EVERYDAY ELECTRONICS

SEPTEMBER 1988

INCORPORATING ELECTRONICS MONTHLY

£1.30

POWER CONTROLLER

BREAKING GLASS ALARM

AMSTRAD PIO

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.

BD1 5 13A junction boxes for adding extra points to your ring main circuit.
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 upright mounting with fixed 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 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.
BD34 48 2 meter length of connecting wire all colour coded.
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 2 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.
BD246 2 Tacho generators, generate one volt per 100 revs.
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.
BD275 1 Guitar mic—clip-on type suits most amps.
BD283 3 Mild steel boxes approx 3in x 3in x 1in deep—standard electrical.
BD293 50 Mixed silicon diodes.
BD296 3 Car plugs with lead, fit into lighter socket.
BD305 1 Tubular dynamic mic with optional table rest.

Most other packs still available and you can choose any as your free one.

VERY POWERFUL 12 VOLT MOTORS—⅓rd HORSEPOWER
Made to drive the Sinclair C5 electric car but equally adapable to power a go-cart, a mower, a rail car, model railway, etc. Brand new. Price £15.00 plus £2.00 postage. Our ref 15P1.

OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's Dozen range and you become entitled to a free gift with each dozen packs.
A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letter.

NEWLY ADVERTISED ITEMS

LASER TUBE
Made by Phillips Electrical. New and unsued. This is helium-neon and has a typical power rating of .9mW. It emits random polarised light and is completley safe provided you do not look directly into the beam when eye damage could result. Do not use in the present of children unless a diverging lens is fitted. DON'T MISS THIS SPECIAL BARGAIN—£29.95 plus £3 insured delivery.

MUSIC CENTRE PANEL
Top section is the radio which is Long, Medium FM and Stereo, with calibrated scale and edgewise tuning control. Below this are the main function controls. To the left, :- Bass, Treble, Vol and Bal. These are all slider controls. In the centre section are the press button function switches:-CD/AUX, Tape, Disc, AFC, FM, LW and MW, and on the right a socket for stereo headphones. Below this are twin cassette decks. Again stereo, giving standard playback and record, also tape copying, editing etc. Finally the tape controls:- Record, Play, Rewind, Forward, Stop, Eject and Pause. There is also lead and plug for a Compact Disc Player. Requires only a mains transformer and a pair of speakers. The unit is beautifully made on a panel, size approx. 14½"×10½". Designed originally for a very expensive HiFi or Midi equipment it is "lovely to look at". Coincidentally, it is almost the identical width of the Akai midi racks we are offering and you could easily fit it into this rack. Price £15. Our ref 15P12.

Ex GPO MULTI-RANGE TEST METER 12/C1
Complete in real leather case with carrying handle—this is a 20,000 OPU instrument, with 19 ranges including AC and DC volts—dc current 5mA to 1A, 4ohms ranges up to 20meg—the low ohms range is particularly useful, you will be able to read right down to one ohm and below. This meter also has provision for reading dc current 0-5 amp and 0-25 amp. Meter size 6" long × 3" wide ×2" deep. Leather case has compartment for test leads, prods, and croc clips all of which are included. Can be used in the case. Not new but are in first class condition—tested and guaranteed. Price is £7.00. Order ref 7P5. Leather case available separately £3.00 ref 3P47.

RE-CHARGEABLE NICADS 'O' SIZE
These are tagged for easy joining together but tags, being spot welded, are easy to remove. Virtually unused, tested and guaranteed. £2.00 ref 2P141 or 6 wired together for £10.00 ref 10P47.

8 TRACK CASSETTE DECK
Complete with cassette holder. In fact, if you have any 8 track cassettes, then with the addition of 2 speakers this unit would play them. As 8 track cassettes are no longer made the units have become surplus, however, they do contain lots of useful parts: motor, tape head and drive, pulley wheels, etc. and a stereo amplifier. Mains operated. Brand new in makers packing. Only £3.00 each plus £1.00 additional postage. Order ref 3P46.

COMPUTER BARGAIN—MEMOTECH MTX 512 64K RAM
Full size QWERTY keyboard with 57 professional keys and additional 12 dual function keys arranged as a separate key pad with cursor control and editing keys. Auto repeat is standard on all keys. This is a very superior home computer and comes complete with power supply, cassette lead, TV lead and 3 cassette programmes. Brand new in manufacturer's original packing with 250 page Operator's Manual. Price £45.00 plus £4.00 postage.

STEREO SPEAKERS
Each 10 watts 8 ohm and twin speakers mounted in Walnut-finish cabinets, size 16" high × 10" wide × 6" deep. Front is black Dacron and the finish is very pleasing. Price £7.00 per pair. Extra postage and packing £3.00.

STABILISED 15v 2a PSU
A kit which mounts on a SRB panel. Mains operated. Ideal to drive monitor, etc. Price only £5.00.

SMOOTHING CAPACITOR
2,350uf 63v 10 amp at 50°C. Can type with mounting bracket. Price £2.00. Our ref 2P206.

SMOOTHING CAPACITOR
2,200uf 63v 5.8 amp at 50°C. Can type with mounting bracket. Price £1.00. Our ref BO644.

10 amp 100v BRIDGE RECTIFIER ASSEMBLY
This comprises of 4 diodes mounted on two 4"×3" sinks with bottom insulators. Price £2.00. Our ref 2P207.

BRIGHT LIGHT SWITCH
This will control mains circuits up to 10amps, gets it switch pulses from car headlights, sun, bright daylight, etc., so it does not use batteries and it's sensor is completely isolated from the mains. With full instructions supplied. Price £10.00. Order ref 10P46.

UNUSUAL MAINS MOTOR
Quite small, measures only 2"×2"×1" approx., but is surprisingly powerful. it revs at 3,000rpm and is reversible. It has good length ⅛" diameter spindle. Price £1.00. Our order ref BO640.

RUBBER 13amp EXTENTION LEAD SOCKET
Virtually unbreakable, made by Ouraplug. £1.00 each. Order ref BO641.

PAPST AXIAL FAN—MANUFACTURERS REF NO. TYP4580N.
This is mains operated. 15 watt rating and in a metal frame with metal blades so OK in high temperatures. Body size approx. 4¾" square x 1⅝" thick. £6.00 each, plus £1.00 postage. Our ref 6P6.

PRICE REDUCTION FOR THAT MODEM CONNECTOR
Standard BT flat plug and 3 metre lead. Price now reduced to 50p, 2 for £1.00. Ref BO552.

VERY POWERFUL MAGNETS
Although only less than 1" long and not much thicker than a pencil these are very difficult to pull apart. Could be used to operate embedded reed switches, etc. Price 50p each, 2 for £1.00. Ref BO642.

AC GENERATOR
This is really a motor with a permanent magnetic rotor. You would have to make a handle. The voltage out could be up to 100v and the frequency would depend upon the speed of rotation. One use could be to trigger our SS relay 2P183. Another use could be for ringing a bell in a 2 wire telephone circuit. Price £1.00. Our ref BO640.

FLIP-OVER DIGITAL CLOCK
Quite an eyecatcher, this is mains operated. The figures flip-over per minute and per hour and give a larger than usual visual display. Supplied complete with front and perspex panels to glue together to make its case. £2.00 each. Our ref 2P205.

MOTOR TO WORK OFF SOLAR CELLS
Could drive a fan or other device. Speed would depend upon the number of cells used. Six of our BO631's in series would cause it to rev at a reasonable speed. With twelve it would be quite fast and current would be 25-30mA depending on load. Price of the motor is £1.00. Our ref BO643.

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. Brighton (0273) 734648 or 203500

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

3½in FDD CHINON 80 track 500k Shugart compatible interface. Standard connections, interchangeable with most other 3½in and 5¼in drives. Brand new. £28.50 plus £3 insured post.
3in FDD HITACHI HFD305SXA Shugart compatible interface. 500k on 3in disc. Recommended for many Amstrads but interchangeable with most drives. £29.50 plus £3 insured post.
FDD CASE AND POWER SUPPLY KIT for the 3in or 3½in. £11.00. Ref 11P2 for the Chinon, 11P3 for the Hitachi.
9in MONITOR made for ICL, uses Phillips black and white tube. Brand new and complete but uncased. £16.00 plus £5.00 post.
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.
POWERFUL IONISER Uses mains transformer. Generates approx. 10 times more ions than the normal diode/cap ladder circuits. Complete kit £11.50 plus £3.00 post.
3 INCH FDD Hitachi ref. HFD 305SXA. Ideal replacement or second drive in most computers, especially Amstrad 6128, etc. Price £30 plus £3 post.
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. BO631. Module C gives 400mA, Price £2, Our ref. 2P199. Module D gives 700mA, Price £3, Our ref. 3P42.
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.
50V 20A TRANSFORMER 'C' Core construction so quite easy to adapt for other outputs—tapped mains input. Only £25 but very heavy so please add £5 if not collecting. Order Ref. 25P4.
15A PANEL METER These have been stripped from Government surplus battery charger units made originally for army use. Unused, tested but of course rather old, diameter 2in can be surface or flush mounted. £3 each. Our Ref. 3P40.
SWITCH AC LOADS WITH YOUR COMPUTER This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.
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. Order Ref. 2P191. Price £1.
BIG SMOOTHING CAPACITOR. Sprague powerlytic 39,000uF at 50V. £3. Our ref. 3P41.
HEAVY DUTY CURLY MAINS LEAD. Can be loaded up to 13A, stretces to almost 3 metres fitted with 13A plug. £3. Order ref. 3P42.
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.
BULK-HEAD MOUNTING LOUDSPEAKER. Metal case with chrome grill front and with mounting lugs for screwing to ceiling, 8in. speaker. £10 each. Order ref. 10P43 add £2 post.
TWIN GANG TUNING CAPACITOR. Each section is .0005uF with trimmers and good length ¼in spindle. Old but unuse3d and in very good condition. £1 each. Our ref. BO630.
13A PLUGS Good British make complete with fuse, 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.
24 HOUR TIME SWITCH—16A changeover contacts, up to 6 on/offs per day. Nicely cased, intebnded for wall mounting. Price £8. Ref. 8P6.
CAPACITOR BARGAIN—axial ended, 4700µF at 25V. Jap made, normally 50p each, you get 4 for £1. Our ref. 613.
PIEZO ELECTRIC FAN—An unusual fan, more like the one used by Madame Butterfly than the conventional type, it does not rotate. The air movement is caused by two vibrating arms. It is American made, mains operated, very economical and causes no interference, so is ideal for computer and instrument cooling. Price is only £1 each. Ref. BO598.
SPRING LOADED TEST PRODS—Heavy duty, made by the famous Bulgin company, very good quality. Price 4 for £1. Ref. BO597.
CURLY LEAD—Four core, standard replacement for telephone handset, extends to nearly 2 metres. Price £1 each. Ref. BO599.
ASTEC P.S.U.—Switch mode type. Input set for +230V. Output 3.5 amps at +5V, 1.5 amps at +12V, and 3 amps at +5V. Should be OK for floppy disc drives. Regular price £30. Our price only £10. Ref. 10T34. Brand new and unused.
APPLIANCE THERMOSTATS—Spindle adjust type suitable for convector heaters or similar. Price ? for £1. Ref. BO582.
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.
INTERRUPTED BEAM KIT—This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components—relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price £2. Ref. 2P15.
3-30V VARIABLE VOLTAGE POWER SUPPLY UNIT—with 1 amp OC output. Intended for use on the bench for experimenters, students, inventors, service engineers etc. This is probably the most important piece of equipment you can own (after a multi range test meter). It gives a variable output from 3-30 volts and has an automatic short circuit and overload protection, which operates at 1.1 amp approximately. Other features are very low ripple output, a typical ripple is 3mV pk-pk, 1mV rms. Mounted in a metal fronted plastic case, this has a voltmeter on the front panel in addition to the output control knob and the output terminals. Price for complete kit with full instructions is £15. Ref. 15P7.

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ABC

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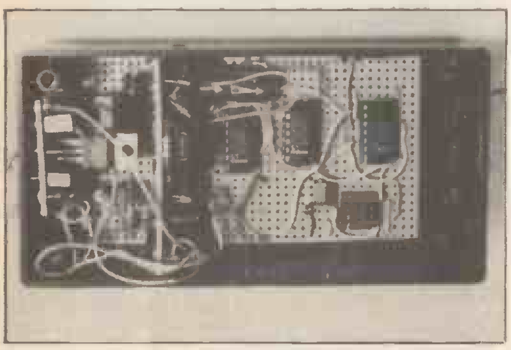
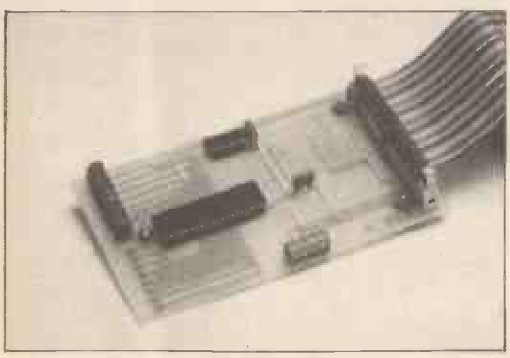
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .





Our October '88 issue will be published on Friday, 2 September 1988. See page 499 for details.

Projects

Series

Features

NEXT MONTH

New C&G City and Guilds Certificate Course

INTRODUCING DIGITAL ELECTRONICS

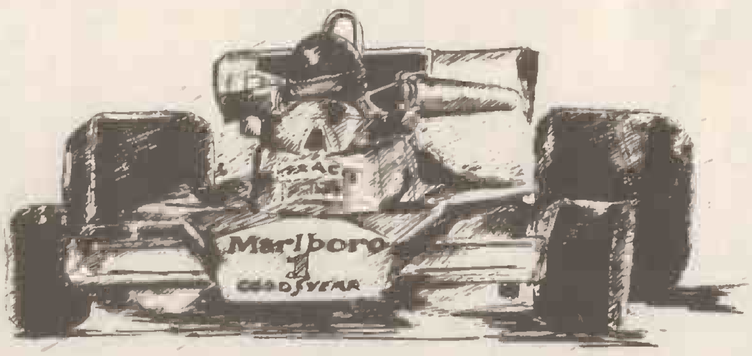
Our first open learning course leading to a City & Guilds Certificate was published last year—it was so popular we are now republishing it in book form (Teach In 88/89—Introducing Microprocessors will be available in November). Due to demand we are now going to publish a course for Introductory Digital Electronics—City and Guilds 726/301—this course is just right for anyone who wants to learn about electronics and, with a recognised qualification for successful students at the end of it, it could be the start of a career—don't miss Part 1 next month.

Free Booklet

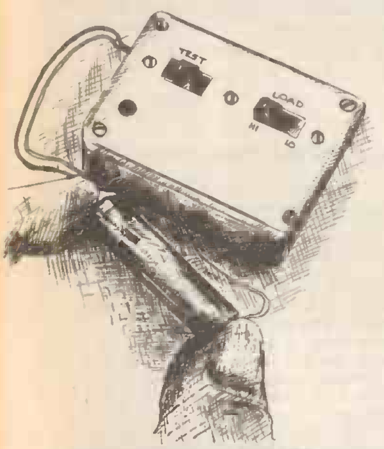
This 16 page booklet explains what the Introducing Digital Electronics course entails, how to register with a college for assessment and lists the registered assessment centres around the U.K.

QUAD CAR CONTROLLER

Double the thrill of scale car racing. This simple design enables two cars to race on each lane of a "Scalextric" track with full independent control.



EPROM ERASER



This ultra safe inexpensive unit is capable of erasing up to four EPROMS in less than twenty minutes. The inverter circuit employed could also be used to drive fluorescent tubes from a 12V supply.

BATTERY TESTER

Get the most from your batteries; this little unit will tell you when they have expired and allow replacement of the useless ones instead of all of them.

EVERYDAY ELECTRONICS

OCTOBER ISSUE ON SALE FRIDAY SEPTEMBER 2

ELECTRONICS TEACH-IN

ONLY £1.95

By Michael Tooley BA and David Whitfield MA MSc CEng MIEE

A COMPREHENSIVE background to modern electronics including test gear projects. This 104 page, A4 size book forms a complete course in basic electronics; designed for the complete newcomer it will however also be of value to those with some previous experience of electronics. Wherever possible the course is related to "real life" working circuits and each part includes a set of detailed practical assignments.

To complement the course computer programs have been produced for the BBC Micro and Spectrum or Spectrum Plus. The software is designed to reinforce and consolidate important concepts and principles introduced in the course, it also allows readers to monitor their progress by means of a series of multi-choice tests.

The book includes details of eight items of related test gear giving full constructional information and diagrams for each one. The items of test gear described are: Safe Power Supply; Universal LCR Bridge; Diode/Transistor Tester; Audio Signal Tracer; Audio Signal Generator; RF Signal Generator; FET Voltmeter; Pulse Generator.

This book is an excellent companion for anyone interested in electronics and will be invaluable for those taking G.C.S.E. or B.T.E.C. electronics courses.

See *Direct Book Service*—page 542 —for full ordering details.

PLEASE TAKE NOTE

BBC SOUND-TO-LIGHT *(June 1988)*
Page 360, lines 30 and 110 should read:
VDU 23,1,0;0;0;
VDU 19,1,C% ;0;
Note the use of semi-colons instead of commas.

AUDIO MINI BRICKS *(August 1988)*
Pages 473, 475. The envelope shaper block (ES) shown in Figs. 3.9, 3.10 and 3.13 should show Fig. 3.7 and NOT Fig. 3.1.

DATA LOGGER *(August 1988)*
We have been informed that the price of the main p.c.b. is now £13.75 and the interface p.c.b. has been increased to £5.50.

CAR ALARM *(August 1988)*
Page 481, Fig. 3. Note that the leads from the Chassis (Black) and the l.e.d. (D2) anode should be transposed. the circuit (Fig. 2) and p.c.b. pattern are correct.

For KITS & COMPONENTS - Choose the easy way – with TK

Send 50p* & SAE for CATALOGUE

*refundable with first order

ORDERS: RING (01) 567 8910 – 24 HRS.

NEW GIANT SOLAR CELLS

NOW IN STOCK these giant size solar panels 12 x 12in will deliver 12 volts 200mA in bright sunlight and 11.5 volts 60mA on a typical British summer day (dull and overcast). **HUNDREDS OF USES** in the car or caravan, e.g. Charging NiCads, powering low voltage circuits where mains or battery supplies are inconvenient or coupled to a lead acid battery and a simple inverter you could build yourself a self contained mains supply for low power appliances. Stock No. 303 145. £14.50 (plus £1.75 for p&p on total order).

SOLID STATE RELAY BARGAIN

*Zero Voltage Switching: No radio interference problems *2.5KV Input to Output Isolation: No risk of damage to your computer or driver circuits. *4KV Terminals to Heatsink Isolation: Simply bolt onto a heatsink. *3V to 32V Input Voltage: easily interfaced to TTl or CMOS Logic. *24V to 240V rms Load Voltage: Allowing mains loads to be switched. *Built in Snubber Network: Enabling switching of inductive loads. *10A Maximum Current: 4A with no heatsink fitted at 40 deg C.

CD240/10 £2.25

ELECTRONIC GUARD DOG KIT

One of the best deterrents to a burglar is a guard dog and this new kit provides the barking without the bite! The kit when assembled can be connected to a doorbell, pressure mat or any other intruder detector and will produce a random series of threatening barks making the would be intruder think again and try his luck elsewhere. The kit is supplied complete with high quality PCB, transformer, all components and instructions. All you need is a mains supply, intruder detector and a little time. The kit even includes a horn speaker which is essential to produce the loud sound required. The "dog" can be adjusted to produce barks ranging from a Terrier to an Alsatian and contains circuitry to produce a random series of barks giving a more realistic effect.

XK125 Complete kit of parts £24.00

DISCO LIGHTING KITS

DL1000K – This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel £19.25

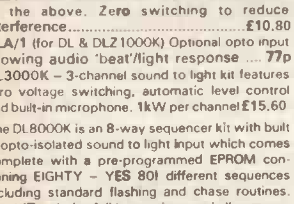
DLZ1000K – A lower cost uni-directional version of the above. Zero switching to reduce interference £10.80

DLA/1 (for DL & DLZ1000K) Optional opto input allowing audio 'beat'/light response 77p

DL3000K – 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel £15.60

The DL8000K is an 8-way sequencer kit with built in opto-isolated sound to light input which comes complete with a pre-programmed EPROM containing EIGHTY – YES 80! different sequences including standard flashing and chase routines. The KIT includes full instructions and all components (even the PCB connectors) and requires only a box and a control knob to complete. Other features include manual sequence speed adjustment, zero voltage switching, LED mimic lamps and sound to light LED and a 300 W output per channel. And the best thing about it is the price

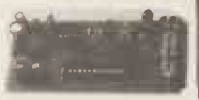
ONLY £31.50



TEN EXCITING PROJECTS FOR BEGINNERS

This Kit has been specially designed for the beginner and contains a SOLDERLESS BREADBOARD, COMPONENTS, and a BOOKLET with instructions to enable the absolute novice to build TEN fascinating projects including a light operated switch, intercom, burglar alarm, and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section on component identification and function is included, enabling the beginner to build the circuits with confidence. ORDER NO. XK118 £15.00

VERSATILE REMOTE CONTROL KIT



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

MK12 IR Receiver (incl. transformer)	£16.30
MK18 Transmitter	£7.50
MK9 4-Way Keyboard	£2.20
MK10 16-Way Keyboard	£6.55
601 133 Box for Transmitter	£2.60

HOME LIGHTING KITS

These kits contain all necessary components and full instructions and are designed to replace a standard wall switch and control up to 300W of lighting.

