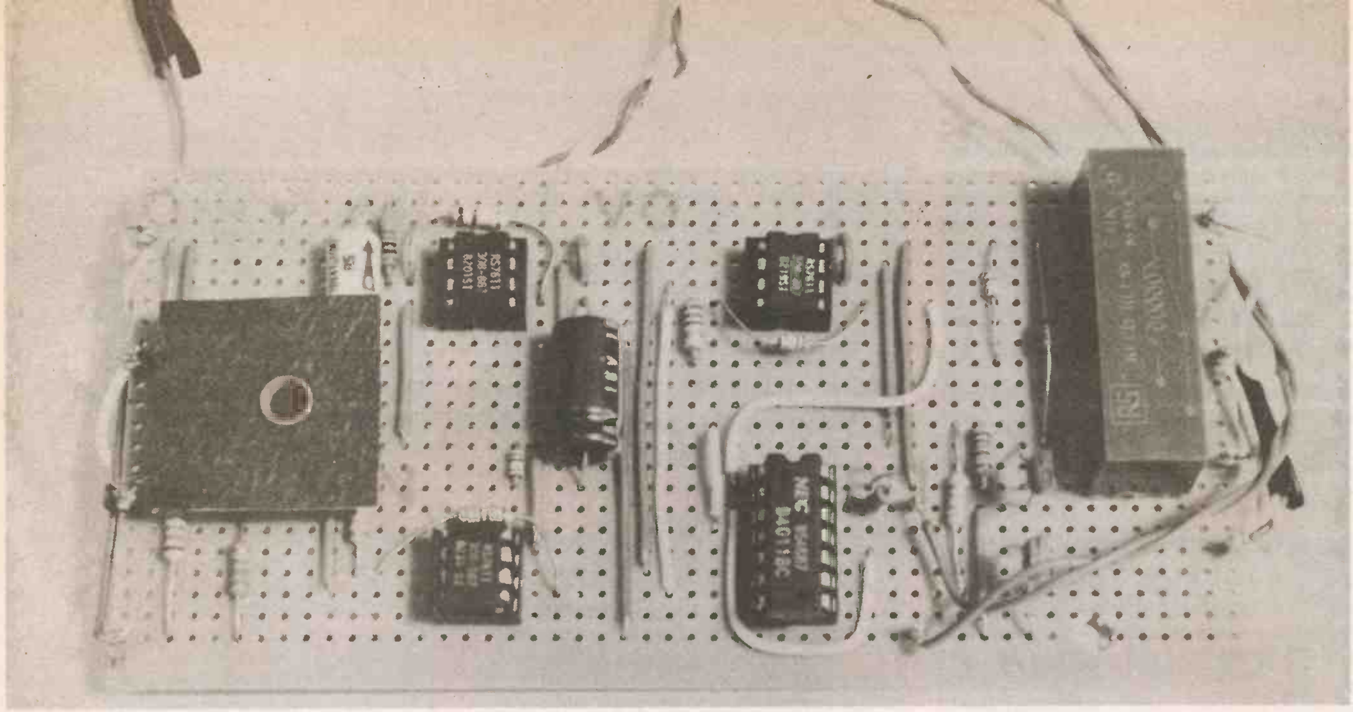
Approx. cost Guidance only **£25**

INSTALLING THE DETECTOR

The detector may be wall-mounted or

Fig. 9. Component positioning inside the case.





stood on a shelf or piece of furniture. It should face across part of the room or across a hallway or corridor so that any intruder is more likely to *suddenly* come into view. This results in a more rapid change in the amount of radiation reaching the sensor and thus a greater response. When testing the prototype we found that it gave a good response when directed towards an open doorway that led to the hall. Persons entering the room or walking along the hall and passing across the open doorway produced a strong effect. But, remember, you must leave an escape route! And there should be some way of approaching the device without triggering it, when you want to turn if off (e.g. S2, as described above). If it has an external power supply, you can simply turn off the power first.

Before setting the detector, turn off the siren, using S2, or remove one of the plugs from its socket. Make sure that the power supply is connected – the l.e.d. should be on. Place the detector in its intended position. Stand well to one side of the device. Wait about ten seconds while voltage levels stabilise, then press the reset button. The l.e.d. should go off. If it does, try waving an arm in front of the window. The l.e.d. should light again. If it does not, increase sensitivity by turning the knob clockwise a little at a time and repeat the test.

If the l.e.d. does not go off when the reset button is pressed it may be that part of your body is visible to the sensor. Move further to one side. If the l.e.d. still does not go out when the button is pressed, turn sensitivity well down, then reset it. You do not need to repeat the sensitivity setting on subsequent occasions. The detector is now set. Plug in the siren or turn its switch to the "on" position, and your room is fully protected against all intruders. Oh! – and keep the cat out of the way! □

Special Feature

SURROUND SOUND

IAN GRAHAM

Audio processors that make your living room sound like the local Odeon—the next consumer electronics boom market?

WHEN YOU watch a movie in the cinema, the soundtrack assails you from all directions. The dialogue comes mainly from the front of the theatre while the music and sound effects blast from a battery of speakers alongside and behind the audience. A shout from the left, an explosion to the right, an aircraft screaming overhead towards the rear left emergency exit—it all helps to place the audience in the middle of the action.

When a video tape of the same film is played at home, the three-dimensional sound experience is lost. Even a stereo video recorder and television set can't do it justice. That being so, it might surprise you to learn that when a movie is released on video, the information used by the cinema sound system to separate out the various audio channels and feed them to the cinema's impressive array of loudspeakers is transferred onto the humble video tape along with the film.

Although the home video recorder and television cannot decode the audio channel information on the tape, a surround sound processor *can*. Sound processors capable of recreating cinema-quality sound in the home from ordinary pre-recorded video tapes of movies are now beginning to come onto the market. Prices are still relatively high for the best processors, but hi-fi amplifiers and even video recorders with built-in surround sound decoders are already becoming readily available.

TWO INTO FOUR

Most movie sound is recorded in Dolby Stereo. Although it's called Dolby *Stereo,* the tape's two audio tracks contain enough information to decode *four* audio channels. The simplest processing system, called "Dolby Surround", creates four channels from the two on the tape by a rather rudimentary technique.

The left and right channels are fed to the left and right speakers. The two input channels are added together and fed to the centre front speaker. Signals that are in phase, such as dialogue, are reinforced by this, while out of phase signals are attenuated. The out of phase signals largely lost from the front channel are fed to the rear (surround) channel.

The Toshiba XB1000 combines a 16-bit four channel sound processor with a 50W four channel amplifier. It has eight preset sound modes including Dolby Surround. The XB1000 retails for £700.

This rather crude signal processing means that any sound is heard from at least three speakers and is therefore less precisely directed than in the cinema. In fact, some Dolby Surround processors do away with the centre front speaker altogether and reduce the system to three channels—left, right and surround.

For convenience, so that the system can be set up with two stereo amplifiers, this version of the system uses one stereo amplifier for the left and right channels and a second stereo amplifier for two identical surround channels. A 20 millisecond time delay is also inserted between the left-right and surround channels. Separation between right and left channels or front and surround channels is quite good, but separation between either side and centre or either side and surround is poor.

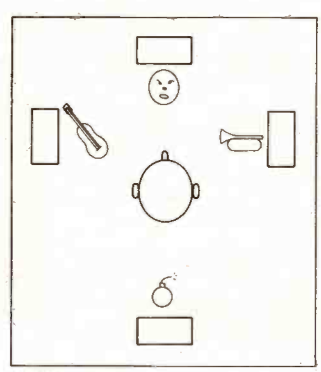


Fig. 1.

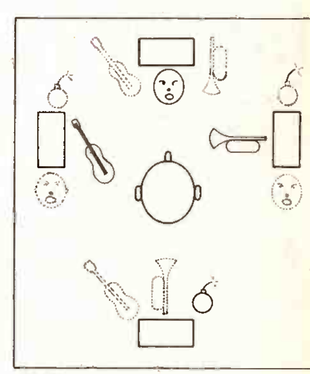


Fig. 2.

Fig. 1. The original movie soundtrack has four channels—one for dialogue and three for music and sound effects. These are combined into two tracks when the movie is transferred onto domestic video tape.

Fig. 2. The most basic surround sound processors cannot separate the four channels sufficiently to recreate the cinema soundtrack accurately. Any sound comes from at least three speakers.

AV AMPLIFIERS

Some Dolby Surround decoders are available as separate add-on units, but most are built into audio amplifiers or "AV Amplifiers" (amplifiers capable of switching both audio *and* video signals). Amplifiers with built-in surround sound decoders normally also have two extra channels of 30W or thereabouts to drive the surround speakers.

The companies that market surround amplifiers normally offer small surround speakers as optional extras. Amplifiers with surround sound are available from Marantz, Pioneer, Sharp, Sony, Toshiba and Yamaha, to name but a few.

Prices range from £200 for the Marantz SP35 add-on decoder to £800 for the incredibly versatile Sharp Optonica comprising a four channel, 80W per channel amplifier and five loudspeakers. An average AV amplifier with Dolby Surround currently costs around £350.

Although Dolby Surround does offer a significant improvement in sound quality, it clearly doesn't recreate the sound field generated in the cinema. A more sophisticated processing standard called "Dolby Pro-Logic" comes closer to the professional cinema system.

Pro-Logic boosts the dialogue sent to the front speaker and removes it from left and right. If a sound is intended to be heard through one channel only, Pro-Logic removes it from the other channels. Similarly, if a sound is intended to be heard somewhere between the speakers, Pro-Logic balances the signal strengths of the various channels to make the sound appear to come from thin air at the intended position. This ability to steer sounds around a room is Pro-Logic's great strength.

DELAYING TACTICS

The system's electronics must react to incoming information from the tape in real time, sensing phase and loudness relationships and adjusting signal output levels before the sound has to be

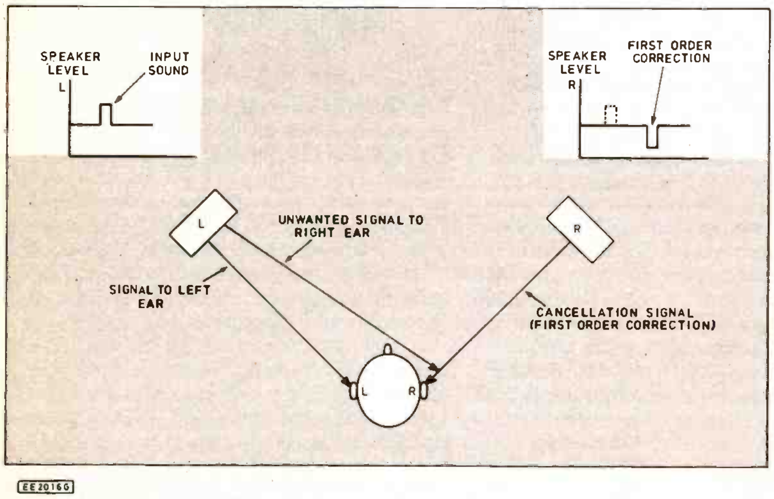


Fig. 3. A sound intended to be heard by the left ear only is also heard by the right ear a fraction of a second later. It can be removed from the right ear by sending a cancelling signal. This is called first order correction.

However, the correction signal itself may be heard in the left ear, so a further correction signal may be necessary—second order correction. Higher orders of correction produce more accurate sound steering. This correction technique is used by Pro-Logic processors.

passed to the speakers to keep pace with the picture. If the processing should take longer than this, the sound would be heard before the on-board logic began to steer it, presumably producing some very odd and nightmare-ish effects.

This places very demanding limitations on the time available for signal processing. Some decoders buy extra time for signal processing by deliberately delaying the whole signal by up to 20 milliseconds. It seems a lot, but it's about the same delay as one would experience in the front row of a cinema and so the lag between picture and sound is quite acceptable.

Badly recorded source material can cause problems. Any misalignment of the playback heads or the film when the movie is transferred from film to video tape can produce small time differences between the two audio tracks. Errors of up to 50 microseconds are common and the time difference between the tracks may vary as the tape plays.

Fifty millionths of a second doesn't sound much, but especially at high audio frequencies even this tiny error can produce significant differences in phase between channels. As the decoder uses these phase relationships to determine where sounds should be steered to, errors in phase will produce incorrect steering.

There are three ways of overcoming this. Cutting the treble in the surround channel where steering errors are likely to be the worst masks any differences between them and the other channels. Alternatively, deliberately narrowing the separation between left and right channels subjectively reduces any treble differences between them.

The best Pro-Logic decoders can detect and correct these input errors, so that even defective software can give satisfactory results without the need to cut or attenuate any part of the input signal. The Lexicon CP-1, for example, does this by continually checking that the dialogue is centred accurately and automatically correcting any errors that tend to shift it to either side. It does this so efficiently that there is no need for a balance control on the front panel—the CP-1 does all necessary balancing automatically.

Pro-Logic decoders are currently very expensive, typically £800 or £900 for the decoder alone. To this, between four and eight channels of amplification must be added together with the appropriate number of loudspeakers.

The total outlay to get one of these systems up and running is thus considerable. The best of them produces astoundingly realistic effects from Dolby Stereo encoded material. Even the cheapest of the Dolby Surround decoders improves sound quality significantly. In addition to Dolby surround or Pro-Logic modes, most decoders also offer processing modes to deal with mono and stereo material that is not encoded in Dolby Stereo.

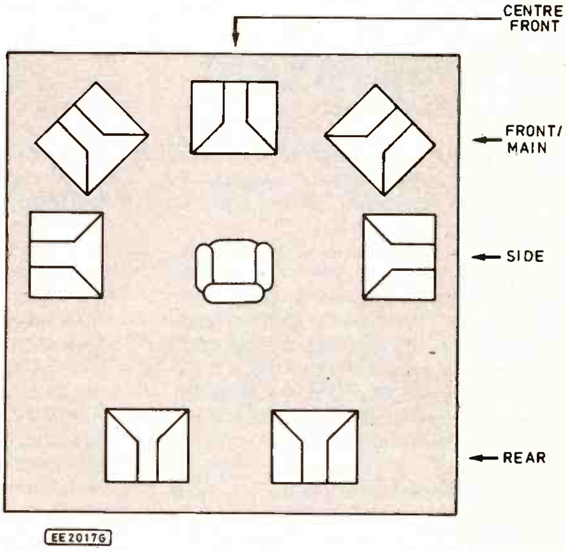


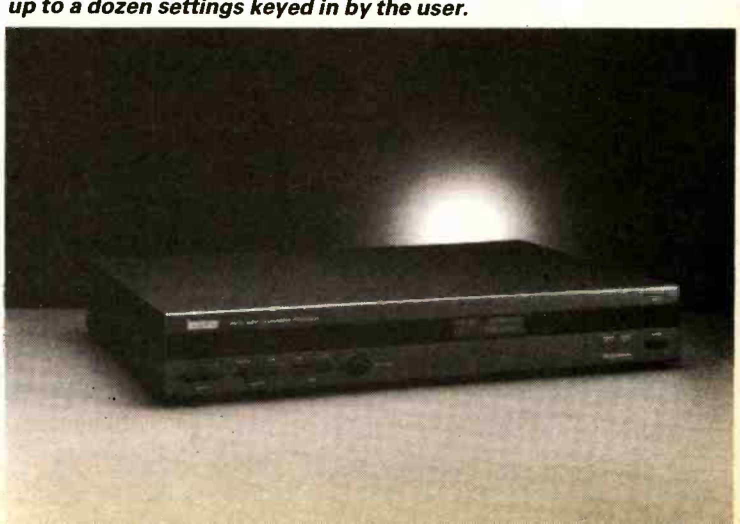
Fig. 4. The ideal speaker layout for movies and music using a Pro-Logic processor. A sub-woofer may be added.

LUCRATIVE SOUNDS

Whilst basic Dolby Surround processors are falling in price to the point where they will undoubtedly enter the mainstream hi-fi market, Pro-Logic processors are still something of a toy for the wealthy. Judging by the activity in the whole surround sound area, the manufacturers believe that there is a demand for it.

Most of us have bought our video recorders and compact disc players and the industry must look for growth elsewhere—such as satellite television, CD-video and now surround sound. Surround sound could be a lucrative area for the industry, because sales of processors not only creates a new market in itself, but it also boosts sales of amplifiers and loudspeakers to deal with the extra audio channels involved. □

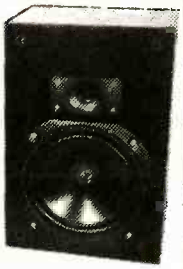
The Lexicon CP-1 has been introduced from the United States by F.W.O. Bauch, the UK distributors of Revox products. It retails for £925 and features four sound modes each with three options. In addition to these 12 preset modes, which include Dolby Pro-Logic, the CP-1's memory can store up to a dozen settings keyed in by the user.



THE RTC MONITOR II

100 WATT SPEAKER KIT £60.00 +£3.50 P&P (pair)

RESPONSE: 55Hz–20kHz
BASS POLYMER CONE D: 22cm
DOME TWEETER: 14mm
OVERALL SIZE
(HWD): 382,252,204mm
RECOMMENDED AMP POWER:
10-100 watts per channel



The performance standard achieved in this compact design is distinctively superior to anything else available at the price. The drive units used are of sophisticated design and have been carefully integrated with a Complex Crossover. Stereo performance is exceptionally good with a well focussed sound stage and sharp resolution of detail. Distortion throughout the frequency range is low even at quite high power input and this gives a great sense of dynamic range and openness especially when used in bi-wired mode.

Supplied with:— 2 READY CUT BAFFLES, ALL CROSSOVER COMPONENTS, 2 BASS MID-RANGE, 2 DOME TWEETERS, HOOK UP WIRE, GRILLE CLOTH, SCREW TERMINALS AND SCREWS.

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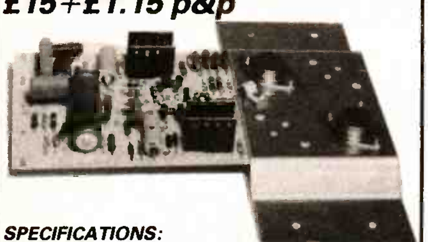
125 watt per channel stereo power amplifier with independent volume controls, professional 19" rack mount and silent running cooling fan for extra reliability.

Output power .... 125W RMS max. per channel
Output impedance .... 4 to 16 ohms
(max. power into 4 ohms)
Sensitivity .... 450V at 22K ohms
Protection .... Electronic short-circuit and fuses
Power .... 220-240V a.c. 50Hz
Chassis dim .... 435×125×280mm
Weight .... 10kg approx

£124.99+£7.00 p&p

125W POWER AMP MODULE £15+£1.15 p&p



SPECIFICATIONS:

Max. output power (RMS): 125W.
Operating voltage (DC): 50-80 max.
Loads: 4-16 ohms.
Frequency response measured at 100 watts: 25Hz-20KHz.
Sensitivity for 100 watts: 400V at 47K.
Typical T.H.D. at 50 watts, 4 ohms: 0.1%.
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BP015A	1	5½" full range 12 watt 4Ω speaker with matching grill. For small p.a. or in car use.
BP015B	1	30 watt, dome tweeter. Size 90×66mil *JAPAN made*
BP016	6	2200µf can type Electrolytic 25V d.c computer grade *made in UK by PHILIPS*
BP017	3	33000µf 16V d.c. electrolytic high quality computer grade *UK made*
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BP019	20	20 ceramic trimmers
BP020	4	Tuning capacitors, 2 gang dielectric a.m. type
BP021	10	3 position, 8 tag slide switch 3 amp rated 125V a.c. *made in USA*
BP022	5	Push-button switches, push on push off, 2 pole change over. PC mount *JAPAN made*
BP023	6	2 pole 2 way rotary switch
BP024	2	Right angle, PCB mounting rotary switch, 4 pole, 3 way rotary switch *UK made by LORLIN*
BP025	4	3 pole, 3 way miniature rotary switch with one extra position off (open frame YAXLEY type)
BP026	4	4 pole, 2 way rotary switch *UK made by LORLIN*
BP027	30	Mixed control knobs
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BP029	6	Stereo rotary potentiometers
BP030	2	100k wire wound double precision potentiometers *UK made*
BP031	6	Single 100k multitune pots, ideal for varicap tuners *UK made by PHILIPS*
BP032	4	UHF varicap tuner heads, unboxed and untested *UK made by PHILIPS*
BP033	2	FM stereo decoder modules with diagram *UK made by PHILIPS*
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BP038	20	5 pin din, 180° chassis socket
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BP041	3	2.8m lengths of 3 core 5 amp mains flex
BP042	2	Large VU meters *JAPAN made*
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli *JAPAN made*
BP045	2	Stereo cassette record and play heads *JAPAN made*
BP046	4	6-0-6 4VA mains transformers, P.C. mount
BP047	1	24V 750mA mains power supply. Brand new boxed *UK made by MULLARD*
BP048	1	Car rear window heater/demister. Self adhesive panel, size 24"×9", complete with switch and cable *UK made* *(Ideal for your old "Moggy 1000" etc)*
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell (or P12) *UK made by MULLARD*
BP050	30	Low signal transistors n.p.n., p.n.p. types *UK made*
BP051	6	14 watt output transistors. 3 complimentary pairs in T066 case *(Ideal replacement for AD161 and 162s)*
BP052A	1	Tape deck pre-amp IC with record/replay switching No LM1818 with diagram
BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diagram
BP056	4	7 segment 0.3 LED display (R.E.D.)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors
BP059	1	Power supply PCB with 30V 4V/A transformer. MC7818CT IC & bridge rectifier: Size 4"×2¾"
BP060	1	Transcription record player motor 1500rpm 240V a.c.
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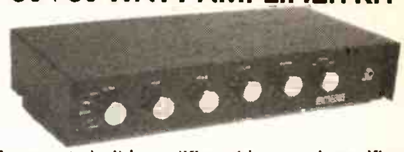

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Size (H.W.D.) 75×400×195mm
Kit enclosed: case, P.C.B., all components, scale and knobs **£36.80.** post £3.50
(Featured project in *Everyday Electronics* April 1989 issue). Reprint Free with kit.

TV SOUND TUNER

In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by chopping this out?" In the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and no tone controls are quite common and that really is quite sad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact independent TV tuner that connects direct to your Hi-Fi is a must for quality reproduction. The unit is mains operated. This TV SOUND TUNER offers full UHF coverage with 5 pre-selected tuning controls. It can also be used in conjunction with your video recorder.

£29.50 +£2,50 p&p

As above but with built-in stereo headphone amplifier for the hard of hearing
You can tune into the TV channel you want while still receiving the picture on your TV set. In fact it is rather like a second television, but without the screen. So that the ordinary TV can be placed for everyone to see, and the volume on it can be comfortable for others, while the sound tuner can be placed where you can control it. You will need to plug in one of your own listening aids such as headphones or an induction loop to hear the sound. The tuner is mains operated, has 5 pre-selected tuning controls and can be used in conjunction with a video recorder.
Size: 270×192×65mm. **£35.90** +£2.50 p&p

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£8.95 *Plus £2.50 p&p*
This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics
For ease of construction and alignment it incorporates three Mullard modules and an I.C. I.F. System.
FEATURES: *VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM-Ferrite rod, FM-75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to strict P.E. specification. Front scale size: 10½"×2½" approx. Complete with diagram and instructions.*

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Pocket Money Project

SNAP INDICATOR

CHRIS BOWES

Ideal for quiz games, this low cost, easy-to-build project should solve the arguments of "who pressed their button first?" and provide endless hours of fun.

ONE OF the problems encountered in playing the game *"Snap"*, or any similar game, is that often it is very difficult to tell who shouted first when two people do so at the same time. This simple project is designed to prevent strife by supplying a visual indication of which of two buttons was pressed first.

It is suitable for use by two players but could be easily adapted for use by two teams of players, simply by wiring several switches in parallel with those provided for the individual players.

The project uses two thyristors (CSR1 and CSR2). These devices are more usually found being used to control a.c. power for motors and lamp dimmers etc., but they have a very useful property in that, when they are used in d.c. circuits, an input pulse to the gate connection causes the CSR to latch and conduct a current between the anode and cathode until the d.c. supply is removed.

This means that we can make use of a thyristor as a memory. When the thyristor conducts the potential difference between the cathode and anode is virtually zero so we can design the circuit so that the thyristor both switches on an indicator and switches off the trigger voltage, which would be passed to the gate of the other thyristor. This gives us a method of detecting who was the first to answer.

CIRCUIT DESCRIPTION

The circuit diagram for the Snap Indicator is shown in Fig. 1. Each of the two players is provided with an identical circuit consisting of a l.e.d. and its associated series resistor, a push-to-make switch, a thyristor and two other resistors.

In the initial state no current flows through any part of the circuit so neither of the l.e.d.s (D1, D2) is illuminated. If the player, whose action is indicated by D1 is the first to press his or her switch (S2) this closes and a very small current is made to flow through diode D2, resistor R2, switch S2 and resistor R3 into the gate of CSR1.

This gate current causes the thyristor to trigger and a current flows through D1, R1 and CSR1. This causes D1 to be illuminated and, because the potential difference at the anode of CSR1 is virtually 0V, pressing S3 would not cause a sufficiently large voltage to appear between the cathode and gate of CSR2 for it to be triggered.

Once one thyristor has been triggered the other thyristor cannot be triggered until the circuit is reset. The operation of the second circuit (indicated by the illumination of D2) is identical to that for the operation of D1.

The thyristors are extremely sensitive and only a minute current flowing into the gate is required to trigger them. Resistors R5 and R6 have therefore been included to conduct any stray signals (such as might be caused by stray charges), to ground and thus prevent false triggering.

Resetting of the circuit is achieved by operating switch S1, which is a push-to-break switch which cuts off the supply of current from the battery B1 to the circuit and thus resets whichever of the thyristors is conducting at the time.

CONSTRUCTION

The first stage of construction is to cut a piece of stripboard, to the correct size (11 strips by 17 holes). The component layout and details of breaks required in the underside copper strips is shown in Fig. 2.

Once the stripboard has been cut to size it should be turned over so that the copper strips are uppermost and the breaks in the strips (shown in Fig. 2), should be made, using a stripboard cutter or a suitable sized drill bit. It is important that all of the copper strip is removed where breaks are marked, since even the merest sliver of copper will cause a short circuit between the two halves of the strip.

Once the track breaks have been made the board can be turned over, care being taken to make sure that it is correctly orientated. To help with this the strips and holes have been numbered/lettered in the two diagrams.

The first operation is to install the wire link in the centre of the board. This should be a piece of bare wire which is bent to the correct shape and inserted from the component side of the board. The board is then turned over and the wire soldered into place, taking care to ensure that the solder does not blob over onto adjacent tracks.

Fig. 1. Complete circuit diagram for the Snap indicator, note that switch S1 is a 'normally closed' type.

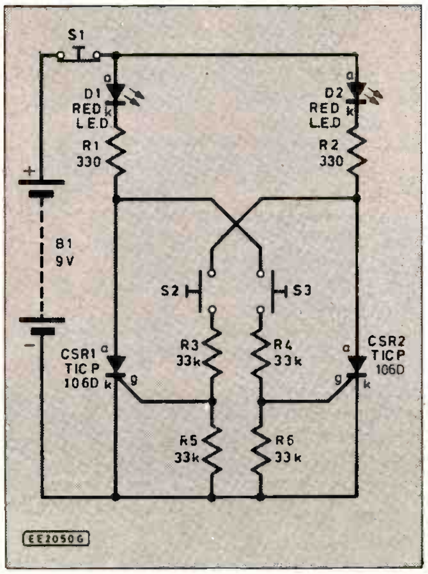
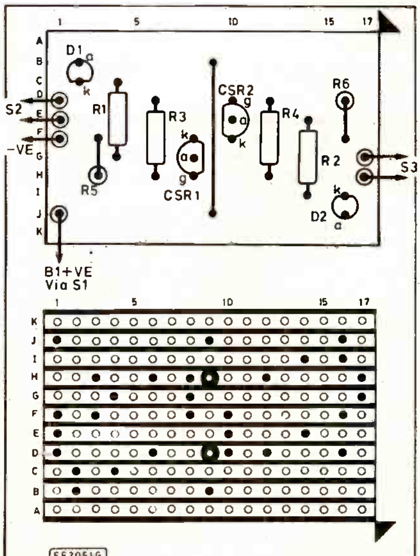


Fig. 2. Component board layout and details of breaks in underside copper strips.



Resistors R1, R3, R4 and R2 should then be similarly installed and soldered into place, followed by CSR1 and CSR2. You must take care to ensure that the thyristors are orientated as shown in Fig. 2.

The two remaining resistors, R5 and R6, are mounted so that they are at right angles to the board. To install these the wire from one end of the resistor is bent over through two 90 degree bends so that it eventually runs parallel to the body of the resistor. The resistor is then placed with its wires in the correct holes in the stripboard and then soldered into place.

The last components to be installed are the two l.e.d.s D1 and D2 which are inserted so that the flat (denoting the cathode (k)) on the l.e.d. base is positioned as shown in Fig. 2. When installing these leave sufficient wire on the l.e.d.s so that, when they are fitted into the case lid, the remaining components on the board will be held clear of the case.

The wires connecting the circuit board to the switches S1, S2 and S3 are then installed. To do this you should strip away some of the plastic covering from the appropriate wire at both ends, twist the bared wire in your fingers to make a neat form and "tin" it by placing the wire on a soldering iron with the solder on the opposite side of the wire to the iron and leave it there until the solder flows evenly over the wire. The wires are then inserted into the appropriate holes in the stripboard and soldered into place before soldering the other ends onto the switch connections.

Finally, the battery connector's negative wire is soldered into place on the stripboard where shown in Fig. 2. The positive wire of the battery connector is then soldered to the remaining connection on switch S1.

TESTING

Once the circuit has been constructed on the stripboard you should carefully check the board to make sure that all of the components are in the correct place, are the correct way round and that there are no blobs of solder or "dry joints" before attempting to connect the battery. Once you are sure that everything is correct then you can connect the battery and operate either switch S2 or S3.

The appropriate l.e.d. should glow brightly and remain lit when the switch is released. Operate the other switch and, although the l.e.d. associated with this switch might glow very dimly when the switch is pressed the l.e.d. wil not be fully lit and the illumination should disappear when the switch is released.

Press S1 to reset the circuit and note that the illuminated l.e.d. goes out. Repeat the above test, operating the other player's switch to the one that you first pressed. The second circuit should operate in an identical manner to the first circuit.

The circuit itself is fairly simple and you should find that there will be no problem in getting it to work. If your initial tests reveal that the circuit is completely dead then you should start by checking that the battery is producing energy both when connected to the circuit and separated from it.

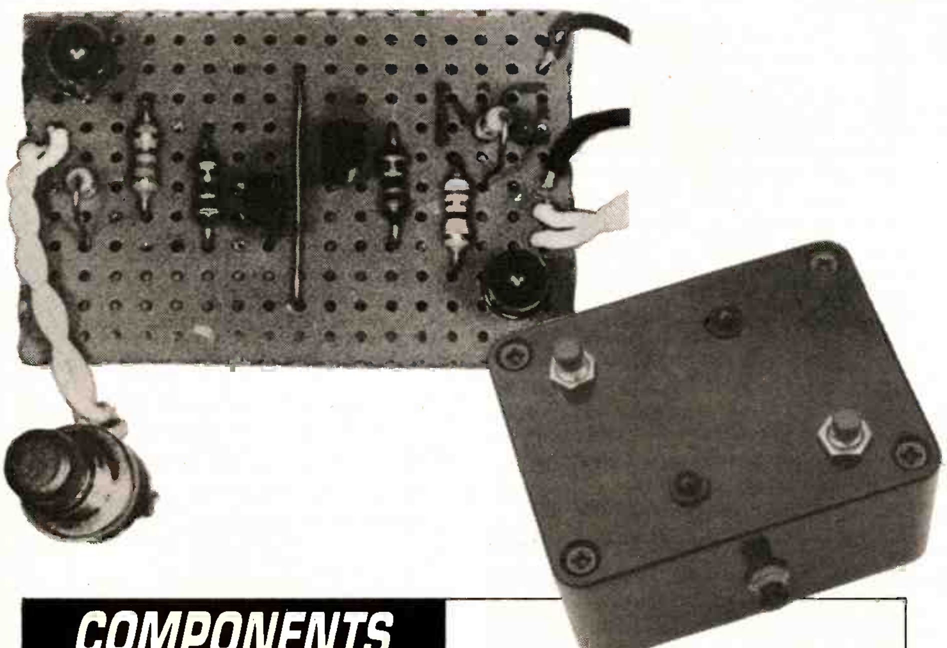
If the battery appears to be "dead" when connected to the circuit but healthy when separated from the circuit you should check for a short circuit between the positive and negative rails on the stripboard. If these checks reveal no problems then it is worthwhile checking that the action of S1 is correct.

If you find that an l.e.d. comes on without any switch being pressed then you should check that the appropriate 33 kilohm resistor between the gate and cathode of the associated thyristor (CSR) is making good contact and that there are no short circuits on the stripboard. If the l.e.d. refuses to light then connect a temporary short circuit between the anode (a) and cathode (k) of the appropriate thyristor (using a short piece of wire) and see if the l.e.d. lights.

If it does not oblige then check that the connection between the cathode of the thyristor and the l.e.d. through the series resistor, is correct. If these appear to be correct check that the l.e.d. is connected the correct way round. If the l.e.d. does light then check that the other l.e.d. circuit is correct by applying the same test.

If all is correct here check that the thyristor is working correctly by applying a short between the battery positive connection and the junction of the 33 kilohm resistor and the appropriate switch. **(Do not apply the battery positive voltage DIRECTLY to the GATE as it will blow the thyristor!).**

If the l.e.d. does not light check that the thyristor is installed correctly, if it is correctly installed then you must suspect that it is faulty. If this test causes the l.e.d. to light then you should check the connections to the switch and its operation.



CASE

The circuit board is held in the case by means of the l.e.d.s and their mounting clips. To make this possible, holes should be drilled in the lid of the case to accommodate D1, D2, S2 and S3. The positioning of the two switches is not critical, as long as they do not foul the circuit board, but the holes for the l.e.d.s D1 and D2 must be drilled so that they coincide with the positions of these components on the stripboard.

Once the holes have been drilled the switches and the l.e.d. clips should be installed in their correct holes. The retaining ring for the l.e.d.s is placed over the l.e.d.s before they are positioned in their clips. Once they are in position the retaining rings are pushed up onto the clips to hold the l.e.d.s and the stripboard in position.

The "reset" switch S1 is mounted in the body of the case and the appropriate hole should be drilled and the switch installed before the battery is connected. The case is finally screwed together with the screws supplied.

COMPONENTS

Resistors
- R1 330
- R2 330
- R3 33k
- R4 33k
- R5 33k
- R6 33k

All 0.25W 5% carbon

Shop Talk
See page 445

Semiconductors
- CSR1 TICP106D 400V thyristor
- CSR2 TICP106D 400V thyristor
- D1 Standard l.e.d., with clip
- D2 Standard l.e.d., with clip

Miscellaneous
- S1 Push-to-break, momentary action switch
- S2, S3 Push-to-make, momentary action switch (2 off)
- B1 9V (PP3 size) battery

Stripboard, 0.1in. matrix 11 strips×17 holes; case, ABS plastic approx. 80mm × 60mm × 40mm; battery connector; connecting wire; solder etc.

Approx. cost Guidance only **£5.50**

IN USE

Using the Snap Indicator is very simple, the two players sit with a convenient finger on their "contestant" push switch. Instead of shouting "Snap" at the appropriate time they simply press their switch.

The first person to press the switch is indicated by the associated l.e.d. lighting. The other switch is immediately disabled by the operation of the first switch and that l.e.d. will not light, even if the second switch is pressed almost immediately.

To continue the game it is necessary only to press the "reset" switch S1 which extinguishes the illuminated l.e.d. and resets the circuit ready for the game to continue. □

City and Guilds

Certificate Course

Introducing DIGITAL ELECTRONICS

Part 10 Diodes and Semiconductors

By Michael J. Cockcroft
Training Manager, Peterborough ITeC

At the end of this months lesson we will have completed another major phase of the course; the phase that provides all the prerequisite background to enable us, next month, to address the subject that this course is about–digital electronics.

The City and Guilds objectives for this month are as follows:

4.5 Diodes

4.5.1 Explain, in very simple terms, the action of a diode.

4.5.2 Identify the cathode connections of a variety of diodes.

4.5.3. Describe a typical application of each of the following types of diode:–

- Rectifier (power)
- Signal (detector)
- Light-emitting
- Zener

4.5.4 Explain the importance of selecting the correct diode rating. (Appendix L)

4.5.5 Perform simple GO/NO-GO resistance checks on typical diodes using an analogue multimeter.

Diodes

A diode is a two terminal **semiconductor** device which acts as a one way valve, letting current flow through it in one direction, while blocking current flow in the other. The diode is the simplest and most fundamental semiconductor device used in electronics; other semiconductor devices, for example, are transistors and integrated circuits.

Semiconductors

Semiconductors, we know from previous work, are materials which are neither conductor nor insulator. The conductivity of semiconductor materials–such as silicon, germanium, cadmium sulphide and gallium arsenide–lies somewhere between a good conductor, like copper, and a good insulator, like air.

Materials having electrons loosely bound to their atoms are good conductors and materials having electrons tightly bound to their atoms are good insulators. Electrons are loosely or tightly bound to the nucleus of their atoms depending on how many electrons exist in that "outer orbit zone" we spoke of in Part 7.

A good example of loosely bound electrons are those in copper, the outer electron in each copper atom is so loosely bound that the thermal energy that exists even at normal room temperature is enough to detach them and cause a random movement of free electrons (note that this random movement does not constitute an electric current, a current exists only when there is a general drift of electrons in one direction–see Part 1). Tightly bound electrons are those of materials whose atoms have only a few free electrons and require large amounts of energy to release them.

Since the electrical properties of materials are determined by the outermost electron orbital (shells) of its atoms and these are the only electrons involved in current flow, it is convenient to simplify the atom as a central nucleus with a single electron shell; for example, Fig. 10.1 shows the atomic structure of silicon in (a) and a simplified version of the same in (b).

Silicon

Silicon has a crystalline structure, as depicted in Fig. 10.2. When the atoms of an element are close together, as is the case for solid materials, they align themselves in

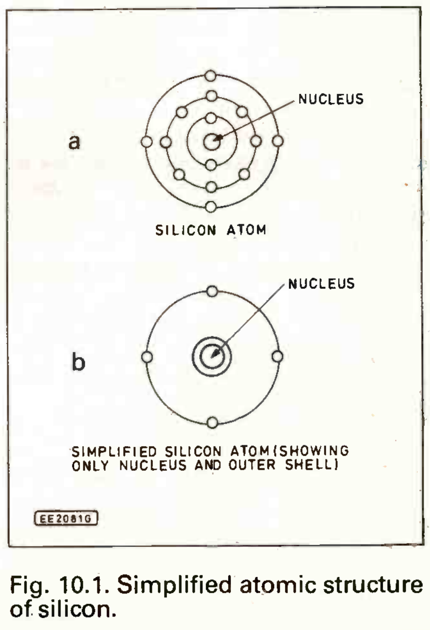


Fig. 10.1. Simplified atomic structure of silicon.

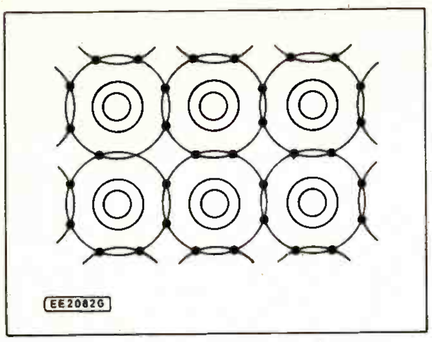


Fig. 10.2. Silicon has a crystaline structure.

this crystalline structure. This diagram may represent germanium or silicon crystal since they both have four electrons in their outer shells, and they both form the same basic structure (but three dimensional, of course); every atom is the same distance from four other atoms and each electron pairs up with an electron of another atom to form what is called a *covalent bond* between each atom.

All the covalent bonds are complete (meaning that there are no free electrons) in this perfect crystal and, in this state (at low temperatures), germanium and silicon would be insulators. The energy present at room temperature is sufficient to dislodge a few electrons leaving an empty space or *hole* for every free electron, as shown in Fig. 10.3.

Both holes and free electrons can lead to conduction in a semiconductor. Electrons will move in one direction creating holes behind them which appear to move in the opposite direction—an atom with a hole has a net positive charge; an electron from a nearby atom can fill this hole and neutralise the charge, leaving a hole in its parent atom—so, it is feasible to say that the hole has moved from one atom to the other. Thus, current flow in a semiconductor consists of electrons flowing towards positive *and* holes flowing in the opposite direction towards negative.

The conductivity of semiconductors can be greatly increased by a manufacturing process called "doping". This entails adding minute proportions (less than one million to one) of another element

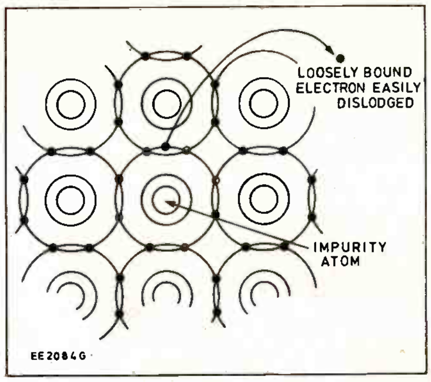


Fig. 10.4. Doped n-type semiconductor.

to the semiconductor. The semiconductor material is melted, the impurity added, then it is allowed to cool and reform with foreign elements distributed evenly throughout the crystal lattice.

These impurity elements have either one more (five) or one less (three) electron in their outer shells than the semiconductor. If an element having three outer electrons is added, an excess of holes will be created and hole conduction will result; an impurity with five outer electrons will create an excess of electrons and electron conduction is obtained.

N-Type Semiconductor

If the semiconductor has been doped with a material having five electrons in its outer shell, the impurity atoms will combine in the crystal structure as shown in Fig. 10.4.

The extra electrons will remain close to their parent impurity atoms, but they will be very loosely bound and available as current carriers. As the current carriers are negative electrons, the resulting material is called n-type (negative carrier) material.

P-Type Semiconductor

If the semiconductor has been doped with a material having three electrons in its outer shell, the impurity atoms will combine in the crystal structure as shown in Fig. 10.5. The impurity atoms, this time, have stolen electrons and created holes in the structure.

The incomplete covalent bonds

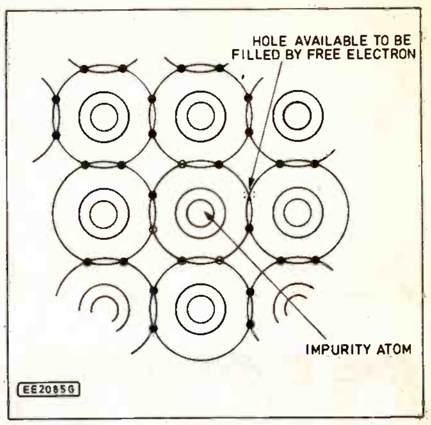


Fig. 10.5. Doped p-type semiconductor.

attract nearby electrons creating hole conduction. As current flow is by means of positive holes, the resulting material is called p-type (positive carrier) material.

The Semiconductor Diode

The diode is the basic semiconductor device from which all other semiconductor devices have developed. Learning the operation of the diode is fundamental to an understanding of other semiconductor devices, such as transistors and integrated circuits.

Diodes come in various shapes and sizes—see Table 2.5 of the November issue for an illustration of some common types and their lead identification. Generally, the larger the physical size of the diode, the greater its current carrying capabilities.

A diode is essentially a tiny block of p-type material (the anode) joined to an equally tiny block of n-type material (the cathode), as shown in Fig. 10.6. The p-type block is treated in such a way as to have a deficiency of electrons and the n-type block is treated to have an excess of electrons, as explained above.

When the two materials are fused

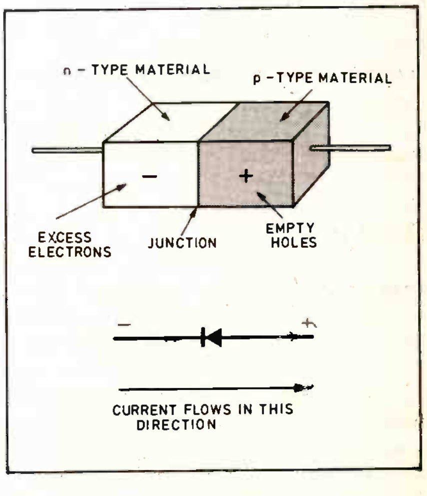


Fig. 10.6. Structure and symbol of a diode.

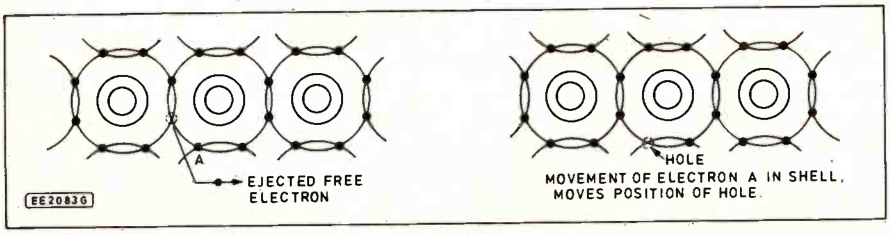


Fig. 10.3. Movement of electrons and holes.

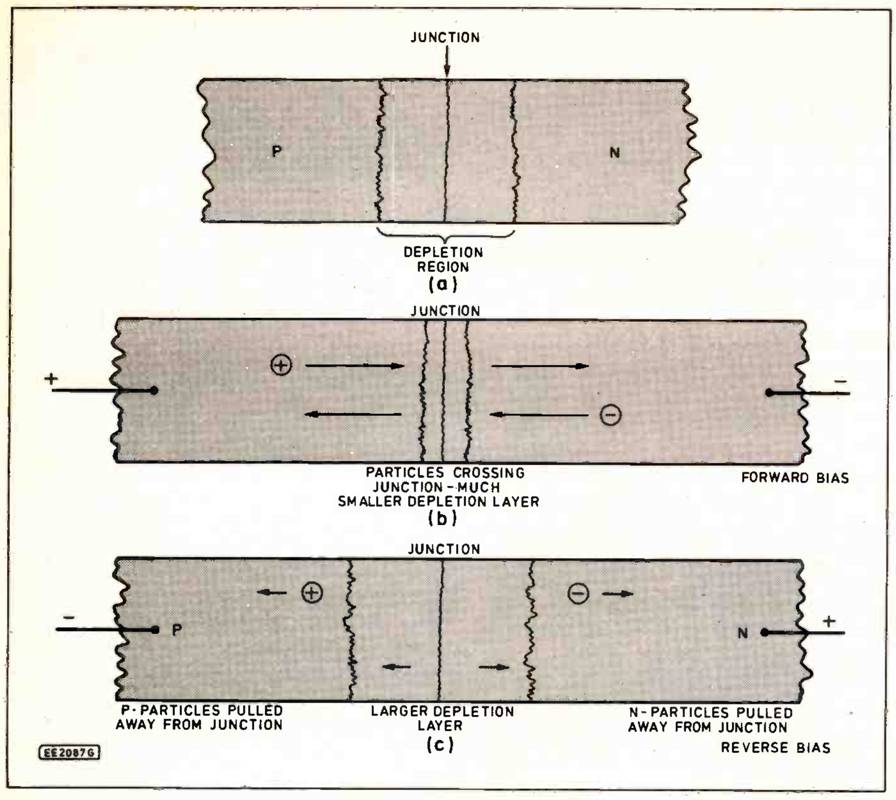


Fig. 10.7. Depletion region.

together a barrier field forms at the junction (called the depletion layer–see Fig. 10.7a), preventing the electrons in the n-type material from moving over to the p-type material; however, when a voltage is applied, as shown in Fig. 10.7b, the depletion layer is overcome and electrons flow across the p-n junction. If the voltage is applied to the diode in the reverse polarity, as shown in Fig. 10.7c, the depletion layer gets larger and no current can flow.

Forward Bias

So, when a voltage source is applied to the diode terminals in the correct polarity, current flows through the diode; however, if the polarity is reversed, very little (if any) current passes through. The diode in Fig. 10.8a is said to be **forward biassed** and current flows in the circuit. The anode (p-type material) is connected to the positive side of the source and the cathode (n-type material) is connected to negative.

Reverse Bias

The diode shown in Fig. 10.8b is said to be **reverse biassed** and will not conduct. The anode is connected to the negative side of the source and the cathode is connected to positive.

When reverse biassed, the internal resistance of the diode becomes very high. Some diodes are able to withstand several hundred volts of reverse voltage before there is a significant amount of current flow in the reverse direction. When current flows in the reverse direction the diode is said to be in a state of *avalanche*. The diode may be destroyed if allowed to avalance for extended periods.

Voltage Drop

Diodes are non-linear devices. This means that they do not follow Ohm's law. When current or voltage across a forward biassed

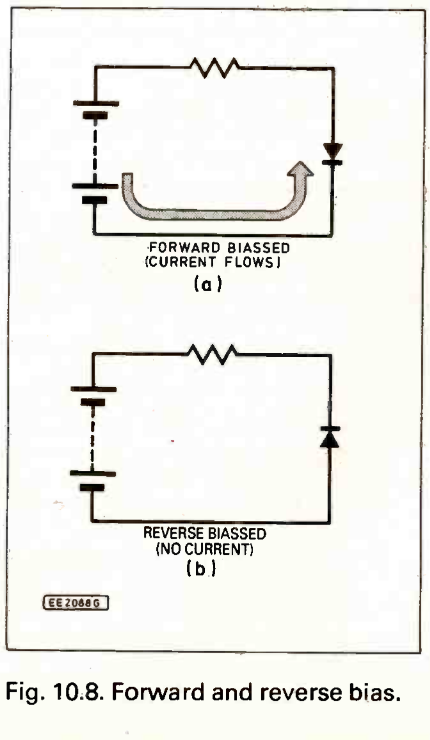


Fig. 10.8. Forward and reverse bias.

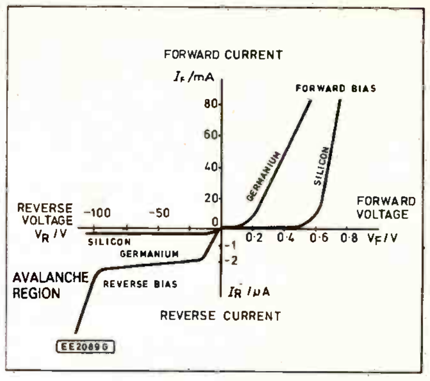


Fig. 10.9. Current flow in relation to applied voltage in silicon and germanium diodes.

diode circuit increases, the voltage drop remains constant. A forward biassed silicon diode drops approximately 0.6 volts; any additional voltage applied to the circuit must be dropped across other resistances in series with the diode. Germanium diodes have a smaller voltage drop, about 0.2 volts, when forward biassed.

Diode Characteristics

The graphs of Fig. 10.9 show current flow in relation to applied voltage in typical silicon and germanium diodes. The vertical line represents current flow while the horizontal line represents voltage.

The upper right quadrant of the graphs represent the diodes being forward biassed. As forward voltage (V_F) increases, there is little current flow until approximately 0.6 volts for the silicon diode and 0.2 volts for the germanium diode; then forward current (I_F) increases as voltage increases.

The lower left quadrant of the graphs represent the diodes being reverse biassed. There is very little current flow in the reverse direction until the reverse voltage (V_R) reaches a potential high enough to cause the diode to avalanche when reverse current (I_R) begins to increase sharply.

As part of the diode specification, the average forward current (I_{Fav}) and the peak inverse voltage (PIV) are usually given. The peak inverse voltage is the maximum reverse voltage and is often abbreviated to V_{rrm}.

The diode and D.C.

If you have the parts for the circuit of Fig. 10.10, you may like to build it and carry out a simple exercise showing the reaction of a diode to d.c. A 12 volt/100mA bulb, an ammeter, and a 1N4002 diode are connected in series across a 12 volt supply. If you have purchased the parts listed in the free booklet, you only need the diode–the bulb is the

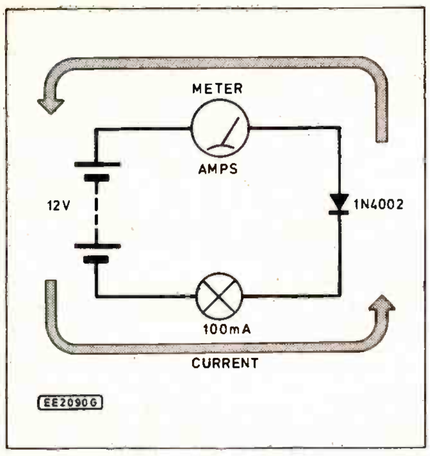


Fig. 10.10. Experimental forward biassed circuit.

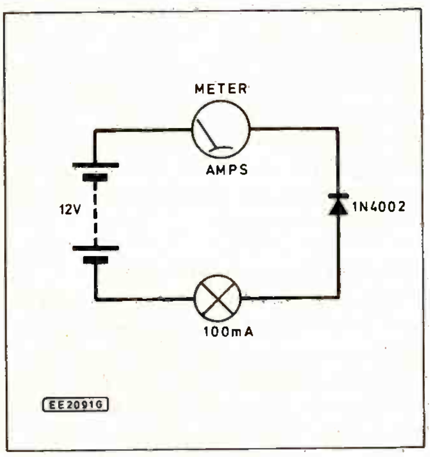


Fig. 10.11. Experimentl reversed biassed circuit.

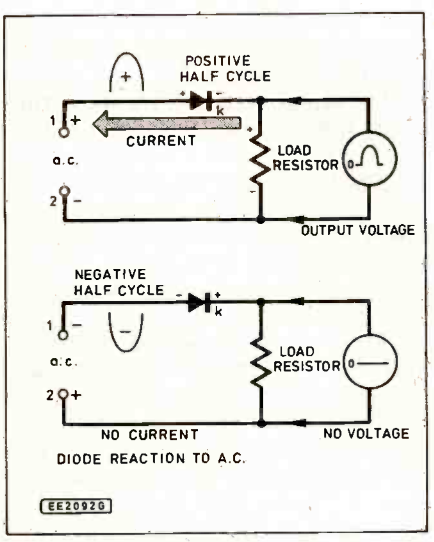


Fig. 10.12. Current flow in a diode circuit with a.c. applied.

same and you may use the PP3 battery if you wish (expect a current reading much lower than that stated below if you use the 9 volt battery).

With the circuit connected as shown, current will flow and the bulb will light. The meter will display less than 100 milliamps. Now reverse the connections of the diode as shown in Fig. 10.11. The bulb will not light and, as indicated in the figure, the meter will remain at zero. The anode-to-cathode resistance of the diode is sufficiently high to prevent a flow of current. A very small amount of current will leak, but it is not enough to record on the meter.

The diode and A.C.

Current flow in a diode circuit with a.c. voltage applied is shown in Fig. 10.12. During the positive half cycle, terminal 1 of the source is positive with respect to terminal 2 (because current only flows in one direction through a diode, and the diode just happens to be that way round); therefore, the anode of the diode is positive with respect to the cathode.

During the next half cycle, terminal 1 voltage becomes negative with respect to terminal 2, and the anode of the diode is negative with respect to the cathode (so current will not flow). The reverse biassed diode has very high resistance in the circuit, so all of the source voltage will be dropped across it and no voltage will be present across the load resistor.

Diode Applications

We mentioned, in a previous article, that diodes are usually named according to the application for which they were manufactured; for example, "signal diodes", "light emitting diodes", "Zener diodes", and "rectifier diodes" are names given to the particular diodes of interest to us in this course. The application of these diodes will become apparent as we proceed.

Table 10.1 shows the diode data from Appendix L of the City and Guilds Resource Document. Note that a "switching diode" is a quick acting "signal diode", its full name is "high speed switching signal diode".

Rectifying A.C.

To rectify means to convert a.c. to d.c. A device that performs the conversion is called a rectifier. Consider the diagram of Fig. 10.13.

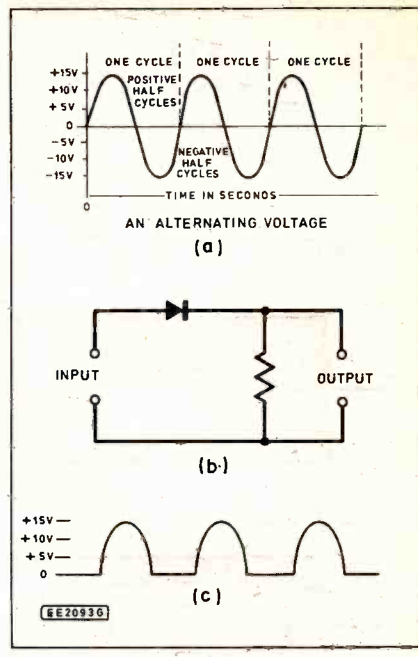


Fig. 10.13. Rectifier action.

Applying the a.c. signal of (a) to the input of the circuit in (b) produces an output signal like that shown in (c).

The circuits of Fig. 10.14 are the three basic rectifier circuits. Rectification is a function of both d.c. power supplies and radio signal detection.

D.C. Power Supplies

The output voltage obtained from the circuits of Fig. 10.14 are d.c. outputs—current flows only in one direction—but is not a smooth, steady d.c. In fact, the waveform is a series of pulses called pulsating d.c.

The peaks and troughs of the pulsating waveform can be smoothed out by the use of a smoothing capacitor, as explained in Part 8. In Fig. 10.15a, as the source voltage rises to maximum positive, current flows through the resistor and diode and charges the capacitor to the value of the source voltage.

When the applied voltage begins to decrease, as shown in Fig. 10.15b, the capacitor starts discharging in an attempt to maintain the same voltage level. The dis-

TABLE 10.1. DIODES

USE	I	V	TYPE	RS CODE
RECTIFIER	1A	100	1N4002	Z61-154
RECTIFIER	3A	100	1N5401	Z61-299
SWITCHING	75mA	75	1N4148	Z71-606
SIGNAL	80mA	150	OA202	Z71-583

LIGHT EMITTING DIODES

COLOUR	I_{typ}	V_{typ}	RS CODE
RED	10mA	2V	586-475
GREEN			586-481
YELLOW			586-497

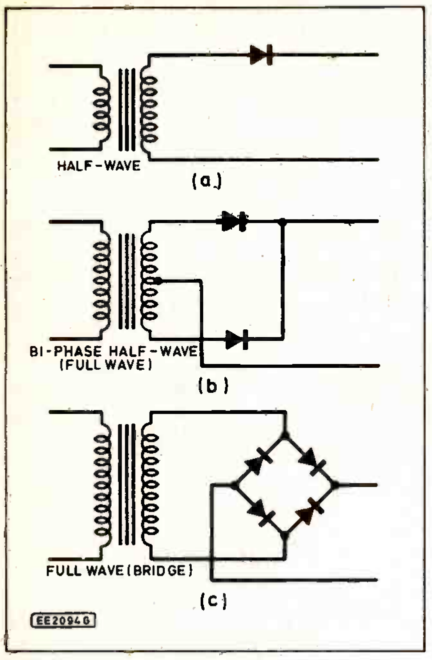


Fig. 10.14. Three basic rectifier circuits.