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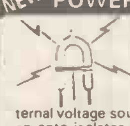

Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator. Instructions are also supplied on modifying the unit for manual triggering, as a slave flash in photographic applications or as a warning beacon in security applications. The kit includes a high quality pcb, components, connectors, 5Ws strobe tube and full assembly instructions. Supply: 240V ac. Size: 80 x 50 x 45.

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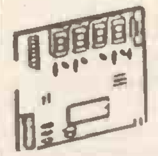

This kit contains a Single Chip Microprocessor, PCB, displays and all electronics to produce a digital readout of weight in Kgs. or Sts. and Lbs. in normal use a toothed wheel (pattern provided) is made to rotate when a weight is placed onto the scales, interrupting two infra-red beams. The processor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

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INCORPORATING ELECTRONICS MONTHLY

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NEXT month we start another "open learning" series which will lead successful readers to a City and Guilds Certificate in Introductory Digital Electronics. This is the second time we have published a course which can lead to a City and Guilds qualification–the last series *Introducing Microprocessors* is now to be republished in book form (a priority order form for this Teach-In 88/89 book will appear in next month's issue).

The new course starts at a very basic level and will form an excellent introduction to anyone wishing to learn about electronics. There is no reason why it should not be undertaken by those following G.C.S.E. courses. Although it is not necessary to take the City and Guilds assessments if you do not wish to, for a small outlay it might be possible to collect another formal qualification.

City and Guilds qualifications are of course recognised throughout the UK business world and our course might lead you on to a good career in electronics. There are further papers in the same C & G series which eventually could lead up to Advanced Digital Electronics. Why not make a start with us next month? The October issue will carry a free 16-page booklet which forms an introduction to the course and provides all the necessary information for students–don't miss it, place an order with your newsagent or take out a subscription now!

AUTUMN PLANS

Just to keep you in the picture we have some exciting plans for our autumn '88 and spring 1989 issues. Following the start of our new course we will be giving away an advertisers 100-page catalogue with the November issue (more about that next month). Then we will start giving away a special series of circuit boards on which you can build some very useful projects, including a remote control. We are working hard on these now– more information in a couple of months.

As I said, make sure of your copies of E.E.

Mike Kenward

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Constructional Project

BREAKING GLASS ALARM

ROBERT PENFOLD

Added protection for your home. Senses ultrasonic sounds generated by broken glass.

As most readers will be fully aware, the human senses are not without their limitations. In particular, the eye only responds to a very small part of the range of frequencies generally accepted as being forms of light, and the ear can detect sound waves over a relatively small range of frequencies. Although you cannot see infra-red or hear ultrasonic sounds, they are both present as part of our natural surroundings.

Electronics seems to be increasingly involved with these unseen and unheard parts of the electro-magnetic and sound spectrums. They find use in such things as remote control systems, automatic light switches, and intruder alarms.

ULTRASONICS

The unit featured here is a form of intruder alarm, and it makes use of ultrasonic sound. However, it is not of the usual "Doppler Shift" movement detector or broken beam varieties. It is designed to pick up the ultrasonic sound waves produced when an intruder tries to break into premises by breaking a window.

On the face of it, the use of ultrasonics in this application is unnecessary, since breaking glass produces strong sound waves in the audio spectrum, and a normal sound activated switch should do the job equally well. In fact there would seem to be advantages to an ordinary sound switch in that it would probably give greater range and a less restricted angle of "view". Ultrasonic sound waves tend to be highly directional, and to be more readily absorbed by air than audio frequency sounds.

There are in fact advantages in using an ultrasonic system. With most types of burglar alarm there is no real difficulty in obtaining good sensitivity. The main difficulty is in avoiding false alarms.

FALSE TRIGGERING

A unit which responds only to ultrasonic sound is likely to be less prone to false alarms as there are fewer sources of strong ultrasonic sounds in most environments. The directivity of ultrasonic systems is helpful in cutting out possible causes of spurious triggering.

The same is true of the high absorption of high frequency sound waves in air. The chances of loud but distant sounds activating the unit are quite remote. For example, something like a low flying aircraft would be quite likely to activate an ordinary sound triggered switch, but would be very unlikely to trigger an ultrasonic type.

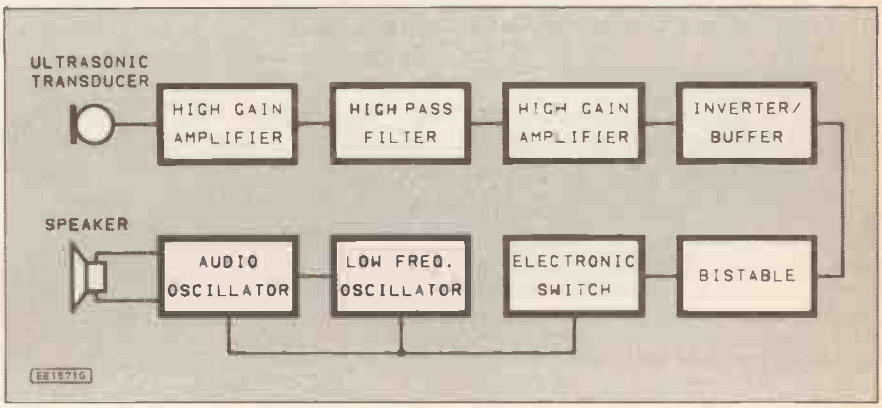


Fig. 1. Block diagram of the Broken Glass Alarm system.

An aircraft probably produces some ultrasonic sound, but very little of what is produced is likely to reach the ground. The same is also true of thunder, with its predominantly low frequency content. Another advantage of ultrasonics is that, unlike low frequency sounds, they are largely blocked by windows and walls.

Alarms of this type are not totally immune to false alarms, but they are generally accepted as being less prone to problems in this respect than many other types of alarm. The most likely cause of a false alarm is when strong audio sound waves vibrate something in the vicinity of the alarm and cause it to produce ultrasonic sound waves.

Apparently it is important that all the broken glass should be removed when a smashed window is repaired, including any tiny chips, as these can be stimulated into producing ultrasonic sound waves by strong audio frequency sounds. Breaking glass alarms have been known to operate when a window in another building some distance away has been broken. This is almost certainly due to this phenomena of audio to ultrasonic conversion, rather than direct pick up of the ultrasonic sound over a long distance.

As described here the alarm is a self contained battery powered unit having a built-in two tone alarm generator circuit. It is intended to act as a simple stand-alone burglar deterrent, but the unit could probably be incorporated into a comprehensive alarm system without too much difficulty by someone with a reasonable knowledge of electronics.

SYSTEM OPERATION

The block diagram of the overall make-up of the Breaking Glass Alarm is shown in Fig. 1, and helps to explain the way in which it functions. Ordinary microphones are very inefficient at ultrasonic frequencies, and so an ultrasonic transducer (of the type designed for remote control applications etc.) is used at the input of the unit.

Although ultrasonic transducers have a sharp peak of sensitivity centred on a certain frequency (usually 40kHz), they offer quite good sensitivity over a much wider frequency range. I tried out several different types of transducer, including 25kHz, 32kHz, and

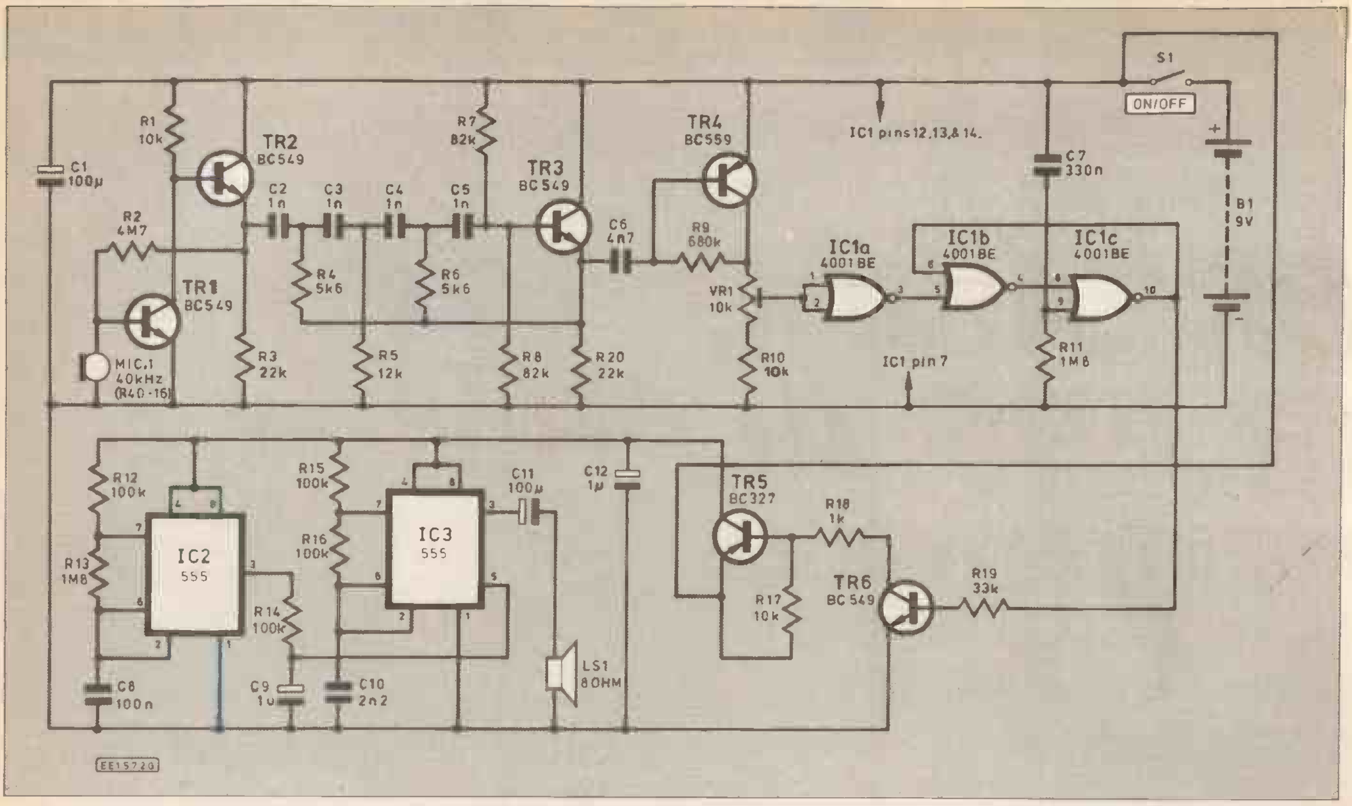


Fig. 2. Complete circuit diagram for the Breaking Glass Alarm.

standard 40kHz components, but it was a 40kHz transducer that gave the best results.

The output level from the transducer is not likely to be very high, and so this signal is boosted by a high gain amplifier. The next stage is an active high-pass filter which severely attenuates any audio frequency signals produced by the transducer.

The sensitivity of an ultrasonic transducer is very low indeed over most of the audio frequency range, but a significant output signal can be produced over the upper part of the audio spectrum. This filter greatly reduces the risk of audio frequency signals spuriously activating the alarm. The filter is followed by a second high gain amplifier stage.

This gives quite a strong output signal when breaking glass is detected. The function of the rest of the circuit is to convert the strong ultrasonic sounds into a switching action that operates an alarm generator circuit, and keeps it switched on indefinitely.

The latching action is provided by a bistable circuit that is driven from the output of the amplifier via an inverter/buffer stage. An electronic switch is driven from the output of the bistable, and at switch-on the bistable is provided with a "reset" pulse that places its output low and turns off the switch.

Normally the output voltage from the amplifier is too high to "set" the bistable, but when an ultrasonic sound is detected the bistable is "set" on the first negative half cycle at the output of the amplifier. Once "set" the bistable remains in this state until it is manually "reset".

The alarm generator is controlled by the electronic switch, and it is therefore activated when the switch is turned on. The alarm is a form of two-tone type, where the pitch of the audio frequency oscillator is swept up and down between two pitches by a low frequency oscillator. This gives a sort of warbling sound that is quite penetrating and effective as an alarm sound.

CIRCUIT OPERATION

The full circuit diagram for the Breaking Glass Alarm appears in Fig. 2.

MIC. 1 is the ultrasonic transducer, and the first amplifier is a common emitter type built around transistor TR1. This stage runs at a fairly low collector current of well under 1 milliamp, but it still provides a high level of gain over the ultrasonic range of about 20kHz to 80kHz. Transistor TR2 is an emitter follower buffer stage, and this is needed in order to give a low output impedance to drive the next stage.

This is a conventional active high-pass filter having transistor TR3 as the buffer stage. The filter is a "four-pole" (24dB per octave) type having a cutoff frequency of slightly over 20kHz. The output of the filter is coupled by capacitor C6 to the input of the second amplifier stage, which is another common emitter type.

Preset control VR1 enables the quiescent output voltage of the amplifier to be adjusted. This permits the output voltage to be set high enough to ensure that the unit is not simply activated at switch-on, but low enough to give good sensitivity.

The inverter/buffer stage uses a CMOS quad 2-input NOR gate, IC1a, wired as a simple inverter, and two of the other gates of IC1 are cross-coupled so that they act as a basic bistable circuit. Capacitor C7 and resistor R11 provide the positive reset pulse to the bistable at switch-on. One gate of IC1 is left unused, and its inputs are tied to the positive supply rail to protect them against static damage.

The electronic switch has the common emitter stage based on transistor TR6 driving a second common emitter switch (TR5). This combination gives very high gain, and can easily handle the fairly high output currents involved when the alarm is activated.

ALARM GENERATOR

Both the oscillators in the alarm generator are standard 555 astable circuits. IC2 provides the low frequency modulation while IC3 operates as the tone generator.

The modulation is applied to pin 5 of IC3, and it has the effect of varying the charge and discharge thresholds of IC3. This gives frequency modulation, and with capacitor C9 omitted the operating frequency of IC3 is simply switched between two frequencies. Capacitor C9, in conjunction with resistor R14, provides lowpass filtering that produces a smoother transition from one frequency to the other, and a somewhat more effective alarm signal.

The basic frequency of the alarm is easily changed if desired, and it is inversely proportional to the value of capacitor C10. Similarly the modulation frequency is inversely proportional to the value of capacitor C8.

The modulation depth is controlled by resistor R14 (lower values giving greater modulation), while the values of both R14 and capacitor C9 control the smoothness of the modulation. By making changes to the values of these components a considerable repertoire of alarm sounds is available..

Output currents of well over 100 milliamps are available from a standard 555 timer, and using an eight ohm loudspeaker quite high volume levels are achieved. The unit is certainly adequate in this respect for a simple burglar deterrent for use indoors.

A load impedance as low as eight ohms can tend to "pull" a 555 oscillator off its natural operating frequency, but a good alarm sound should still be obtained even if this should happen. A higher impedance loudspeaker can be used, but these seem to give significantly lower volume levels. The use of an "improved" version of the 555 for IC3 is not recommended, as many of these devices are low power types which have much lower maximum output currents than the standard device.

Burglar alarms often incorporate a timer that automatically shuts off the alarm a few minutes after it has been activated, so as to prevent the alarm from causing a public nuisance. This feature has not been incorporated in the present design, and it would be of limited value in a low power unit for indoor use.

S1 is the on/off switch, and the alarm is reset by switching off, waiting a second or so, and then switching on again. It is advisable to use a key-switch for S1 so that there is no quick and easy way for an intruder to silence the alarm once it has been activated.

The stand-by current consumption of the unit is only about 1 milliamp. This is low enough to permit economic battery operation, and six good quality HP7 size cells fitted in a plastic holder are sufficient to power the unit for well over 2000 hours of operation, which equates to around 3 to 4 months of continuous operation. Assuming the unit is used intermittently, the batteries will have something not far short of their "shelf" life.

Note that once the unit is activated the current consumption increases to something in the region of 80 to 90 milliamps. A fairly high capacity battery *MUST* be used in order to allow this fairly high current drain to be met, as well as to give good battery life.

CONSTRUCTION

The printed circuit board accommodates all the components apart from the loudspeaker, battery, on/off switch and microphone. The component layout and full size copper foil master pattern is shown in Fig. 3.

COMPONENTS

Approx. cost Guidance only **£18**

Resistors

R1, R10, R17	10k (3 off)
R2	4M7
R3, R20	22k (2 off)
R4, R6	5k6 (2 off)
R5	12k
R7, R8	82k (2 off)
R9	680k
R11, R13	1M8 (2 off)
R12, R14, R15, R16	100k (4 off)
R18	1k
R19	33k

All resistors 0.25W 5% carbon

Potentiometer

VR1	10k sub-min hor. preset

Capacitors

C1, C11	100µ radial elec. 10V (2 off)
C2, C3, C4, C5	1n polyester (4 off)
C6	4n7 polyester
C7	330n polyester
C8	100n polyester
C9, C12	1µ radial elec. 63V (2 off)
C10	2n2 polyester

Shop Talk

See page 527

Semiconductors

TR1, TR2, TR3, TR6	BC549 *npn* silicon (4 off)
TR4	BC559 *pnp* silicon
TR5	BC327 *pnp* silicon
IC1	4001BE CMOS quad 2-input NOR
IC2, IC3	NE555P timer (2 off)

Miscellaneous

B1	9V (six HP7 size cells in holder)
Mic.1	40kHz ultrasonic transducer (R40-16)
LS1	80mm diameter, 8 ohm impedance speaker
S1	Keyswitch

Printed circuit board available from *EE PCB Service*, code EE617; case (161mm×96×59mm), with aluminium front panel; 8-pin d.i.l. i.c. holder (2 off); 14 pin d.i.l. i.c. holder; battery connector (PP3 type); wire; solder; etc.

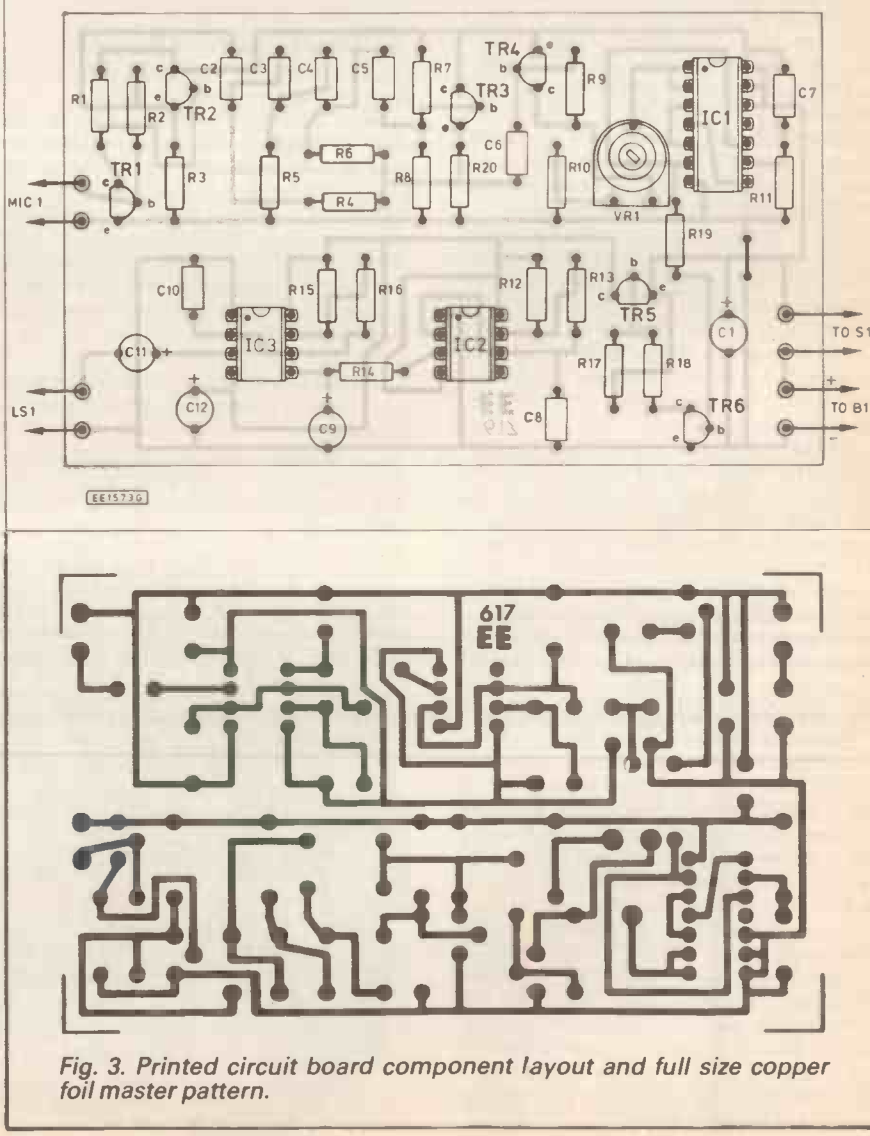
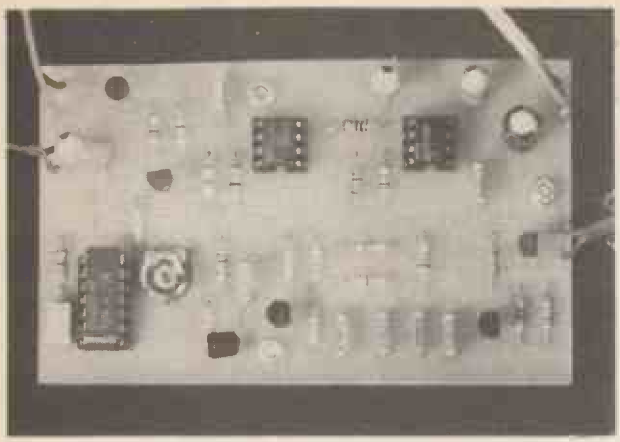
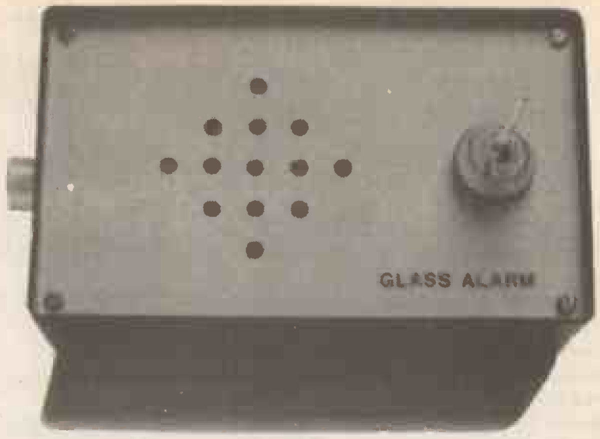


Fig. 3. Printed circuit board component layout and full size copper foil master pattern.