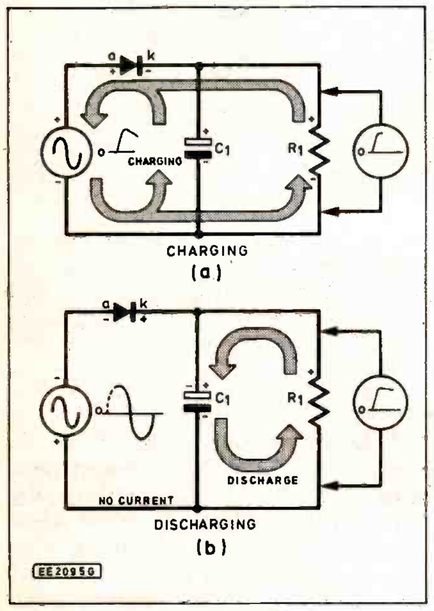


Fig. 10.15. Smoothing action.

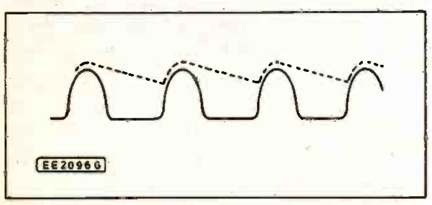


Fig. 10.16. A smoothed voltage —shown dotted.

charge path of the capacitor, though, is through the resistor, because the current from the capacitor cannot flow in the reverse direction through the diode, and decreases at a much slower rate.

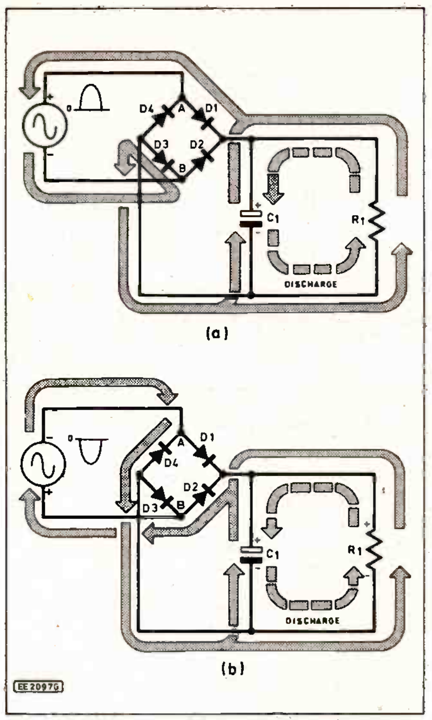


Fig. 10.17. Full wave rectifier and smoothing current flow.

During the negative input half cycle the diode prevents the flow of current, although the capacitor continues to discharge. The discharge current decreases as the capacitor charge diminishes. On the next positive half-cycle the diode does not conduct until the input voltage has increased to a level greater than the charge on the capacitor (the anode must be more positive than the cathode for the diode to conduct). This sequence continues to produce a d.c. ripple voltage output like that shown dotted in Fig. 10.16.

We call the circuit in Fig. 10.15 a half-wave rectifier. It allows only half the a.c. wave (positive half cycle in this case) to appear across the load reistor. Full-wave rectification can be achieved by the switching action of the diodes in the circuit of Fig. 10.14c.

Full-wave rectification uses a network of four diodes called a **bridge rectifier.** When terminal A of the bridge rectifier in Fig. 10.17a is positive with respect to terminal B, diodes D1 and D3 are forward biassed and current follows the shaded path. When the voltage at terminals A and B of the bridge rectifier is the other way round, diodes D2 and D4 are forward biassed and current follows path shown in Fig. 10.17b. The pulsating d.c. output of a bridge rectifier looks like that in Fig. 10.18a. A full-wave rectified signal provides for better smoothing since the time between the peaks is shorter—see Fig. 10.18b.

Full-wave rectification can be achieved using only two diodes but this requires a special *centre tapped* transformer. This is an ordinary transformer with an electrical connection placed at the mid point of the secondary winding. Fig. 10.14b shows the configuration of a two diode full-wave rectifier.

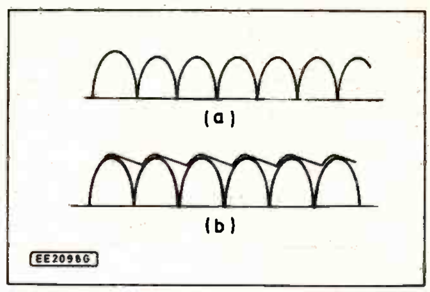


Fig. 10.18. Full wave rectified and smoothed voltage.

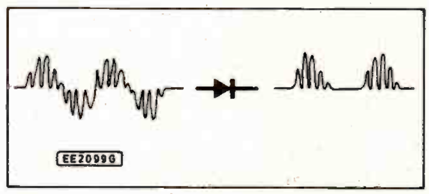


Fig. 10.19. Radio signal detection.

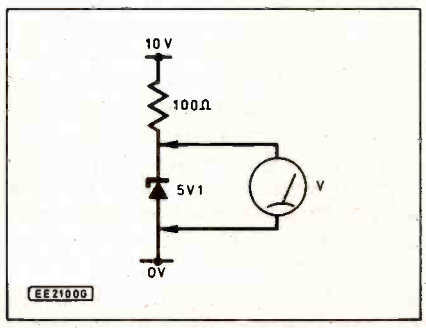


Fig. 10.20. Voltage across a Zener diode.

Radio Signal Detection

When a diode is used to rectify a radio signal, as shown in Fig. 10.19, the diode is said to "detect" the radio signal. A *signal diode,* rather than a *rectifier diode,* would be used for this purpose; the difference is simply the size (current carrying capability) of the diode.

Zener Diodes

A Zener diode is a special purpose diode that is designed to operate in a reverse biassed mode, as configured in Fig. 10.20. This type of diode is designed to avalanche at a predetermined voltage and will maintain that voltage even when current through the diode changes.

If you have a variable power supply you can convince yourself of this by a simple experiment; build the circuit of Fig. 10.20 using a variable power supply and connecting a voltmeter across the Zener diode.

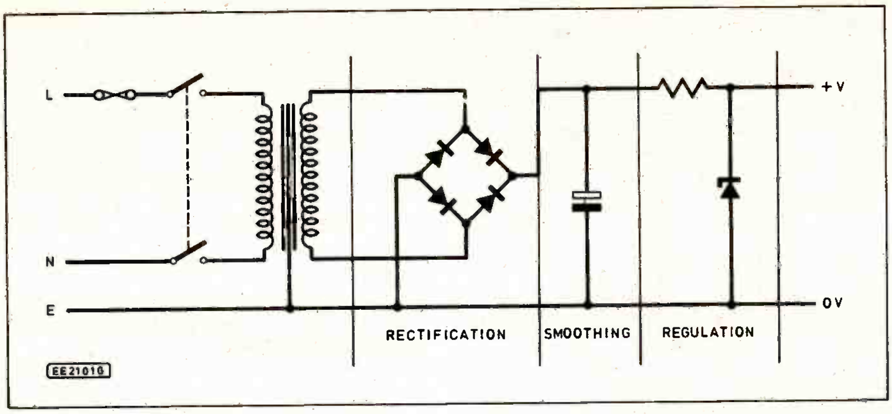


Fig. 10.21. A simple regulated d.c. power supply.

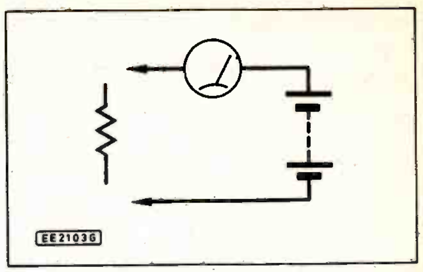


Fig. 10.23. Operation of an ohmmeter.

Start at 2 or 3 volts and gradually increse the supply up to about 10 volts. You will observe that when the input voltage exceeds (about) 5.1 volts the voltage across the Zener remains at 5.1 volts.

This particular characteristic makes Zener diodes very useful as voltage regulators in d.c. power supplies. A voltage regulator keeps the output of a power supply at a steady voltage no matter how much (within limits) the load current varies. We stated in a previous lesson that digital circuits, for example, require stable regulated supplies to operate properly.

Now, using the same (Fig. 10.20) experimental circuit with a fixed supply of voltage, experiment with different load currents (say, between a few micro-amperes and a few milli-amperes) by connecting half-a-dozen different value resistors across the output. You will find that the voltage remains constant even when the current drawn at the output changes. This is called voltage regulation.

The circuit diagram of a complete simple regulated d.c. power supply is given in Fig. 10.21.

Zener diodes, when forward biassed, function as any other silicon diode and will drop approximately 0.6 volts. When reverse biassed they block current flow until the reverse voltage reaches the diodes rated "Zener" voltage. This *reverse breakdown* characteristic is a property of all diodes, Zeners are simply manufactured to breakdown at a predetermined voltage. Zener diodes are designed to operate (avalanche) at many different voltages. Some typical values are 4.7V, 5.1V, and 5.6V.

The Light Emitting Diode

Light emitting diodes (l.e.d.s) are used as indicators. They are similar in operation to ordinary semiconductor diodes but they emit red, green or yellow light when forward biassed. The forward voltage (voltage when forward biassed) dropped across an l.e.d., at 2 volts, is greater than ordinary diodes.

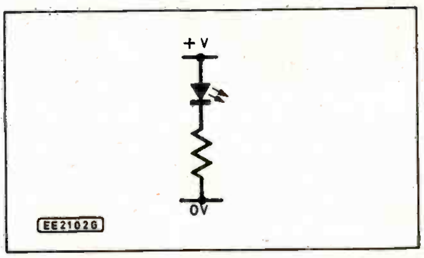


Fig. 10.22. Use of an l.e.d.

L.e.d.s are placed in a circuit in series with a resistor, as shown in Fig. 10.22. The value of the resistor is selected to drop the supply voltage less the forward voltage (two volts) of the l.e.d. across the resistor at about 10mA:

$$R=\frac{V}{I}=\frac{\text{supply voltage}-2V}{0.01A}$$

The resistor required for a 9 volt supply is therefore:

$$R=\frac{9-2}{0.01}=700 \text{ ohms}$$

In practice we would use a resistor of the nearest preferred value (see Table 7.3–Part 7): either 750 or 680 (providing the lower value does not exceed the maximum forward current specification of the l.e.d.).

There are distinct advantages of using l.e.d.s as indictors in preference to bulbs; they are smaller, more reliable, consume less current (typically 10mA), have a longer life, and operate at higher speed.

Go/No-Go Diode Testing

An ohmmeter (or multimeter on the ohms range) can be used as an approximate test to check if a diode is functioning. The idea is to first measure the resistance of the diode when it is forward biassed, then again when it is reverse biassed.

Ohmmeters work on the principle of converting resistance to current; a known voltage applied across a resistance produces a relative current. For example, if a voltage source of known value is connected to a suitable ammeter, as shown in Fig. 10.23, the needle will deflect according to the resistance in the circuit.

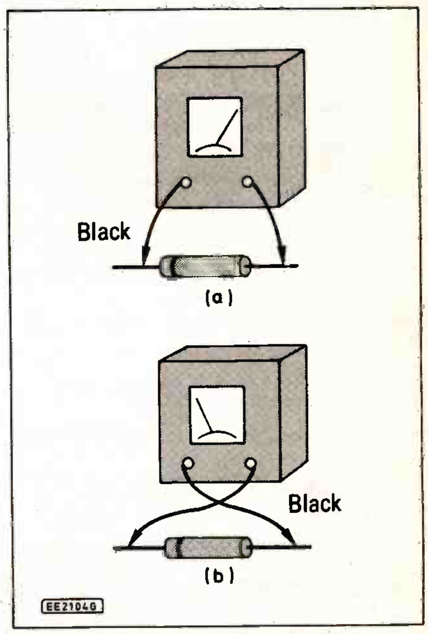


Fig. 10.24. Checking a diode with an ohmmeter.

The ohmmeter, itself, can therefore be used to bias the diode.

Forward biassing the diode, as shown in Fig. 10.24a, should produce a low resistance reading of a few hundred ohms. Reverse biassing the diode, as shown in Fig. 10.24b, should produce a very high resistance reading, near infinity (that's if it registers a reading at all on silicon diodes).

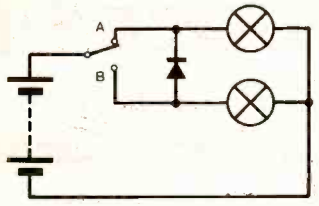
This procedure cannot determine that a diode *is* definitely working properly. The test is useful, however, for indicating when one definitely *is not* working properly; for example, if the resistance reading is very high in both directions, the diode is open circuit; if the reading is low in both directions, the diode is short circuited.

Next month: Combinational Logic.

Questions

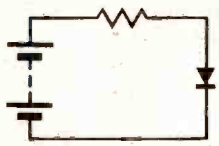
1. State one application for a Zener diode.
2. State one application for a light emitting diode.
3. State one application for the diode in Table 10.1 having the identification code 1N4002.

4. Which bulb/s, in the circuit below, illuminate when the switch is
   (a) in position A
   (b) in Position B

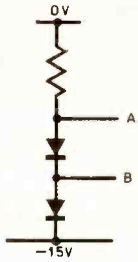


5. Identify the cathode of the diode below.

6. What type of bias is applied to the diode in the circuit below?



7. What type of bias is applied to a diode having −5 volts on its anode with respect to zero volts on its cathode?
8. What will be the voltage at points A and B in the circuit below, assuming that the diodes are silicon.



9. A half-wave rectifier provides a better signal for smoothing than that of a full-wave rectifier (true or false?).
10. A rectifier converts ....to........

INTRODUCING DIGITAL ELECTRONICS

PLEASE NOTE

Under the heading "The Transformation Ratio" (pages 376 and 377) last month the equations in Table 9.3 were incorrect. The previous equation showing the relationship of primary current and turns to secondary current and turns was also incorrect. We appologise for this error, the correct versions are shown below.

$$\frac{I_s}{I_p}=\frac{N_p}{N_s}$$

TABLE 9.3

$$I_s=\frac{I_p \times N_p}{N_s} \quad N_s=\frac{I_p \times N_p}{I_s} \quad I_p=\frac{I_s \times N_s}{N_p} \quad N_p=\frac{I_s \times N_s}{I_p}$$

ANSWERS TO LAST MONTH'S QUESTIONS

1. From Table 9.3—see above $-I_p=\frac{I_s \times N_s}{N_p}$

$$=\frac{3 \times 400}{2000}=600\text{mA}$$

2. Power in the secondary equals power in the primary (in an ideal transformer)
3. Step down ratio is 2:1
4. Step up ratio is 2:1
5. The secondary winding.
6. Applying an alternating curent to the input coil (primary winding) of a transformer produces a changing magnetic field. This changing field cuts across the secondary coil and induces a current in the output of the transformer.
7. The transformer has a step up ratio of 2:1. Therefore the voltage at the secondary will be twice that at the primary. Answer 6V.
8. From Table 9.2

$$V_s=\frac{V_p N_s}{N_p}=\frac{50 \times 800}{200}=200\text{V}$$

EE CROSSWORD ANSWERS

ACROSS		DOWN	
3	APERIODIC	1	ISOPAUSIC
6	INTERLACING	2	BAIRD
9	AUDIO	3	ARTWORK
10	ELEMENT	4	IMAGE
11	STROKE	5	ION
13	CLUTCH	7	REEL
17	CANDELA	8	INDENT
19	PIXEL	12	RUN IN
21	LINEARITY	14	LIP SYNC
22	DENSITY	16	CAVITY
		18	ESAKI
		20	X RAYS

ON SPEC

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS MONTH we have details of a simple motherboard for the Spectrum. This novel arrangement allows users to extend the Spectrum's bus system. So, if you have a vast array of boxes and boards stacked behind your Spectrum, this could be the answer to your prayers. We begin, however, by taking a look at the quaintly named **Pick-POKE-It** software package available from **Miles Gordon Technology.**

Pick-POKE-It

Most assembly language programmers will readily admit to having learned at least some of their craft from inspecting other people's code. In this respect, the ability to "freeze" a running program, break into it to inspect and modify the code, and then return to the point at which the program was left is essential. Provided you are the owner of a Plus-D interface, Pick-POKE-It provides a means of doing it!

The software is designed to be used in conjunction with the "snapshot" facility incorporated in the immensely popular Plus-D interface and offers a number of useful features for those who enjoy "tinkering" with commercial software. Pick-POKE-It effectively provides a range of extensions to the Plus-D's "snapshot" facility, including the ability to disassemble the contents of memory, display and modify the contents of the CPU registers, and edit the contents of given memory locations.

It is supplied on cassette together with a 24-page Instruction Manual. This booklet provides full details of how to install the software so that you have a disk master from which it is possible to generate further Pick-POKE-It system disks. All that is required is a GDOS disk with at least 80K of free space. The installation process produces three additional files (each of about 4K) together with a modified system file (+SYS PP1).

Once installation has been completed, the modified boot disk will automatically provide the Pick-POKE-It extensions whenever the snapshot facility is used. The Plus-D will behave as before but when the snapshot button is pressed followed by the Spectrum's "P" key (rather than the usual "1", "2", etc.) there are a few seconds of disk activity followed by a menu appearing on the screen.

I found the system very easy to install and a delight to use. I tested the package on several popular programs (including the suggested POKEs for Paper Boy) and everything worked well. The memory search facility proved to be extremely useful in locating routines which required inspection and/or modification.

Unfortunately, one penalty associated with the use of packages such as Pick-POKE-It is that modified software is likely to be somewhat less robust than when left unmodified. The user must accept that this is part of the learning process associated with performing "trial and error" operations on someone else's code!

It should also be noted that a few owners of early versions of the Plus-D (those which were fitted with a "Version 1" ROM) will not be able to use Pick-POKE-It until a later version of ROM is fitted. The units in question were originally sold in December 1987 and January 1988 but are easily identified by referring to the serial number printed on the bottom of the Plus-D. If this number comprises four-figures commencing with a "1" then you have a Version 1 ROM and should contact MGT to arrange for a replacement to be supplied.

If you are already the owner of a Plus-D interface then Pick-POKE-It can be highly recommended as it provides an extremely useful range of extensions to an already powerful snapshot facility. If you don't own a Plus-D this could be yet another good reason for acquiring one!

Miles Gordon Technology are at Lakeside, Phoenix Way, Swansea, SA7 9EH. ☎ 0792 791100.

SPECTRUM MOTHERBOARD

At some time or another, most Spectrum owners realise the need to connect several devices simultaneously to the Spectrum's expansion bus. The normal method which is employed with commercial interfaces is simply that of running the bus through the interface so that the Spectrum's expansion edge connector is duplicated to facilitate the connection of other peripherals which require access to the bus signals.

This seems to work reasonably well when only one or two interfaces are stacked together, however, it can be somewhat problematic when a large number of external boards and devices are present or when external modules do not possess a "through bus" facility. The obvious answer to this problem is the use of a "motherboard" which makes connection to the Spectrum's edge connector and provides a set of identically wired connectors for external cards and modules.

Norman Belham (from Badsey near Evesham) has provided a simple but elegant solution to the problem of constructing a motherboard based on commonly available copper stripboard. Norman writes:

Two pieces of Veroboard are placed back to back (so that the track sizes are exposed) and held together by a Veropin placed in each corner. A convenient available size is 36-strips each with 50-holes (127mm×95mm).

These pieces are large enough to take a Spectrum edge connector along one side, across the copper tracks, and two or three other connectors standing on the surface. If more connectors are required, Veroboard can be obtained 4in. wide and up to 19in. long cut to length from J. R. Hartley of Bridgnorth.

According to "*Murphy's Law*", anything that can go wrong will and so extreme care is needed in construction! The double Veroboard (arranged so that the copper tracks are outermost) should be inserted between the rows of pins of the edge connector leaving a space, equal to about half a pin length, between the edge of the board and the body of the connector.

The pins should be soldered to the corresponding tracks on the top and underneath the board. It is best to solder pins at each end first so that the connector is correctly located.

When it has been decided just where on the surface of the board the other connectors are to be placed, it is wise to check that they are on the top side when the edge connector is mated with the Spectrum. The pins to be soldered to the top side of the board should be bent at right angles to their mid-point (see Fig. 1 for details). This will make soldering easier when several connectors are in position. A piece of 0.25in. square section beading can be used as a bending bar.

The holes through which the other row of pins reach the lower tracks will require careful counter-sinking using a small drill (1/16in. or smaller). *Very* light pressure and *very* few turns are all that is required to produce an insulating "collar" around each hole.

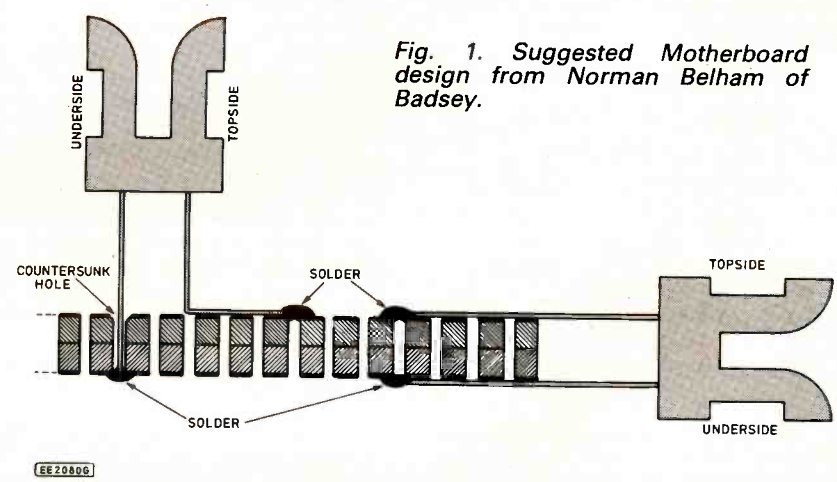


Fig. 1. Suggested Motherboard design from Norman Belham of Badsey.

Although the specified drill is too small to cut away the track completely, it is better not to drill the hole completely. (If a track is cut accidentally, all is not lost as a small insulated "jumper" link can be soldered in place). The pins may then be soldered to the lower tracks.

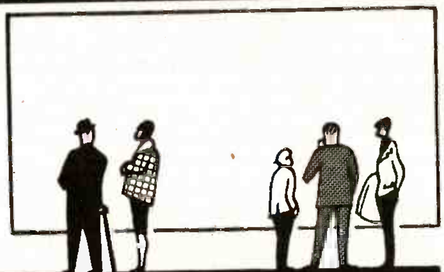
Since only 28 of the tracks are used, the remaining few on either side may be used for other purposes such as an external power supply. Rigorous testing with an Ohmmeter (multimeter set to the "Ohms" range) is essential to ensure tht there is no contact between tracks. If, in spite of this, an unusual graphic display is produced when the board is attached to the Spectrum, there *is* contact somewhere!

It is also wise to test for continuity between the pins which *should* be connected. With such a large number of soldered connections, a "dry" joint may slip by! Finally, since the board does not rest on the bench or table surface when mated with the Spectrum, suitable rubber or plastic feet should be fitted.

Next month: In next month's On Spec, we shall be taking a look at two recently updated compilers from Mira Software. We also have a roundup of Hints and Tips received from readers over the past few months.

In the meantime, please drop me a line enclosing a large (250mm×300mm) *adequately* (i.e. 42p for UK postage) stamped addressed envelope if you would like to receive a copy of our *On Spec Update*. Please note that I can no longer provide individual replies to queries but instead will do my best to provide answers through *On Spec* or through the *Update*. Mike Tooley, Faculty of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

SHOP TALK

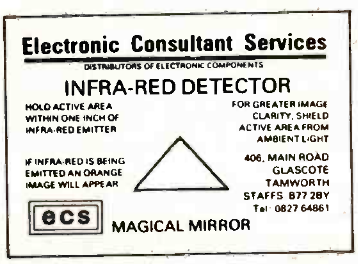


BY DAVID BARRINGTON

HiFi Crossover Kit

Due to popular demand, we have been informed by **Radio & TV Components (Acton) Ltd.**, that they can now supply all the crossover components for our *HiFi Speaker Design* (May '89 issue) as a complete crossover kit.

The kit—suitable for a stereo set up—cost £11 plus £1.75 for p&p and is available direct from **Radio — TV Components (Acton) Ltd., Dept EE, 21 High Street, Acton, London W3 6NG.**



Magic Mirror

Ideal for checking for possible infra-red emissions from such everyday items as TV remote controls, video recorders etc, **Electronic Consultant Services** have recently marketed an Infra-Red Detector Card. It is also claimed that it can be used for checking the functioning of I.R. Burglar Alarm projects.

About the size of a credit card, the Magic Mirror, as it is called, has a small white triangle shaped pad in the centre of the card which changes colour to orange when exposed to infra-red radiation.

The card costs £11.72 all inclusive and further information may be obtained from **Electronic Consultant Services, Dept EE, 406 Main Road, Glascote, Tamworth, Staffs, B77 2BY (☎ 0827 64861).**

Passive Infra-Red Intruder Detector

We have only been able to locate one single source for the special infra-red sensor used in the *Passive Infra-Red Intruder Detector*. This sensor is called a "Pyroelectric Infra-red Sensor" and includes a ceramic element of doped lead-zirconate-titanate, a field effect transistor and resistor in a single package.

The sensor device was purchased from **Maplin** (£5.95) and is listed as an infra-red detector type F001P, order code FD13P.

We understand that a similar device (type RPY96), but with a larger element for greater sensitivity is available in a T05 case. To date, we have been unable to locate any source of supply for this infra-red sensor.

The reed relay used in the prototype model is a RS type and was obtained through their mail order ocmpany **Electromail *(☎ 0536 204555)***. This is listed under their standard encapsulatd reed relay range for circuit board mounting and should be ordered as: Green 348-970. Almost any circuit board mounting reed relay could be used here, provided it is capable of operating from 6V-9V d.c. and has a coil resistance of 700 ohms.

Programmable Pocket Timer

Although the components called up for the *Programmable Pocket Timer* project are standard items, their physical dimensions are fairly critical if the specified case is to be used. You can, of course, use a different size case.

The d.i.l. switches usually come as a complete unit and the quad or 4-way version should be ordered. The small "latching" on/off switch used in the prototype model was purchased from Maplin and is listed under their Modular Switch range, code FP52G, UH74R for a grey button and MP53H for the switch bezel.

The negative temperature coefficient polypropylene type capacitor, quoted for C1, seems to be rarely listed in suppliers catalogues and may prove difficult to locate. To save undue troubles, it is suggested that a close tolerance "polystyrene" or "poly layer (Siemens)" capacitor be used here.

The 4000 series CMOS i.c. devices are now stocked by most good component suppliers. The 6V silver oxide battery type PX2 should be available from any good camera shop.

The small printed circuit board for the timer is available from the *EE PCB Service*, code EE648 (see page 473).

Caravan Stereo

It may be a problem to locate *single* resistors with the correct values for the *Caravan Stereo* project and it might cause less hassle to use multiple resistors wired as outlined in the article. The low ohm types used in the author's prototype appear to be wirewound resistors.

It is important to use the correct value for resistor R11 and also correctly rated relays (i.e. 320 ohm coils) to prevent any damage to the l.e.d. The relays used in the author's model were obtained from Maplin and listed under their "Ultra Miniature Relay" range. The one to specify—which has the required coil rating—is the 12V double-pole changeover type, code YX95D (£2.50).

It is also very important to use only the correct rated auto-type wires and connectors where stated. The auto-wire and 6-pin non-reversible plugs and sockets should be stocked by most auto-spares shops or stores.

Finally, prior to installing and linking up the two units in the car and caravan the car battery ***MUST*** be disconnected. When installed the wiring should be double-checked ***BEFORE*** reconnecting the battery.

Snap Indicator

We do not expect any component buying problems for the *Snap Indicator*. The ABS plastic case does not have to be of identical dimensions as the author's model, but it should be of sufficient size to take the small circuit board and push-button switches. Most of our advertisers will certainly stock a suitable case, remember to make allowance for the battery.

The thyristors are usually listed in components catalogues as just C106D's. These are very common devices and should be generally available.

Rain Alarm

We cannot foresee any component sourcing problems for readers undertaking the *Rain Alarm* project. The self-adhesive stand-off insulators or "feet" for mounting the circuit board in the case should be generally available. No doubt readers will have their own ideas about mounting the board in the case.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Satellite Battle

Imagine what would have happened around ten years ago, at the beginning of the big video shakedown, if all the major electronics companies had backed both available systems, VHS and Beta. The systems war could still be raging.

As it is, most companies backed VHS, rather than Beta, and VHS won by attrition.

In the satellite industry, there is an equally bitter battle raging between Sky and Astra, with PAL transmission, and BSB with D-MAC. But most companies are now trying to back both systems. This may well prolong the all-round agony. The background is a tangled web.

On 10 May 1988, BSB announced that it had signed a contract with General Instruments of the US, worth £100 million, to develop a conditional access system called Eurocypher for use with line cut and rotate encryption of D-MAC. The same day, BSB announced a £50 million deal with ITT Intermetall in West Germany, to produce 4 million D-MAC receiver chip sets. At the same time BSB invited 15 companies to tender for the production of receivers.

BSB said that between three and five firms would be selected and given exclusivity for three years; only the selected firms would be able to buy the ITT chips for under £20 a set, and no-one else would be able to buy Eurocypher modules for three years. The full receiver kit would cost £200, said BSB.

On August 2, BSB unveiled the now famous 25cm diamond-shaped flat aerial – dubbed the Squarial. BSB failed to explain that what it was showing was only a wood and plastic dummy.

The same day BSB announced that Ferguson, Salora (owned by Nokia of Finland) and Tatung had won the beauty contest and would make receivers to work with the Squarial. The system price had by now risen to £250.

Cryptic Note

Hedging their bets, all three companies subsequently developed, and publicized, alternative systems to receive Sky from Astra.

On February 22 1989, BSB selected Philips as a fourth supplier of D-MAC receivers. Robert Martijnse, Philips Consumer Electronics UK Group Managing Director, took the opportunity to volunteer catagorical denial of press and trade rumours that Philips would also be jumping on the Astra PAL bandwaggon by making equipment to de-scramble Sky's movie channels when they start scrambling later this year using a system called Palcrypt (now called Videocrypt).

"It is not true that Philips will open a factory to make Palcrypt in the UK", said Martijnse. "We have no plans. We reaffirm our commitment to MAC".

Peter Groenenboom, Managing Director of Consumer Electronics for Philips International, affirmed Philips' commitment to MAC, comparing PAL to an engine that had run out of steam, and was at the end of its line.

"It is very difficult to achieve secure scrambling with PAL", said Groenenboom.

Even when pressed hard by repeated questions he would only admit grudgingly that:

"If PAL becomes a reality in the UK, then we cannot deny that reality. So we can't exclude the possibility of supplying PAL equipment to the UK. But we have no plans yet".

I dutifully reported what the two Philips MDs said–despite the knowledge that Philips had long been talking to Sky. . . . Silly me.

On 16 March at the Olympia Satellite show, Philips blithely announced that it had signed a deal with Sky, to produce Videocrypt PAL decoders.

"In Britain there is a particular need for PAL equipment", said the very same Robert Martijnse who had so recently denied any interest in Videocrypt. "We will meet that local requirement".

Ferguson, will make Videocrypt decoders too, because the Videocrypt system was developed by Ferguson's parent company Thomson of France. The decoders will sell for around £80 each. Each company will supply half the demand.

Smartcards and Pirates

The Smartcards needed to operate the decoders will initially be made in France by Gemplus. From early next year they will be produced at a new factory to be built by Rupert Murdoch's News International Group at Livingston in Scotland.

This factory, says Andrew Neil, Executive Chairman of *Sky Television*, will produce 12 million cards a year. Each decoder will come with a free starter card that lasts for a month. After that the viewer will buy a new subscription card every three months. When slotted into the decoder this will conduct an electronic handshake with the expired starter card and thereafter "chain" with future cards, to validate them for use.

There is vague talk of de-validating stolen cards, by over-the-air address signals. There is also grand talk of the cards being impossible to copy. But experts, like Dr Mark Medress, of GI, are not convinced.

Medress believes pirates will soon develop a technique to suck out the secret codes from one card and use them to make clones.

"It is expensive to make a card that is secure", he says. "But the cards will have to be cheap, because viewers will get a new one every three months and throw away the old one".

Medress predicts that Sky's transition to scrambling will be painful.

"We went through that pain in America with Videocypher (from which Eurocypher was derived)" he says. "We genuinely believed the pirates would not be able to crack our system. We were shocked when we found that they used all kinds of inventive techniques, like running the chips at seven times their intended speed, to extract our secret codes".

As BSB's appointed manufacturers hedge their bets by developing PAL equipment for Sky, manufacturers of Sky equipment look for ways to hedge their bets in case BSB start to look successful.

In accordance with BSB's pledge of exclusivity, GI can only supply ACMs to Salora, Tatung, Ferguson and Philips. But it now emerges that GI is free to sell ACMs to anyone, for integration in a satellite TV set or video recorder.

Micro X is distributing the Maspro receiver made in Japan. Says MD Julian Behrman:

"With a moveable dish, our system will be able to receive from BSB. If we can't buy ACMs, we will simply go to one of the suppliers, like Tatung, and place a firm order for 50,000 receivers. No-one says no to an order like that. And BSB won't object, they want to sell subscriptions, don't they?"

Obvious Absense

Arguably the most significant feature of the Olympia show, was the one exhibit that was missing–a working model of BSB's Squarial.

Last August, BSB said it had acquired "the exclusive marketing and manufacturing rights for the aerial".

It seems this, like Philips' denial on PAL, simply was not true.

BSB now say it only signed a "development" deal with Squarial inventor John Collins and his company Fortel. On March 17, during the Olympia show, BSB proudly announced that it had secured "exclusive marketing and manufacturing rights to the antenna in Europe, Australia and New Zealand". (Fortel retain these rights in other countries). Only now, is BSB "intending" to appoint manufacturers for the Squarial. BSB and Fortel have so far been unable to demonstrate a working prototype to the press, trade or public. Watch this space for the next episode of the Squarial saga.

SOUND FX MICRO

Make the most amazing range of sounds with this special price Super Sound-FX Micro. Just press a few buttons to reproduce all the following sounds plus various musical notes, etc:

- ★ **Steam train & whistle**
- ★ **Continuous train**
- ★ **Hovering helicopter**
- ★ **Electronic fly**
- ★ **Police car siren**
- ★ **Foghorn**
- ★ **Trimphone**
- ★ **U.F.O.**
- ★ **Alien communicating**
- ★ **Rally car reving**
- ★ **Rally**

£7.95

plus 95p p&p

These incredible sound routines are already mask programmed into the G.I. microprocesor which forms the heart of the unit.

The kit comes with a fully built p.c.b. just wire up the switches, one resistor and the loudspeaker to get all the noises you could want!

ALL PRICES INCLUDE VAT

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Constructional Project

PROGRAMMABLE POCKET TIMER

CHRIS WALKER

Never again will the cakes be burnt. Never again will you miss your favourite TV programme. No more parking tickets. This project could be the first step towards re-organising your lifestyle . . .

HAVE YOU ever received a parking ticket after forgetting that you only had one hour on the parking meter? How many times have you promised to phone back a client in half an hour and had it slip your memory, or spent twice as long as intended on that expensive call to America?

A "quick hour" relaxing in the garden (or down the local) can easily protract into an entire afternoon; after all, time flies when you're having fun!

Human beings are notoriously bad at keeping track of time, especially when preoccupied. This can have embarrassing or downright dangerous consequences. Consider, for example, the holiday motorist who has promised himself a rest after two hours on the hectic motorway driving a car full of kids.

Enter the *Programmable Pocket Timer!* Small enough to carry in a pocket or handbag, simple to operate, and carrying a penetrating alarm, the device can accurately time any period from 15 minutes to 3 hours 45 minutes in 15 minute steps.

TIMING MECHANISM

The circuit for the Programmable Pocket Timer can be divided into four discrete parts as illustrated in the block diagram, Fig. 1. The pulse generator causes the counter to increment once for every pulse received, and these form the basis of a timer. If the pulses are produced at a regular rate then any multiple of the pulse interval can be timed by waiting for a specific number at the output of the counter.

The programmable logic looks for this number and, when it appears, activates the oscillator which sounds the alarm via a piezoelectric transducer. The alarm will continue to sound until silenced.

The pulse generator in this design is centred around a CMOS 4541 integrated circuit, Fig. 2. The three external components form part of an oscillator which runs at a frequency of:

$$f=\frac{1}{2.3R_XC_X}$$

Following the oscillator is an on-chip programmable divider which divides the oscillator frequency by either 256, 1024, 8192 or 65536 depending on the binary code on pins 12 and 13: with both at logic 1 the 65536 division is selected and the output is available at pin 8. Pin 6, when taken high, resets the output from pin 8 to zero.

The pulse counting technique requires a stable pulse generator. Now, since the pulse frequency depends on the product of the resistor R_X and capacitor C_X, it is important that the resistance and capacitance of these components remains stable over long periods of time.

Temperature fluctuations are likely to be the major cause of pulse rate inconstancy, but one can reduce the temperature instability by the use of a metal film resistor. These devices have a low, positive temperature coefficient of about 50 parts per million per degree Celsius, i.e. their resistance increases by 0.005% for every rise of 1°C.

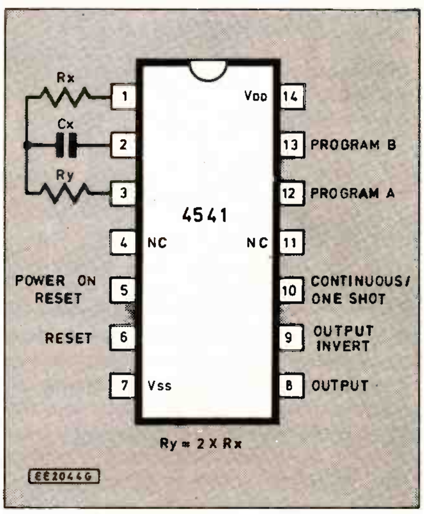


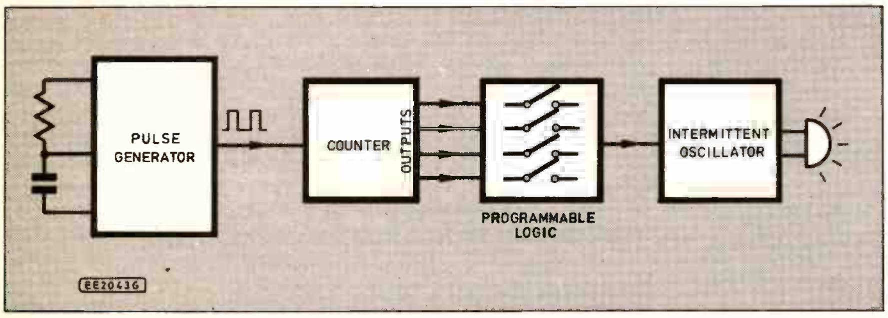
Fig. 2. Pinout details for the CMOS 4541 i.c.

Capacitors are, generally, even more unstable than resistors and care must be taken to choose a type with a low temperature coefficient for C_X. Considering the value of capacitor needed for this design, polyester, polycarbonate, and polystyrene (what would we do without polymers?) offer similar characteristics: about 100-200 p.p.m./°C.

However, some polypropylene types are available having a *negative* temperature coefficient of -100 p.p.m/°C; i.e. the capacitance reduces with increasing temperature. This creates an ideal situation because the opposite temperature dependent effects of the resistor and capacitor tend to cancel each other out resulting in a stable timing element and hence a stable pulse generator.

The prototype unit was tested over a temperature range of 7°C to 35°C with the timing varying by only a few seconds per

Fig. 1. System block diagram for the Programmable Pocket Timer.



hour—more than accurate enough for this application.

COUNTER

Referring to the circuit diagram for the Programmable Pocket Timer shown in Fig. 3, resistors R1 and R2 and capacitor C1 determine the time constant for the oscillator within IC1. Preset VR1 is a 22-turn cermet type potentiometer wired as a variable resistor and is used to fine-tune the oscillator frequency to 1165Hz.

Following the division by 65536 the oscillator output is available at IC1, pin 8. This pin completes one cycle (i.e. from low to high and back to low again) in 56.25 seconds.

A 12-stage ripple counter IC2 increments on every falling edge of the pulses from IC1. Each successive output from this counter changes state at half the rate of the previous output. Therefore, the first output, pin 9, completes one cycle in twice the pulse interval, 2×56.25=112.5 seconds, or just under two minutes.

Every time pin 9 of IC2 goes high, capacitor C3 and resistor R4 generate a pulse which is used to "bleep" the sounder WD1. Constructors who do not require this regular two minute reminder that the circuit is timing can omit components C3, R4 and D2.

which hold the inputs to the AND gate "high" when the switches are open.

When switch S1 is closed the output of the AND gate (pin 13 IC3) will go high when IC2 pin 3 goes high: i.e. after a period of 15 minutes. If S1 and S2 are closed, pin 13 IC3 goes high after 15+30=45 minutes. Should switches S1, S2 and S4 be closed then pin 13 IC3 goes high after 15+30+120=165 minutes (two hours 45 minutes).

Therefore, by various combinations of the four switches, a binary code is formed whereby fifteen individual times can be programmed (in 15 minute steps) from 15 minutes to three hours 45 minutes. Further examples are given in Fig. 4.

ALARM

The various "bleep request" signals are fed through the three-input OR gate (formed from diodes D1 to D3 and resistor R9) to pin 1 of IC4a. When this pin goes high the relaxation oscillator formed by IC4a, resistor R10 and capacitor C4 starts running at about 3Hz. The output from this oscillator modulates the second oscillator (IC4c) which runs at about 3kHz. IC4d buffers the oscillator output to drive the piezoelectric sounder WD1.

Preset potentiometer VR2 provides the facility to adjust the oscillator frequency to

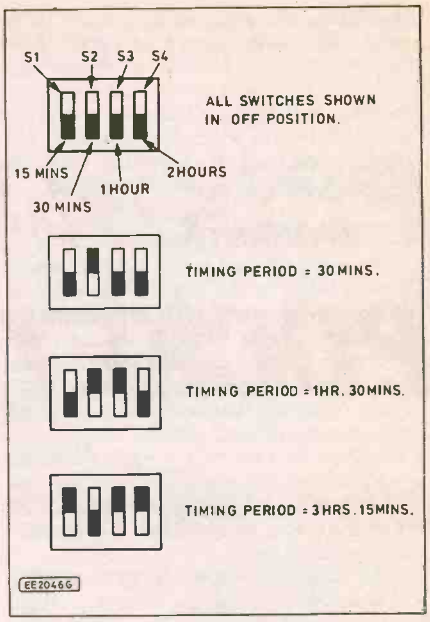


Fig. 4. Examples of the various timing combinations possible using the d.i.l. switches. Timing periods range from 15 minutes to 3 hours 45 minutes, in 15 minute steps.

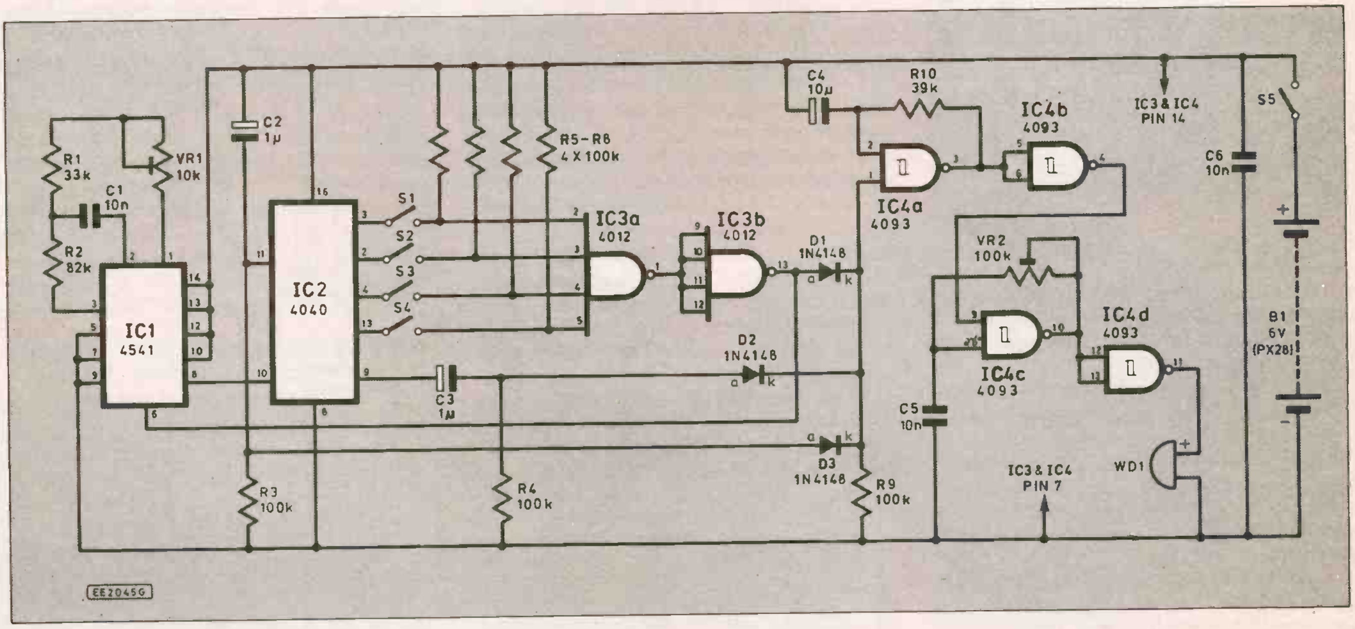


Fig. 3. Complete circuit diagram for the Programmable Pocket Timer.

Capacitor C2 and resistor R3 produce a pulse at pin 11 of IC2 which ensures that the counter is reset when power is applied. This pulse is also sent, via diode D3, to the output oscillator so that WD1 bleeps when the circuit is switched on, providing evidence that the alarm has commenced timing.

The output at pin 3 of IC2 first goes "high" (1) on the 16th pulse from IC1, i.e. 15 minutes after the circuit is switched on. Similarly, pin 2 goes high after twice this period (30 minutes), pin 4 after one hour and pin 13 after two hours.

BINARY CODE

These four outputs are fed, via miniature panel mounted d.i.l. switches S1 to S4 into a four-input AND gate formed by IC3. Resistors R5 to R8 are "tie-up" resistors

match the resonant frequency of WD1. At resonance, the sound output from piezoelectric transducers increases substantially, but the exact resonant frequency depends on the type of transducer used and the conditions in which it is mounted, e.g. type of case used. By adjusting VR2, the loudest sound output can be obtained.

COMPONENTS

The ability to build "pocket-sized" devices relies on the large range of miniature components which are available to the constructor these days. It is, therefore, important to select carefully when purchasing the parts for the Programmable Pocket Timer to ensure that they will fit comfortably onto the printed circuit board.

As explained above, capacitor C1 should preferably be a negative temperature coefficient polypropylene type and resistor R1 of metal oxide construction. All resistors must be 1/4W types.

The program switches S1 to S4 are four d.i.l. switches mounted in a single package and the on/off switch is a low profile push-on/push-off type appearing in many catalogues under the name "Modular Switch".

The power source used in the prototype is a PX28 6V camera battery. These batteries are available in "standard-life" silver oxide or "long-life" lithium. The silver oxide version is adequate for this design and has the bonus of being about half the price of its lithium counterpart!

It must be stressed that a miniature soldering iron bit is essential if you wish to make a good job on the crowded printed circuit board used in this design. Using a 50W iron with a 5mm bit is asking for trouble!

CONSTRUCTION

The unit is mounted in Verobox type 301 measuring 71mm×49mm×24mm. Begin by cutting two rectangular holes in the end panel to mount the on/off switch S5 and the d.i.l. switches S1 to S4. The exact dimensions of these cut-outs will depend on the switches used but they are probably best drilled as round holes and then filed square with a miniature file. Drill a single 5mm hole in the centre of the lid and glue the sounder WD1 inside the lid to line up with this hole.

Apart from the battery, sounder WD1 and switches, all the components are mounted on a small printed circuit board (p.c.b.). The component layout and full size copper foil master pattern is shown in Fig. 5. This board is available from the *EE* PCB Service, code EE648.

Commence assembly of the p.c.b. according to the component layout (Fig. 5) by fitting the two wire links followed by the four d.i.l. sockets for the integrated circuits, but do not insert the i.c.s until all assembly is complete. Solder in place all the resistors and capacitors (checking the polarity of the tantalum types).

The three diodes should be soldered with their cathodes (marked with a band) connected to resistor R9. Finally, mount the two preset potentiometers.

Solder eight flying leads about 10cm long for connection to the d.i.l. switches and two more to the battery B1 and switch S5. Attach the leads from the sounder WD1 to the printed circuit board.

The d.i.l. switches are soldered onto a small piece of stripboard (6 holes by 8 strips) with breaks in the tracks between

COMPONENTS

Approx. cost guidance only **£13** plus case

Resistors

R1	33k metal oxide
R2	82k
R3 to R9	100k (7 off)
R10	39k

All ¼W 5% carbon, except where stated

Shop Talk
See page 445

Potentiometers

VR1	10k 22-turn miniature vertical cermet preset
VR2	100k miniature vertical skeleton carbon preset

Capacitors

C1	10n n.t.c. polypropylene ±5% (see text)
C2, C3	1µ tantalum 35V (2 off)
C4	10µ tantalum 16V
C5, C6	10n ceramic (2 off)

Semiconductors

D1 to D3	1N4148 silicon diode (3 off)
IC1	4541 CMOS oscillator/divider
IC2	4040 CMOS 12-stage ripple counter
IC3	4012 CMOS dual 4-input NAND
IC4	4093 CMOS quad 2-input NAND Schmitt trigger

Miscellaneous

S1 to S4	Miniature single-pole d.i.l. switches (4-way)
S5	Latching action push-switch (Modular Switch)
B1	PX28 6V silver-oxide camera battery
WD1	Piezo-electric sounder in plastic case

Printed circuit board, available from *EE PCB Service*, code EE 648; stripboard, 0.1in. matrix, 6 holes by 8 strips; case, Verobox type 301; 14-pin d.i.l. i.c. sockets (3 off); 16-pin d.i.l. i.c. socket; thin connecting wire; solder etc.

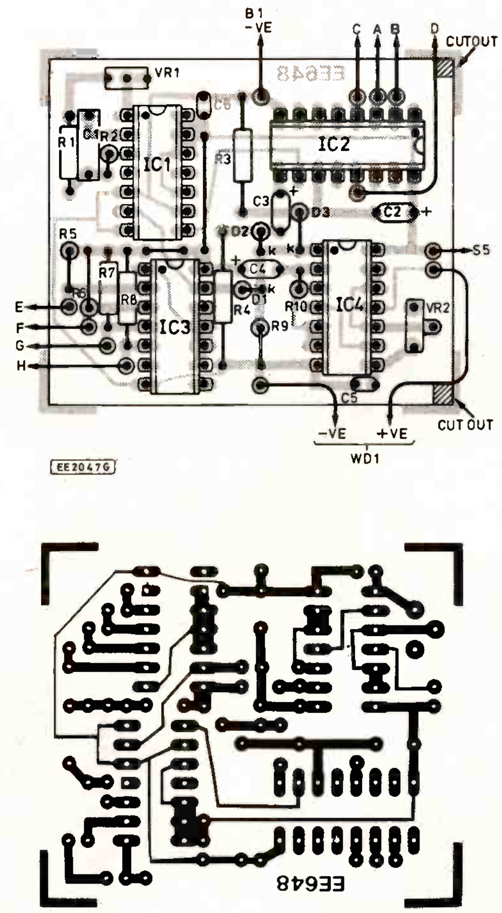
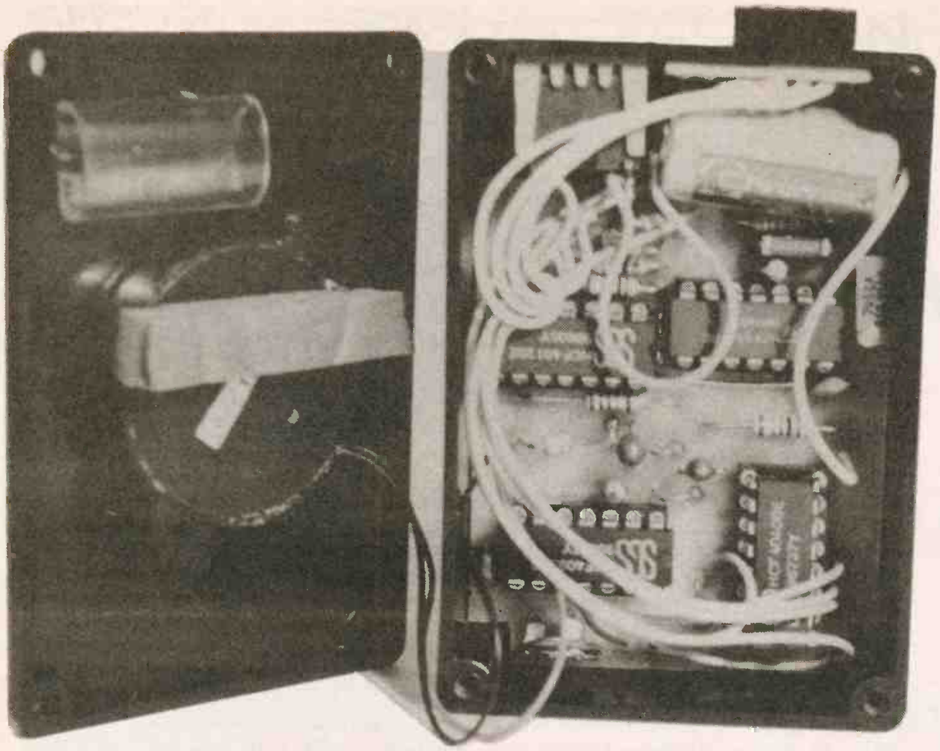


Fig. 5. Circuit board component layout and full size copper foil master pattern. The letters on the lead-off wires go the the d.i.l. switches S1-S4 via the small stripboard (see Fig. 6).



Completed timer showing the "flexible" tubing and sponge glued onto the lid mounted components.

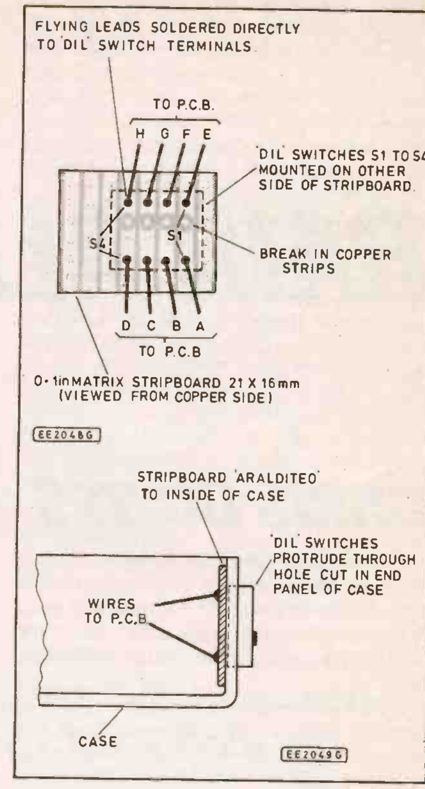
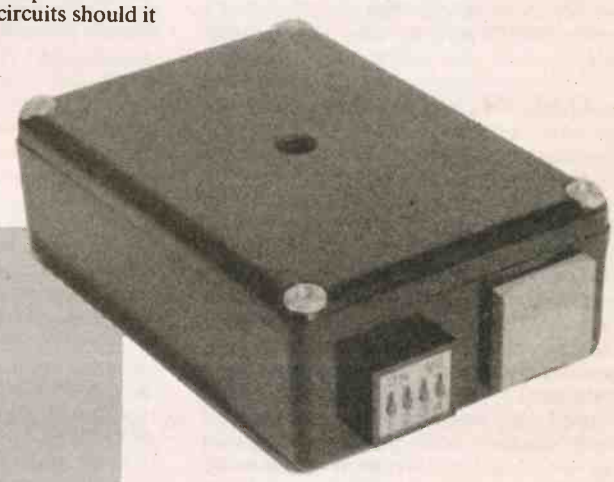


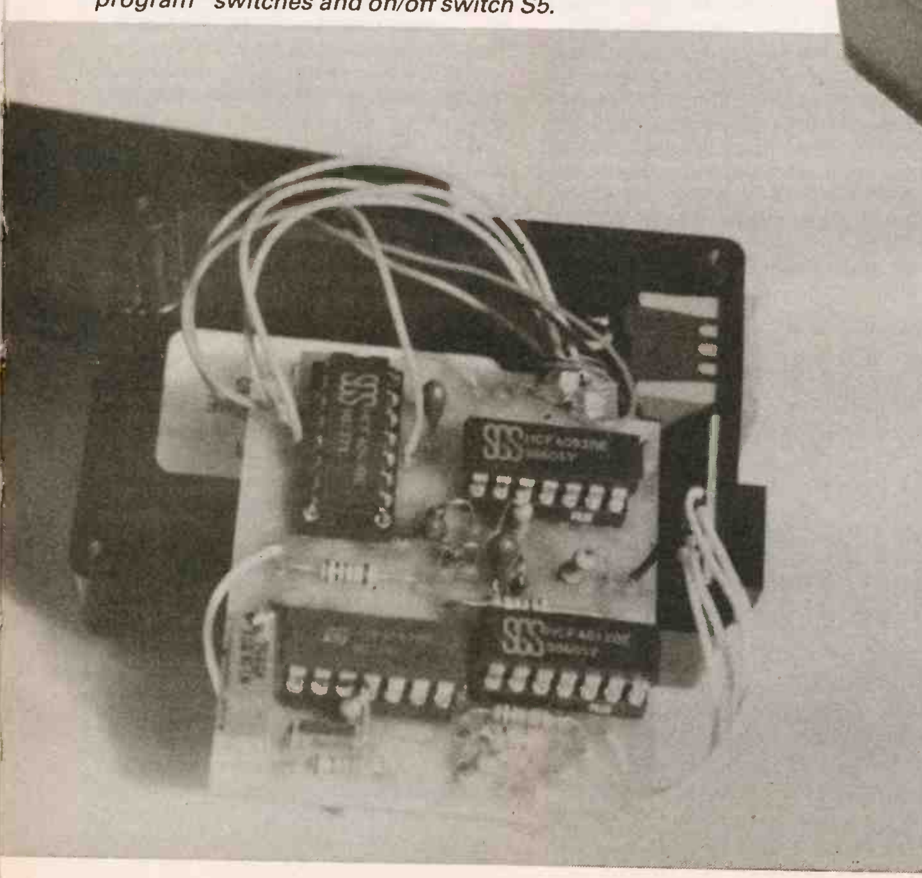
Fig. 6. Mounting the d.i.l. switches on the stripboard, wiring to the underside copper tracks and details of assembly in the case.

opposite pins, see Fig. 6. The flying leads from the p.c.b. should be soldered directly to the pins on the *underside* of the stripboard. The switch assembly is then glued (using epoxy-resin) to the inside of the plastic case, leaving the d.i.l. switch body protruding through the hole cut in the end panel.

Connections to the battery are made by soldering the wires directly to the terminals. If the latter are roughened with emery paper and cleaned with "meths" before soldering then no problems should be encountered. The battery lies in the case just behind the d.i.l. switches: if your battery has a metal case then wrap it in insulation tape to prevent short circuits should it touch the stripboard.

The circuit board removed from the case showing wiring to the "program" switches and on/off switch S5.





The prototype unit uses small pieces of flexible plastic tubing and sponge draught excluder glued into the lid to hold the battery and p.c.b. in place.

ADJUSTMENTS

Set both presets to mid-position, open the four d.i.l. switches and apply power. The sounder WD1 should immediately start bleeping and preset VR2 can be adjusted for the most piercing output.