Layout of components on the circuit board.



Completed alarm showing the key-operated switch.

This board is available from the *EE PCB Service*, code EE617.

Construction of the board presents little that is out of the ordinary, but bear in mind that IC1 is a CMOS device and that it consequently requires the usual anti-static handling precautions. Also, do not overlook the single link-wire just to the right of resistor R19. Pins are fitted to the board at the points where connections to off-board components will be made.

A plastic case having an aluminium front panel is used as the housing for the prototype, this has approximate outside dimensions of 161mm by 96mm by 59mm, but a somewhat smaller case should be capable of accommodating everything. For any security application it is advisable to use a reasonably tough case, but in this application it is not essential to use something as hardy as a diecast aluminium or heavy gauge steel type.

Switch S1 is mounted on the right hand section of the front panel, and the component I used required a 20mm diameter mounting hole which was made with a chassis punch. This seems to be typical of the mounting requirements for keyswitches. The loudspeaker is mounted to the left of S1, leaving space for the batteries to fit between these two components.

A loudspeaker grille can be made by drilling a matrix of holes about 5mm in diameter. Be very careful with the positioning of the holes as it is a lot more difficult to make a really neat job of this than you would imagine.

With miniature loudspeakers there is usually no obvious means of fixing them in place, and it is generally a matter of carefully gluing them in place using a good quality adhesive such as an epoxy type. Try to avoid smearing adhesive onto the diaphragm.

The situation is similar for the ultrasonic transducer (MIC. 1), which is mounted on the left hand end panel of the case, and which will almost certainly have to be glued in place. The unit will probably work quite well with any 40kHz ultrasonic transducer, but of the types tried the Chartland Electronics R40-16 gave comfortably the best results.

To complete the unit the small amount of point-to-point style wiring is added. The connections to the battery holder are made via an ordinary PP3 type battery connector.

Many ultrasonic transducers, including the R40-16, have one terminal connected to their metal case. With such transducers this terminal should be the one which connects to the negative supply rail.

TESTING AND USE

After giving the wiring a thorough final check, set preset VR1 at a mid-setting and switch-on the unit. The alarm will probably not be activated, but if it is, switch off again and set VR1 fully clockwise. The alarm should then fail to activate when the unit is switched on again.

It is not necessary to smash glass to test the unit, and any ultrasonic sound in front of the transducer should activate it. Rubbing your fingers together in front of the unit should be sufficient!

By adjusting VR1 in an anticlockwise direction it will probably be possible to gain some increase in sensitivity. However, it is probably best to adjust VR1 well off the point at which the alarm is triggered, as otherwise the unit may well be prone to spurious triggering.

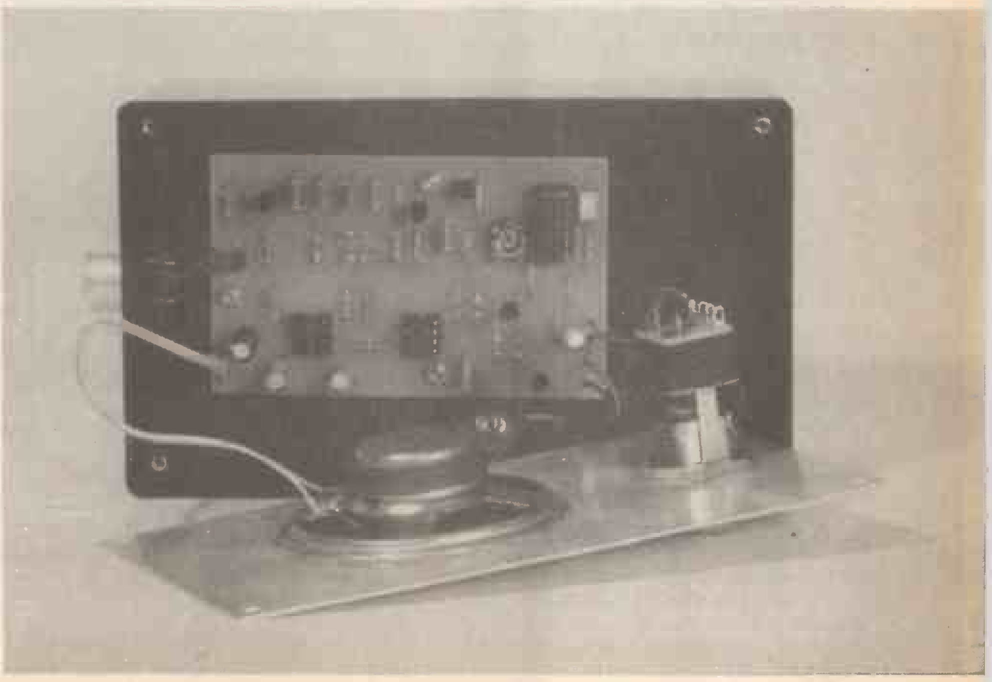
With the prototype there were no problems with vibration from the on/off switch tending to trigger the unit at switch-on. However, if this should prove to be problematical, making the initial reset pulse longer by increasing the values of capacitor C7 and (or) resistor R11 should eliminate the problem.

When deciding where to install the unit, bear in mind that the angle of "view" of the transducers is fairly narrow. With a large window, or several windows side-by-side, coverage will probably be better with the unit angled across the window rather than aimed perpendicular to it.

During experiments, using two transducers connected in series, with the two of them aimed in slightly different directions, seemed to work quite well, giving a wider acceptance angle. Optimum reliability would probably be obtained with the transducer mounted on the window, but this would be likely to give away the presence of the alarm. The sound of breaking glass should be detected reliably at a range of at least three metres.

Avoid mounting the unit very close to electric fires, refrigerators, mains wiring, and other likely sources of electrical impulses that could be picked up by the unit and cause false alarms. □

The completed Breaking Glass Alarm with front panel removed to show positioning of the circuit board and wiring to the transducer, speaker and keyswitch.



b...Beeb...Beeb...Beeb...B

...HEART RATE MONITOR INTERFACE...

ELECTRONICS in medicine is one of the more interesting aspects of electronics, but is one that may seem to have no significance whatever for the amateur enthusiast. I would certainly not advocate do-it-yourself diagnosis of heart conditions, which has about as much to commend it as teach yourself brain surgery! However, provided you are not the type that gets every disease under the sun within five minutes of starting to read a medical book, there are some interesting heart rate experiments that can be easily carried out.

These do not need to be based on a computer, but there are definite advantages in using one. These are mainly a computer's ability to do some mathematics so that data can be displayed in a meaningful fashion, and the graphics capability which enables oscilloscope type displays to be obtained.

With the low frequencies involved in this application the storage oscilloscope capabilities of the BBC micro are very useful. These low frequency signals are also well within the digitizing capabilities of the BBC micro's built-in analogue to digital converter.

Photoplethsymography

An alternative (and very simple) approach to monitoring the heart's activity is to use an optical sensor. I suppose that strictly speaking this type of sensor detects blood-flow, and is only indirectly monitoring the activity of the heart. It is still quite an interesting and effective way of doing things though.

The basic idea is to have a bright light shining through some fairly thin part of the body, which generally means a fingertip or the flap of skin between two fingers (or the forefinger and thumb). A photocell placed opposite the light source registers the amount of light passing through the fingertip (or whatever), and this light level varies in sympathy with the pulse of the person being monitored. Apparently this method of sensing is called photoplethsymography!

The block diagram of Fig. 1 helps to explain the set-up used in the design featured here. The sensor uses an ultra-bright l.e.d. as the light source and a cadmium sulphide photo-resistor as the light detector.

The l.e.d. must be an "ultra-bright" or "super-bright" type, and not a standard device or even a high brightness type. I tried these and found the standard devices to be completely useless in this application, with the higher brightness types failing to perform adequately much of the time.

The best l.e.d.s for this application are ones which give an output of around 250mcd or more (as sold by Rapid Electronics and Maplin Electronic Supplies for example). Only use a 0.2in. (5mm) or other large types. The 3mm diameter ultra-bright devices seem to provide a far lower output level than the larger types. Out of interest I tried some infra-red l.e.d.s in the unit, but these just failed to give sufficient output to drive the unit reliably.

It is unlikely that the output from the photocell circuit will be particularly strong, and a signal of around 10 or 20 millivolts peak-to-peak would be expected. This is amplified by a factor of ten in the first amplifier, and then by a further factor of ten in a second stage of amplification. This gives an output signal of typically about 1 to 2 volts peak-to-peak which can drive the analogue input of the BBC micro.

There is no need to worry about isolation between this circuit and the micro because the person being monitored is not in electrical contact with the circuit. They need only touch the plastic cases of the l.e.d. and photo-resistor.

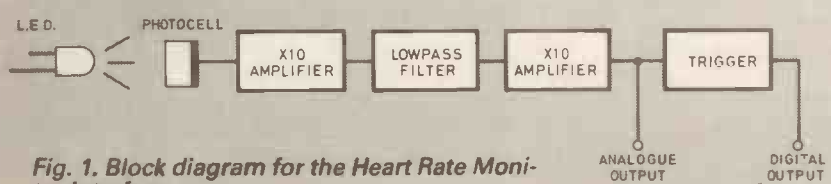


Fig. 1. Block diagram for the Heart Rate Monitor Interface

Opto Sensor

One way of monitoring the activity of the heart is via electrodes which pick up the electrical signals in the body. This requires less sophisticated equipment than you might expect, and the only real difficulty is in obtaining consistent electrical contact between the electrodes and the skin of the "patient". The special electrodes and conductive jelly can be obtained though, or it is possible to improvise something that will give satisfactory results.

There is an additional problem when utilizing this method with the BBC micro, and this is that the BBC computer is mains powered. For safety reasons an isolation circuit must be included between the person being tested and any mains powered equipment in the system. There is no great difficulty here if the information being passed to the computer is digital in nature, and the most basic of opto-isolator circuits will then suffice.

However, when measuring the electrical activity of the body it is interesting to view the waveforms obtained, and this necessitates the use of an analogue isolator circuit. This is a little more difficult, but is perfectly possible, and something that we will return to at a later date.

Noise

The circuit is likely to pick up a certain amount of electrical noise, and in particular mains "hum" may be loosely coupled from the body of the person being monitored into the photocell due to their very close proximity. Although the level of pick up is not likely to be very great it can still cause problems. Some low-pass filtering is, therefore, used to attenuate any noise that is picked up.

Although mains "hum" is at the rather low frequency of 50 Hertz, low- pass filtering can still be used to good effect as the frequencies we require are much lower at around 0.5Hz to 5Hz. Some simple filtering is sufficient to severely attenuate any interference from the mains supply.

If the unit is to be used as a heart rate monitor it is a pulse output signal at standard logic levels that is required. A suitable signal is produced by processing the analogue output signal with a Schmitt trigger circuit.

Heart Rate Interface

The full circuit diagram of the Heart Rate Interface is shown in Fig.2. Diode D1 is the l.e.d. and R1 is its current limiting resistor. The latter sets the l.e.d. current at approximately 45 milliamps, but can be made a little higher in value if the l.e.d. used for D1 cannot handle a current this high (100 ohms is

COMPONENTS

Resistors

R1	68
R2, R6, R12	100k (3 off)
R3	ORP12 light dependant resistor
R4, R5	6M8 (2 off)
R7, R8, R13	1M (3 off)
R9	10k
R10	2k2
R11	10M

All 0.25W 5% carbon

Capacitors

C1	100µ elec. 10V
C2	100n poly. layer
C3	4µ7 elec. 10V
C4	47n poly. layer
C5	470n poly. layer
C6	10µ elec. 10V
C7	4n7 poly. layer

Semiconductors

D1	Ultra-bright l.e.d.
IC1, IC2	CA3140E MOSFET Op. Amp (2 off)
IC3	CA3130E MOSFET Op. Amp

Miscellaneous

SK1, SK2, co-axial socket (2 off); 8-pin i.c. holder (3 off); stripboard; case; connecting wire, solder, etc.

Approx. cost Guidance only **£7**

suitable for 30 milliamp l.e.d.s). The photocell, R3, is the ever popular ORP12 cadmium sulphide photo- resistor.

The two amplifiers are based on IC1 and IC2, and use the non-inverting and inverting modes respectively. Frequency selective negative feedback is provided by capacitors C4 and C7, and this gives the low-pass filtering. Although only two stage filtering is provided, giving a 12dB per octave attenuation rate, this seems to be more than adequate.

Note that the coupling and decoupling capacitors have been made much higher in value than would be the case if the circuit was for audio use. This is essential as here we are dealing with signals at frequencies in the so called "infra-audio" range, and the circuit must have an extended low frequency response.

The trigger circuit is built around IC3 and a certain amount of hysteresis is introduced by resistor R12. This is important as the input waveform can be quite complex and there would otherwise be a danger of multiple output pulses being generated.

Note that IC3 is a CA313OE and not a CA314OE (as used in the IC1 and IC2 positions). In the past I have used the

It is worth pointing out that the unit should work properly with other computers having suitable digital and (or) analogue inputs. It could even be built as a simple stand-alone unit with a l.e.d. indicator being driven from the output of IC3.

The output from SK1 can, of course, be coupled to an oscilloscope if desired.

Construction And Use

Construction of the unit is, in the main, quite straightforward. Although the unit has quite high voltage gain, due to its very restricted bandwidth it is highly unlikely that any problems with instability due to stray feedback will be experienced.

The only out of the ordinary aspect of construction is the optical sensor. Obviously the l.e.d. (D1) and the photo resistor (R3) must be positioned where it is easy for someone to place their fingertip between the two, and with a suitable distance separating them (about 15mm should suffice).

One possible approach is to have them mounted on the circuit board and inside the case, with a cutout in the case to accommodate the subject's (victim's?) finger. The leadouts of both components would have to be bent at right angles in order to get them

A crucial point to keep in mind is that the optical sensor and the subject's fingertip must be kept still when the equipment is being used. This type of sensor is not suitable for heart rate monitoring when the subject is exercising or on the move. The equipment is not suitable for use on the move anyway, since the BBC micro is not exactly portable, and so this is not a major drawback.

Another important point to bear in mind is that the extended low frequency response of the circuit means that it will take several seconds after switch-on before it will begin to function properly. Also, when a fingertip is placed into the sensor it may take a few seconds for the d.c. levels in the circuit to settle down and the circuit to start functioning properly.

When initially testing the unit it is probably best to ignore the analogue output and just use the digital signal at SK2. This simple program, Listing.1, simply prints "HIGH" or "LOW" on the screen, reflecting the logic output level of the unit.

If the unit is functioning properly this should switch from one state to the other at a fairly consistent rate. It will not change to-and-fro at an absolutely constant rate though. For instance, it is normal for ones'

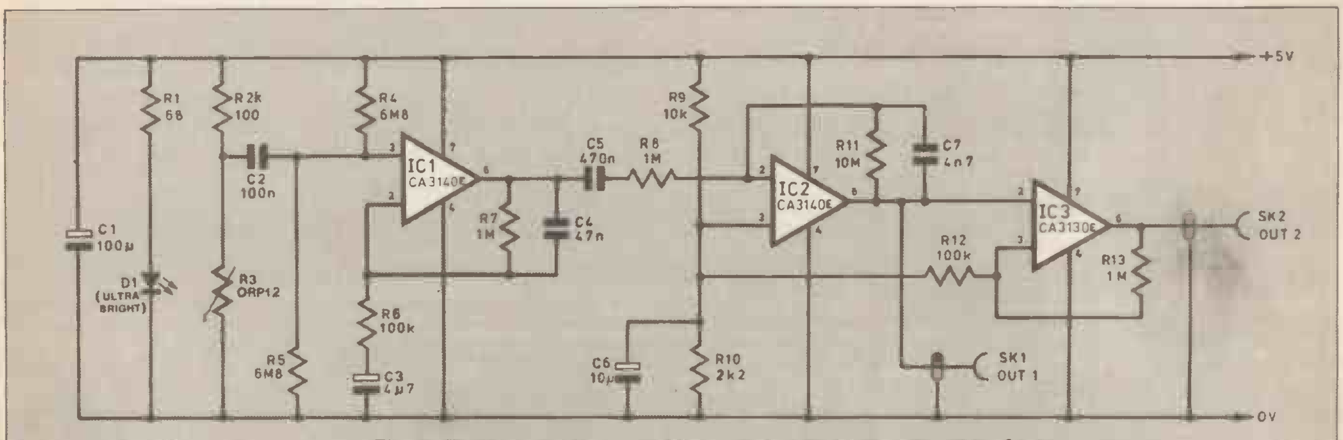


Fig. 2. Full circuit diagram for the Heart Rate Monitor Interface

CA314OE to successfully drive the digital inputs of the BBC computer, but not all the current devices give reliable results when used in this way.

The CMOS output stage of the CA313OE seems to give more reliable results with the BBC micro's digital inputs. Either device can drive the very high input impedance of the analogue inputs successfully.

Note though, that these devices have output stages that enable them to provide output voltage almost right down to the 0V supply potential. Most other operational amplifiers can not do this, and will not work in this circuit.

A five volt supply is required and the current consumption of the unit is about 50 milliamps. The +5V supply output of the BBC micros's analogue port can, therefore, be used to power the unit.

The analogue output at SK1 (Output 1) can be used to directly drive any of the four analogue inputs of the computer. The values of bias resistors R8 and R9 have been chosen to give an output voltage range that suits the 0V to 1.8V range of the analogue inputs. The digital output signal from SK2 (Output 2) could be used to drive an input of the user port, but it is probably easier to use it with one of the "firebutton" inputs of the analogue port.

properly aligned. This method has the advantage that the photocell will be largely shielded from the ambient light level.

The unit will work perfectly well with the photocell subjected to a moderately bright ambient light level, even if this light is generated by mains lighting and is heavily modulated with a 100 Hertz "hum" signal. The subject's fingertip should shield R3 to a large extent and keep the problem down to an acceptable level, but avoid having R3 subjected to very high light levels.

Another approach is to have the two opto-components constructed as a separate unit and connected to the main unit via a *screened* cable. This is likely to be much more difficult, but it enables the sensor to be used on other parts of the body (earlobes for example).

heart rate to be marginally higher when breathing in than when breathing out.

If the output state remains the same or changes randomly do not panic. This indicates a problem with the interface and not imminent death!

The most likely cause of problems is the sensor. Most ultra-bright l.e.d.s have a built in lens that gives a very narrow beam of light. The l.e.d. must, therefore, be accurately aimed at photo-resistor R3.

Also, as explained previously, the fingertip must be kept still, or spurious signals will be generated. If reliable operation of the unit cannot be obtained, try boosting the gain by making resistor R6 higher in value (about 3M3), and reduce the hysteresis of the trigger circuit by making resistor R12 higher in value (say 2M2).

Listing.1: Interface Test Program

```
>LIST
   10 REM HEART RATE MONITOR TEST PROGRAMME
   20 REM USE EITHER "FIREBUTTON" INPUT
   30 CLS
   40 REPEAT
   50 IF (ADVAL(0) AND 3) = 0 THEN PRINTTAB(10,10) "LOW "
   60 IF (ADVAL(0) AND 3) <> 0 THEN PRINTTAB(10,10) "HIGH"
   70 IF (ADVAL(0) AND 3) <> 0 THEN SOUND 1,-15,53,1
   80 FOR D = 1 TO 78: NEXT
   90 UNTIL FALSE
>
```

exploring electronics

OWEN BISHOP

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

Part 27 Field Effect Transistors.

FIELD effect transistors, or f.e.t.s, are widely used in electronic circuits today and are taking over many of the tasks for which we previously used the ordinary bipolar junction transistor. We will look at the difference between the two types but, before we can do that, we must say something about semiconductor *junctions*.

There are two types of semiconducting material, *p*-type and *n*-type. There is not enough space here to go into the nature of these materials, or precisely what their names mean, but the essential point is that something interesting happens when we join *p*-type to *n*-type.

The *pn junction* (Fig. 27.1) is the basis of many semiconductor devices. The simplest of these is the diode, which we have met several times in this series, and which consists of a single *pn* junction.

We have previously shown in this series that a diode conducts in only one direction. This is because of the nature of the *pn* junction. What happens is that when the two types of material are placed in contact, a potential difference appears between them. The *n*-type has a potential about 0.7V higher than the *p*-type. Further, on either side of the junction, there appears a *depletion zone*, a zone in the semiconductors in which there are no carriers of electrical charge (e.g. no electrons).

To make current flow across the junction we apply a p.d. greater than 0.7V, as in Fig. 27.2. This overcomes the p.d. between *p*-type and *n*-type, the depletion zone disappears and the diode conducts. It is said to be *forward-biassed*. But, if we apply a reverse p.d., the depletion zone simply becomes wider, as in Fig. 27.3. There is no conduction.

BIPOLAR JUNCTION TRANSISTOR

Now we are ready to look at the action of a bipolar junction transistor, Fig. 27.4. The *npn* transistor (the commonest type used today) has a very thin layer of *p*-type (the **base**) sandwiched between two *n*-type layers (**collector** and **emitter**).

Taken together, the base and emitter form a *"diode"*, as do the base and collector. If the base is made positive of the emitter (more than 0.7V), current flows in at the base and out at the emitter.

It might be thought that it is impossible for any current ever to flow from collector to emitter, since the collector-base diode would be *reverse-biassed*. However, because the base layer is so thin, quite the opposite occurs. As Fig. 27.4 shows. when a small base current I_B flows from base to emitter and the collector is a few volts positive of the emitter, it causes a much larger collector current I_C to flow from collector to emitter.

ELECTRONIC SWITCH

By turning the base current on or off, we can turn the collector current on and

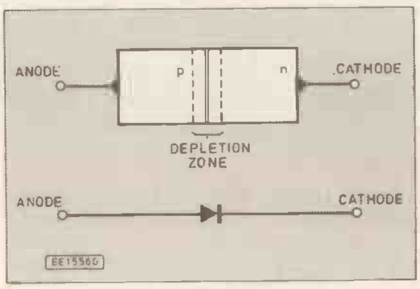


Fig. 27.1. The Diode, diagram and circuit symbol.

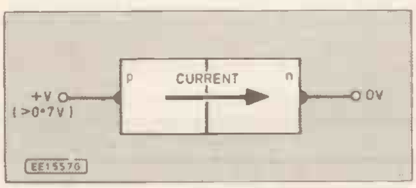
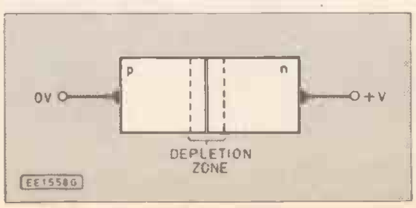


Fig. 27.2. Forward-biassed, diode conducts.

Fig. 27.3. Reverse-biassed, diode does not conduct.



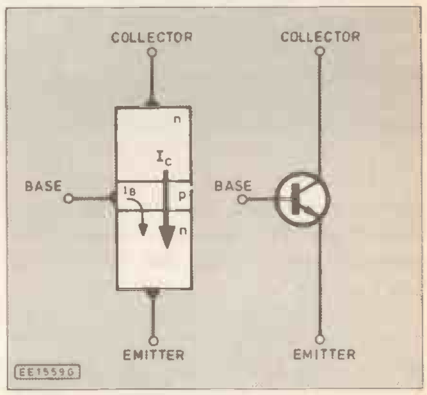
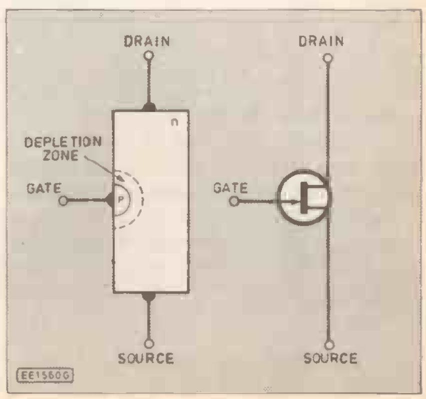
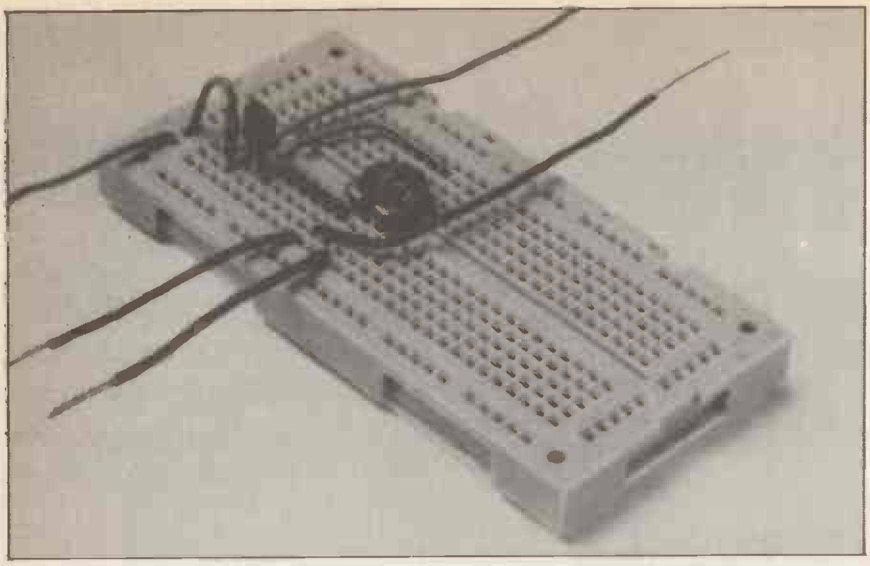


Fig. 27.4. Bipolar junction transistor, diagram and circuit symbol.

Fig. 27.5. Junction f.e.t., diagram and circuit symbol.





COMPONENTS

Resistors

R1	1M
R2	100
R3	470
R4	2k7

All 0.25W
5% carbon

Shop Talk
See page 527

Potentiometer

VR1 10k sub-min. skeleton preset horiz.

Semiconductors

D1	TIL209 red l.e.d.
TR1	2N3819 *n*-channel f.e.t.
TR2	ZTX300 *npn* transistor

Miscellaneous

Breadboard (Verobloc); B1, B2 6V battery and connectors (2 off); materials for touch plate (see text); connecting wire and Voltmeter (multimeter), set to 10V f.s.d. scale.

Approx. cost Guidance only **£5** *(excluding meter)*

off–the transistor works as a *switch*. Since the collector current is much bigger than the base current (20–200 times) we can also use the transistor as a *current amplifier*. Circuits making use of these properties have been demonstrated many times in this series.

FIELD EFFECT TRANSISTOR (f.e.t.)

The field effect transistor (f.e.t.) works in an entirely different way. Fig. 27.5 shows it to be a single bar of semiconductor material (*n*-type in this example, but it could be *p*- type). Current flows freely along the bar of *n*-type material. Normally one end, the **drain,** is made positive of the other end, the **source**, so electrons flow from the source to the drain.

To one side of the bar is a small region of *p*-type material, the **gate**. This is surrounded by a depletion zone, as explained above. The depletion zone insulates the gate from the drain and source.

If the gate is at zero volts (with respect to the source) the depletion zone is small. Electrons cannot flow though this zone, so it restricts the flow of electrons along the bar, but not unduly. However, if the gate is made negative of the source, the gate and *n*-type material are equivalent to a reverse-biassed diode.

The more negative we make the gate, the wider the depletion zone becomes. The conducting region of the bar gradually becomes pinched off, reducing the current along the bar. If the gate is made negative enough, the depletion zone extends right across the bar and no current can flow.

The action of this type of transistor depends *not on the flow of current* (such as the base current of a bipolar transistor) but on the *effect of the electric field* caused by the *potential* of the gate. This is why it is called a *field effect* transistor.

FET SWITCH

A circuit to demonstrate the switching action of a f.e.t. is shown in Fig. 27.6. The l.e.d. D1 is used to show whether or not current is flowing through the f.e.t. The demonstration breadboard component layout for the FET Switch is shown in Fig. 27.7.

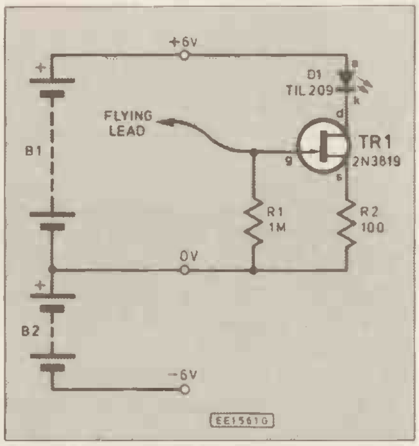
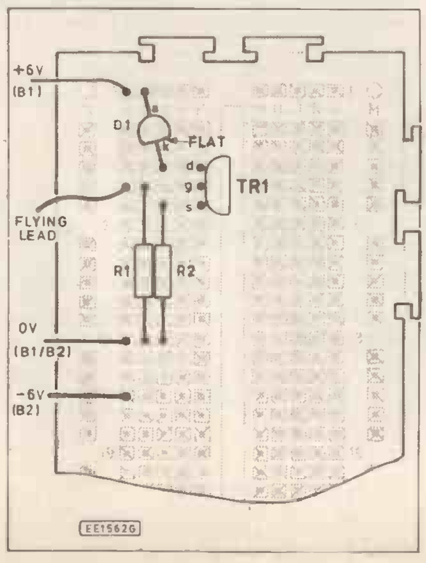


Fig. 27.6. *Circuit diagram demonstrating switching action of an f.e.t.*

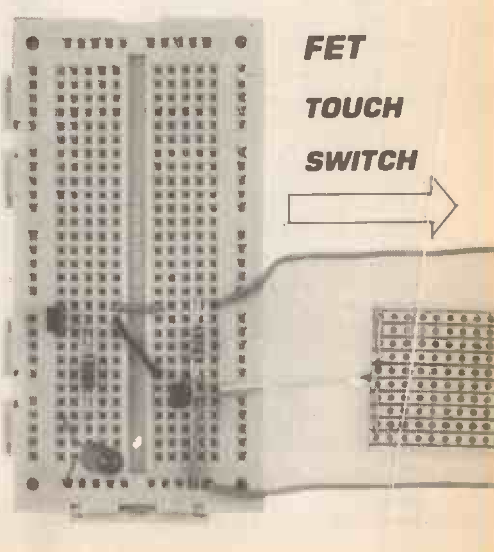
Fig. 27.7. *Demonstration breadboard component layout for the FET Switch.*



With the flying lead unconnected, resistor R1 brings the gate potential to 0V. With the lead unconnected, the l.e.d. in on.

Now touch the flying lead to the −6V terminal. The negative voltage at the gate, makes the depletion zone so wide that the drain-source current is pinched off. The l.e.d. goes out.

Like the bipolar transistor, the f.e.t. can be used as a switch. It has the advantage that its switching action is very fast. It has another advantage that becomes apparent in our next demonstration.



FET TOUCH SWITCH

FET TOUCH SWITCH

A simple FET Touch Switch circuit diagram is shown in Fig. 27.8. The circuit has the gate connected by a *short* lead to a small metallic touch plate. This could be a drawing-pin pushed into a piece of wood.

The demonstration breadboard component layout for the simple FET Touch Switch is shown in Fig. 27.9. Switch on the power and note that the l.e.d. is off.

Now touch the touch-plate with your finger. It is obvious that the amount of current that passes between you and the gate is extremely minute. Yet the act of touching the plate is enough to turn the l.e.d. on.

Normally, the touch plate and gate have a potential about 0.7V below that of the rest of the transistor. Your body has a potential somewhat higher than this. This is due to the fact that you are surrounded by electromagnetic fields generated by the alternating currents flowing in wires in your house, or in power lines outdoors. Add to this the effect of friction as you move around, and you finish up with a potential relatively higher than that of the gate.

When you touch the plate, a minute current flows for an instant. The potential of the gate is raised, the depletion zone decreases and the f.e.t. becomes more conductive.

Increased current flows through resistor R1 and the potential at point *A* (Fig. 27.8) rises. This causes an increased base current to flow from *A* to TR2, turning TR2 on and causing the l.e.d. to light.

This investigation shows that the amount of current needed to operate a f.e.t. is virtually nil. Such a device is ideal for use in logic circuits where thousands of transistors have to be switched on perhaps millions of times a second. The saving in power is enormous.

Before leaving this circuit, try wiring up the touch plate with a longer lead, say 20cm long. Explain the effect of this change.

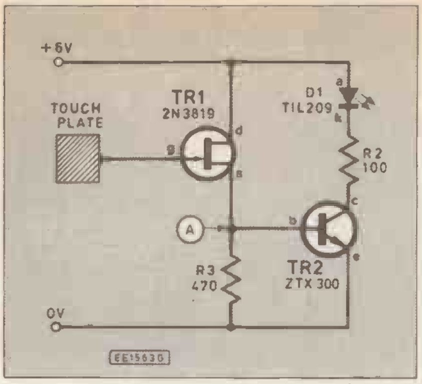


Fig. 27.8. Circuit diagram for a simple FET Touch Switch. The "touch plate" can be a metal drawing pin or a piece of stripboard, with tracks interconnected.

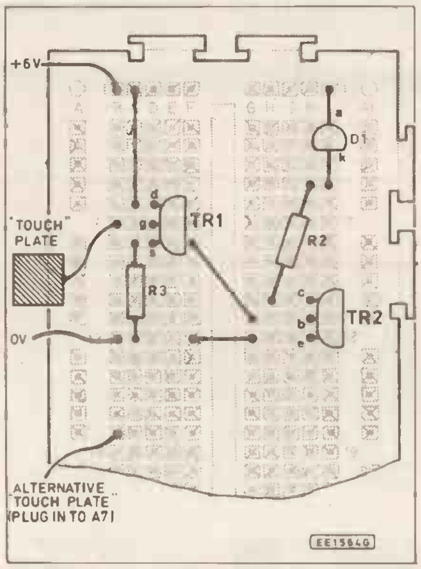


Fig. 27.9. Demonstration breadboard component layout for the FET Touch Switch.

Now substitute a short piece of insulated wire, stripped at both ends, as the touch plate. Try the effect of touching the bare end. Try the effect of touching the *insulated* part of the wire. Can you explain what is happening?

VOLTAGE-CONTROLLED RESISTOR

The bar of *n*-type material in a f.e.t. has a resistance which varies according to the width of the depletion zone. The width depends on gate potential. Thus we have a resistor whose resistance is controllable by its gate potential.

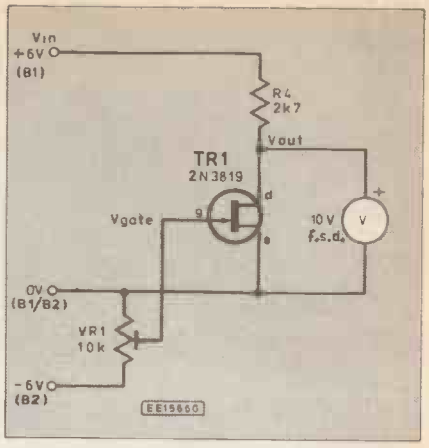


Fig. 27.11. Demonstration FET Potential Divider circuit diagram.

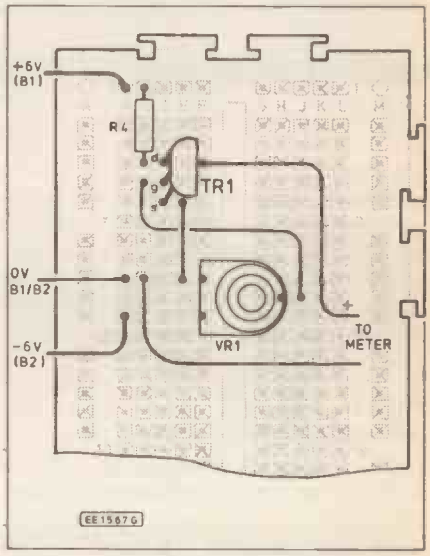


Fig. 27.12. Demonsration breadboard component layout for the FET Potential Divider.

How this property may be used is shown in Fig. 27.10. Fig. 27.10a is that well-known configuration of resistors, often quoted in this series–the potential divider. V_{IN} is related to V_{OUT} like this:

$$V_{OUT}=\frac{V_{IN}+R_B}{R_A+R_B}$$

Fig. 27.10. (a) Standard potential-divider circuit and (b) f.e.t. potential divider circuit.

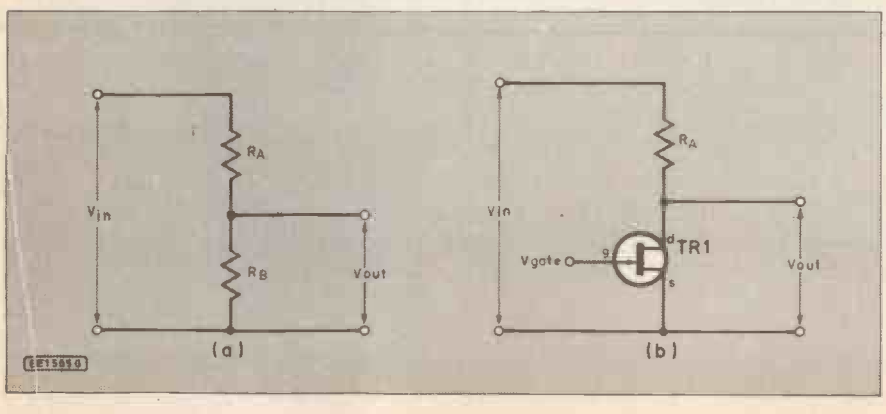
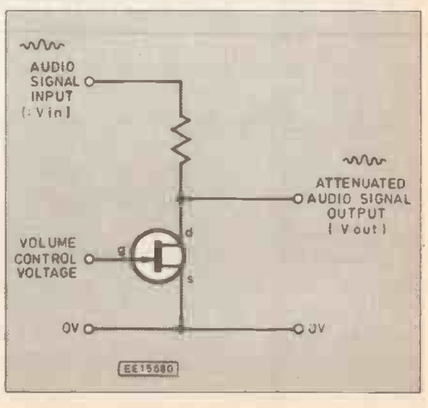
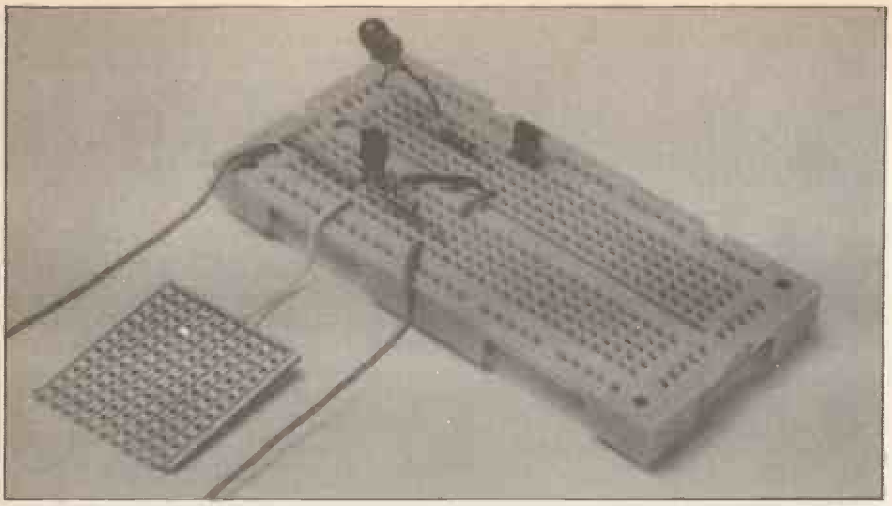


Fig. 27.13. Using a voltage-controlled attenuator.