Switch off and then close S1, thus setting the circuit for a 15 minute timing interval. On closing S5 a bleep should be heard followed by another bleep after 56.25 seconds. Adjust preset VR1 until this interval is approximately set. Turning VR1 clockwise will increase the pulse generator frequency.

Accurate setting of VR1 should be made over longer time intervals. One revolution of this multi-turn preset will change the timing period by about 10 seconds per hour. □

Pocket Money Project

RAIN ALARM

CHRIS BOWES

A very simple and inexpensive unit that can alert you to the first drop of rain.

ONE OF the most annoying things in our house is the fact that it always seems to rain on washing day and we often don't notice that it is raining until everything is soaking wet. The project described in this article overcomes this problem by detecting the merest spot of rain and operating an alarm so that we can dash out and gather in the washing before too much damage is done.

Although most people do not realize it, water is a conductor of electricity, although in comparison with most accepted conductors (such as metals) it is a very poor conductor but it can be made to conduct an electrical current nevertheless. Because water is such a poor conductor we cannot use the passage of the current through water to operate the alarm directly, but we can use a pair of transistors in the *Darlington Pair* configuration to amplify the small current passing through drops of water falling on a sensor to operate the alarm.

CIRCUIT DESCRIPTION

The circuit for the Rain Alarm is shown in Fig. 1. The power to run the circuit comes from the battery (B1) which is a standard 9V, PP3 or similar type.

The circuit works because when a drop of rain bridges the sensor "vanes", a piece of stripboard wired with adjacent strips connected to each of the two wires labelled as sensor connections in the circuit diagram, it lets a very small current flow between the two wires. This current flows through resistor R1 and the base/emitter junction of transistor TR1. This causes a much bigger current, about 200 times bigger, to flow through the collector of TR1 to its emitter. (Resistor R1 is not actually required to make the circuit work but it is included to stop the transistors being burnt up if a very good conductor should fall onto the sensor.)

Both of the currents (from the base and the collector) flowing through the emitter

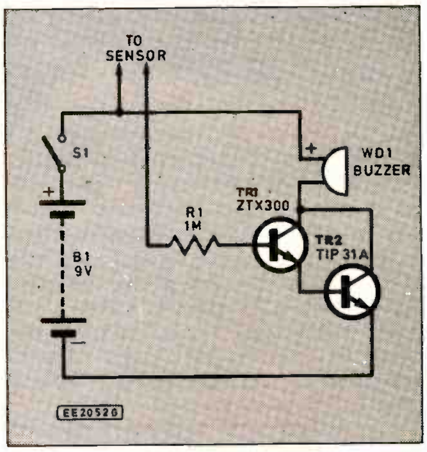
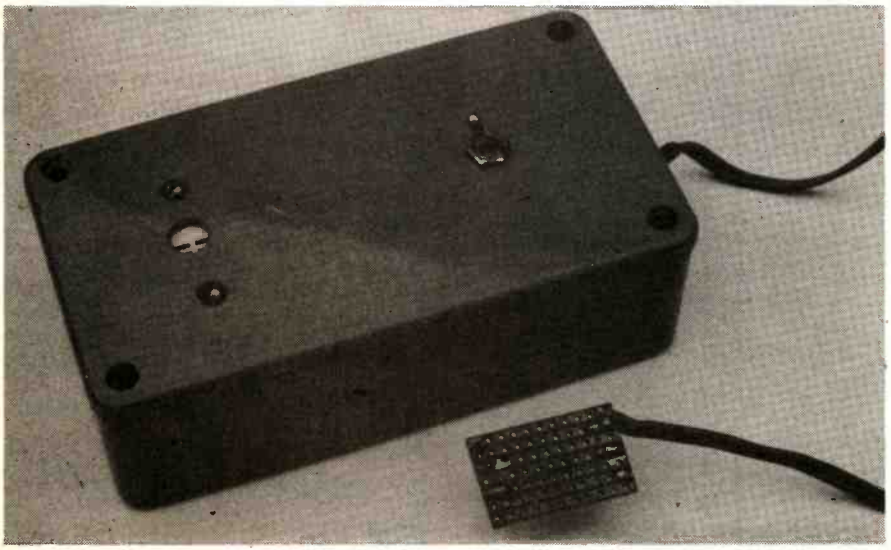


Fig. 1. Circuit diagram of the Rain Alarm.

of TR1 form the input current to the base of the second transistor (TR2), which is a power transistor. Not only is TR2 able to switch the buzzer on, but it also provides current gain in addition to that provided by TR1.

When transistors are wired up in this manner (referred to as a "Darlington Pair" circuit) the current gain (collector current/base current) of the entire circuit is equal to the gain of the two transistors multiplied together. In this circuit, with the two transistors specified, the current gain is over 4,000, so that only 1/4,000th of the already very small current drawn by the buzzer is required to flow through the sensor to make the circuit operate. When this minute current flows through the two transistors TR2 acts like a switch and turns the buzzer on.



CONSTRUCTION

The Rain Alarm is built on two pieces of stripboard, one for the main circuit and one for the sensor. The two boards are shown in the photographs and Fig. 2 and Fig. 3. No breaks are required in the underside tracks of both boards.

The first task is to cut a piece of stripboard to the correct size for the circuit board. You will need a piece which is 14 strips deep and 12 holes wide. If you are going to mount the project into a box you will need to drill four 4mm fixing holes as shown in Fig. 2, before mounting any components on the board.

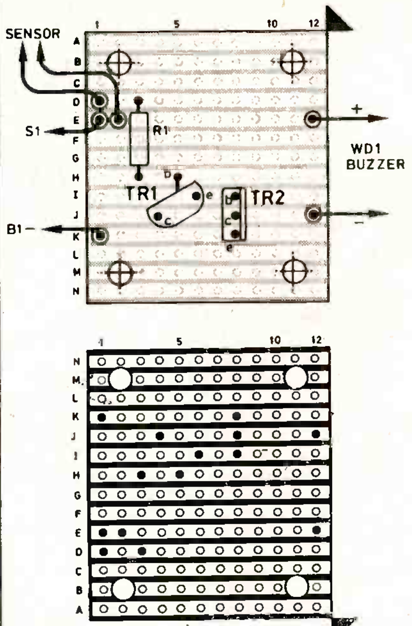


Fig. 2. Veroboard layout.

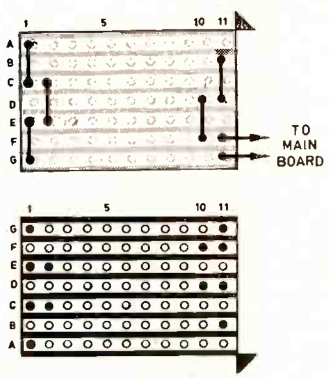


Fig. 3. Sensor connections.

COMPONENTS

Resistors
R1 1M
0.25W 5% carbon

Semiconductors
TR1 ZTX300 *npn* silicon
TR2 TIP31A *npn* power trans.

Miscellaneous
B1 9V battery, PP3 size
S1 s.p.s.t. min toggle switch
WD1 6V to 9V buzzer

Stripboards, 0.1in matrix 14 strips×12 holes (1 off); and approx. 8 strips×12 holes (1 off); case, ABS plastic approx. 120mm ×100mm×45mm; battery connector; self-adhesive stand-offs (4 off); connecting wire; solder etc.

Approx. cost Guidance only **£7**

Once the board has been prepared you can start the electronic construction, by bending the wires of R1 at right angles to the body of the resistor so that they will fit through the holes, as shown in Fig. 2. Place the stripboard so that the strips of copper on it are underneath the board and run from left to right and not up and down.

Starting at the top left hand corner of the board count across and then down the correct number of holes until you can place the resistor leads in the correct position on the board (see Fig. 2). Now turn the board over and solder the component into place. Cut off the excess wire from the resistor with your cutters and turn the board back over (topside).

Using the same counting technique put transistor TR1 into the correct position on the board, taking care to bend the middle (base) wire *carefully* so that it goes in the correct hole. Make sure that the transistor is the correct way round by checking that the flat edge is closest to resistor R1. Once more turn the board over, solder the transistor in place and cut off the excess wire.

Repeat the process for transistor TR2, taking care to see that the metal heatsink tab is on the side of TR2 which is furthest away from TR1.

INTERWIRING

The wires connecting the buzzer to the circuit board are then soldered into place. You will need to strip off the insulation with the cutters to leave about 3mm more of the conductor exposed than you expect to need. (This is more difficult than it looks so, unless you have done this task before, it is a good idea to practice on a bit of scrap wire first.)

When the wire is stripped you should twist it into a smooth form with your fingers and then "tin" it using a soldering iron and solder. Tinning a wire is very important since it stops the wire unravelling as you feed it through the hole in the stripboard.

To tin the wire melt a little solder onto the bit to tin the iron, place the wire onto the iron tip and place the solder on the opposite side of the wire to the iron. Leave the solder there until it melts and flows evenly over the wire *before* removing the solder and iron from the wire. This will probably leave a little blob of solder on the end of the wire which you should then cut off (which is why you stripped the wire slightly longer than required in the first place.)

The tinned wire should now fit easily through the hole in the stripboard. To connect the wire you simply feed it through the correct hole, then solder it into place and cut off the excess.

In the case of the battery connections you will need to connect the black (negative) wire from the battery connector to the board as shown in Fig. 2 and solder the red (positive) wire of the battery connector to one of the connections on switch S1. You will then need to solder a piece of wire between the other connection of S1 and the point on the board labelled S1.

With some buzzers you may find that it matters which way round they are connected to the circuit. If this is so then connect it as shown in Fig. 2. If the buzzer does not carry any indication of polarity then the wires are connected to the two points shown without worrying which wire goes to which point.

SENSOR

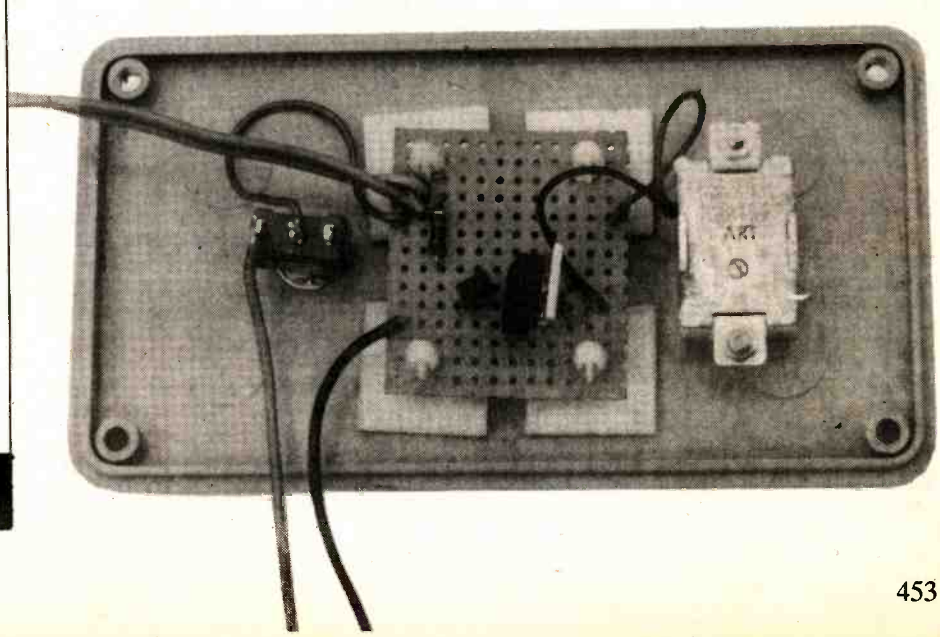
The sensor is very simple to make. All that is required is to wire a piece of stripboard, which is a few copper tracks deep and a few holes wide, (the exact size is not critical) so that alternate strips may be connected together.

The wiring to the copper tracks is carried out using small wire links on the topside of the board as shown in Fig. 3. This forms a series of adjacent connections on the stripboard which are then connected, by a convenient length of two core wire, to the sensor connections on the main circuit board.

TESTING

Before testing the circuit and connecting the battery, you should carefully examine the board to make sure that all of the components are inserted into their correct places and that there are no blobs of solder shorting out the copper tracks. Once the board has been checked then the battery should be connected and the on/off switch S1 turned to the the ON position. Nothing should happen at this point so if your buzzer sounds you will have to check for shorted tracks on either of the stripboards or components with an internal short circuit.

Assuming that all is well when you switch the unit on you can test the sensor by putting a finger across the copper tracks of the sensor board. The buzzer should sound at this point and stop sounding as soon as you take your finger off the sensor. The final stage is to test that the sensor works correctly when a drop of water is allowed to fall on it.



If the buzzer does not sound for either of the above tests then the likely cause is an "open circuit" somewhere. You should check that there is actually a connection between each of the points in the circuit. This is probably most easily done with a multimeter set to the "ohms" setting.

CASE

It is relatively easy to put this project into a suitable case. The easiest method is to mount all of the parts on the removeable lid of a suitably sized box.

This will entail drilling a hole to allow the sound from the buzzer to escape and suitable mounting hole(s) to hold the buzzer in place. You will also have to drill a hole through which to pass the wires to the Sensor and another hole to accomodate the switch S1.

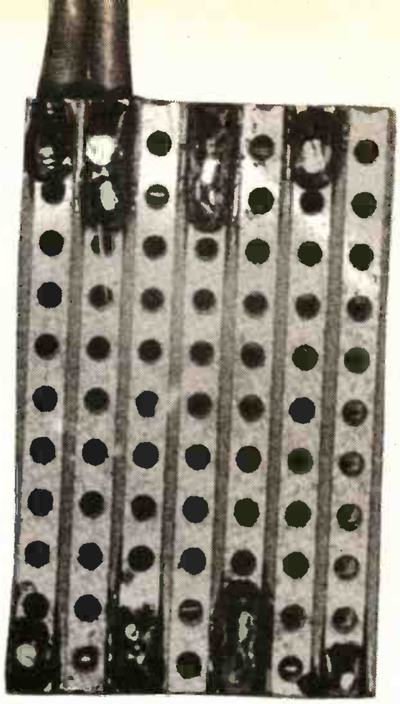
The four holes in the main circuit board have been positioned so that you may use self adhesive "stand offs" to hold the circuit in position. You will find it easier to case the project if you think carefully about where the various parts of the project will be placed on the case lid before drilling and also pass the wires connecting the sensor to the main circuit board through the hole in the case before making the connections to the circuit board.

IN USE

Using the Rain Alarm project is very simple. All that you need to do is to lead the wires connecting the Sensor to the main part of the project through a suitable space, such as the gap in a window, and place the sensor outside the house.

When the washing is hung out on the line it is a simple matter to turn the alarm circuit on. The circuit will patiently monitor the conditions outside and the alarm will sound as soon as the first drop of rain falls on the sensor.

It is not advisable to leave the project running permanently, even though the battery drain when the buzzer is not sounding is minimal and it will not matter too much if it is inadvertantly left on, although there is the risk of the buzzer going off at inopportune moments. □



The finished sensor.

MARKET PLACE

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Special Series

STABILIZED POWER SUPPLIES

STEVE KNIGHT

Part One

Apart from delving into the basic theory of p.s.u. design and potential problems, this short five part series will introduce three practical projects which are fairly simple to build and have reasonably good specifications.

The three stabilized units are: Variable 0V to 12V 1.5A; Variable 0V to 25V 1A; Variable 1.5V to 25V, with switched current limits of 0.5A, 1A, 1.5A and 2A.

POWER SUPPLIES often seem to be the poor relations of the electronics scene when it comes to design, some unconsidered trifle to do the job of pumping primary power into your pet project, to be alliterative. One of my acquaintances, not so long ago, built himself an amplifier system with loving care and no expense spared. When he came to use it, it proved to be unstable.

He had obeyed all the rules about earth loops, screening and all the rest of it, but he hadn't paid too much attention to his power supply. What problem could there be about that?—transformer, rectifier and a hefty great electroyltic capacitor—oh, yes, and a bit of stabilization thrown in.

Easiest part of the project. Well yes, but it was also the easiest part of the project to cause trouble, which in his case it did. In fact, the bit of stabilization he had thrown in proved to be his downfall. When his amplifier was supplied from a well designed, good quality power unit, it performed as it should.

The moral of this is that a power supply should never be dismissed as something a lot less important than the equipment it supplies. This applies particularly to those among us who dabble and experiment all the time with a variety of circuits and setups; the unit which supplies our power must be above reproach. When something isn't doing what it should, we want to make sure that the power supply is out of the running when we look for the cause.

This short series will introduce a few practical stabilized power unit projects which are reasonably simple to build and have good specifications. To get on our way, as it were, we begin this month with some of the elementary theory of stabilized supplies and the problems to be looked for (and avoided) in practical designs.

TYPES OF SUPPLY

Battery supplies and the basic transformer-rectifier-smoothing systems are not our concern here. We shall be interested in those circuits which can be classified under the two main headings of constant-voltage (C-V) and constant-current (C-C) supplies.

A particular power supply may be exclusively designed to operate in one or other of these categories, most commonly the former, but a design is possible in which both modes may be incorporated in a single unit. We begin by looking at the characteristics and evolution of both these systems.

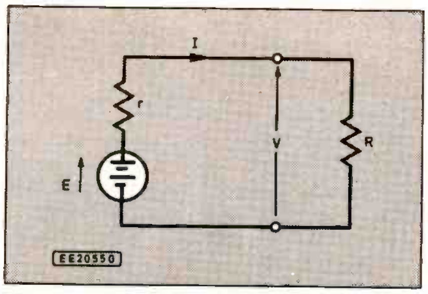


Fig. 1. Circuit conditions for a constant voltage output.

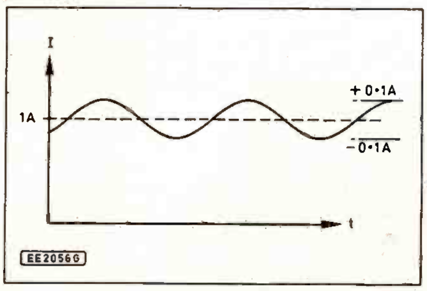


Fig. 2. The effects of superimposing a 1kHz current with peak excursions of ±0.1A on a load which draws a steady 1A.

CONSTANT-VOLTAGE SUPPLIES

An ideal voltage supply is defined as an electrical source for which the output voltage remains absolutely constant irrespective of the current being drawn from it. This statement, of course, applies only to the maximum current capacity of which the supply is capable. No source can supply an unlimited current, but within the limit for which it is designed, a constant voltage supply will maintain a constant voltage output independent of the imposed load impedance.

A fully charged car battery is a close approximation to such an ideal source. A flat battery is anything but. When your car gives a despairing "clunk" on a cold and frosty morning, you will know what I mean!

The necessary condition for a constant voltage output is *zero* internal impedance. Fig. 1 shows us the real situation; here the voltage source is, for convenience, represented as a battery. This battery, like any other, has an internal resistance *r*. This resistance may be extremely small but it is never zero.

When a load resistance *R* is connected across the battery terminals, the current *I* flows through *r* and *R* in series, hence a part (*Ir* volts) of the available e.m.f. *E* is dropped across the internal resistance. The terminal voltage *V* (=E−Ir) is consequently *less* than *E* and depends entirely upon the current being drawn by the load.

In fact, of course, the full e.m.f. will only be available at the terminals when the "load" is an open-circuit, an infinite resistance. Otherwise, the greater the current drawn, the smaller *V* becomes, hence the output is not independent of the load current and the source is not the ideal constant voltage supply we are (vainly) looking for. But we are well on our way if we can make the internal resistance extremely small.

However, there is a further complication. Any load device connected to a power supply is rarely of such a form that it requires a constant flow of direct current from the supply.

The load is not often made up of purely passive components such as resistors; active components such as diodes and transistors will be present in the load, hence the current drawn from the supply will be made up of an alternating component superimposed on the direct component. So it is not just a cosy matter of the supply having a zero source impedance at d.c., it must have a zero source impedance at *all* frequencies, or at least over that range of frequencies in which the load is likely to be operating.

Suppose by way of an example we have a 25V d.c. constant voltage power unit having a negligible source resistance at d.c. but a five ohm resistance at a frequency of 1kHz. If this supply is connected to a load which draws a steady current of 1A on which is superimposed a 1kHz current having peak excursions of ±0.1A (see Fig. 2), the power supply will deliver an output which is varying sinusoidally between 24.5V and 25.5V at a 1kHz rate.

Don't confuse this situation with mains "ripple" coming from the power unit. Connecting an additional smoothing capacitor aross the output terminals is not necessarily going to improve things, in fact, in some cases it can make things worse!

Additional to the fact that our power supply fails to provide us with a truly constant voltage, there is the possibility that the variation in the output will be coupled into some other load or to some other part of the connected circuitry fed from the supply. This can constitute an undesirable coupling which may result at best in noisy performance from low level amplifier stages or at worst oscillation over the entire system.

Because it is not possible to build a power supply having zero source impedance at all frequencies, all practical designs have to be a compromise between the ideal and whatever the state of the art happens to be at the time. Of course, for amateur experimenters and dabblers in general, many of the sophisticated features of a high quality power unit design are perhaps academic, but it is necessary to be aware of such aspects for all that. Many a frustrating problem can often be traced back to a poorly designed power supply.

BASIC CIRCUIT

The basic constant voltage regulated power supply is shown in Fig. 3. It consists of the conventional rectifier (usually a "diode bridge") and reservoir capacitor *C*, followed by a series regulator transistor controlled by a feedback amplifier, a reference voltage (which may be adjustable) and an output (smoothing) capacitor C_O.

The amplifier may be in integrated circuit form or made up from discrete transistors. Whatever its form, it continuously controls the conductance of the series transistor so as to maintain the two amplifier inputs exactly equal; hence the voltage at the output terminals is held equal to the reference voltage.

The amplifier, for this reason, is often known as the *error* amplifier. There are of course a number of practical variations on this set-up, but the overall function comes to the same thing.

Suppose for the moment we imagine the circuitry betwen the broken lines in Fig. 3 to be eliminated, so that we have the most simple power supply of rectifier bridge and filter capacitor C_O alone. Then the output impedance of the supply will be that of the capacitor.

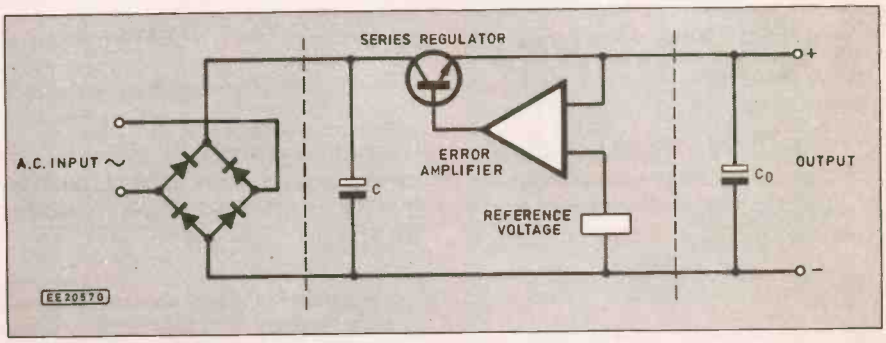


Fig. 3. The basic constant voltage regulated power supply.

Since we want the output impedance to be as small as possible, a large value electrolytic is used in this position. This is all right at frequencies between d.c. and a few thousand hertz, but the impedance of any capacitor (particularly electrolytics) is not capacitive at all frequencies.

At very low frequencies, the impedance of a capacitor is mainly reactive with a bit of resistance and is relatively large, anyway. At high frequencies the impedance is no longer purely capacitive reactance but has associated with it both resistance and inductance resulting from the finite connecting leads and the constructional form of the component.

For this reason it is common practice to shunt an electrolytic with a small value ceramic capacitor having a negligible inductive reactance at the highest operating frequency. It is not enough just to think about the 100Hz ripple frequency coming from the rectifier.

IMPEDANCE versus FREQUENCY

A typical impedance versus frequency characteristic for a 470μF electrolytic capacitor is shown in Fig. 4(a). We have assumed that this capacitor has a resistance of 0.1 ohm and an inductance of 1μH.

The impedance (almost purely capacitive) at 10Hz is 34 ohms and at 1kHz it is 0.34 ohm. The resistive component of 0.1 ohm becomes effective before this frequency is reached and the curve, which would otherwise follow the broken line, levels out at the impedance minimum of 0.1 ohm.

As the frequency increases further, the inductive component begins to have its effect and the impedance (now inductive) increases from this point onwards. We have, in effect, a resonant circuit of capacity and inductance in series.

When the regulator circuit is added, its effect is to make the supply output impedance at each frequency *lower* than the impedance of the capacitor alone by a factor equal to one + loop gain of the feedback amplifier at the same frequency. This result comes from feedback theory.

The three power supply units that will be described, with full constructional details given, in this series.

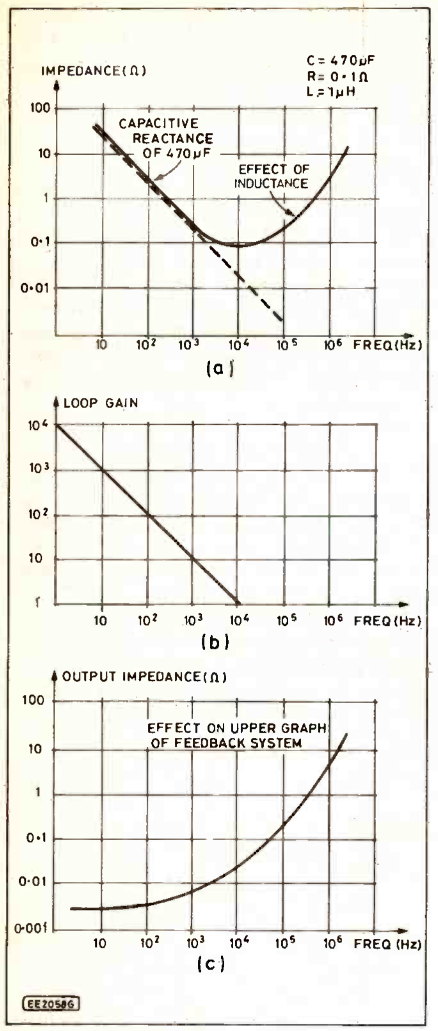


Fig. 4. (a) Impedance versus frequency characteristic using a 470µF electrolytic capacitor, (b) loop gain and (c) overall output impedance.

Since the loop gain of the amplifier will be very much greater than one over most of the frequency band of interest, we can treat (one +loop gain) as being simply (loop gain). Hence supposing the amplifier gain to be 10,000 (10^4) at 1Hz falling linearly to unity at 10kHz (10^4Hz) as shown in Fig. 4b, the characteristic of Fig. 4a becomes that of Fig.4c which shows the resulting *overall* output impedance of the supply.

This is a big improvement over the first graph, particularly for frequencies up to about 5×10^4Hz where the impedance remains below 0.1 ohm. At frequencies up to 10^3Hz the amplifier gain is high and the output impedance is correspondingly low, less than 0.01 ohm. At frequencies from 10^3 to about 10^4 the output impedance remains reasonably low because some amplifier gain remains and the impedance of the output capacitor is also low throughout this range.

At those higher frequencies which are beyond the upper bandwidth figure for the amplifier the output impedance is and remains inductive, depending solely on the characteristics of the output capacitor and the effect of the wires connecting it to the actual output terminals. And, of course, anything beyond that. The curves are illustrative only and are not derived from any actual power unit, though they are quite typical of practical systems.

From all this it might seem that by making the gain of the amplifier large enough we could achieve the magical zero output impedance. Alas, this is not so. No amount of gain, however great, will be enough to reduce the output impedance to zero.

But this doesn't mean that a zero impedance is impossible to achieve. It is, but only by employing positive feedback; just enough positive feedback, in fact, to cause the feedback amplifier to oscillate if it was not held within a negative feedback loop having overall stability.

This calls for sophisticated design procedures which are not easy for the amateur to achieve; and in any case such configurations remain for the most part in a designer's laboratory and rarely have significant practical applications. But it's a thought, perhaps, for those of us who like to dabble in such things.

CONSTANT-CURRENT SUPPLIES

An ideal current supply is defined as an electrical source for which the current remains absolutely constant irrespective of the voltage demanded by the load. Such a constant current source is generally required for specialized applications and is not so much in demand as constant voltage.

However, there are applications where constant current is a necessity; it may be that a stable magnetic field is required from an electromagnet. If the coil of the magnet is simply placed across a constant voltage source, the current through the coil will depend upon the resistance of the coil. This could change through ambient temperature variations or as the result of self heating. So the current would change and the magnetic field strength might vary sufficiently to invalidate the circuit tolerances within which it operated. If the current can be held constant irrespective of what the coil resistance or the applied voltage does, the problem does not arise.

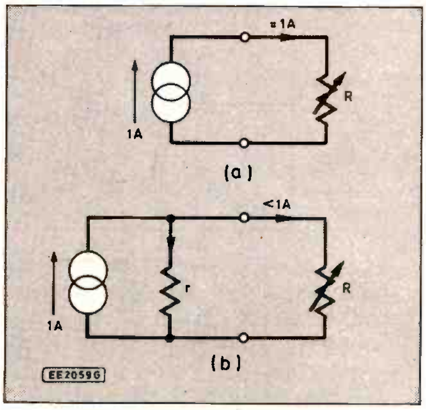


Fig. 5. (a) Idealised constant current source and (b) the "practical" effect of the internal resistance r on the output.

We have seen that the ideal voltage source should have a zero output impedance. Because it is possible that the load resistance connected to a constant current supply may vary with time, an ideal current source must have an *infinite* internal impedance at all frequencies.