Completed FET Touch Switch using a piece of stripboard as the "touch plate".

If either or both of the resistors are variable, V_{OUT} can be varied. Fig. 27.10b shows a circuit using a f.e.t. in place of R_B. A variable *negative* voltage is applied to the gate. A typical circuit diagram for a f.e.t. potential divider is shown in Fig. 27.11. To demonstrate this circuit, connect the components on the breadboard as shown in Fig. 27.12 and see what happens.

This type of circuit has many applications as a *voltage-controlled attenuator*. You have probably used a remote-controller to adjust the volume on a TV set. At some stage in the sound amplifier, the sound signal passes through such an attenuator. The attenuator is controlled by a voltage from the remote control receiver i.c. (Fig. 27.13).

Although it is possible to construct an attenuator from bipolar transistors, f.e.t.s are better. This is because they work just as well if the p.d. between source and drain is only a few millivolts, as it might be in an audio amplifier. To work without introducing distortion, bipolar transistors need several volts across collector and emitter.

OTHER FETS

The MOSFETs (f.e.t.s based on CMOS technology) are widely used both as individual transistors or as integrated circuits. In the more popular types, the gate is controlled by positive voltages, obviating the need to have a negative supply.

In logic circuits MOSFETS have the great advantage that they use virtually no current except when they are actually changing state from on to off. As transistor switches (used similarly to the f.e.t. in Fig. 27.6), they can be used to switch analogue signals under logic control.

Readers of this series may remember the Darlington pair, a configuration of two bipolar transistors connected to obtain very high gain. Recently the f.e.t equivalent of this has been put on the market—named appropriately, though with scant regard to etymology, a *Fetlington!*

Last, but by no means least, are the VMOS transistors. These are MOSFET power transistors, capable of handling currents of several amps, up to 30A or more for the heftier members of the group.

It is obvious that f.e.t.s cover the complete spectrum of transistor functions. With the advantages that we have discussed above, it is not surprising that they are being used in an increasing number of applications.

Next Month: We conclude the series with a look at shift registers and their applications.

ACTUALLY DOING IT!

by Robert Penfold

I MUST admit that one of my least favourite aspects of construction is making large cutouts in panels. These are required for a variety of components, such as slots for slider potentiometers, exotic shapes for some of the larger computer connectors and "windows" for seven segment displays. Most cutouts can be made using a twist drill and a miniature round file, with a larger file being used to tidy things up (see *Actually Doing It*–August 1987).

This method can certainly provide good results, it is applicable to virtually any cutout in any case, and it does not require either expensive tools or a very high degree of skill. It is not particularly fast though, and it requires quite a lot of "elbow-grease". This month we will consider some of the alternatives.

THE HOLE TRUTH

What is probably the nearest thing to a standard tool for large cutouts of any shape is the coping saw. A fretsaw is pretty much the same, but it has a larger frame that can reach further into a panel (making it a little more awkward to guide and use). These are general purpose tools that are used in woodworking and other applications, and no doubt most readers are familiar with them. They are straightforward in use. You drill a small hole somewhere within the required cutout, thread the thin blade through the hole, fix it to the saw, and start cutting.

Both types of saw are often suitable for making cutouts in panels and cases. Metal cutting blades are available, but most cases used in electronics are made of plastic, aluminium, or a combination of the two. These are almost invariably soft enough to be cut using any type of blade! On the face of it these saws are just about ideal for our purposes, but in practice things are not necessarily quite so rosy. They are most suitable when it is possible to remove a panel from a case and fix it in a vice while the cut is made. The more skilled users can probably saw straight along the cutting line, but the rest of us can cut just within it, and then file out the hole to precisely the required size and shape.

Problems arise when trying to work on cases where (say) only the rear panel is removable, but you require the cutout in the front panel. The case can probably still be fixed satisfactorily into a large vice, but the depth of the case may be nearly equal to the length of the saw's blade. This means that the sawing has to be done using very short strokes, which is likely to be both slow and awkward. Also, it is all too easy to keep smashing the frame of the saw into the case, possibly damaging it.

CUTTING PLASTICS

When cutting plastics the blade can get quite hot. This tends to melt the plastic which then clogs the blade. I have found some plastics to be virtually uncuttable using a fretsaw or coping saw. You can even end up with the blade sort of welded to the case! The blades used in these saws are necessarily very thin, looking much more like thin pieces of wire than saw blades.

The sawing needs to be done very carefully if the blades are to have a reasonably long life. Perhaps there is something wrong with my technique, but the life of my fretsaw blades seems to be so many blades per cutout, rather than so many cutouts per blade.

A similar alternative to coping and fretsaws is available in the form of tension files. These are very small diameter round files which fit either into a special frame, or into a hacksaw frame. They require a bit more effort than the saws due to the wider cut they make, but the files are generally quite tough and less prone to breaking (but are a bit more expensive to replace when they do break). Personally, I find these preferable to coping and fret-saws as they seem to be less prone to clogging.

It is also necessary to aim the saw in the direction you wish to cut. With tension files you can cut in any direction simply by applying pressure in that direction. You can cut any desired shape without moving the frame from a vertical position, and this can make intricate shapes much easier to cut.

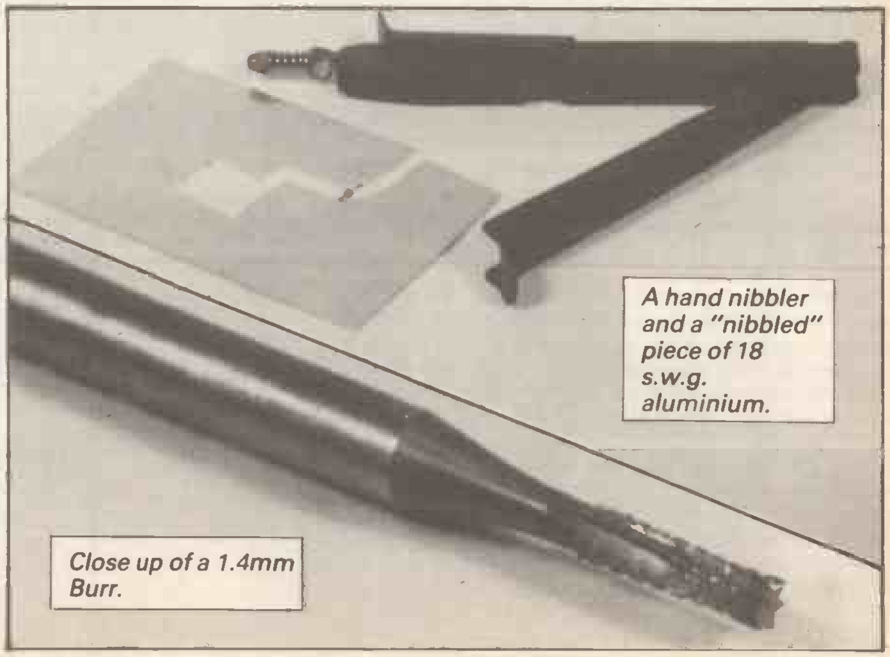
HAND NIBBLERS

The cryptically named "hand nibbler" is a tool I have only recently tried out, and it seems to be well suited to the production of many types of panel cutout. These are by no means the cheapest of tools, but one of the less expensive types is probably suitable for our purposes where the panels are mostly made from relatively thin and soft materials.

A nibbler has two handles which are joined by a hinge and held open by a spring. Looking at one of these tools you would probably get the impression (as I did) that the cutting takes place at the hinged part. In fact the nibbler I obtained must be held with the hinged part towards your body, and the cutting takes place at the opposite end of one of the handles (but apparently some of these tools are of a different style and do indeed have the cutter at the hinged end).

At the "sharp end" of the tool there is quite a simple arrangement, whereby a heavy cutting blade is brought down into a hole as the handles are brought together. With a panel placed over the hole, operating the tool punches a small rectangle out of the panel. By repeated operation of the tool you can literally nibble into a panel. Most cutouts are somewhere in the middle of a panel rather than at one edge, but by drilling a start hole the cutout can be anywhere on a panel. Unlike coping and fret-saws, a nibbler can be used anywhere on a panel, no matter how large it is. Also, if a panel cannot be removed from a case, a nibbler can still be used just as easily.

I expected panels to become distorted by the cutting action of this tool, but there was no evidence of this, even in the area immediately around the cuts. I also expected it to be quite tough going when making large cutouts, but with plastic and aluminium anyway, long cuts can be made quite quickly and with remarkably little effort. After a little practice on some



A hand nibbler and a "nibbled" piece of 18 s.w.g. aluminium.

Close up of a 1.4mm Burr.

scraps of aluminium you soon master accurate cutting, and a nibbler is by no means difficult to use.

If there is a drawback to this tool it is that it cannot make very fine cuts. The one I have, makes a cut some 6 millimetres wide, which could preclude its use on occasions. Despite this limitation I would have no hesitation in recommending this type of tool, and wish I had obtained one many years earlier.

BURRS

At a quick glance a burr looks very much like a miniature high speed twist drill of the type used for drilling holes in printed circuit boards. In fact it still looks very much like a miniature drill bit even after quite close scrutiny. With the aid of a magnifier it can be seen to have a surface more like that of a file, and I suppose that it is a form of file. The idea is to use it in a miniature drill. After drilling a start hole, the burr is placed into the hole, and with sideways pressure it is used to cut out the required shape.

As a hand-held tool I have never found a burr to be very effective. It tends to wander off course and be very difficult to control accurately. A burr is generally much more successful if the drill is mounted in a stand. With the drill fixed and both hands used to direct the work-piece, accurate control is very much easier. This method works well with small to medium size panels, but may be unusable with some work-pieces.

Something that surprises me about burrs is the speed with which they cut, or rather the lack of it. They are certainly very good for accurately cutting out intricate shapes provided the two-handed approach described above can be used. However, after trying several burrs and a wide range of drill speeds I have always found them to be rather slow going, even in soft materials.

PUNCHING

For large round cutouts there are some very quick and easy methods. The traditional one is the so-called "chassis-punch", which operates in the manner shown in Fig. 1. First a guide hole must be drilled in the panel, and a large screw plus the top piece of the punch (the "die") are then fitted in place. Next the cutting blade is screwed firmly in place on the underside of the panel. Finally, the Allen Key is fitted into the screw-head, and the screw is rotated.

This forces the cutting blade, which is of very heavy construction, through the panel and into the top piece of the punch assembly. Once it has cut right through the panel, the assembly is removed from the panel and dismantled so that the punched-out piece of metal can be removed from it. This piece of metal will be very distorted and rough, but the hole in the panel will be very neat with defined edges. In fact I do not know of any tool which produces neater cutouts than a chassis-punch.

Although chassis-punches are only generally available in round versions, the blade could be shaped to give any desired cutout within reason. The Electromail catalogue lists some square and rectangular punches designed to produce cutouts for specific components (rocker switches, battery holders, etc.).

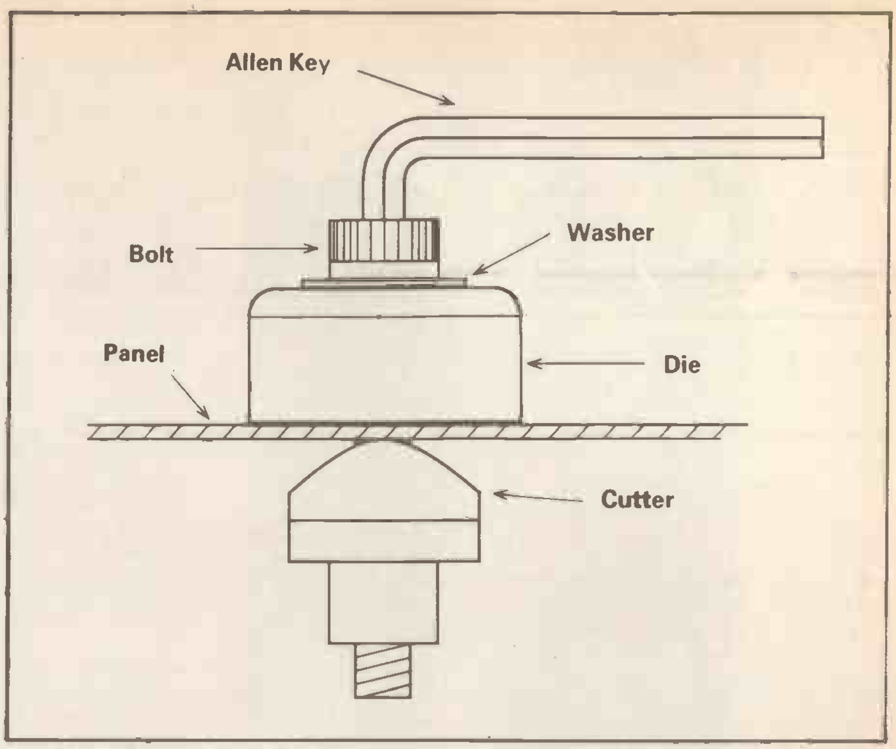


Fig. 1. Correct method of assembly for a chassis-punch.

Provided the bolt is kept well greased these tools are very quick and simple to use. The only real problem with these tools is the cost. A set of good quality punches covering a wide range of sizes would probably cost more than several average sized projects. Some of the more exotic types cost over £50, and the smaller round types are still around a tenth of this figure. A more practical solution might be to obtain one of the low cost chassis-punch sets. These cover a useful range of sizes, and should be adequate for occasional use with aluminium, plastics, and other reasonably soft materials.

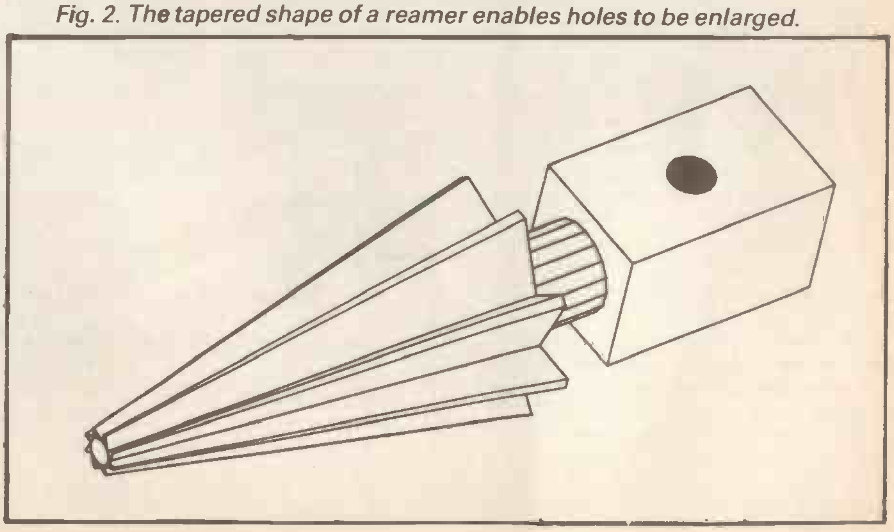
When using any form of punch (including hand nibblers) with plastics, bear in mind that there can be disastrous consequences with the harder and more brittle plastics. These tend to shatter unless they are worked very carefully, and any form of punching tool is likely to ruin them. Fortunately, most cases seem to be made of soft plastic these days. However, if you are in any doubt, it would be as well to play safe and use some other method of making the cutouts.

REAMERS

A reamer is a cone shaped tool with around eight blades each running the full length of the cone (Fig. 2). It is used like a drill, but to enlarge an existing hole rather than to make a new one. They differ somewhat in design at the top end, as some are intended for use in an electric drill, but most are for hand use. The hand operated variety either have a screwdriver style handle, or a hole through which a simple rod handle can be threaded so that the tool can be used with considerable force. Reamers are mainly used for holes of around 6-30mm in diameter.

With larger drills and chassis punches tending to be extremely expensive, a few drills and punches plus a reamer to fill in the gaps in their coverage is a good low cost solution. Some sets of chassis-punches seem to be supplied complete with a reamer. One slight problem with reamers is that they invariably seem to produce a pronounced rim around the edge of the hole. This is easily removed with a burr or a file though, and I now frequently make use of a reamer.

Fig. 2. The tapered shape of a reamer enables holes to be enlarged.



Digital Circuits VOL.1

reviewed by Mike Tooley

FOR many people, whether employed in the electronics industry or simply enthusiastic hobbyists, Open Learning provides the obvious answer to the ever pressing need to keep abreast of technology. For the newcomer to modern educational terminology, Open Learning is the name given to flexible study programmes which, unlike most further education courses, are not tied to a conventional academic programme. Open Learning can thus be tailored exactly to one's needs; in theory, one should be able to obtain a ready made learning package whenever the need arises.

Having spent some time examining Open Learning packages (of varying quality) I was pleased to be asked to take a look at this latest package from the National College of Technology (NCT Ltd). This particular course is designed to provide students with approximately 45 hours of study and the course material is based on Business and Technician Education Council (BTEC) and City and Guilds (C&G) material. Unlike most BTEC and C & G courses, however, the NCT programme is designed to be studied in the workplace or in the comfort of the student's own home. The ability to study when and where a student wishes is a prime advantage of Open Learning; there is no need to make the regular trek to the local Tech. after a hard day's work when one probably just wants to get home and put one's feet up!

It is important to realise that the NCT course is designed to teach practical as well as theoretical skills. The kit comprises three workbooks, a digital circuit breadboard (together with a pack of six digital integrated circuits, links and components), and an audio cassette. The course is neatly packaged in an attractive "bookshelf style" case and the only additional items required are a 9V PP9 battery and an audio cassette recorder.

Students who follow the full programme (which includes tutorial support via a telephone "hot-line" and an assessment programme based on multi-choice tests) can qualify for a BTEC Certificate of Achievement.

APPROACH TO OPEN LEARNING

Open Learning will almost certainly be an entirely new concept to students of the NCT *Digital Circuits* package. Open Learning demands a radically different approach from that associated with conventional study programmes and success depends primarily on two factors; commitment on the part of the student and the overall quality of the Open Learning package. The first of these is a matter for the individual student but the second relies largely on the professionalism of the provider of the Open Learning package and, more particularly, on the extent of any back-up which he or she can provide the student with. In this respect, personal tutoring and assessment feedback is vital and both of these are very well catered for in the NCT *Digital Circuits* package.

Open Learning courses require a good deal of self-discipline on the part of the students and it is heartening to note that the importance of a regular weekly study plan is stressed in both the workbooks and in the audio cassette. Indeed, students are actively encouraged to plan their timetable in advance; "Your tutor may very well ask you what your timetable is" warns a pleasant sounding female in the audio cassette . . .

HARDWARE

The circuit board supplied with the NCT *Digital Circuits* package is of a very high quality. Approximately 40 per cent of the area is devoted to a 0.1 inch matrix breadboard which is capable of accomodating seven 14-pin dual-in-line (d.i.l.) integrated circuits and associated components. The remaining area is devoted to a bank of eight l.e.d.s and associated drivers, a d.i.l. package containing eight s.p.s.t. switches, a +5V regulator, and an on-off toggle switch. Sockets are fitted to accommodate two daughter boards (for use with more advanced courses) and two BNC sockets are available for linking to external equipment such as an oscilloscope. NCT can provide a special adapter to convert a standard TV into a dual-channel oscilloscope but this item of equipment is not required for the introductory *Digital Circuits–Volume 1* package.

One further point should be noted. Students should regard the circuit breadboard as something of an investment since not only can it be used as the basis for further NCT programmes but it makes an excellent breadboarding aid in its own right. I, for one, shall be loathe to part with this particular component of the NCT *Digital Circuits* study package!

COURSE CONTENT

The course provides a comprehensive introduction to digital circuits and covers the following topics:

* integrated circuits
* digital logic
* binary numbers
* inverters
* AND, NAND, OR, AND NOR gates
* combinational logic
* exclusive-OR gates
* truth tables

Tuition moves backwards and forwards between the workbooks and audio cassette and this provides some useful variety in the study programme. Self-assessment questions are provided within the workbooks and students are encouraged to attempt these before referring to the answers provided. An assessment is provided at the end of each workbook and, for those following the full version, this must be returned to the tutor for marking and comment.

WORKBOOKS

It is important to realise that the workbooks are not only study texts but also provide students with a personal reference of progress through the course. Furthermore, since the course is highly structured, the workbooks should be followed in exact sequence. Each workbook contains between 66 and 94 pages and the workbook for part 3 contains an index for all three parts.

The standard of the workbooks is extremely satisfactory, with "chatty" text and neatly presented computer-generated graphics. I particularly liked the way the course had been divided into three separate modules, each with its own workbook. This has the effect of making the course easily manageable with a definite goal at the end of each book. Spaces are provided within the workbooks for students to complete and those wishing to obtain a BTEC Certificate of Achievement should note that workbooks *may* be "called-in" for inspection by an external moderator.

The workbooks contain numerous "student centred assignments". This fashionable phrase (coined by BTEC) simply means that the student is presented with a task (such as showing that a two-input NOR gate can be made to act as an inverter) and left to get on with it! Happily, each student assignment is supplied with a solution so that, in the event of the task being unsatisfactorily completed, the student is not left completely in the dark.