This concept might be more difficult to understand than it was in the case of a voltage source. Let me illustrate with a simple example. Fig. 5a shows a hypothetical generator that will deliver a current of, say 1A irrespective of whatever value the load resistance *R* takes, including a short-circuit. This is the ideal case. In real life, something is present which prevents this happening. This something is again the internal impedance which we represent this time as a resistance *r* in *parallel* with the perfect generator, see Fig. 5b. In this situation some of the 1A current supplied by the source is "lost" internally by flowing through *r* and so is not available to the load. As the load resistance changes, the current distribution between *r* and the load also changes; hence the load current is no longer ideally constant. In fact, it will be precisely 1A *only* when the load is a short-circuit. Only if the internal impedance is infinitely large do we get the ideal generator. So the real voltage generator is considered as a constant voltage source in series with a *small* impedance, and the real current generator is considered as a constant current source in parallel with a *large* impedance.

BASIC CIRCUIT

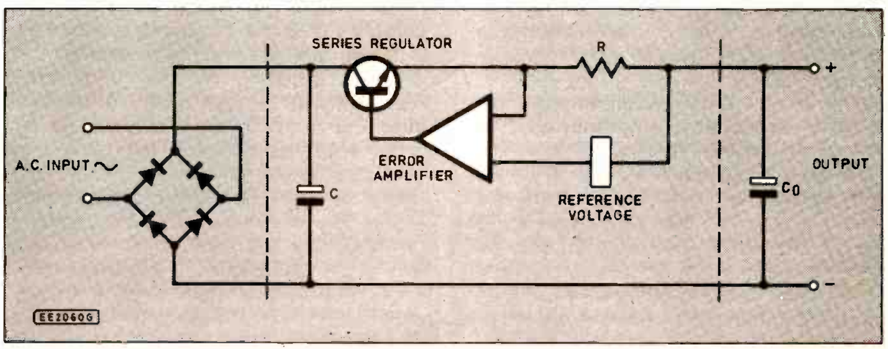
The block diagram of a constant current regulated power supply is shown in Fig. 6. The bridge rectifier and reservoir capacitor are identical with that of the constant voltage supply, and the other component parts are similar in form also.

However, instead of comparing the reference voltage with the output voltage, the error amplifier compares the reference voltage with the *voltage drop* caused by the output current flowing through a current monitoring resistor *R*. The action of the feedback loop is then similar to that of the constant voltage system; the conductance of the series transistor is varied in such a way that the voltage drop across *R* is maintained equal to the reference voltage, thereby holding the output current to a fixed value.

In a constant current supply, the output impedance without feedback is made up of the output capacitor C_O effectively in parallel with the current monitoring resistor *R*. This assumes that the impedance looking back into the series regulator and the rectifier is small compared with the resistor.

The effect of current derived feedback is then, from feedback theory, to *multiply* the

Fig. 6. Block diagram for a constant current regulated power supply.



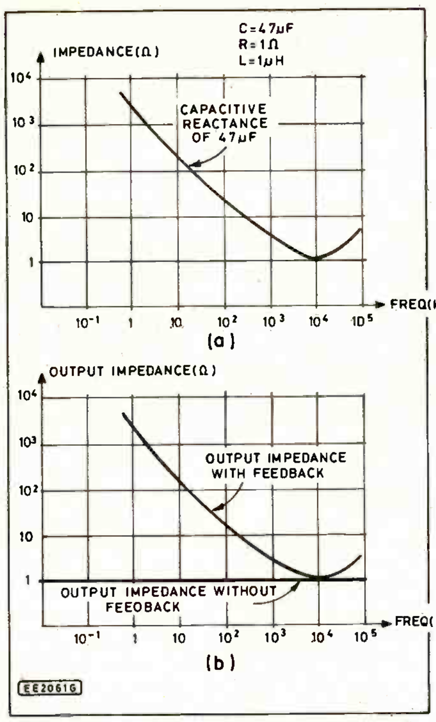


Fig. 7. (a) Impedance versus frequency characteristic of the output circuit using a 47μF electrolytic capacitor, (b) overall output impedance of the constant current source with feedback.

effective value of the monitoring resistance by the loop gain of the amplifier throughout its frequency range, this increased resistance still remaining in parallel with the output capacitance. And at this point we meet another problem. Since the output capacitor behaves as a low impedance, particularly as the frequency increases, a large value electrolytic of the kind conventionally put across the output terminals of a power unit for its so-called smoothing effect, is actually working to the detriment of the constant current characteristic we want, namely, a high effective output impedance over all frequencies.

Suppose we analyse this situation in the same way as we did for the constant voltage circuit. There a large value electrolytic served our purpose but here we ought to think in terms of something smaller, say, a 47μF capacitor.

The impedance of such a capacitor at 1Hz is about 3400 ohms and at 1kHz about 3.4 ohms. If we further assume that the current monitoring resistor is one ohm (a common value), then the impedance versus frequency characteristic of the output circuit will be as shown in Fig. 7a.

While the capacitive reactance is dominant, the impedance falls as the frequency increases, but the inductive component takes over at around 10kHz and causes the impedance to rise again. If we take the gain characteristic of the feedback amplifier to be the same as that mentioned for the constant voltage supply (Fig. 4b), and combine this with Fig. 7a, the overall output impedance of the constant current source will be as illustrated in Fig. 7b.

Now this graph may not appear to be any improvement over the characteristic for the capacitor alone, but what the feedback has done is to increase the effective value of the parallel monitoring resistance which would otherwise have appeared simply as a one ohm shunt. This shunting effect has been eliminated.

At 1Hz, for example, the amplifier gain is 10^4, hence the resistance is effectively increased to 10^4 ohms; and at 100Hz where the gain is 10^2 the resistance appears as 10^2 ohms. So it is the capacitor impedance which is "spoiling" the otherwise favourable output impedance state; the reason why, as already mentioned, the output capacitor works against our aim of an ideal current source.

Thus, while the supply has a high output impedance at d.c. (and frequencies up to about 1Hz) it does not have a high impedance over a wide band of frequencies. Nevertheless, most applications involving constant current supplies require a high impedance only at d.c. and are not severely affected by the low impedance at high frequencies.

The problem is sometimes reduced by removing the bulk of the output capacitance from the circuit, so permitting a higher impedance generally. This results in an increase in the output ripple of the supply which can be offset up to a point by heavier filtering after the rectifier, using a choke in addition to large value electrolytics.

There is another aspect to the desire for a reduction in the size of the output capacitor; if it is omitted or made very small, there is the possibility that the feedback loop can go into oscillation for a particular state of the phase angle of the load impedance. This usually shows itself as oscillation at a very low or a very high frequency.

There is not a lot to be gained from an extremely high gain amplifier either. No finite amount of gain will ever cause the output impedance to become infinite. Like its constant voltage counterpart, it *is* possible to provide positive feedback to give an infinite impedance at d.c. but this is fraught with design problems not recommended for amateur project work.

CURRENT LIMITING

It is not desirable that a power supply unit should be able to provide a maximum *instantaneous* current. The reasons for this are: (a) it might be damaging to the series regulator, and (b) it might be sufficient to blow a fuse or trip a circuit breaker on the power supply by suddenly charging a large load capacitance.

Consequently, it is necessary for a power unit to have some sort of current limiting protection circuit which will restrict the maximum output current under any imposed load condition. This protection circuit may have a fixed or an adjustable current setting.

When a supply is being used well below its rated current maximum, it is still possible that although the supply unit itself is in no danger, the load circuit may be unprotected, in so far as the magnitude of the current available, even though limited, is much higher than the normal load requirement. A careless or accidental interconnection within the load circuitry might allow a large current to flow in part of it and cause damage. Consequently, it is necessary to make the current limiting point adjustable rather than fixed so that the current limit can be set to a value which cannot damage the load device even in the event of an inadvertent short-circuit during experimentation or setting-up.

Any constant voltage supply incorporating a current limiter is essentially a unit having a built-in adjustable constant current supply. This situation must not be confused with a "true" CV/CC supply where an automatic crossover point occurs between the two modes of operation and two separate feedback amplifiers are used.

An example using actual values may illustrate this point better. On a normal CV supply having a preset current limit, let us suppose we have set the voltage control to 15V and the current level to 0.5A.

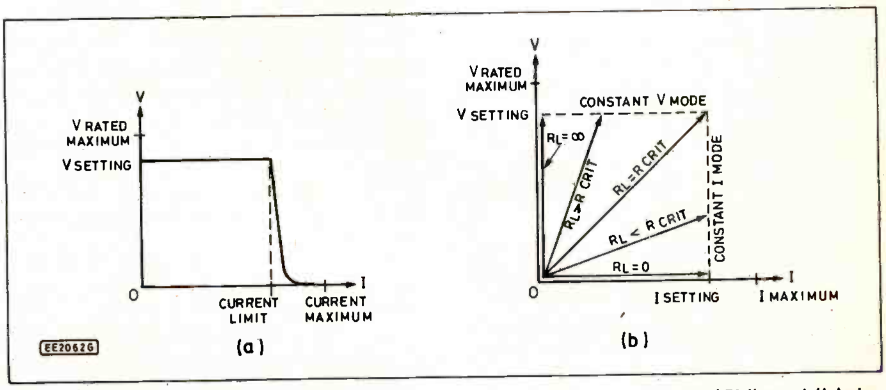


Fig. 8. (a) The operating curves for the constant voltage supply (CV) and (b) the constant voltage/constant current supply (CV/CC). The switchover or limiting point is determined by the setting of the voltage and current controls.

With a large load resistance connected to the output terminals the output voltage will be 15V and a small current will flow into the load. As the load resistance is reduced, the current will rise but the voltage will remain at 15V until the load resistance reaches 30ohms.

The current will then be at its permitted maximum of 0.5A. Any further decrease in the load will not increase the current but the voltage will fall rapidly, reaching zero when the load is a short-circuit; the current, of course, still remains at 0.5A.

This is the operation of a normal constant-voltage current-limited source. For the true CV/CC supply, the transition point corresponds to an automatic switchover from the CV feedback amplifier to the CC feedback amplifer; decreasing the load from that point on keeps the current at a constant 0.5A while the output voltage drops by exactly the right amount to maintain that current constant through the load provided.

The switchover point occurs at the critical value of the load, R_{crit}, determined by the settings of the voltage and current controls. Fig. 8 shows the operating curves for the CV supply at (a) and the CV/CC supply at (b).

Next Month: Zener diode stabilizer and fixed voltage regulators using the 78/79 series.

Constructional Project

CARAVAN STEREO

T. R. de VAUX-BALBIRNIE

Use your car audio system in the caravan

FOR OCCASIONAL use, there seems little point in buying stereo radio/casette equipment for the caravan when it already exists in the car. There are several advantages to be gained by "piping" the existing facilities into the caravan–the most obvious being cost. Also, for radio reception the car aerial is much more efficient than one situated inside the caravan–the expense of an external aerial and associated wiring here being hardly justified.

The present circuit gives good quality sound for a fraction of the cost of a separate caravan-based machine. It also saves valuable caravan space. Some readers will wish to use simple mono radios with or without a cassette player and this would involve slightly less construction work.

There are, of course, disadvantages too. The system cannot be used inside the caravan when the car is not parked nearby. It cannot operate in the car and caravan at the same time (although this is a small detail). Also, in the case of cassettes, a trip to the car will be required when the tape needs to be started, rewound, etc. and similarly when tuning the radio to a different station.

Depending on the type of cassette player, it may also be necessary to remove the cassette at the end of the listening session if it does not self-eject. This is because it is bad practice to leave a cassette in the operating position–the pinch roller will develop a "flat".

This circuit has been designed for low-powered systems (up to 5W output per channel approximately)–it is not suitable for high-powered abd "boosted" equipment. The add-on circuit requires 50mA while switched on and this imposes negligible additional drain on the car battery. No current is required when switched off.

The Caravan Stereo System is suitable for car audio equipment having the standard four ohm output impedance and using four ohm loudspeakers. The output impedance may be checked by referring to the manufacturer's handbook. If this states that the equipment is suitable for four ohm (or four and eight ohm speakers) it will be suitable to use with this circuit.

With no caravan present, in-car use of the audio equipment is unaffected. On coupling the system to the caravan and switching on at the remote switch, however, a red l.e.d. indicator lights and control is passed from the car to the caravan panel. As well as the on-off switch and l.e.d. indicator, this provides a six-position volume control for the caravan speakers.

This operates at reasonably constant impedance so that the amplifier output stage is matched to the new circuit at all times. No balance control is provided–with the control in the car correctly adjusted, the caravan system will preserve good balance whatever the setting of the volume control.

Circuit description

The system is divided into two sections, one in the car and one in the caravan. The Caravan Stereo System circuit diagram, with the car section to the left and the caravan part to the right of the dotted line, is shown in Fig. 1. Note that in the car-based section, two separate but identical relays, RLA/2 and RLB/2 are used each having d.p.d.t. contacts.

Only three sets of contacts are needed so a single three-pole relay could be used instead. However, it appears that many suppliers stock double-pole relays only and where those having three or four-pole contacts are available, they tend to be expensive.

With the remote on/off switch (S2) off current cannot flow through the relay coils and all contacts, RLA1, and RLB1 and RLB2 remain in their normally-closed (a) positions. Relay contact RLA1a allows a positive feed to the audio equipment from the car radio position of the ignition switch and through the existing line fuse. The car speakers then operate through contacts RLB1a and RLB2a.

With S2 switched on, the relay coils connected in parallel draw current from the car battery through fuse FS1 and the l.e.d. indicator D2, connected in series with the relay coils, is illuminated. Resistor R11 bypasses some current from the l.e.d. so allowing the relay coils to draw the correct current without damaging the l.e.d.

The equipment can now operate with the ignition key removed. All contacts have switched over to their normally-open (b) positions and a battery positive connection for the audio equipment is made through fuse, FS1 and relay contact RLA1b. Both left and right loudspeaker outputs are directed to the caravan system through contacts RLB1b and RLB2b and a plug and socket arrangement at both car and caravan.

Inside the caravan, the speaker wires are connected to the volume control network consisting of a two-pole six-way switch, S1, and resistors, R1 to R5 for the Left channel (using S1a) and R6 to R10 for the Right (using S1b). Since both left and right volume control sections operate in identical fashion, a description of S1a is sufficient.

In position 1 (MAXIMUM), the moving or "wiper" contact is connected direct to the stereo system output and the caravan left-hand loudspeaker receives maximum power. With the moving contact at position 2, resistor R1 appears in series with the amplifier output and the chain of resistors R2 to R5 are connected in parallel with the speaker.

As the switch is moved through positions three to six, fewer resistors in the chain appear in parallel with the loudspeaker. The effective resistance is therefore less and the speaker becomes quieter. Position 6 gives a virtual short-circuit across the loudspeaker but it is found in practice that there is sufficient contact resistance at the switch and resistance in the wires to allow some current to flow in the loudspeaker which will now sound with minimum volume.

The values chosen for resistors R2 to R5 gave a good degree of control in the prototype unit. Note that if resistor R1 were to be bypassed, the amplifier output would be short-circuited. It is essential, therefore, to preserve the correct value of resistor R1 in any experimenting with the values of R2 to R5. **If this is not done, the amplifier output stage could be ruined.** Readers using mono equipment need use S1a and associated resistors only and ignore S1b,.

It will be necessary to "pipe" the loudspeaker signals from the car to the

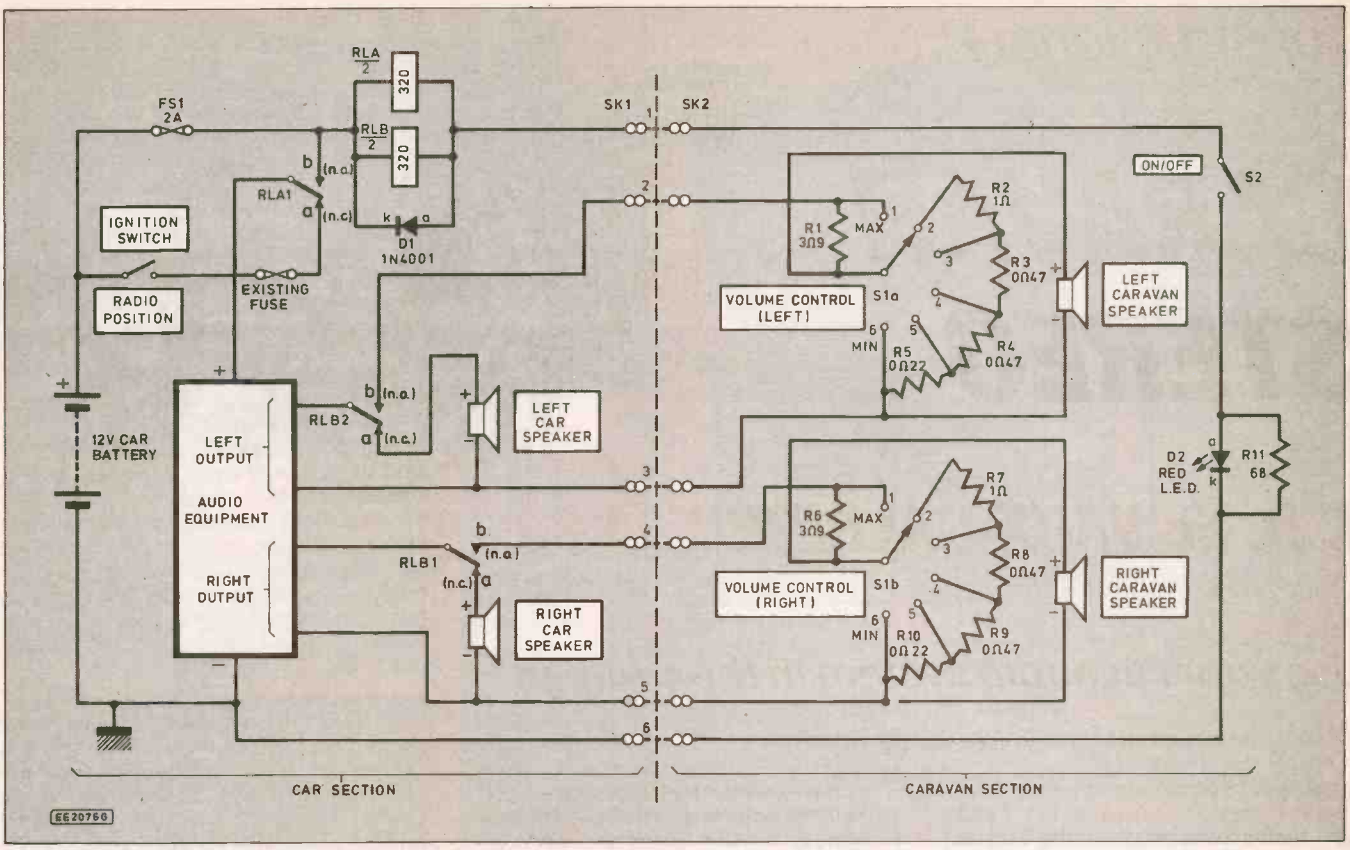


Fig. 1. Circuit of the Caravan Stereo.

caravan using multi-way connectors at both the car and caravan end. If these are to be permanently sited outside the vehicles they must be of a waterproof pattern.

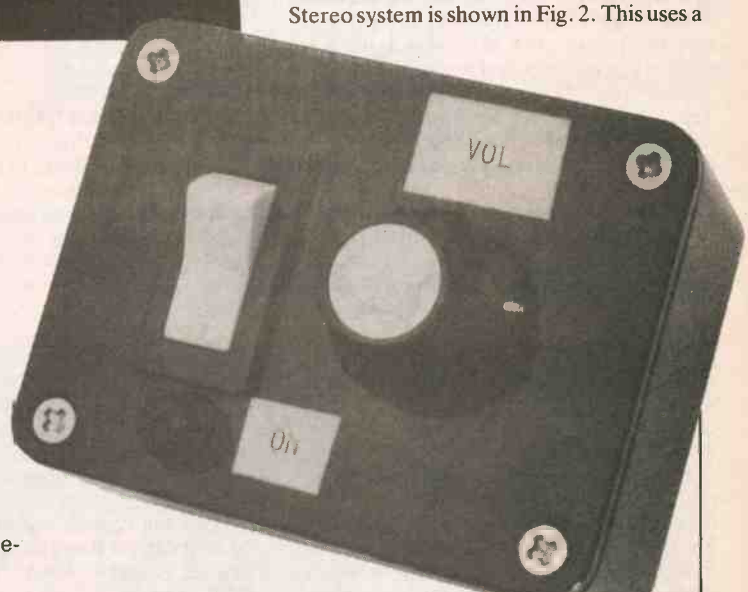
With a little thought, it may be possible to site them in dry places then standard six-pin auto-type connectors may be used. One relay coil feed wire, one earth (car chassis) and four loudspeaker connections are needed. In some systems, there will be a common loudspeaker return wire but this is not assumed. Six-way connectors are therefore needed for a stereo system and four-way ones for mono.

Note that the specified relays have a coil resistance which, in conjunction with resistor R11, gives the correct l.e.d. operating current—excessive current through l.e.d. D2 will ruin it. Diode D1 prevents the high reverse voltage produced by the magnetic field collapsing in the relay coils from damaging the l.e.d.

CONSTRUCTION

The circuit board component layout used in the car section of the Caravan Stereo system is shown in Fig. 2. This uses a

COMPONENTS



Resistors

R1, R6	3Ω9 (2 off)—see text
*R2, R7	1 (2 off)
R3, R4, R8, R9	0Ω47 (4 off)—see text
R5, R10	0Ω22 (2 off)—see text
R11	68

All 1W 5% carbon, except R11 which may be 0.25W 5% carbon. *R2 to R11 may be 1, 0.6W (18 off) — see text

Diodes

D1	1N4001
D2	Red l.e.d.

Miscellaneous

RLA, RLB	12V 320 ohm coil min. relay, with double-pole changeover contacts (2 off) or single 3 or 4-pole relay —see text
S1	2-pole 6-way rotary switch, break-before-make
S2	1A On/Off rocker switch
TB1, TB2, TB3	3A screw terminal block—18 sections
FS1	Line fuseholder with 2A fuse.

Stripboard, 0.1in. matrix size 12 holes × 20 strips; case, 79mm × 61mm × 40mm (2 off); loudspeakers for Caravan, 2 off for stereo — one for mono; 6-pole non-reversible auto plugs and sockets (2 off); loudspeaker wire; 3A auto-type wire; auto-type connectors; 4 or 6-core cable; solder etc.

Shop Talk
See page 445

Approx. cost Guidance Only **£13** plus speakers

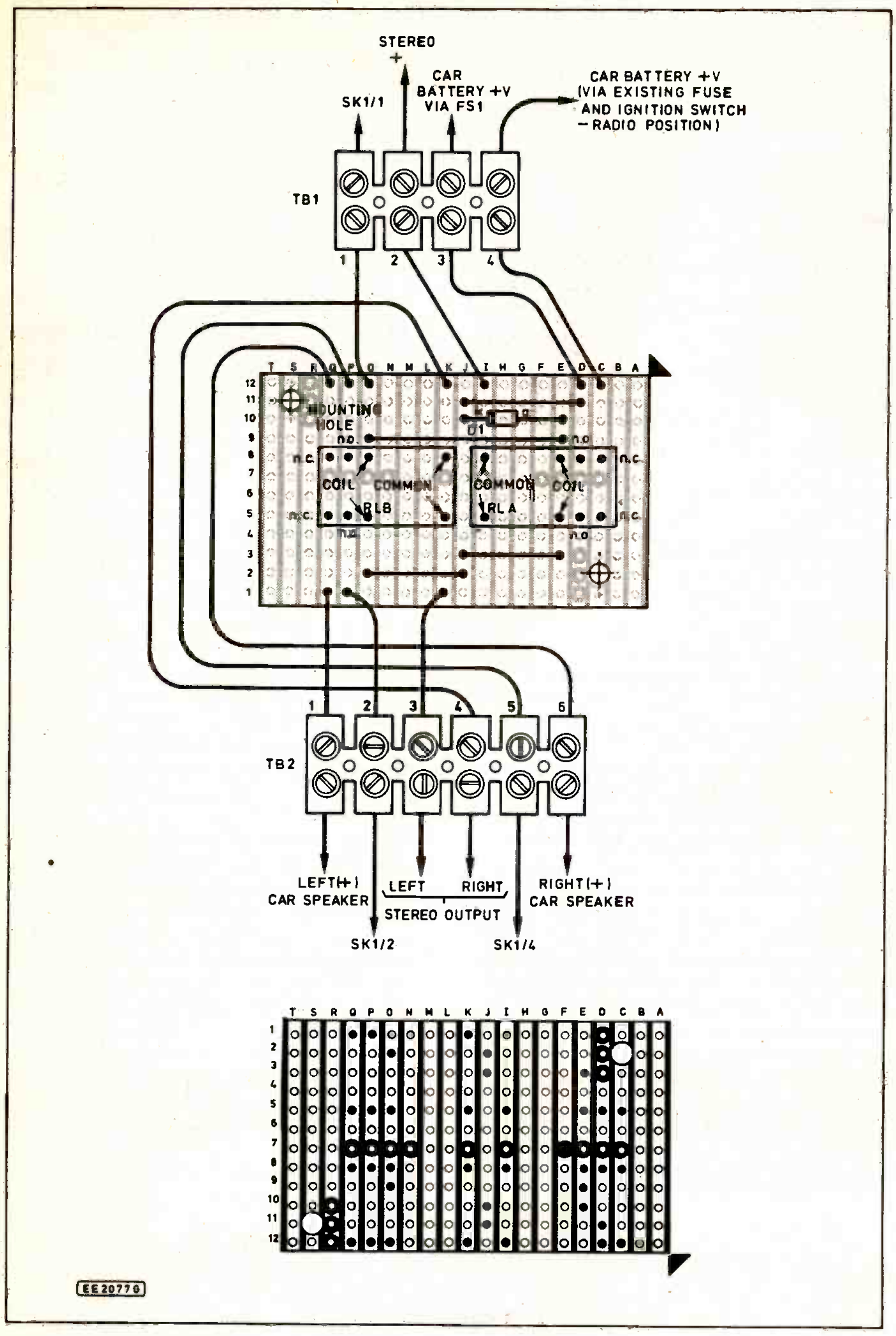
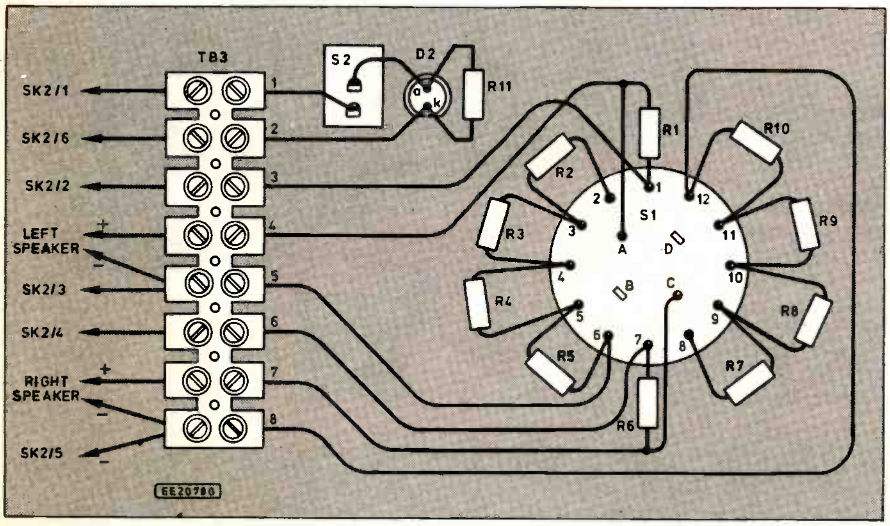


Fig. 2. Veroboard layout and wiring of the car section.

Fig. 3. Wiring of the caravan section.



piece of 0.1in matrix stripboard, size 12 holes×20 strips.

Begin construction by drilling the two mounting holes in the board as indicated. Make all breaks in the underside copper tracks and insert the inter-strip links on the topside then solder the relays and diode D1 (noting the polarity) into position.

Solder 15cm pieces of light-duty stranded connecting wire to copper strips C, D, I, K, O, P and Q along the top edge and K, P and Q along the bottom one. It would be a good idea to use rainbow ribbon cable—not only does this keep the wiring neat, it also makes for easy identification and minimises the chance of error.

Two sections of screw terminal block, TB1 and TB2 are mounted on the box. The first, TB1, has four sections and is responsible for the power supply and on-off switch connections while the second one, TB2, has six sections and carries the loudspeaker wiring. Drill holes in the box for attaching the circuit panel and terminal blocks. Drill holes nearby for the wires leading from the relay panel to pass through. Attach the terminal blocks and circuit panel then, referring to Fig. 2, complete the wiring.

CARAVAN SECTION

The caravan-based unit wiring is shown in Fig. 3. This is built into a similar box to that used for the car section. Begin by preparing "volume control" switch S1 by soldering resistors R1 to R10 in position as shown. Note that S1 must be of the *"break-before-make"* type as specified in the parts list. There is no room for error here and all work must be thoroughly checked.

If the specified value for resistors R1 to R6 is difficult to obtain, a near-value to 3.9 ohms may be made up by connecting a 4.7 ohm and a 22 ohm resistor in parallel. Similarly, 0.47 ohms may be constructed by connecting two one ohm resistors in parallel and 0.22 ohms by connecting four one ohm resistors in parallel.

Drill holes in the lid for the Volume switch S1, On/Off switch S2 and l.e.d. indicator D2. Drill holes in the back of the box for the eight-section terminal block, TB3. Drill two small holes near TB3 position to carry the wires leading through from inside.