COST

Under NCT's special introductory offer, *Digital Circuits–Volume 1* costs £135+ VAT (£20.25). This price includes full tutorial support and the opportunity to qualify for the BTEC Certificate of Achievement. NCT will also be offering a cut-down version of the *Digital Circuits* package in the Autumn. This package will be particularly suitable for hobbyists and those operating on a limited budget and will be priced at a more modest £89.99 (including VAT).

The reduced price version will be delivered without the bookshelf style box and with a cheaper version of the workbooks. The package will also be supplied without the tutoring and full assessment facilities of the original version. A nice feature is that, having seen what the course offers, students will be able to "buy back" into the tutoring and BTEC assessment if they wish.

IN CONCLUSION...

Open Learning packages are bound to gain an increasing following in the years to come since they permit flexible study which can be available as, and when, required and NCT's package must be one of the best that I have seen to date. My only reservation is related to the cost of the package. At over £150 (including VAT), the full version of *Digital Circuits–Volume 1* is rather expensive. It will, therefore, appeal rather more to corporate users (such as colleges, ITECs, and company training departments) rather than to the independent learner. At £90 (including VAT) the cut-down hobbyist version is more realistically priced but, even so, the price tag may be something of a deterrent. *(Some investigation has shown these prices to be very competitive in this market–Ed).*

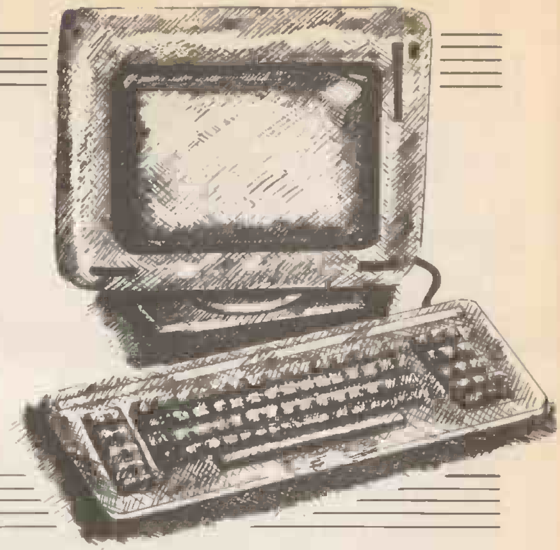
Furthermore, it is also important to be aware that *Volume 1* provides an *introduction* to digital circuits. Students who follow the programme to its conclusion will have certainly gained a thorough understanding of digital logic but there still remains a huge area for further work. *Volume 1* does not, for example, deal with sequential logic and students will certainly require further study of other important topics (such as monostable pulse generation, bistable circuits, counters, and shift registers) before they have a *complete* grasp of digital circuits. Later volumes of *Digital Circuits* will, therefore, almost certainly be required and one should plan accordingly.

Having said this, *Digital Circuits–Volume 1* can be highly recommended. It is thorough, comprehensive, very professionally presented, and ideal for the absolute beginner. I am eagerly looking forward to future products from this talented concern–well done NCT!

NCT Ltd are at Bicester Hall, 5 London Road, Bicester, Oxon OX6 7BU. Telephone: (0296) 613067.

The NCT course is designed to teach practical as well as theoretical skills, comprising three work-books, a digital circuit breadboard and audio cassettes.

Constructional Project



PIO FOR THE AMSTRAD

M. SNOOK

An easy to build, inexpensive interface for the popular Amstrad PCW 8256/512 computer

INTERFACING the Amstrad PCW8256/512 can be achieved cheaply and simply, especially if you are familiar with other Z80 based machines, such as the Spectrum.

The Z80 microprocessor, which forms the heart of the PCW8256/512, supports both memory mapped I/O and input/output mapped I/O, the latter being easily accessed from BASIC using the INP and OUT commands. Both types of I/O use the address bus, however input mapped I/O only uses the lower eight bits and is distinguished by taking the $\overline{IORQ}$ line low. Interface chips can be programmed by selecting certain ports or I/O addresses, and writing data to them. The address bus is decoded so that the interface chips are enabled when these ports are selected.

Probably the easiest interface chip to use is the Z80A-PIO, a parallel interface controller specially designed to work with the Z80-CPU. This requires very few external components and provides two 8-bit wide input/output (I/O) ports.

Since "Mallard BASIC", supplied with the PCW8256/512 is relatively fast, it should be adequate for most purposes, and will only be dealt with in this article. Anyone with some knowledge of Z80 machine code should have no problem writing short machine code fragments to drive this board, should it be necessary.

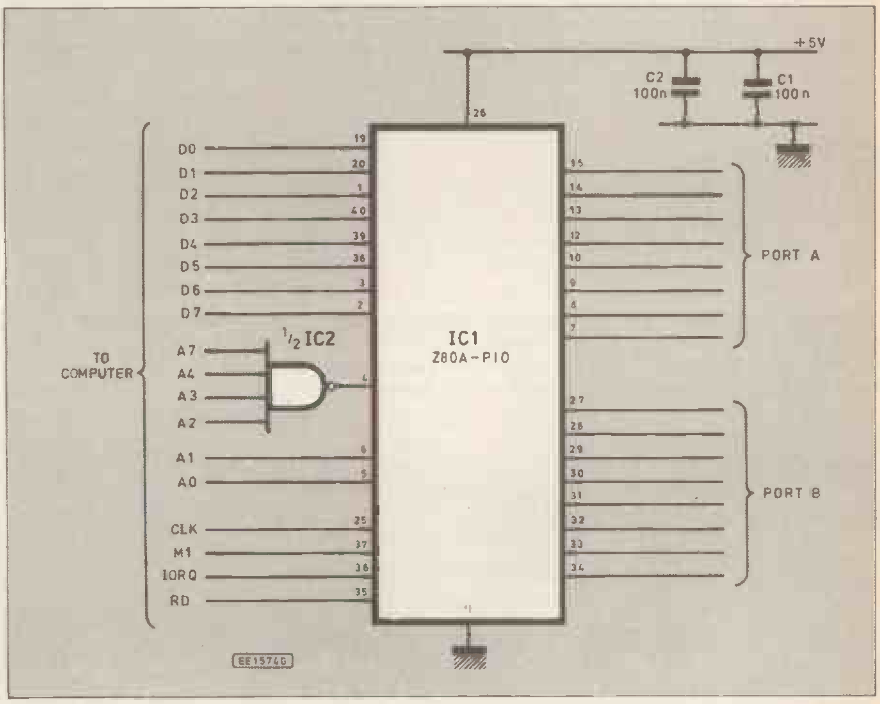
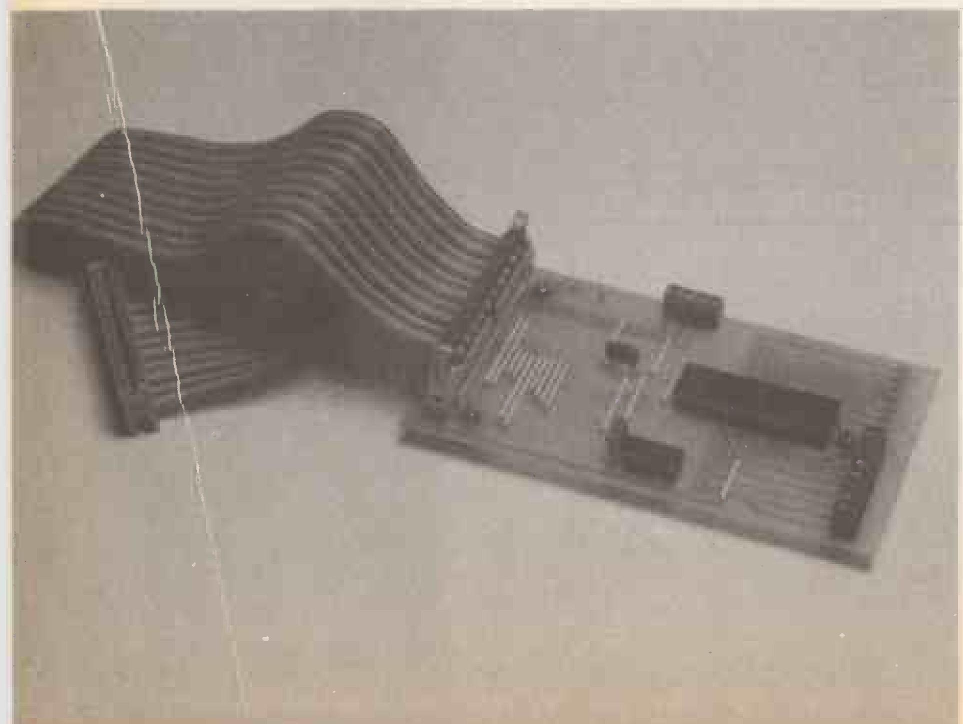


Fig. 1. Circuit diagram of the Amstrad PIO



CONSTRUCTION

The circuit diagram is shown in Fig. 1, it consists simply of a Z80A-PIO (IC1) and a NAND gate (IC2) to perform some limited address decoding. The circuit can be built either on stripboard or a p.c.b., and connected to the computer by a 50-way ribbon cable terminated with a 50-way insulation displacement connector (IDC). Connection information for the Amstrad PCW8256/512 edge connector is shown in Fig. 2, and the PIO pinouts are shown in Fig. 3. The ports themselves can be brought out to any connectors of the user's choice. P.C.B. mounted terminal blocks were used on the prototype to provide a flexible method of connecting wires.

Construction using the given p.c.b. couldn't be easier providing reasonable care is taken with the soldering. The foil pattern for this p.c.b. is shown in Fig. 4. First solder

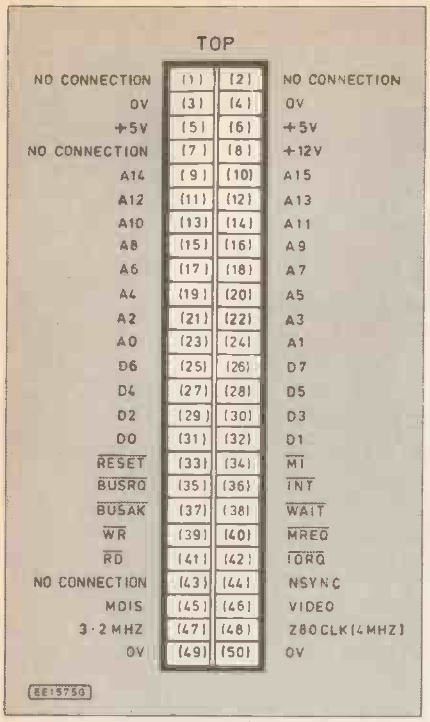


Fig. 2. Amstrad PCW8256/512 edge connector

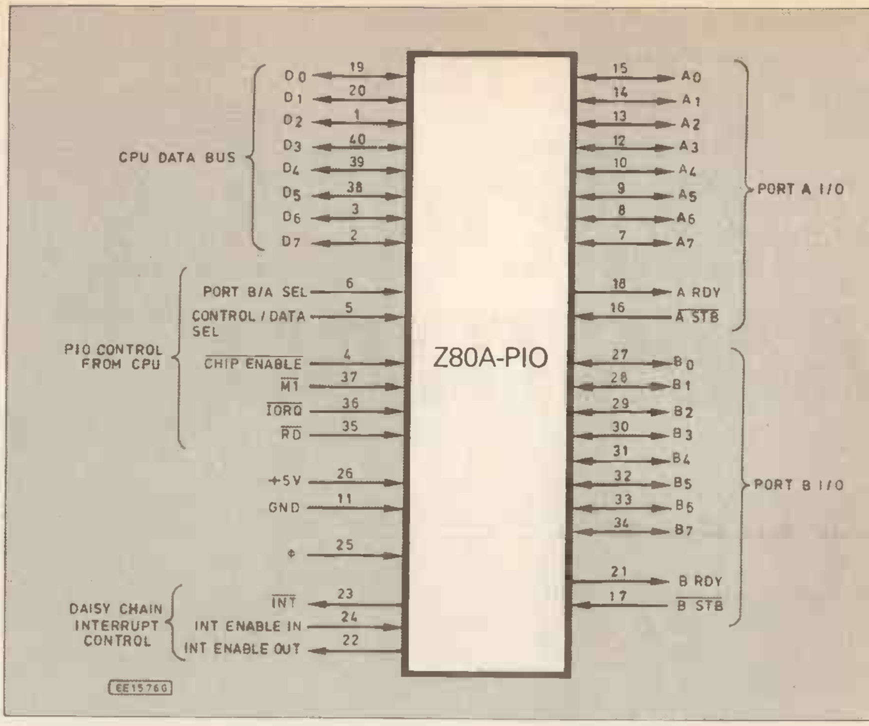


Fig. 3. Pin connections for the Z80A-PIO

in the wire links and then the i.c. sockets as shown in the layout. It is advisable to use insulated wire as the links run close to each other. Next the decoupling capacitors should be soldered and finally the ribbon cable attached. There are a number of variations on exactly how the cable is attached depending on your requirements and how much you want to spend. Since the ribbon cable assembly is the most expensive part of this project the following set-up is suggested:

At one end of the ribbon cable is fitted the 50-way IDC edge connector that plugs directly onto the exposed p.c.b. at the back of the VDU. This will be the same for all methods. At the other end is a 2×25 way d.i.l. IDC cable socket which attaches to a p.c.b. mounted header plug on the board. This means that only one lead need be made up for a number of projects.

IDC connectors can be assembled with care in a bench vice, however some component suppliers (e.g. Maplin, RS) make IDC leads to order and these are worth considering if there is any doubt as to the procedure.

Alternatively a p.c.b. transition header could be used, thus providing a permanent connection to the board. Finally the cheapest, but least reliable method is to simply solder the individual wires to the board. Whatever method is chosen, check that the input lines to the board are correct. The layout of connections on the component side of the board is the same as the edge connector and is shown in Fig. 2.

There are seven unused pads on the p.c.b. and these are attached to pins 16, 17, 18, 21, 22, 23 and 24 of the PIO. They need not be connected, however, they have been provided for those who wish to expand the board further. Pins 16, 17, 18 and 21 are used in Modes 1 and 2 as handshaking lines. Pins 22, 23 and 24 are connected with interrupts and should be used with care on the Amstrad. It is vital that the Z80-PIO data sheet is obtained if these additional lines are to be used.

TESTING

After the soldering has been completed check the board for bridged tracks and dry joints. When everything is in order, plug in the i.c.s ensuring correct orientation (see Fig. 4) and check that no pins have been bent under, especially on the PIO. Finally the board will be ready for testing.

Power to the board is supplied by the computer whose internal supply is sufficient for only a few external chips. This power supply can be accessed from the p.c.b. mounted terminal block, however it is important to use an additional power supply to drive any circuits that are attached to the PIO.

With the computer switched off press the edge connector onto the exposed p.c.b. at the back of the VDU, making sure the numbers on the connector run from top to bottom. This can be facilitated by fitting a polarising key to the edge connector between the 11th and 12th rows.

Next switch on and try to boot up by inserting the CP/M system disk. If the operating system refuses to load, remove the disk and switch off immediately. Check that all the i.c.s and connectors are orientated correctly and there are no loose wires or other obvious errors on the board. When these have been corrected reconnect the board and try again.

When CP/M is installed, load BASIC and proceed to test the board with the programs given. If at any time the computer locks up, remove any disks and switch off. Disconnect the board and recheck for loose wires and bad connections.

Note that the programs given are for guidance only and each application will have its own routines. To test the board small circuits can easily be built up on a breadboard or pieces of stripboard. Some ideas have been given in Fig. 5.

Once the board is up and running it is advisable to keep the ribbon cable attached to the computer and disconnect the board at the PIO end. This will help to avoid wear and tear on the computer's p.c.b. The P.I.O. p.c.b. can be enclosed in a plastic case if required or rubber feet can be added to protect work surfaces.

ADDRESS DECODING

The I/O addresses on the Amstrad PCW8256/512 are something of a mystery to many users, and it is perhaps for this reason that few electronic projects have appeared so far.

To begin interfacing it is necessary to know only which I/O addresses are not used by the computer itself, so that projects can be built that will not interfere with the computer's function.

COMPONENTS

Shop Talk

See page 527

Capacitors
C1, C2 100nF ceramic (2 off)

Semiconductors
IC1 Z80A-PIO (4MHz)
IC2 74LS20 dual 4-input NAND gate

Miscellaneous
40-pin d.i.l. i.c. holder; 14-pin d.i.l. i.c. holder; 50-way ribbon cable (approx. 300mm); 50-way IDC edge connector; polarising key; **either,** 2×25 way d.i.l. IDC socket; 2×25 way p.c.b. header plug; **or,** transition header; printed circuit board available from the *EE PCB Service*, order code EE618; insulated wire for links; rubber feet or case as required.

Approx. cost
Guidance only **£11.50**

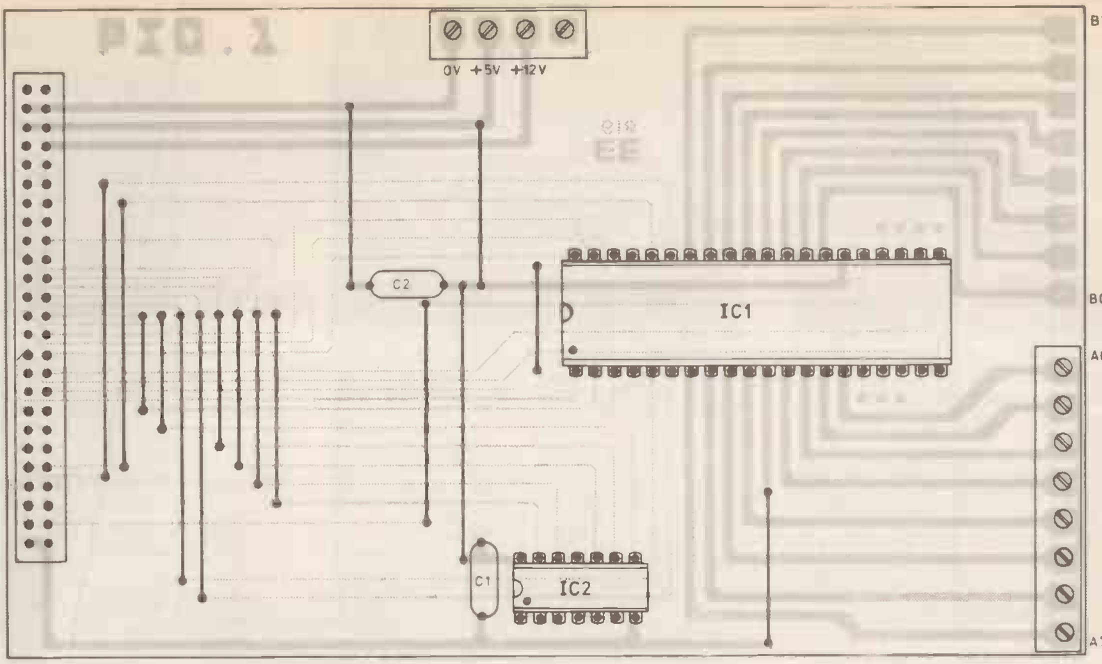
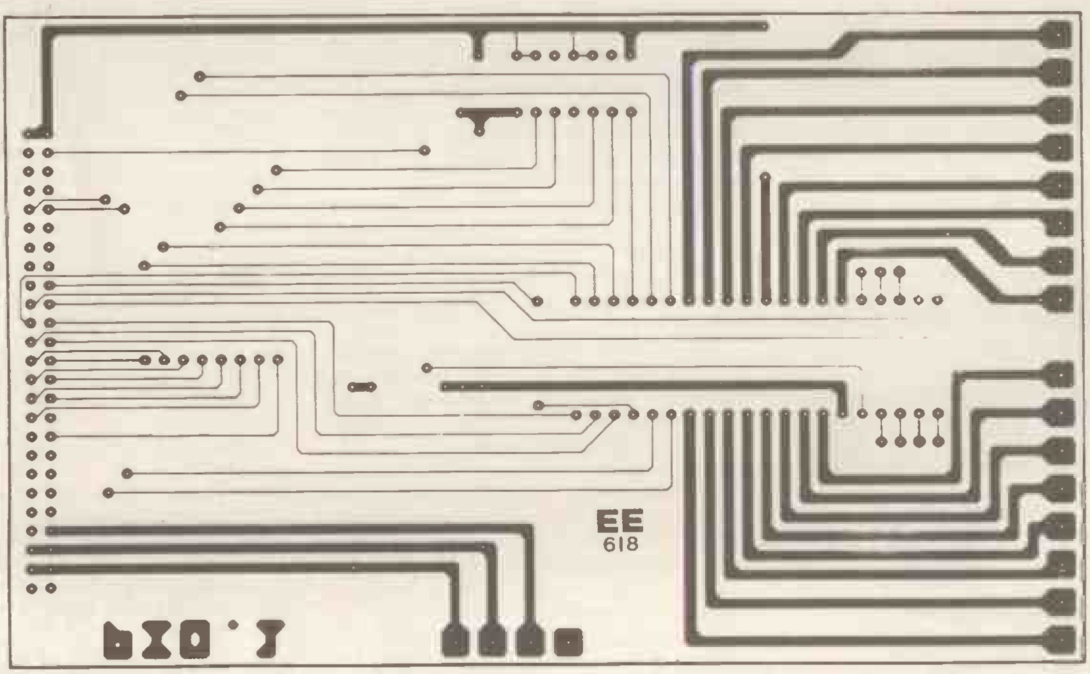


Fig. 4. P.C.B. Layout and wiring for the PIO



The Z80 supports 256 I/O addresses in all, but only four of these are needed, and they are numbered 156-159. In order to enable the PIO, pin 4 (chip enable) must be taken low and this is achieved by NANDing address lines A2, A3, A4 and A7 of the address bus. Only when A2, A3, A4 and A7 are all high will the output of the NAND gate go low. In addition the A1 line is used to select either Port A or Port B, and A0 is used to select either the control register, or the data register for each port. The full list is shown in Table 1. (See Fig. 3 for the PIO pinouts).