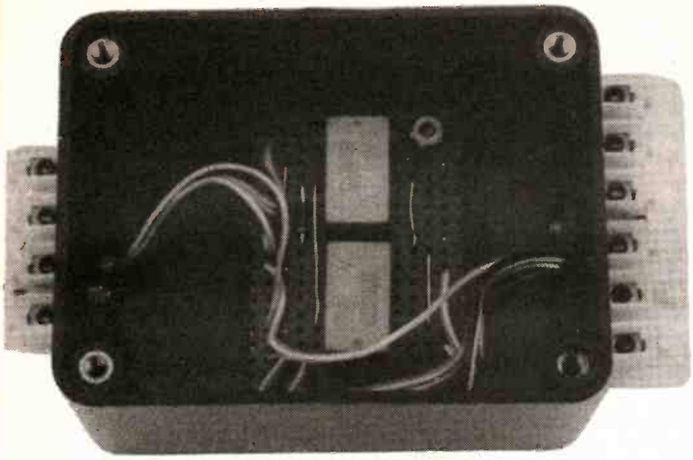
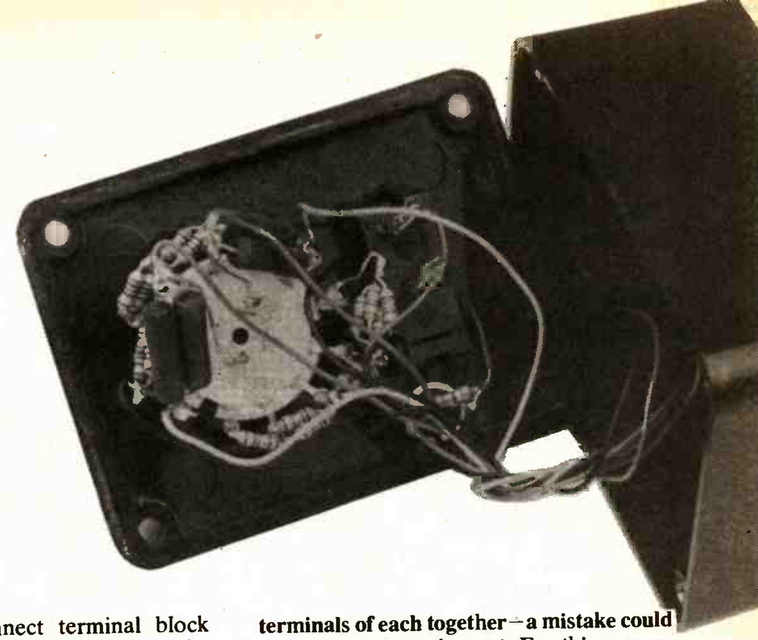
Referring to Fig. 3, mount the above components and complete the wiring noting the polarity of diode D2. Resistor R11 is soldered direct to D2 terminals—do this quickly to prevent heat damage.

Installation and testing

Begin the installation with the car section. Before starting work, you ***must*** disconnect the car batery completely. Decide on the best positions for the unit and socket, SK1, at the rear of the car.

Access is required to the wires leading to both speakers. Check the polarity of these, the speaker terminals may be marked "+" and "−" or the positive one may be marked red. Cut the *positive* wire at each speaker. Using loudspeaker wire, extend the newly-cut ends to reach the unit. Proper connectors should be used—*not taped joints*.

The extended wires leading to the loudspeakers should now be connected to terminal block TB2/1 (left) and TB2/6 (right). The other cut ends, i.e. those leading to the stereo system amplifier outputs, are connected to TB2/3 (left) and TB2/4 (right). Connect terminals TB2/2 and TB2/5 to SK1/2 and SK1/4 respectively.

Return to the car speakers and, make connections to the wires which have not been cut. Without breaking them, make connections using "Scotchloks" and run wires from here to SK1 pin 3 (left) and pin 5 (right).

Cut the positive supply feed wire for the stereo equipment *after* the existing line fuse and, using proper auto-type connectors and light-duty auto-type wire, connect the free ends to terminal block TB1/4 (Ignition Switch end) and TB1/2 (Stereo Unit end). Using similar wire, connect TB1/1 to socket SK1/1 and TB1/3 to a fuse which is "live" continuously–not just when the ignition is switched on. Include the separate line fuse, FS1, in this wire and fit a 2A fuse. Connect SK1/6 to a nearby earth point (car chassis). ***Before proceeding, check all wiring very carefully.***

Decide on the best positions for the caravan speakers, the unit and six-way caravan socket, SK2. Refer to Fig. 3 and make all external connections. Using light-duty auto-type wire, connect terminal block TB3/1 to SK2/1 and TB3/2 to SK2/6. Make the other TB3 connections using loudspeaker wire. Note however that where any wire passes beneath the caravan, light-duty auto-type wire should be used since this will better withstand the conditions. Connect TB3/3 to SK2/2 and TB3/6 to SK2/4.

Connect twin wire to TB3/4 and TB3/5 long enough to reach the left-hand speaker and to TB3/7 and TB3/8 to reach the right-hand one. Observing speaker polarity, connect these wires as shown. Connect TB3/5 and TB3/8 to SK2/3 and SK2/5 respectively. The car battery may now be re-connected.

The car and caravan six-way polarised multi-sockets should now be interconnected pin for pin using a suitable piece of six-core wire (4-core for mono equipment) having the matching plug at each end. Telephone wire is suitable for short distances. **Note that it is essential to connect the same terminals of each together–a mistake could ruin the audio equipment. For this reason, plugs and sockets which can be inserted only one way must be used.**

The volume control inside the caravan should be set to minimum (position 6), S2 switched off and the ignition switched to the "Car Radio" position. The radio or cassette player should now operate normally and play through the car speakers. Tuning, cassette selection etc. may now be carried out.

The car volume control should now be adjusted to the maximum likely to be needed in the caravan. This will probably need practice due to the effects of the resistance of the connecting wires and differing loudspeaker efficiencies. Now switch on S2 in the caravan. The l.e.d. indicator, D2 should light and the sound come from the caravan speakers. The ignition key may now be removed and the volume control on the caravan control panel adjusted as required. □

EE CROSSWORD

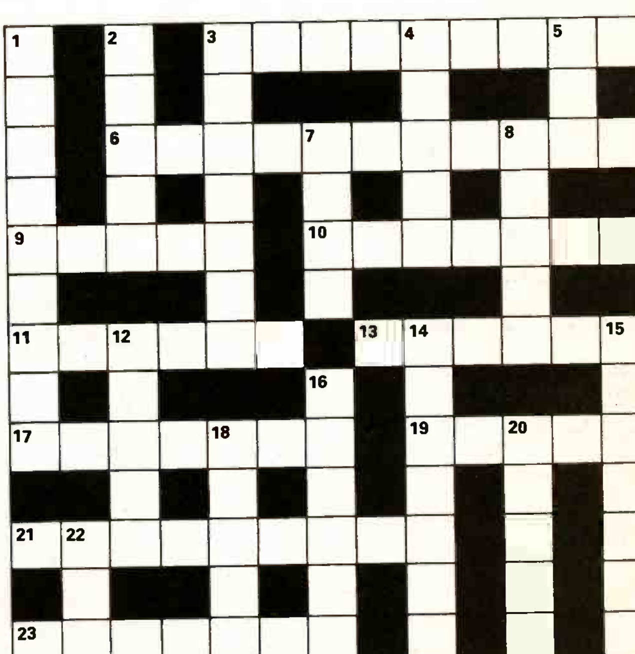
CLUES ACROSS

3 An L-C circuit where resonance does not take place (9)
6 In TV scanning, a method of reducing flicker without increasing bandwidth (11)
9 You can hear this (5)
10 Basic material and part of a TV aerial (7)
11 In computer graphics, a line as a segment of a display (6)
13 This lets slip a medium (6)
17 Unit of intensity of light (7)
19 A picture element not at the bottom of the garden (5)
21 Describing constant velocity of a scanning system (9)
23 Relating to the amount of information recorded on tape.

DOWN

1 Type of glass used in delay lines (9)
2 British inventor of TV (5)
3 The required patterns of i.c. manufacture (7)
4 This frequency is also known as "second channel" (5)
5 An atom, for example, that has an electric charge (3)
7 Tape held in this form before cassettes.
8 In CTV, a signal that is derived from the swinging burst (5)
12 This clock does this before each teletext line (3,2)
14 Sound and vision altogether(3,4)
15 Scanning format used by all domestic vtr's (7)
16 This resonator replacs tuned circuits for h.f. applications (6)
18 Tunnel diode by another name (5)
20 Electromagnetic radiation between UV and gamma waves (1,4)

For fun only–answers on page 442



Robot Roundup

NIGEL CLARK

ROBOTS AT PLAY

Visitors to the Edinburgh *Science Festival* were treated to a fine display of how to adjust their expectations. They had been treated to invitations to see robots playing "ping-pong" and advertisements in the scottish press for robot table tennis players. They turned up expecting to see humanoids with bats trying to outdo Desmond Douglas and Carl Prean.

As regular readers will know the reality was different. In the words of one of the organisers all they got was a lot of people diving under their machines with spanners to fix something which had gone wrong. However, once they adjusted their expectations they began to share in the small triumphs and larger disasters which characterise robot competitions.

As expected the Swiss world champions did not turn up. As the organiser said, *"I understand they shared their computer with some people who were doing other things, so they couldn't get away."* But the Finns, runners-up to the Swiss in the last world championship with *Byrokrat,* the Swedes and the British were represented.

Unfortunately, the hopes of the organisers were not satisfied and there were no entries from Scotland. There was no shortage of silly offers, people willing to dress up as robots and the like, but there were very few serious possibilities. The most likely came from the nuclear power establishment at Dounreay but they found it impossible to produce anything workable in time.

With the Swiss absent the Finns took advantage and came first, even managing a respectable rally with the Swedes. Their machine came second despite blowing two transformers, one of which had been loaned by Portsmouth Polytechnic.

John Knight, maintained his record of having been in every heat of the contest since it began, but came third with the latest version of *Charlie*.

Despite shattering the illusions of quite a few spectators who had been hoping to see the possibility of robot servants in the near future, it is intended to invite the Roboteers back to the second festival being held next year. It can only be good that while seeking to expand the boundaries of technology the contest can also act as an illustration of where those limits lie at present.

TWO-LEG SHUFFLE

Arthur Collie's *Cockroach* has changed into a *Shufflebum* or *Robug II* as he would prefer to call it. What began at Portsmouth Polytechnic as an attempt to create a dynamic walking device has developed into a crawling shuffling robot which he considers to have commercial possibilities.

From the original six-legged robot, known as the *Cockroach* because each leg had its own control system, the latest machine has a basic two legs with suckers and a body with a further two suckers. The nickname *Shufflebum* comes from its movement with the body raising and falling to the ground between steps by the legs.

Collie is very excited by the latest developments as he believes he has produced a viable robot which will be in demand for examining high-sided constructions such as ships and large tanks. He thinks that if someone made a request for a specific purpose, the final robot could be produced within 18 months. All the mechanical work has been completed but he thought the writing and checking of the software would take up the time.

"It is beginning to be practical," he said. "We have changed the original concept and gone for a crawler rather than a walker."

The main items remaining from the walking robot is the design and powering of the limbs. Each leg is driven by a combination of three "muscles" in the form of pneumatic cylinders. As can be seen in the photograph they are configured to allow backwards, forwards and sideways movement. Each cylinder is controlled by its own on-board processor.

The chassis is slung below the knees, in the same manner as a spider, or, as Collie said, looking like a JCB without the cab. This combined with having only two legs, has increased the stability compared with the *Cockroach*. Collie said the original had a tendency to get its front and back legs tangled as it progressed.

At the moment the prototype is linked to a central IBM PC controller and to its compressed air source via two umbilical cords but it's planned to run the fibre-optic computer link inside the compressed air tube. Collie said that it had been possible to give *Robug II* a wide range of movement because the normal power requirements during motion were fairly low and it was possible to make the compressed air tube very long. The robot will carry a reservoir on board should extra power be needed at any stage of its working.

Positioning could be very precise, and on-board readings of angles and distances travelled by each limb could allow for any slippage and be used to calculate new positions precisely. Collie added that the speed of movement would be sufficient for the uses to which it might be put. One of these was inspection work. Collie said that inspection was required at the rate of a square metre per minute, something which *Robug II* could easily achieve.

It is strong enough to lift 20lbs to 30lbs. The unit had become known as the "floortile lifter" after some accidents in the workshop when the robot tried moving while its chassis was still stuck to the floor.

The *Robug II* uses a modular design allowing devices to be customised for particular purposes. Any number of legs can be added and the chassis expanded to carry the required tools. It is also possible to replace the suckers on the feet with tools.

It uses established technology, although in different ways to the ways it had been used in the past, making it easier to maintain. As Collie said, it could be maintained by anyone experienced in the existing technology. The on-board electronics consists of single-chip computers linked by RS232 serial interfaces to the central IBM.

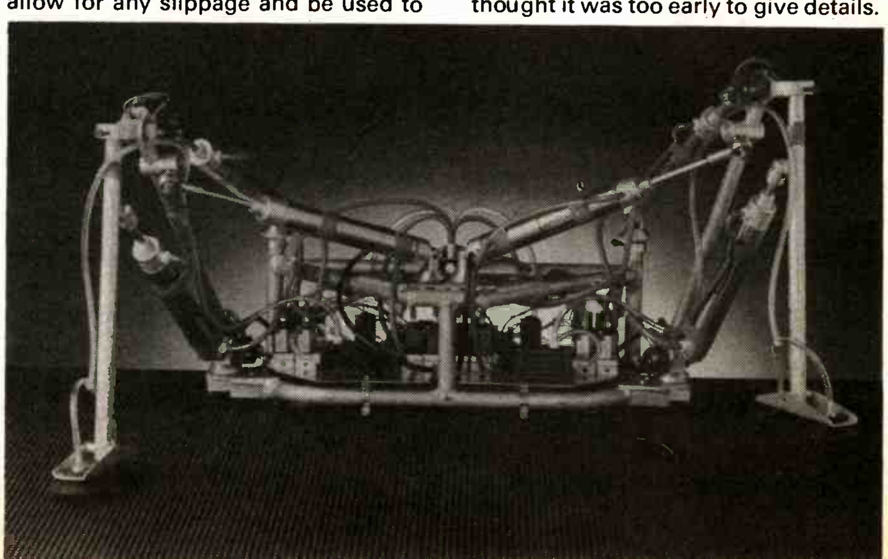
"What we have here is a demonstratable device with all the mechanical engineering complete. We are now ready so that if someone came to us with a specific task it would take about 18 months to get the software implanted." said Collie.

SOFTWARE DEVELOPMENTS

Meanwhile, the work-cell development continues at other manufacturers. With almost every arm maker having added a number of items to put the arm through its paces they are now making improvements, usually in the controlling software.

The latest to join the trend is Computer Voice. It is developing software for the IBM PC and IBM compatibles for the *Cyber 310* cell to make it easier to use and improve the graphics. It is expected later this month (June).

Paul Ritson of Computer Voice added that improvements were also being considered for the hardware and make-up of the cell with additions to the present turntable and conveyor. But he thought it was too early to give details.



...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

YOUNG RADIO AMATEUR OF THE YEAR

The Department of Trade and Industry has announced its sponsorship of the *Young Amateur of the Year Award for 1989*. This is open to anyone under the age of 18, and achievement in any area of amateur radio will be considered, e.g.,

* an interest in amateur radio home construction;
* operating skills, particularly teamwork in club contests;
* use of the hobby for the good of the community, such as RAYNET, St. John's Ambulance, sponsored walks, help for the disabled;
* the ability to spread the word—presentations or demonstrations at schools, clubs, etc;
* in a school scientific project.

A £250 cash prize will be awarded by the DTI for the most outstanding achievement between 1st April 1988 and 31st July 1989, and will be presented at the Radio Society of Great Britain's HF Convention in October. The winner will also have the opportunity to see the DTI's experts at work at its Radio Monitoring Station at Baldock in Hertfordshire. All other entrants will receive a copy of the DTI's coloured chart of radio frequency allocations in the UK.

ROYAL PRESENTATION

The award was launched last year during the RSGB's 75th birthday celebrations when HRH Prince Philip, the Society's Patron, presented the first award to Andrew Keeble from Norwich for his enthusiasm in encouraging others' interests in radio, his radio construction skills, and voluntary activities. Andrew received additional, unexpected awards in the form of a one-week training course at the College of Marine Electronics, sponsored by the Mobile Radio Users' Association; an engraved RC14 receiver given by the RSGB; and a week in Vienna as the guest of the Austrian radio society.

Applications, should be sent to The Secretary, RSGB, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE, by 31st July, 1989. Young people may enter directly, or an adult may nominate a candidate for the award.

NEW CALL BOOK

The RSGB's new call book was published at the beginning of April. This book represents the official records of the Radio Amateur Licensing Unit (RALU) and lists the call-signs and other details of all UK radio amateurs. It also includes details of stations in the Irish Republic and contains a wealth of other information for the active amateur.

For the first time the callbook has been produced on the RSGB's own desk-top publishing equipment and the format and readability is certainly much better than it has been previously. With more than 400 pages, over 20 per cent more information is included in this new edition, including the full text of the terms and conditions of the newly revised (1989) amateur licence.

Apart from the callsign listings there are 60 different useful information sections. Taking a few at random, these include advice on operating abroad, with details of overseas licensing authorities; details of affiliated clubs and societies; services and facilities for disabled amateurs and general rules and guidelines for contests.

At one time this annual publication was little more than the listing of all current call-signs. Now it is a detailed handbook in its own right, particularly helpful for beginners who constantly need advice and information to point them in the right direction as they discover ever new aspects of the hobby of amateur radio communication.

The *1989 Amateur Radio Call Book & Members' Handbook* is available from the RSGB, address as above, price £7.95 incl., for members and £9.35 for non-members.

CELEBRATIONS STATESIDE

After the RSGB's big event last year, American amateurs are celebrating their national society's 75th anniversary this year. The American Radio Relay League's birthday was on 14th May and special greetings were sent to the League via amateur radio from around the world. I hope to report further on the celebrations and special events during the anniversary year.

The ARRL has always interested me, and especially the story of its joint founder Hiram Percy Maxim who has an important place in the history of amateur radio, as well as the history of the USA itself.

His father was a famous inventor knighted by Queen Victoria who, among other things, invented the Maxim machine gun. Hiram followed in his father's footsteps with 59 patents of his own, including the Maxim silencer which ceased production in the '30s after a public outcry in the US when people believed it would increase the use of firearms by criminals.

Long before this he was an automobile pioneer, designing the Columbia electric motor carriage and a complete range of road vehicles before the turn of the century. His book "Horseless Carriage Days" covering that period in his life is a small masterpiece, describing step by step the problems encountered by him and others in constructing road-worthy vehicles, and how they overcame them. He then went into the new world of aviation and also took up that other wonder of the time, wireless telegraphy.

In 1914, when another amateur relayed a message for him when he was unable to make direct contact with a distant station himself, he conceived the idea of a national Relay League of amateurs handling messages across America. Thus the ARRL was founded and it has been the national society of the USA ever since.

After WW1, ARRL was one of the leading lights in setting up the International Amateur Radio Union and Hiram Percy Maxim was its first President until he died in 1936. Over those years he also remained as the first President of ARRL and to this day, the international headquarters of the IARU is located at ARRL headquarters in Hartford, Connecticut.

One thing is sure, among the many who have contributed to the development of amateur radio over the years, there will be a lot said in the ARRL celebrations about "the Old Man" as he was affectionately known. His call-sign, W1AW, lives on as the call of the League's headquarters station. This is available for use by visiting amateurs, and also puts out daily news bulletins, Morse practice and qualifying runs, plus emergency transmissions when the occasion arises.

HIGH SPEED TELEGRAPHY

IARU Region 1, which roughly covers Europe, Africa, and European USSR, is holding its 2nd High Speed Telegraphy Championships in Hanover in November. Years ago high speed Morse championships were very popular especially among professional telegraphers in the USA. At one time participants used traditional hand keys, and the world record for hand key sending is held by Harry Turner of Alton, Illinois, who achieved 35 wpm. in 1942.

The IARU has revived interest in high speed contesting, although electronic keys capable of much faster speeds than hand keys are now the order of the day. At the 1st Region 1 Championships held in Moscow, in 1983, sending speeds of up to 44wpm were achieved, with receiving speeds of up to 64 wpm. These were groups of random letters. With groups of random figures, the speeds jumped to nearly 59 wpm transmitting and 100 wpm receiving.

The various national societies in Region 1, including the RSGB, have been invited to send teams to compete at Hanover. The winners in 1983 came from Russia and Rumania. In November there may be a stronger challenge from other countries. There are specialist clubs in several European countries, including the UK, with operators capable of working at high speeds in normal "on-the-air" amateur operation. It's just a question of whether they can put in the same performance under Championship conditions.

DOWN TO EARTH

BY GEORGE HYLTON

WHAT HAVE I MEASURED

One day I found myself chatting with a bloke who did market research. His speciality was soft drinks, and he told me about a little problem. It seems remote from electronics, but bear with me.

To test products like soft drinks you enrol a cross section of the buying public and ask them to sample, blindfold, two products, A and B. They show a marked preference for A.

Now, here's the problem. A and B are not new products but well known ones which have been on the market for ages. You know from the sales figures that in the real world the brand that sells better is B. What's gone wrong with the tasting test?

SAMPLING

One possibility is that your human guinea pigs don't in fact form a true cross-section of the consuming public. This may be so, but you can guard against it by carefully selecting people whose buying habits are known to embrace your type of products, and by including people from different regions, to allow for local preferences.

It is, of course, important to use a large enough sample of consumers. Not much use asking just half a dozen. But here a statistical theory comes to your aid.

There's a well-known formula which indicates how much error is likely to arise from using a limited sample. If you have a rough idea, before you do your tests, of what percentage of subjects is likely to opt for the product you're interested in, then you can work out how many guinea pigs you'll need to obtain results reliable to within 10 percent one per cent or whatever you want. Naturally, for greater accuracy, you need a larger number of guinea pigs.

PSYCHOLOGY

My market researcher knew all about such things and his cross section of consumers was sufficiently numerous and representative. But he still got the wrong answer. Why?

The environment in which the test was made was unnatural. In real life, when you feel the need to quench your thirst, you don't go by appointment to a special place where you meet a lot of strangers nor do you, before taking a sip, put on a blindfold. You just say: "Gosh, I'm thirsty. Let's have a Coke."

The psychological effects of the artificial test procedure could easily affect the results. By the way, in case you've been wondering, the blindfold is to ensure that people don't identify the products by their appearance and so prejudice their judgement.

To cut a long story short, my market researcher told me that in blindfold tests people tend to express a preference for whichever drink is *sweeter*. In real life, however, they may well choose to buy the one which is less sweet.

SUBJECTIVE EFFECTS

Clearly, subjective effects are hard to assess. Yet they are important. If you are designing an audio system, you may be anxious to achieve the greatest possible fidelity. You can measure frequency response and distortion in the laboratory, but at the end of the day what matters is how it sounds to human beings.

Technical specifications may be misleading. Given two systems (Fig. 1), one with a response flat from 20-20,000Hz and the other from 40-12,000Hz it seems clear that the first is better. In practice the situation may be much less clear-cut.

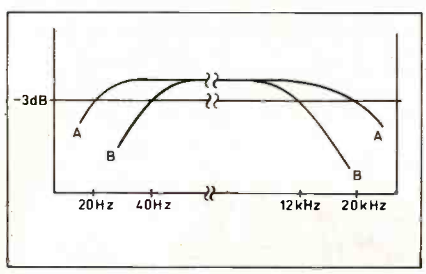


Fig. 1. Frequency responses of two audio amplifiers. Is a system based on A necessarily better?

It's actually rather difficult to reproduce very low notes in a small space such as the average living room, so the l.f. response may not have much practical significance. As for the h.f. response, many people past middle age can't hear anything as high as 20kHz. With guinea pigs like these in a listening test it wouldn't be at all surprising if a preference were expressed for the less wide band system. Other factors may be exercising more influence.

Listening tests are often done blind, with the different bits of apparatus hidden from the audience. This seems fine, but of course it excludes "irrelevant" factors which may nevertheless have a profound influence on sales. Look around people's homes and it's clear that a system which looks attractive is likely to be bought, though attractive appearance is quite irrelevant to fidelity.

If you like designing your own equipment bear in mind the possible effects of subjective, psychological factors. Is tone control A better than B? If you designed A and someone else B then you are motivated to prefer A and in the solitude of your workshop you are quite likely to think that it really sounds better. In market research terms, you are a sample audience of one, and heavily biased.

All development laboratories (which suffer from the same sort of prejudice) should display two notices to remind themselves. One should say: BEWARE OF THE EGO!, and the other: NOT INVENTED HERE? NEITHER WAS THE ROLLS ROYCE.

MEASURABLE FACTORS

Fortunately there are many cases in engineering where subjective factors are not important. All the same, measurements can still go wrong because the experimenter is not aware of the effects of purely objective ones.

Ordinary analogue meters are a common source of error. We tend to expect more accuracy from them than they can really be expected to deliver.

The maker's specification for a multimeter may indicate that the d.c. ranges are reliable to within say two per cent. From this it seems reasonable to expect to measure d.c. volts and milliamps to within two per cent. But this is optimistic.

The quoted accuracy, whether or not the spec. says so, is likely to apply only at full scale. Suppose the scale is divided into 100 small segments. Each division then represents one per cent of full scale.

Reading the meter is a subjective process and there will be errors. If you can read accurately only to within one division then this introduces a further uncertainty of one per cent. The credible full-scale accuracy is now ±one per cent.

Worst still, at deflections much less than full scale a one-division reading error is much more serious. On the 100V range each division represents 1V. If you measure 10V on this range and misread by one division the resulting 1V error amounts to 10 percent. So the total error (reading plus maker's tolerance) is 12 per cent.

Even this is optimistic. It assumes that the pointer deflection is linear, that is, exactly proportional to the current through the meter's coil. In practice there are errors in linearity which may further reduce accuracy.

Of course, I've considered the worst case, where all the errors add together. It may well be that in reality some errors cancel others. Unfortunately this can't be guaranteed so the worst case must be taken seriously.

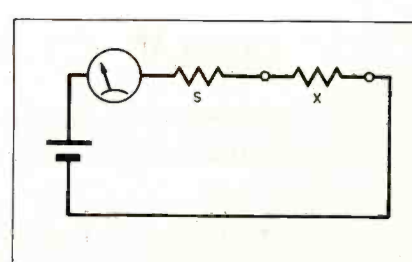


Fig. 2. D.C. ohmmeter circuit. X is the resistance under test.

OHMS MEASUREMENT

The high-resistance end of the scale on an ohms range is obviously very cramped. A small reading error here can make a big difference. At the low-resistance end, the scale is quite open and good accuracy seems possible. But consider how the meter works (Fig. 2).

Assuming that the set-zero arrangement (not shown) compensates for any variation in battery voltage V, the current is I=V/(S+X), where S is the internal standard and X the resistance under test. At the low ohms end X is small compared with S. The current I is then influenced much more by S than by X. The response to variations in X is weak.

The result is that small errors in S have a large effect on accuracy. On ohms ranges, multimeters often give the best accuracy near mid-scale, where the scale is fairly open and X has about the same effect on meter current as S.

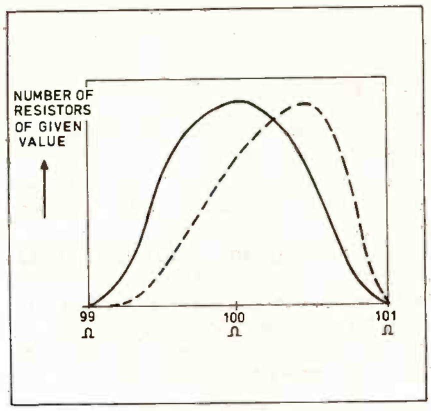


Fig. 3. The actual values in a batch of 100 ohm, 1 percent tolerance resistors should be distributed as shown. But the dotted-line distribution could also occur.

PRODUCTION SPREADS

If you have a batch of equal resistors of one per cent tolerance, what is the effect on precision of connecting them in series?

If they are all one per cent high then the total resistance is one per cent high and still within tolerance. If some are one per cent high and others one per cent low, then the series chain will be in error by less than one per cent since the lows tend to compensate for the highs.

Classical probability theory says that in a large batch of resistors whose values vary randomly within certain limits the errors should be spread evenly about the nominal value as in Fig. 3. Most specimens are close to the nominal value; relatively few are near or at the tolerance limits.

If this were a true picture then the accuracy of a large series chain would stand a very good chance of being much better than the tolerance suggests. The trouble is that you don't know whether the theoretical curve of Fig. 3 really applies. In reality the peak might be shifted to one side, as shown dotted. All resistors are still within tolerance and a series string is still likely to be an improvement, but now the total resistance is more likely to be a multiple of the new peak value than the nominal value.

A manufacturer may in some cases find it profitable to depart from the expected spread of values. Suppose the components are 100 ohm, 10 per cent power resistors and the wire they are wound from is very expensive. If his production process is sufficiently precise the maker could set up his plant to make resistors of 95 ohms, five per cent tolerance. All would be within spec. but five per cent of the precious wire would be saved!

MATCHING

Sometimes, instead of absolute accuracy you need two components to be as nearly equal as possible. If you buy just two they either match or they don't; you give yourself one chance. If you buy three (call them A, B and C) you can try A with B, B with C or A with C: three chances of finding a matched pair.

Buy four and you get six chances; five, and you get ten. The number of chances of a match increases rapidly so that a relatively modest investment gives a high probability of success, though there's never a guarantee.

6821, 6522, 6850 . . . More on the 1MHz Bus . . . 6821, 6522, 6850 . . .

FOLLOWING on from the basics of the 1MHz Bus that were covered last month, in this article we will take a detailed look at how some popular 6502 peripheral chips can be connected to this port. We will not overlook the all important (and often omitted) information about how these chips are set up and used in practice. The three chips we will consider initially are the 6821, 6522, and 6850. I believe I am right in stating that the 6821 is also available as the 6520.

Obviously the 6821 and 6850 are not strictly speaking 6502 peripheral devices; they are intended for operation with the 6800 series of microprocessors. However, as the 6500 and 6800 series of chips are bus compatible, there is no difficulty in using 6500 series microprocessors with 6800 series peripherals, or vice versa.

Serial And Parallel

Pinout details for all three chips are shown in Fig 1. The 6821 is a dual 8-bit parallel port which provides two handshake lines for each port. The 6522 is similar, but it additionally has two 16-bit timer/counters and a serial register. This device should not need any detailed explanation here, as it is the chip which provides the user and parallel printer ports of the BBC computers. In fact there are two of these devices in the BBC computers, but the second one is mainly used for internal interfacing.

If you require more parallel input/output lines than the user port can supply, a 6821 installed on the 1MHz Bus will normally be adequate, and is cheaper than the 6522. The 6522 would only seem to be worth the additional cost if its timers and (or) serial register are required. Probably in most cases the timers and serial register available via the user port will be adequate, although if you already have a mouse or some other device connected to the user port, then I suppose it could become necessary to fit a 6522 onto the 1MHz Bus.

The 6850 is a serial interface chip, as used to provide the BBC computer's RS423 serial port. Again, the built-in capabilities of the computer will often make it unnecessary to fit this chip onto the 1MHz Bus, but in some circumstances it could become necessary. For instance, you might wish to have serial communications at a baud rate which the built-in port cannot handle, or you might simply need more than one serial port.

Right Connections

Connecting these chips to the 1MHz Bus is reasonably straightforward, but it is something that we will consider in more detail as errors could prove to be costly, and would certainly lead to a frustrating time trying to sort everything out. If we start with the 6821, each line of its data bus simply connects to its corresponding terminal on the 1MHz Bus. The "RES" terminal is the reset input, and this connects to NRST on the 1MHz Bus.

"IRQA" and "IRQB" are two interrupt request outputs, and if required these can be connected to "NIRQ" of the 1MHz Bus. Unless you intend to make use of interrupts it is probably wise to leave these outputs unconnected. Incidentally, although it is not normally acceptable to connect two or more logic outputs together, it is acceptable in this case. The IRQ outputs of the 6821 have open drain outputs, and there is no risk of one driving a high current through the other if they adopt opposite logic states. The outputs driving the IRQ line of a 6502 microprocessor are in what is termed the "wired-OR" configuration.

Enable

The "E" terminal is the "Enable" one. This name always strikes me as being a little misleading, as it suggests that this line must be taken high in order to activate the chip. In fact this is the clock input, and most 65/6800 series chips require the clock signal if read and write operations are to be successful. Therefore, this terminal should be connected to the 1MHz clock signal of the 1MHz Bus.

The other standard 6502 control bus line is R/W, the read/write line. This simply connects to its equivalent on the 1MHz Bus, which is R/NW. "RS0" and "RS1" are the 6821's register select pins. One would reasonably expect a chip which has two register select inputs to have four internal registers. In fact the 6821 has six registers, and the means used to select the desired register will be discussed later.

Usually "RS0" and "RS1" would connect to A0 and A1 (respectively) of the 1MHz Bus. This then places the 6821 at four consecutive addresses in the memory map.

There are three chip select inputs on the 6821, and two of these ("CS0" and "CS1") are positive types. The CS1 input which has the "not" or "negative" line over the top is, as one would expect, a negative chip select input. If interfacing to the 1MHz Bus is made as basic as possible, the negative CS1 terminal will be taken to the NPGFC or NPGFD line of the bus, depending on which page of the memory map you wish the interface to occupy. "CS0" and "CS1" would simply be permanently enabled by being connected to the positive supply rail.

Mapping

If the chip is to be mapped into part of page &FD or &FC, then some address decoding must be used ahead of one of the chip select lines. The other chip select lines can be used to provide some of the address decoding, or they can just be tied to their active logic states.

I suppose the obvious place for your add-ons is in the area allocated by Acorn, which is from &FCC0 to &FCFE (see the list of address allocations in last month's article). As pointed out in the previous *Beeb Micro* article, it is by no means essential for private individuals to heed the Acorn recommendations if they will not be fitting any commercial add-ons to the 1MHz Bus of their computer. Also, address &FCFF is allocated to operation in a form of memory expansion that does not seem to be used to a significant extent, if at all. Consequently, there would seem to be no problem in using the full &FCC0 to &FCFF range for your add-ons.

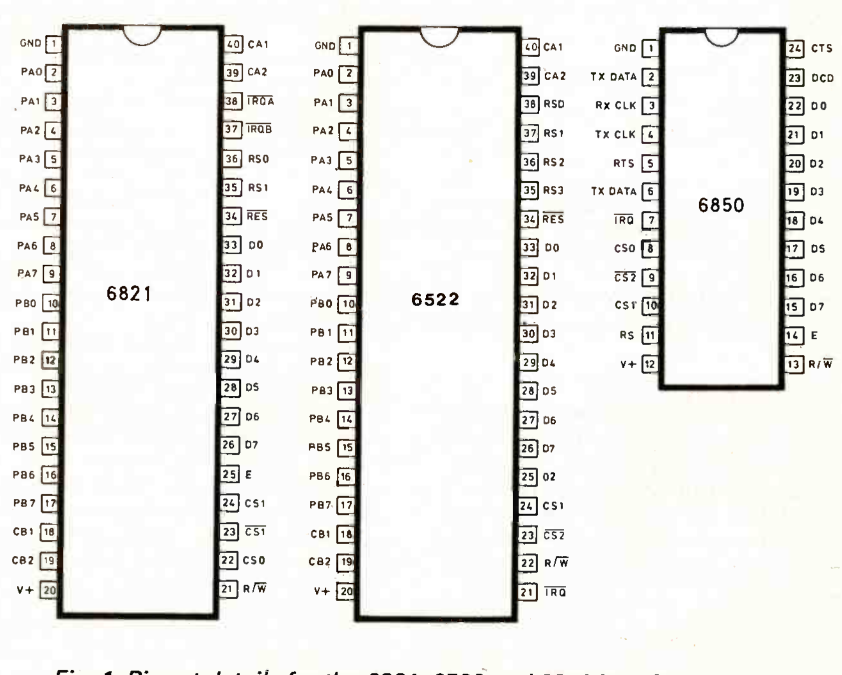


Fig. 1. Pinout details for the 6821, 6522 and 6850 interface chips.

A useful little address decoder based on a 74LS138 three-to-eight line decoder is shown in Fig. 2. This is designed to give four decoded outputs which cover these address ranges:

OUTPUT	ADDRESS RANGE
1	&FCCO - &FCCF
2	&FCDO - &FCDF
3	&FCEO - &FCEF
4	&FCFO - &FCFF

For any of these addresses lines A6 is always high. Line A7 is decoded by the positive enable input of the 74LS138, while address lines A4 to A6 are taken to its address inputs. The cleaned up NPGFC line drives on negative chip select input of the 74LS138, while the second one is wired to the 0 volt supply rail so that it is permanently enabled.

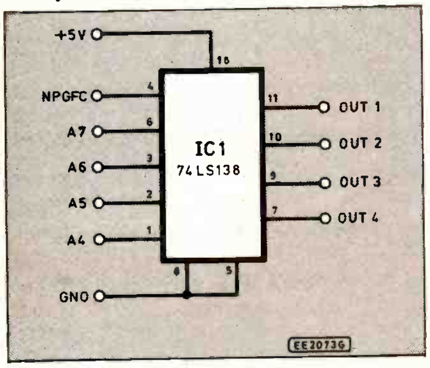


Fig. 2. An address decoder to place user add-ons in the appropriate address range of the 1MHz Bus.

There is no need for the address decoder to deal with the four least significant address lines. The register select inputs of the peripheral chips map their registers to individual addresses within the block of sixteen covered by each output. Not all chips, including the 6821, will occupy all sixteen addresses.

If we take the 6821 as an example, it occupies only four addresses, which with output 1 in use, would be &FCCO to &FCC3. These registers would then appear again as so-called echoes at &FCC4 to &FCC7, &FCC8 to &FCCB, and &FCCC to &FCCF. These "echoes" do not represent a problem provided you remember that these addresses are occupied, and do not try to use them for other hardware.

I should perhaps point out that the other four outputs of the 74LS138 provide further decoded outputs, but these are not within the memory area allocated to user add-ons by Acorn. Should you wish to use them anyway, pins 15 to 12 pulse low when addresses in the ranges &FC80 to &FC8F, &FC90 to &FC9F, &FCA0 to &FCAF, and &FCBO to &FCBF (respectively) are accessed.

Input/Output

So far we have not covered the input/output ports of the 6821. Terminals PA0 to PA7 are port A, while PB0 to PB7 are port B. Like the BBC computer's user port, both of these ports can have each line individually set as an input or an output. Also like the user port, each one has two handshake lines (CA1, CA2, CB1, and CB2).

Port A is fully CMOS and TTL compatible, with two TTL drive capability. Port B has similar TTL compatibility, and in practice is unlikely to give any problems if used with CMOS devices.

VIA And ACIA

The 6522 pinout configuration has obvious similarities to the 6821 pinouts. The same two input/output ports are provided, although the greater internal capabilities of the 6522 means that these can operate as something more than two 8-bit ports plus handshake lines. The read/write and reset lines are there, and are connected in the same way, as are the eight bidirectional data lines.

The "02" terminal is a clock input, and is equivalent to the 6821's "E" terminal. For the 6522 the clock signal is not just needed to provide a timing signal during read and write operations, but it can also act as the clock signal for the timer/counters and shift register. Hence the different name for this terminal. There is only one IRQ output on the 6522, and this should be ignored unless you intend to make use of interrupts.

The 6522 has only two chip select inputs; one positive active and one negative active. In this context CS1 should be connected to the positive supply rail, while CS2 should be fed from the cleaned up page select line, or from the address decoder circuit. The sixteen registers of the 6522 require four register select inputs. RS0 to RS3 would normally be connected to A0 to A3 respectively.

6850

Altough physically smaller than the other two chips, the 6850 is a quite complex device. Do not worry if it gets quite warm in use. This is normal, and is something it has in common with most serial interface devices. It has most of the usual control lines, and these are used in the same manner as the equivalent terminals of the 6821. There is an omissison in that there is no reset input. The 6850 has to be reset by writing the appropriate value to one of its registers.

There are four registers; two read registers and two write types. Consequently, the 6850 only occupies two addresses. The register select input ("RS") would normally be fed from A0 on the 1MHz Bus. There are three register select inputs, but CS0 and CS1 should simply be connected to the positive supply rail. Only CS2 is required in this context, and it is fed from the cleaned up page select line, or the address decoder circuit.

Separate transmitter and receiver clock signals are available, permitting split baud rate operation. The clock frequency can be equal to the baud rate, sixteen times this rate, or sixty four times higher than the baud rate. In practice the clock normally has to be at sixteen or sixty four times the baud rate, as it is only at these rates that internal synchronisation of the clock to the received data is provided.

Data input and output terminals are provided, together with the standard serial port handshake lines. Note that for RS232C or RS423 uses these lines cannot be used directly. RS232C signals are at nominal plus and minus 12 volt levels, not standard logic levels. Incoming signals must be processed in order to drop them to standard 5 volt logic levels, and outgoing signals must be processed in order to give the correct drive voltages.

Another point to note is that line drivers and receivers must provide a signal inversion. Without this inversion the interface will send signals of the wrong polarity, and will not correctly interpret received signals.

6821 Registers

The 6821 has three registers for each port, but the data direction and peripheral register for each port share the same address. For the sake of this example we will assume that a 6821 has been placed at addresses from &FCC0 to &FCC3 (plus "echoes" to &FCCF). The six registers would then be at the addresses indicated below:

REGISTER	ADDRESS
Peripheral Register A	&FCC0
Data Direction Register A	&FC00
Control Register A	&FCC1
Peripheral Register B	&FCC2
Data Direction Register B	&FCC2
Control Register B	&FCC3

One purpose of the control registers is to set the handshake lines in the desired modes, but they are also used to set the other registers to operation as the peripheral or data direction register. It is bit 2 of each register that performs this function. It is set to 0 for access to the appropriate data direction register, or to 1 to give access to the peripheral register. This bit will be low initially, so the data direction register can be set up in the required manner, with bit 2 of the control register then being set to 1 in order to give access to the peripheral register (which is effectively the eight data lines of the port). The data direction register operates in user port fashion (set bits to 0 for inputs—1 for outputs).

This should enable you to use the two 8 bit ports of the 6821, and presumably any BBC hardware enthusiast will already be familiar with programming the 6522. Next month we will consider control of the 6821 handshake lines, plus using the 6850 as an extra serial port or MIDI interface.

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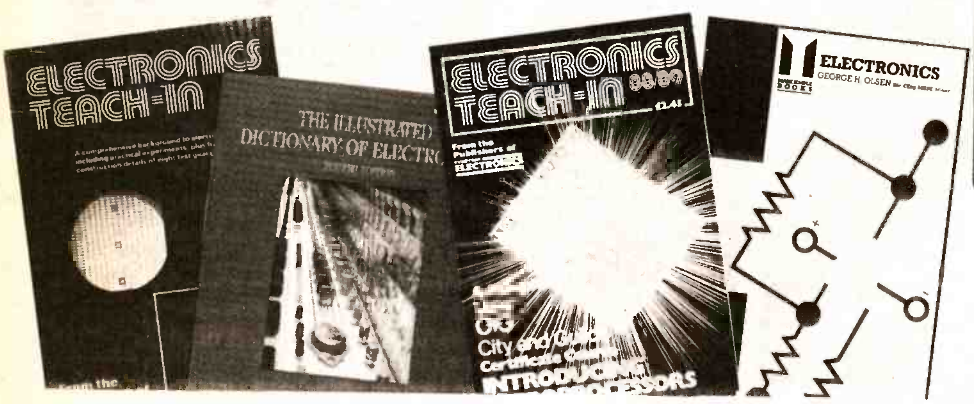

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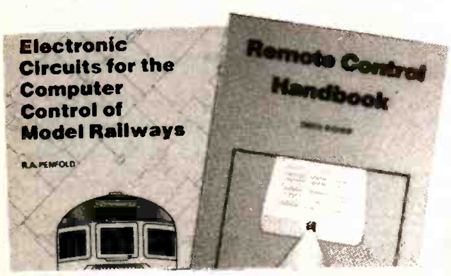

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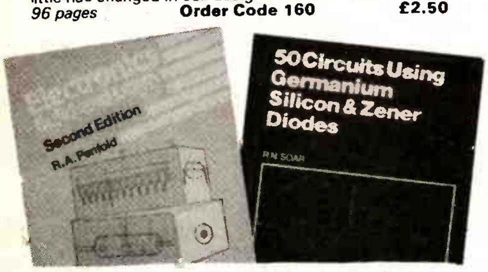

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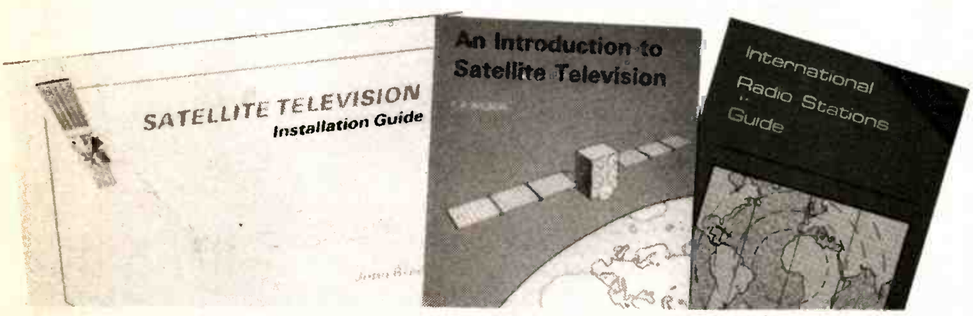

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ACTUALLY DOING IT!

by Robert Penfold

I THINK it is true to say that most aspects of electronic project construction are pretty straightforward. It is the odd problem that turns up from time to time which either makes things irksome, or provides the challenge which makes the hobby worthwhile, depending on how you care to view matters. In this months's *Actually Doing It* we will consider some of the more common problems which can cause confusion for beginners to the hobby.

COLOUR CONSCIOUS

Colour coding of values, particularly resistors, has been a source of confusion over many years. In days gone by there were slightly different methods of colour coding for low, medium and high power resistors. Gradually things settled down, with the standard four band codes being used, or values simply being written on the bodies of resistors (this second method being common amongst higher power components).

Things then went slightly wrong when a five band colour code appeared on the scene. Matters became worse when a second form of five band code turned up. This development was very unhelpful, since in some cases there is probably no way of telling which method of five band code is in use, and the only way of ascertaining the value of the component in question would then be to measure it!

Details of the four and five band methods of colour coding are shown in Fig. 1. It would probably be as well to explain the four band system before considering the two five band methods.

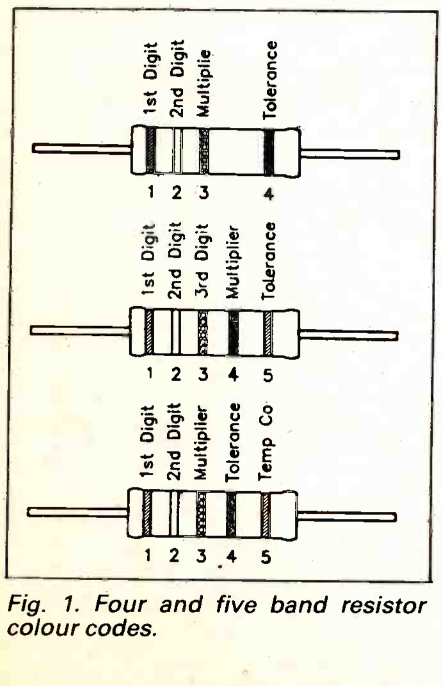

Fig. 1. Four and five band resistor colour codes.

The chart provided below shows the significance of each colour, which is not the same for all four bands. The first two bands operate in the same way, and the colours here just indicate the first two digits of the value. As an example, suppose the colours of the four bands are brown, black, red, and gold. In the first two bands brown and black respectively represent "1" and "0", giving 10 as the first two digits of the value.

The third band is the multiplier. In other words, you multiply the number provided by the first two bands by the multiplier indicated by the third band. In our example the third band is red, indicating a multiplier value of 100. This gives a value (in ohms) of 10×100=1000 ohms, or 1k in other words.

Many people find it easier to think in terms of the third band being like the first two, but indicating the number of zeros to be added to the first two digits. In this example, red for the third band equals 2, and adding two zeros to 10 again gives an answer of 1000 ohms. The fourth band shows the component's tolerance. In our example this is gold, which indicates a tolerance of ±5 percent. In other words, the actual value of the resistor is within 5 percent of 1k, or betwen 950 ohms and 1050 ohms.

COLOUR	BAND1	BAND2	BAND3	BAND4
Black	0	0	1	—
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1000	—
Yellow	4	4	10000	—
Green	5	5	100000	0.5%
Blue	6	6	1000000	0.25%
Violet	7	7	—	0.1%
Grey	8	8	—	—
White	9	9	—	—
Gold	—	—	0.1	5%
Silver	—	—	0.01	10%

No fourth band=20% tolerance

I suppose a reasonable question is how do you tell which band is the first one and which is the fourth one? Often it is very obvious, since the fourth band will be gold or silver, and this colour is never used for the first band. Usually the first band is very near to its end of the component, while the fourth band is offset at little further from the other end. The difference is often very small though. A more reliable guide is that bands one to three are usually grouped close together, while band four is set slightly apart from the others.

FIVE BANDS

The most common system of five band marking operates in very much the same way as the four band system, but there are three bands to indicate the first three digits of the number. The fourth band is the multiplier, and the fifth indicates the tolerance. This system is more versatile in that it enables more precise values to be marked on resistors, and it is normally only used with close tolerance (1 percent or better) components.

The resistors available to amateur users are only the usual "preferred" values (1.0, 1.2, 1.5, 1.8, etc.), and the third band is not really necessary. It is usually black (0), and this makes it reasonably easy to deal with these components if you are already conversant with the four band codes. If you simply ignore the third band, and augment the fourth one by one zero, this will give the correct value.

As an example, suppose the colours of the bands are orange, white, black, orange, and brown. This indicates that the first two digits are 3 and 9. The fourth band is orange, indicating three zeros to be added. Adding a further zero to compensate for the ignored third band gives us 39 plus four zeros, which is 390,000 ohms, or 390k, in other words. The brown final band shows that the component's tolerance is 1 percent.

The second five band method is very easy to deal with, since the first four bands indicate the value and tolerance of the component in standard four band resistor coding fashion. The fifth band shows the temperature coefficient. This is not normally of any interest, and can simply be ignored.

ON A PLATE

Modern ceramic plate capacitors do not have their values marked using colour codes, apart from those which have a coloured band at the top. This indicates the temperature coefficient, which is something you will not normally need to worry about.

The value in picofarads is normally marked on the body of the component (e.g. "150p" for a value of 150 picofarads), but sometimes the value is given in nanofarads. A marked value of something like "n39" can look a little confusing, but as is often the case in electronics, the letter which indicates the units in use also shows the position of the decimal point. In this example the "n" shows that the units in use are nanofarads, and its position indicates that the value is zero point something nanofarads. In our example the value is obviously 0.39 nanofarads. As one nanofarad equals 1000 picofarads, this value in picofarads is 390p.

Ceramic plate capacitors from the U.S.S.R. were sold by many retailers a few years ago. These seem to be more rare these days (they have red bodies with black lettering, and are sometimes referred to by the nickname "dirty reds"). The lettering on these can be a bit confusing due to the use of some unusual characters, which I presume are from the Russian alphabet. The ones that have the value marked in picofarads should not provide any problems, as they are marked somethink like "150PИ". The last character (which is a mirror imaged "N") is presumably some sort of tolerance code.

The capacitors which have their values marked in nanofarads are a bit more confusing, as the "n" seems to be replaced with an "H" (e.g. "H15C"=150p). However, once you know this, there should be no difficulty in deciphering the values.

LEAD ASTRAY

Perhaps rather unhelpfully, some transistors are produced with more than one leadout configuration, and in some instances in more than one case style. There is no problem when the different versions of a device are given totally different type numbers, but you need to be a bit more careful when the only difference in the type numbers is a suffix letter. In a few cases there is no difference in the type numbers at all. You know which version of the device you have only by examining it to find out what style of encapsulation it has! You then look up the leadout diagram for that version of the device.

The popular 2N3819 field effect transistor (f.e.t.) is the only common example of a device which falls into this category. It was originally in a standard TO92 encapsulation, with the leadout configuration of Fig. 2(a). However, a lot of recent devices seem to have exactly the same type number with no suffixes or prefixes, and the leadout configuration shown in Fig. 2(c).

Some other field effect transistors are available with two case styles and leadout configurations. The 2N5457 series normally have the case style and leadout arrangement of Fig. 2(c), but they are also available with a TO92 case and the leadout configuration shown in Fig. 2(b).

SUFFIX

Some transistors, such as the BC184 and BC212, can have a suffix letter of "K" or "L" to denote an alternative leadout configuration. All versions have the standard TO92 plastic encapsulation incidentally. Fig. 3 shows the leadout configurations for all three versions of these transistors. Obviously you must take care to obtain the right version of these transistors. The "K" versions are now obsolete, but the other two versions are widely available.

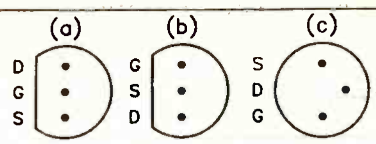

Fig. 2. Three different leadout configurations (viewed from the underside) but only two different types of transistor.

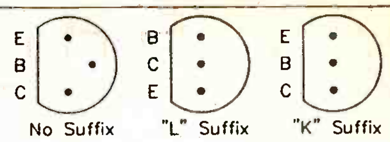

Fig. 3. The BC182 and BC212 series of transistor have different leadout configurations, depending on the suffix letter (viewed from the underside).

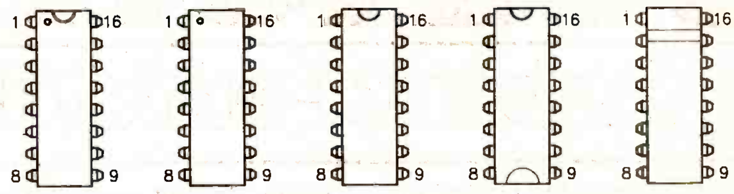

Fig. 4. Various methods of showing integrated circuit orientations (viewed from the topside).

Actually, it is not too difficult to fit the wrong version of a transistor into a circuit provided you take into account the differences in the leadout configurations, but obviously this gives increased risk of a wrongly connected component. Electrically there is no difference between devices having the same type number but a different suffix letter—only the order of the leadout wires is different.

SPOT ON

Getting an integrated circuit plugged into circuit around the wrong way is a potentially expensive mistake. Modern components are mostly quite tolerant of this type of thing, but some will be almost instantly destroyed. Many of the more complex and expensive chips, such as EPROMS and other memory devices, are easily damaged. Other chips, such as the popular 555 timer and most CMOS logic devices, are not damaged directly by having the incorrect orientation, but will draw a high supply current and quickly overheat unless corrective measures are taken. Most of the the more straightforward integrated circuits seem to be unbothered by the experience.

Trial and error cannot be recommended as a way of determining the correct orientation for integrated circuits. Most d.i.l. (dual in-line) integrated circuits have a "U" shaped notch at what is conventionally thought of as the "top" of the component, plus a small dimple next to pin 1. As viewed from above, the pin numbering of integrated circuits always runs counterclockwise.

In practice, very few integrated circuits seem to have both the notch and the dimple. Looking through my stock of integrated circuits, I would estimate that only about one third of the linear devices and virtually none of the logic chips have both. This does not really matter, since only one or the other is needed in order to determine which way round a device should be fitted.

Rather unhelpfully, a very few devices seem to have a "U" shaped notch at both ends of the component. This can be very confusing indeed if the dimple next to pin 1 is absent. The notch which is narrower and deeper seems to be the one which marks the "top" of the component.

A few d.i.l. integrated circuits do not use either the notch or the dimple method of indicating the "top" of the device. Instead they use a band marked on the top of the component. This seems to be something of a rarity, and the only chips of this type I have encountered in the last couple of years are an 8086 microprocessor and its 8087 maths co-processor. Fig. 4 shows the various means of showing integrated circuit orientations, and this should help to clarify things for you.

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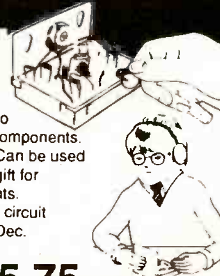

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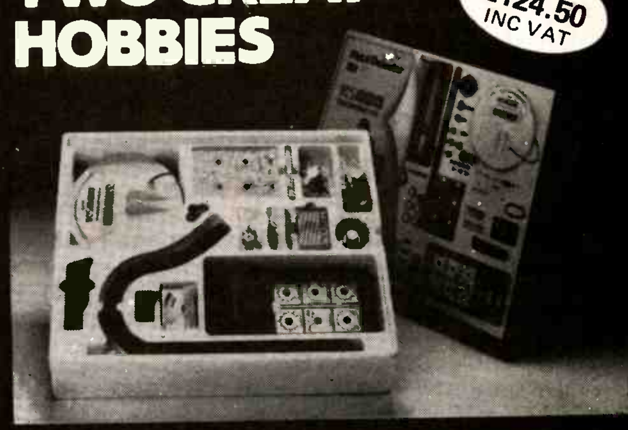

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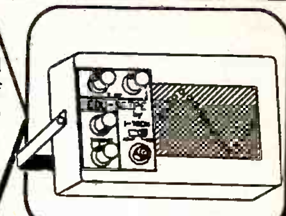

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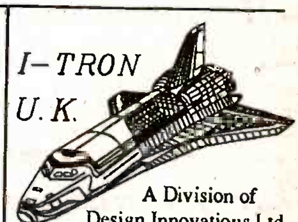

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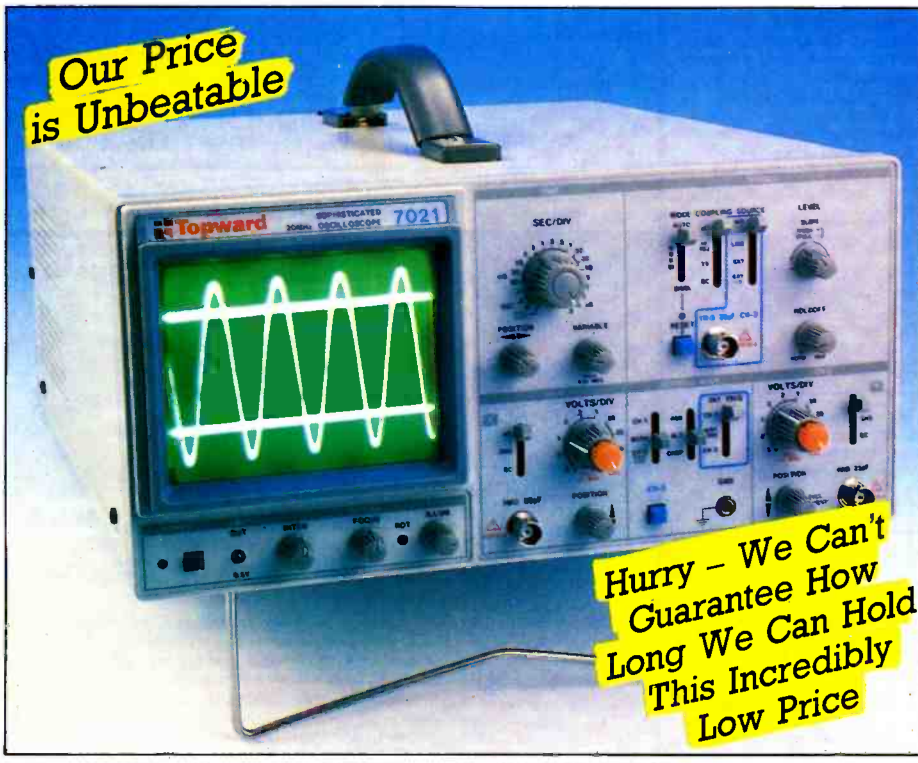

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