TABLE 1

Address	Function	Port
156	data	A
157	control	A
158	data	B
159	control	B

PROGRAMMING THE PIO

The Z80A-PIO, supports four software selectable modes of operation, these being:

Mode 0—Byte output
Mode 1—Byte input
Mode 2—Byte bidirectional (port A only)
Mode 3—Bit control

For each of the two ports, A and B, there are two registers, a control register and a data register. The operating mode required is specified by sending a byte to the control register of the desired port, immediately after a reset, in the following format:

D7	D6	D5	D4	D3	D2	D1	D0
M1	M0	X	X	1	1	1	1

M1 and M0 being defined as follows:

M1	M0	
0	0	—Mode 0
0	1	—Mode 1
1	0	—Mode 2
1	1	—Mode 3

So to set up port A of the PIO in Mode 3 the binary byte 11111111 (255 decimal or &HFF hex) can be sent to the control register of port A. Note that X means that bits D5 and D4 can take any value (1 or 0).

Although all these modes have their applications, for practical experimentation Mode 3 is the most useful. In this mode each bit of the PIO port can be specified as either an input or output bit. This means that a total of

16 lines can each be read or written to. Therefore almost any interface circuit that has been produced for other microcomputers with parallel ports, such as the BBC, can be used with an Amstrad PCW8256/512. This includes A to D converters, speech synthesis and stepper motor control to name but a few.

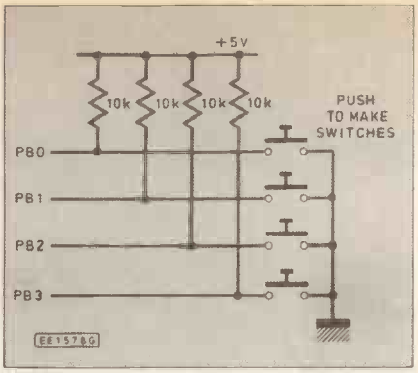
To program the PIO in Mode 3, the sequence of events is as follows:

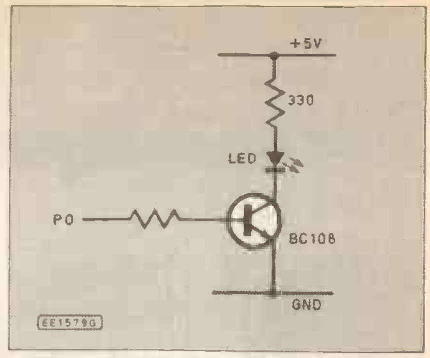
1) After a reset, select the control register for port A or B and write the data byte 255. This selects Mode 3.

2) Select the control register as above and send a byte that describes which lines are to be input and which are to be output. Defining a bit as a 1 means it is an input and a 0 means it is an output. So a binary byte of 11000011 (195 dec or &HC3 hex) defines bits P7, P6, P1 and P0 as inputs and P5, P4, P3 and P2 as outputs.

3) Select the data register and write the byte of data to be output, or read this register for the state of the inputs.

Consider the following example program fragment,





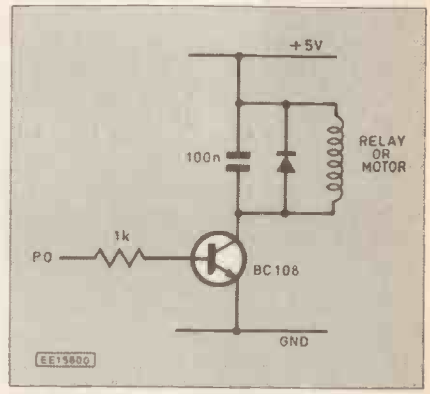


Fig. 5. Some interfacing ideas for the Amstrad PSO

```
10    REM initialise the PIO
20    da= 156: ca= 157: db= 158: cb= 159    :REM define the I/O addresses
30    OUT ca,255: OUT cb,255                :REM put both ports in Mode 3
40    OUT ca,0                              :REM make port A all outputs
50    OUT cb,255                            :REM make port B all inputs
60    REM this completes the initiation
70    :
80    OUT da,15           :REM output the pattern 00001111 on port A
90    x= INP (db)         :REM x holds the data value read in from port B
```

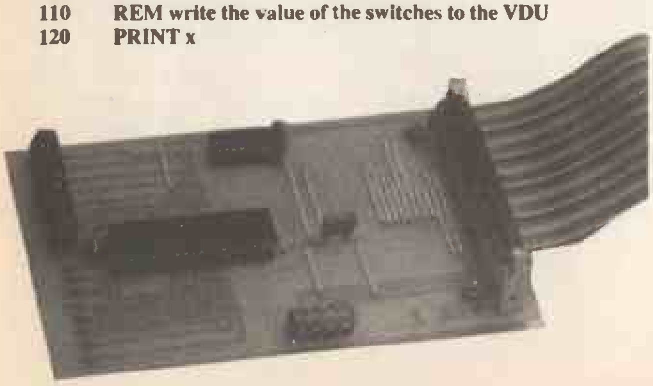
The crucial lines of this program are 30-50 which define the mode of operation and specify which lines are inputs and outputs. Lines 40 and 50 could also be of the following form, for example,

```
40    OUT ca,128     :REM PA7=input, PAO-PA6=output
50    OUT cb,1       :REM PBO=input, PB1-PB7=output
```

Similarly the Mode of operation could be changed by altering line 30. Note that Mode and data direction need only be set once, and not for each data transfer.

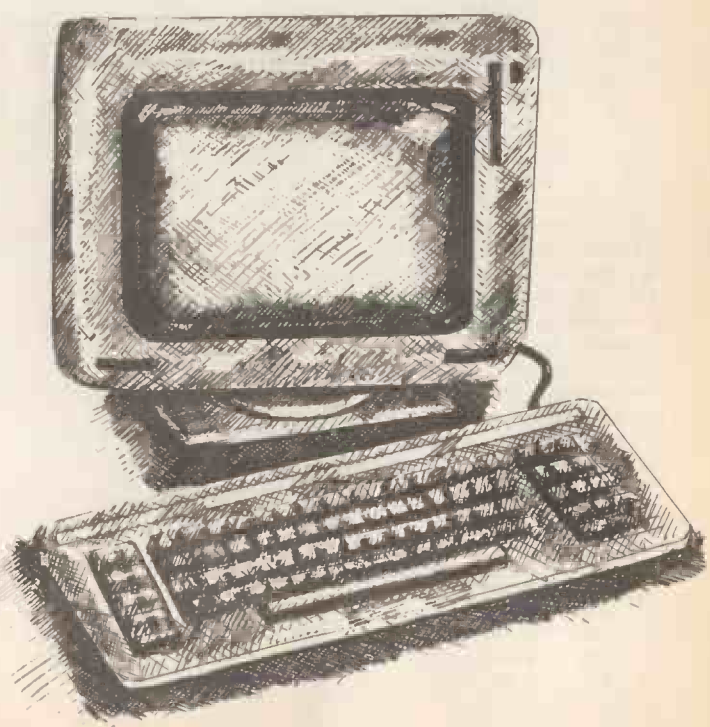
In order to interpret a read value correctly, it will be necessary to mask off those bits that are not connected, as these may take any value (0 or 1). For example if four switches are connected to port B lines, PBO-PB3, then the following program fragment will read them correctly.

```
10    REM Initialise the PIO
20    db=158: cb=159      :REM define the I/O addresses
30    mask=15             :REM mask is bits P0-P3
40    OUT cb,255          :REM Port B in Mode 3
50    OUT cb,mask         :REM define PB0-PB3 as inputs
60    :
70    REM Read the switches
80    x= INP (db)         :REM read port lines PB0-PB7
90    x= x AND mask       :REM mask off lines PB4-PB7
100   :
110   REM write the value of the switches to the VDU
120   PRINT x
```



Some simple interface circuits that could be attached to the PIO board are given in Fig. 5. If mains powered devices are to be controlled it is suggested that opto-isolators are used to protect the computer and operator from any high voltage faults that may occur.

It is hoped that this article has geven an insight into the use of Z80 peripheral chips. The Z80-PIO has other functions that have not been described here, such as interrupt control, and these are all open to the user. However if further experimentation is intended, it would be advisable to obtain a copy of the manufacturer's data sheet. □



FOR YOUR ENTERTAINMENT

BY BARRY FOX

Video Call

My bet is that the next phone gadget to go on sale in Britain will be the video phone. Already they are in Japanese and American shops, and not selling particularly well. So it is only a question of months before someone siphons off some container loads for the UK and sells them here, with or without "green sticker" approval.

The idea of a video phone is as old as the idea of television–even older. Sci-fi writers have often painted the picture of two people talking by telephone, while watching each other's every move on a screen.

Technically there is no magic in sending pictures down telephone wires– the snag is that a TV signal contains frequencies around a thousand times higher than a telephone call–so you need to sacrifice a thousand speech lines to make one picture connection. That would put the price of using a picture phone at £50 a minute, just for a local call.

The Germans experimented with video phones before the war, building public booths from which callers in different cities could talk to each other.

The police in Britain already use a new generation of video phones to send mug shots from station to station; so do hospitals and doctors, to communicate X-rays.

How it Works

The new systems use a technique called slow scan, which has been made possible by low cost solid state computer memory.

An ordinary telephone is plugged into a display unit that looks like a small black and white television, with a 5" screen on its side, i.e. as an upright oblong. This unit plugs into an ordinary telephone wall socket which incorporates a budget TV camera.

The unit has three keys, marked "view", "take" and "transmit". When the operator presses "view", the screen shows what the camera sees. When the "take" key is pressed the displayed image is converted into digital code and frozen as a still picture into solid state memory. When the "transmit" key is pressed the stored image is transmitted over the telephone line to a matching unit at the other end.

The image is frozen by breaking the picture down into 16,000 picture points or "pixels" and then coding each point into a 4-bit word. The digits then amplitude modulate a 2KHz analogue carrier tone at a rate of 8000 bits per second.

It takes around six seconds for all the bits needed for one still picture to travel down the telephone line. The callers cannot speak while the a.m. warble goes down the line.

At the receiving end of the line the incoming warble is converted back into digital code and stored in a solid state memory. The stored code is then displayed as a still picture on the recipient's screen. In practice the picture scrolls down from the top of the screen as it builds up in the memory.

Each telephone has enough memory to store three pictures and as the picture tone is carried by a conventional telephone line there are no extra hidden charges, over and above the cost of the call.

There is a bonus in amplitude modulating the carrier tone. The data is effectively converted into a conventional audio signal and can then be taped by a conventional audio cassette recorder and replayed later through the video phone monitor.

Therefore, anyone making a telephone call can illustrate a point by showing an object and the person at the other end can keep a visual record of the illustration on an audio cassette.

Only a Gimmick!

A video phone system from Sony has been selling for at least a year now in Japan along with a system produced by Mitsubishi.

I recently saw Mitsubishi's system demonstrated in Tokyo and although the monochrome pictures were reasonably clear, they were nowhere near as crisp as the public has grown to expect from domestic television.

Mitsubishi are quoting a price of around £200 per station, but similar systems are available in America, and the price has now fallen to around £200 a pair, which sounds like a "flog-off".

The adverts talk about children phoning Grandma and sending her a picture, but in practice low definition monochrome still picture video phones are likely to have only gimmick appeal for most people.

They are more useful for Oriental and Middle Eastern countries where the alphabet is pictorial, or where businesses need to communicate sketches. However, for most people fax does the job far better.

Videophones could be useful for sending how-to-get-to-my-house sketch maps. Even so, in Britain BT is decidely cool on the idea.

As BT introduces the new ISDN digital services, it will be easier to send pictures which move, and are in colour, but complex digital circuitry is needed to "compress" the digital data and the quality will never be as good as for conventional TV. High prices will keep high quality videophones a business tool.

Even if all the technical problems were solved, who really wants to be seen talking on the telephone? Most people prefer privacy and would rather not pay extra for the privilege of being seen half-dressed at home or surrounded by a mess of paper in their office, and bored by an unwelcome call.

3-D Coke

Coca Cola in the US was recently stuck with 40 million pairs of 3-D spectacles. The plan was to distribute them through 40,000 retail outlets, so that TV viewers in North America could watch a Coca Cola commercial in 3-D.

This was scheduled for transmission during the last episode of the TV series *Moonlighting* which also had a 3-D sequence, but the plan fell apart thanks to a film and TV scriptwriters' strike in Hollywood. However, with all those spectacles ready to hand out, you can be sure that the idea will re-surface again before long.

The 3-D system to be used is called Nuoptix and Coca Cola may well try to persuade a British TV station to try a similar transmission because inventor Terry Beard of California has filed patent applications on the idea all round Europe.

Nuoptix is one of two systems devised recently which work with a single lens camera and only creates an illusion of depth if the camera or scene on screen is moving. One system, called Aspex, relies on colour fringing– which looks decidedly odd to anyone not wearing coloured spectacles.

Natural Phenomenon

Instead of colour fringing, Nuoptix relies on a natural phenomenon known as the "Pulfrich effect". Both eyes see the same view but one eye is given a dimmer image than the other. so if the image is moving, the brain is fooled into seeing 3-D because it takes longer to process the dimmer image and thus registers different perspectives for each eye.

For Nuoptix to work there must be relative movement between the camera, scene and actors. The camera can move in an arc, circle round the actors, track alongside them or it can pan and turn on its own axis.

Alternatively, the actors can keep moving backwards and forwards in front of the camera, or the image can be manipulated by a digital special effect system, as used for pop videos.

Shades of Colour

To see 3-D, the cinema audience or TV viewer must wear a pair of spectacles, with different light attenuation for each eye. One lens can be clear glass, and the other a grey, neutral density filter of the type used by photographers to cut down excessive light on sunny days.

Beard says colour heightens the effect, and the Coca Cola spectacles will have a deep purple filter for one eye and pale green for the other. This system, claims inventor Terry Beard *"creates a dramatic and entirely real three dimensional effect'.*

Although Coca Cola's system will create none of the colour fringing which mars Aspex images for viewers without spectacles, audiences will surely soon get tired of watching images on screen which rely on continual relative movement between the scene and camera to achieve a 3-D effect.

It is also doubtful whether patents can legally protect the age-old idea of moving a camera while filming, or wearing coloured spectacles to watch the results on screen.

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Constructional Project

POWER CONTROLLER

A. R. WINSTANLEY

A multi-purpose mains power controller based on phase control. Maximum output 1200W at 250V. Incorporates full RFI suppression. Robust and simple design makes for easy construction.

ANY READER who will be familiar with the operation of a light dimmer switch will no doubt be aware of the principle of mains power control by chopping the a.c. sinewave, in order to vary the total power applied to the load. A dimmer switch incorporates a triac and a triggering circuit, and the triac can be made to conduct at differing points in the a.c. cycle. The effect is that the sinewave can be curtailed by cutting off the triac part way through a mains cycle (see "How It Works").

The effect is that the power output can be reduced, and in this example the light level emitted by the lamp can be reduced in accordance with one's requirements. Of course, the light level cannot be increased beyond the brilliance which would be observed if there were no dimmer switch at all.

In practice, this *phase control method* is probably the simplest method of power control, although technically it is perhaps a little crude. It is still a major improvement on its rheostat predecessor! One drawback is that there is a considerable amount of radio frequency interference (R.F.I.), because of the sharp "edges" which result in the waveforms when the a.c. cycle is suddenly interrupted. This necessitates r.f.i. suppression components to combat this.

In the interests of simplicity the Power Controller to be described here employs a phase-control circuit to vary the power applied to the load. To further simplify matters, the Power Controller is based upon a thick-film CSR device which incorporates its own firing circuit within the same package. This reduces the number of mains connections we have to make, easing construction and generally improving reliability.

The Power Controller can be used for light-dimming (except fluorescent tubes), heater control or motor speed control, and further application notes are given at the end. The design also includes a complete r.f.i. suppressor circuit to substantially reduce interference.

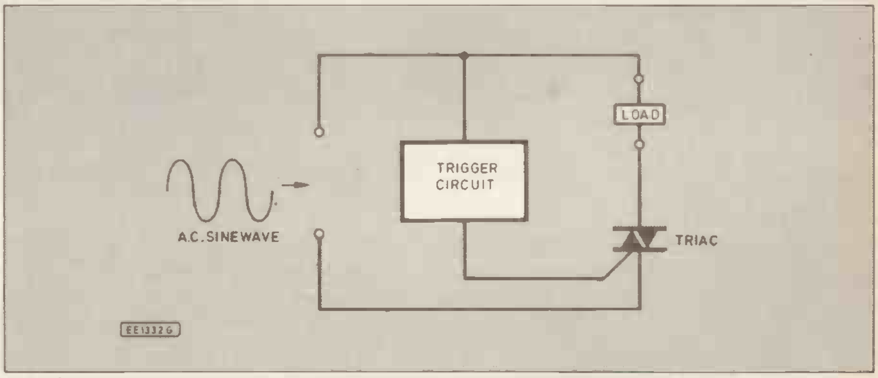


Fig. 1. Block diagram for the Power Controller. The controller employs a special i.c. incorporating both the trigger circuit and triac in a three pin package.

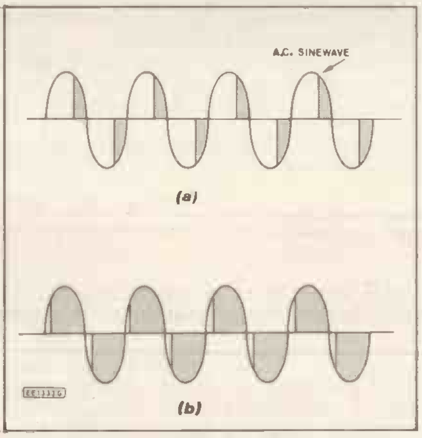


Fig. 2 (left). Output waveforms of the controller under (a) low power and (b) high power. This is depicted by the shaded areas.

HOW IT WORKS

The mains a.c. waveform is applied as shown in Fig. 1, and a trigger circuit causes the triac to conduct at a certain point in the sinewave cycle.

When the triac is triggered at the start of each sinewave, it passes full power to the load. The trigger circuit can be made to interrupt the sinewave part way through its cycle, so that the "chopped" waveform is applied to the load, resulting in an overall reduction in power output.

The waveforms as seen by the load under low power and higher power output levels is shown in Fig. 2. In Fig. 2a the shaded area under the sinewave represents the portion of the a.c. sinewave when the triac is conducting, i.e. it is the power applied to the load.

In this case, the load operates at a low power. The unshaded area is lost completely, so that all the load sees is a series of "spikes".

In Fig. 2b, with the triac conducting more fully, the power applied to the load is increased, as the shaded area depicts more power is driving the load.

CIRCUIT DESCRIPTION

The full circuit diagram of the Power Controller appears in Fig. 3. IC1 is a power controller i.c. around which the design is based. It has three terminals, those designated A (Anode) and K (Cathode) are in effect connected in series with the load to be controlled.

The S terminal (pin 1) is connected via a 220k potentiometer (VR1) to the mains sinewave, and by adjusting VR1, the triggering point of the internal triac is advanced or retarded. This chops the a.c. sinewave applied to the load, thereby varying the power across the load.

Whilst it is customary to include r.f.i. suppressors to reduce interference, sometimes the suppression is in the form of a small

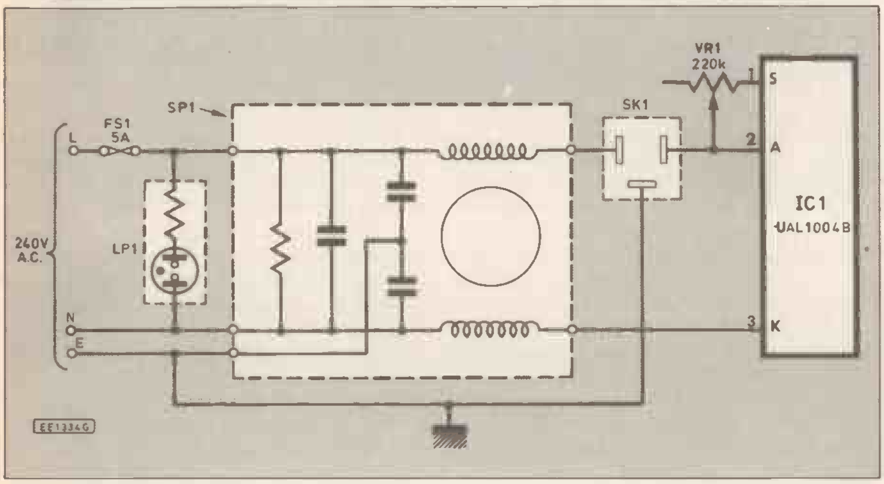


Fig. 3. Complete circuit diagram for the Power Controller. The dotted area marked SP1 is the mains suppressor unit, which prevent interference reaching the mains supply.

choke and these may only be partially effective. The Power Controller includes a complete r.f.i. mains filter unit which takes care of r.f.i. generated in the triac component.

As can be seen from the circuit diagram, the mains filter unit SP1 incorporates several devices, namely a delta capacitor which shunts noise away, and a 2mH 5A choke which further reduces r.f.i. There is also a "bleeder" resistor which discharges the capacitor network when the mains supply is switched off—*important to prevent electric shocks when handling the mains plug.*

The mains supply itself is connected through a 5A fuse FS1, and LP1 is a neon indicator which illuminates when the mains is on. The load itself is plugged into SK1, a panel mounted 13A square pin mains socket.

Although the specified power controller i.c. is rated at 10A r.m.s., the power output of the complete design is determined by the current rating of the suppressor (5A maximum) and also the thermal resistance of the heatsink used to cool IC1. Obviously other factors such as the rating of the interwiring etc., determined the maximum current, too.

CONSTRUCTION

It is recommended that the Power Controller is built into a diecast aluminium box. This provides a very rugged housing, which is especially important if the unit is to be used on a workbench, for example. The box also acts as a heatsink for IC1, though normally you can expect it to barely rise in temperature in normal use.

The box used for the prototype was BIMBOX No. 5006-16 measuring 192 ×113×61mm and this comfortably housed all components with some room to spare. The main criterion when selecting the box is to ensure that there is adequate depth for the mains filter, which measures 38mm diameter.

The front panel of the case must be prepared to take the potentiometer, fuseholder, neon lamp and socket. If the specified socket is used, then a 50mm round cutout is required; on the prototype this was achieved with a Q-Max chassis cutter, using a smaller Q-Max to punch the pilot hole.

The alternative is to drill out a ring of holes and/or saw out the centre with a hacksaw-type Abrafile blade, then file the edge with a half-round file until a smooth finish is achieved.

COMPONENTS

Shop Talk See page 527

Potentiometer
VR1 220k linear

Semiconductor
IC1 UAL1004B power controller, 10A 240V

Miscellaneous
SP1 mains suppression filter Roxburgh SDC 051, 5A

SK1 Panel mounting 13A mains socket
FS1 20mm panel mounting, 5A fuse
LP1 240V a.c. panel mounting neon indicator

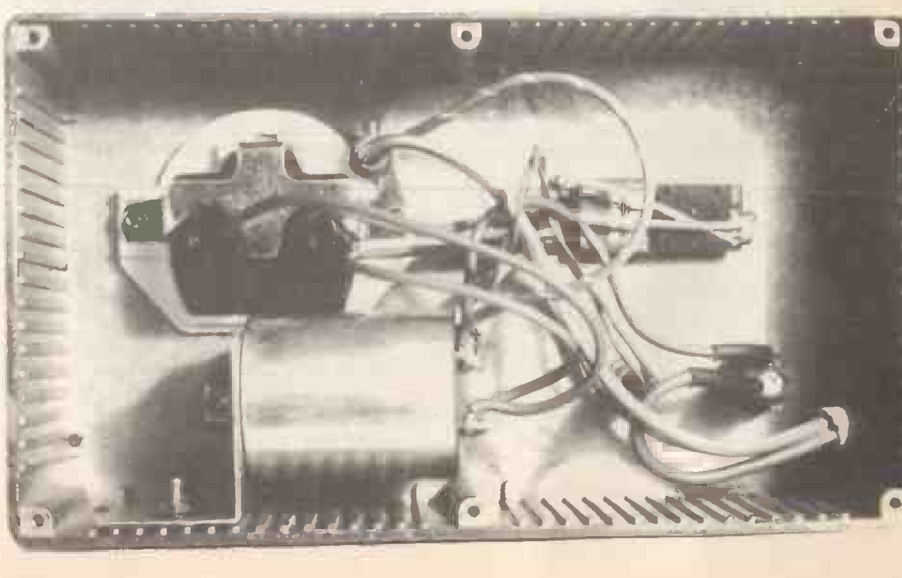
Case, diecast box BIM5006-16, 192×113×61mm: knob to suit VR1: aluminium for SP1 mounting bracket; 13A 3-core mains cable, 1.5 metres approx; 13A plug, fused 5A; cable gland, large, to suit 3-core cable; nuts; bolts; solder; etc.

Approx. cost Guidance only **£25**

Two countersunk holes will also be required for the 3.5mm socket mounting screws, and these holes are 30.5mm from the centre of the large 50mm cutout. It is quite essential that these holes align correctly with the socket, of course: to make marking out easier, the socket itself can be used like a template to mark the mounting holes, once the main 50mm cutout has been punched.

Further drilling is required for a cable entry gland. As usual, it is necessary to provide some support around the cable at the point where the cable passes through the box. Normally a grommet would be used, but because the walls of the diecast box are comparatively thick—3mm or so, including the moulded p.c.b. guides—then a grommet will not fit in this application. Instead, it is best to utilise a cable gland, since this will accommodate the thickness of the wall; it will also firmly clamp the cable, so it dispenses with the need to use a "P" clip to prevent the cable from pulling out.

The completed Power Controller showing the layout of components inside the diecast metal box.



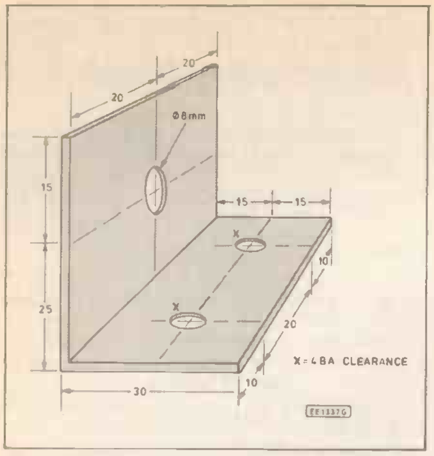


Fig. 4. Dimensions of the aluminium mounting bracket for the mains suppressor SP1.

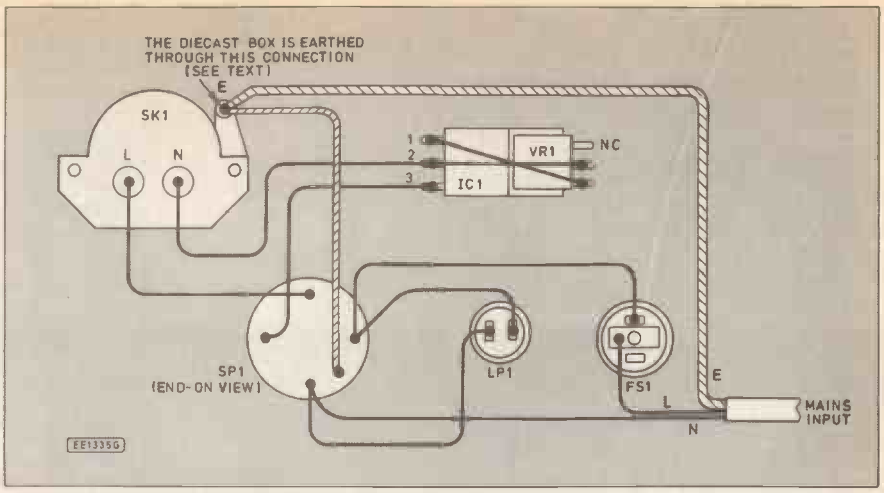


Fig. 5. Interwiring details to the "load" socket SK1, mains suppressor SP1, IC1/VR1, power on lamp and fuse FS1. Use cable rated at 6A minimum and cover all soldered joints with insulated sleeving.

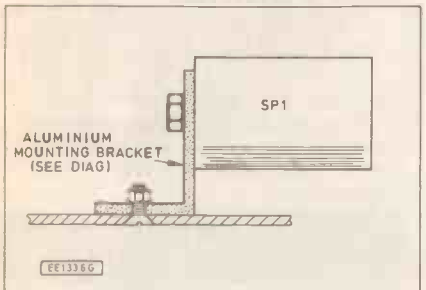


Fig. 6. Method of mounting the suppressor inside the case.

Two 4BA clearance holes are drilled along the bottom side of the case to carry the mains filter bracket. This bracket can be fabricated from a small piece of scrap aluminium, and the dimensions are summarised in Fig. 4.

After all drilling and metalwork has been completed, the diecast box can be painted as required; the prototype box was in its raw unfinished state and so it was given a coat of spray-on primer. Several coats of a car touch-up aerosol paint were applied afterwards. You may also wish to embellish the case by adding labelling etc. according to taste, and rub-down lettering can be used in the normal manner.

The next stage of construction is the interwiring and it is recommended to start with the potentiometer and power controller i.c. sub-assembly, see Fig. 5. The bush of the potentiometer passes through the large hole in the tab of IC1: using the mounting nut of VR1, loosely bolt the two components together while you complete the interwiring between IC1 and VR1. Next solder two flying leads to terminals two and three of IC1 as shown, taking care to insulate with heatshrink tubing or p.v.c. sleeving as necessary.

The power controller i.c. and potentiometer can now be bolted finally into place in the mounting hole on the front panel. The rest of the interwiring is very straightforward and is completed in accordance with Fig. 5.

It is preferable to wire the connections to the mains filter SP1 and mains socket SK1 prior to bolting these components into their intended positions. When soldering wires to SP1, a larger tip or iron may be needed to bring the joints up to the correct temperature.

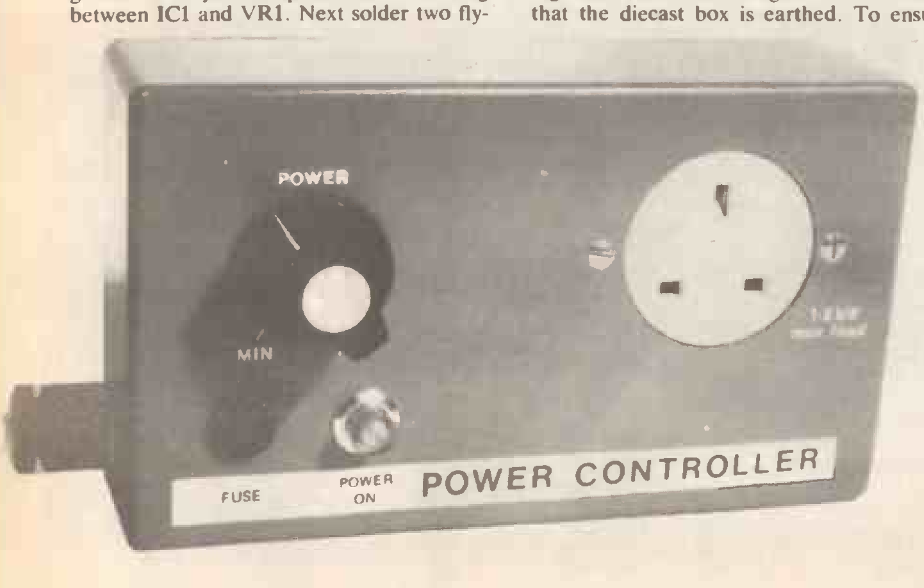
Since all wiring is at mains voltage it is essential that the soldered joints are of a good quality and they should be properly insulated as necessary. Cable of 6A rating should be used, i.e. 32/0.2mm, though the neon lamp can be hooked up with general-purpose interconnecting wire.

The mains input cable is rated 13A, chosen more for its mechanical strength rather than its electrical rating. It is fitted with a square pin plug fused at 5A.

EARTHING

The Earth input lead is wired straight to the earth terminal of SK1 as shown in Fig. 5 and a further Earth wire then runs to the appropriate terminal of the mains filter SP1. It will be seen that the Earth terminal of SK1 is electrically connected to the socket mounting screws, and it is through these two screws that the diecast box is earthed. To ensure that the screws are in sound contact with the diecast box, remove any excessive paint from around the screw holes to make certain of a good connection.

When you are satisfied that all construction is complete, you can test the assembled Power Controller in conjunction with a table lamp or desk light, since this will suffice as a low power load to check for correct operation of the device. If the lamp can be dimmed by rotating the control knob of the Power Controller, then go on to test the unit with, say, an electric drill just to confirm that it functions correctly.



APPLICATION NOTES

The Power Controller will find several uses in the home and workshop, but there are some appliances that the device CANNOT control. We have already mentioned fluorescent lamps, and brushless motors such as shaded-pole "gram" motors or other induction motors, should not be connected to the controller; such motors respond more to a change in frequency than the applied voltage, and the Power Controller therefore cannot provide effective control.

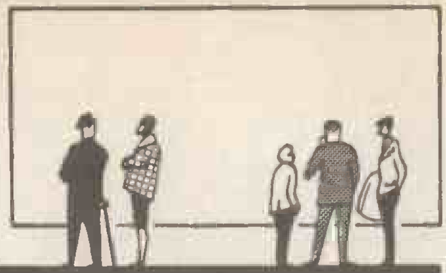
In general terms, any mains motor up to 1000 Watts (1kW) which is fitted with brushes can be used, and the prototype has been used with motors up to 800W with success. When used with electric drills, when the load on the drill is increased, the torque output will decrease. At the extreme, when the drill is running at very low speeds under a high load, the motor may stall completely.

In these circumstances the power applied to the drill is very low and it is improbable that the motor will be damaged. However, since the Power Controller does not of course include any feedback elements, it cannot compensate for the decreased torque when a slow-running motor is under load. This implies that it cannot operate an electric drill with a view to power-screwdriving or machining.

You will still find the design of benefit when starting off drilling centres, wire brushing, or other applications where it is undesirable to run a drill at full speed.

The prototype has been pronounced a success when powering electric fires up to 1kW (one bar)—though you *MUST NOT* use the controller on electric Fan Heaters, because they incorporate a shaded-pole motor to drive the fan. No doubt readers will find other applications for this simple and robust design. □

SHOP TALK



BY DAVID BARRINGTON

Catalogue Bargains

With the busy autumn season fast approaching there is just time enough to blitz the workshop, draw up a shopping list and take advantage of some of the excellent "summer bargains" still on offer from advertisers. Mind you, having seen just some of the plans for the months ahead (including a 100-page catalogue being given Free to EE readers) it might be a case of *"not putting all your components in one basket"*.

Coinciding with their Catalogue update, ***TK Electronics (☎ 01 567 8910)*** are currently offering giant size solar panels (12"×12") which, they claim, will deliver 12V 200mA in bright sunlight and 11.5V 60mA on a typical British summer day (dull and overcast). They also claim that coupled to a lead acid battery and a simple inverter you could build a self-contained power supply for boat or caravan to run low power appliances.

These solar cells cost £14.50 plus VAT. However, the cells are deposited on glass to protect them against the environment and are, therefore, fairly fragile to send through the post. Consequently TK have to levy a p&p charge of £1.75 per order.

With the recent publicity surrounding fires in the home, another item from TK that caught the eye was a Smoke Alarm for £8.50 (plus VAT) or £8.00 each(plus VAT) for three or more.

One of the incentives to buy the 184-page **Cirkit** Summer Catalogue is that, not only does it contain "discount vouchers" and an easy to enter competition with a top prize of a 10MHz oscilloscope, worth over £200.00, but for the first 500 constructors who send in orders valued at over £50.00 (excluding VAT) each will receive a Free digital travel alarm.

Being shown for the first time among over 3,000 lines are a low cost 10MHz scope and the latest Vero Easiwire solderless wiring system. The catalogue cost £1.30 and is available from newsagents or direct from **Cirkit** *(☎ 0992 444111)*.

The new 70-page **Magenta** catalogue has just been released and contains a range of EE project kits and sets of Leggo Technic educational products, including computer control models such as a robot arm.

The Robotics and Computing section also lists stepping motors and accessories, and a low cost 68000 microprocessor computer board. It is designed to be used as an evaluation tool with particular emphasis on educational applications.

The catalogue is issued with a separate price list, for future updating, costs £1.00 and is available direct from **Magenta Electronics** (☎ *0283 65435*).

The **Maplin** 16-page Summertime Collection brochure includes a novel stereo infra-red link (£39.95, YP63T) which allows users to listen, via headphones, to their favourite programme or piece of music without disturbing other people in the room and also without trailing headphone leads across the carpet.

The system has a range of about 30ft. You simply plug a small transmitter into the headphone socket on your hi-fi or TV and plug your headphones into the receiver. The receiver can be clipped to any convenient pocket or attached to a belt.

The brochure also contains details on radio control models and a range of digital thermometers, including a quality clinical digital thermometer for family care.

The Summertime Collection brochure should still be available from any Maplin shop or direct from Maplin Head Office (☎ *0702 554161*).

Finally, we would mention that **Greenweld** have issued a 4-page listing of special "summer sale" bargains from their 1988 components catalogue.

Many of the items mentioned are at half price or less. These include power supplies, headphones, connectors and a vast range of semiconductor devices.

To take advantage of the **Greenweld** offer ring them on ☎ *0703 772501* for full details, the sale will be finishing at the end of this month (August).

Shop Front

With over 1000 sq. ft. of sales area offering not only a wide selection of components, including 100's transistors, i.c.s, cables, opto devices, but also loudspeakers rated from 4W to 200W, **Marco Trading** have just opened their third retail shop in the heart of Birmingham.

Called **Supertronics**, the new shop also carries large stocks of new and secondhand test equipment and video surveillance cameras. Another bonus is that they have a resident engineer who runs a full on-site audio and video repair service.

At the opening of the new shop Mrs. Cox of Marco commented. *"We have designed this shop so that we are able to display nearly all the items we sell. Naturally our Mail Order catalogue (only £1.00) is available 'over- the-counter'.–It comes complete with £6.50 worth of credit vouchers".*

"We invite readers to come and browse at their leisure during opening hours of between 9.00 a.m. to 6.00 p.m.–Mon-to-Sat (closed Wednesday)–You will find many bargains".

Supertronics is five minutes walk from New Street Station and Birmingham's new shopping area at **65 Hurst Street, Birmingham B5.** (☎ *021 666 6504)*. There is a large car park directly opposite.

CONSTRUCTIONAL PROJECTS

PIO For The Amstrad

All the components required to complete the *PIO For The Amstrad* project should be feely available from most advertisers. The coloured ribbon cable, the "locking" header plug, 50-way IDC edge connector and polarising key are now widely stocked and should not cause any purchasing problems.

Some of the copper tracks on the printed circuit board are very fine and it is advisable to use a soldering iron with a fine pointed tip when soldering components on the board. This board is available from the *EE PCB Service*, code EE618. (see page 549).

Breaking Glass Alarm

Checking through the components list for the *Breaking Glass Alarm*, it appears that most component suppliers only sell ultrasonic transducers as matched transmitter/receiver sets. These are usually priced at about £5 per set.

If readers do have difficulty in locating a suitable 40kHz transducer, the R40-16 device (£2.20 plus 60p postage) used in the author's prototype is available from **Chartland Electronics Ltd., Dept EE, Chartland House, Twinoaks, Cobham, Surrey. ☎ 037284 2553.**

The printed circuit board for the Breaking Glass Alarm project is available through the *EE PCB Service*, code EE617

Power Controller

The two main components used in the *Power Controller* project are "special" items and only available from one source.

The power triac i.c. and mains filter unit are stocked by **Verospeed.** The latest prices we have for these devices are: power controller i.c. £8.66, order code 253-25997H; mains filter £4.96, code 228-41490G. For latest prices contact: **Verospeed, Dept. EE, Boyatt Wood, Eastleigh, Hants, SO5 4ZY. ☎ 0800 272555.**

Although the controller is built around the two main components, mains voltage is still present and extreme care should be taken when carrying out *any* work on the unit. In fact, it should *always* be disconnected from the mains before undertaking any wiring and then switched on again *after* checking the work over.

The use of a suppression/filter unit does keep the number of mains connections down to a minimum and can, with care, be tackled by the less experienced constructor. Also, it is a good idea to use a plastic bodied and spindle potentiometer or, at least, the more common plastic insulated spindle type.

Audio Mini Bricks

The master printed circuit board (255A–£7.90) for the *Audio Mini Bricks* series of projects is available from **Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.**

Heart Beat Monitor Interface

There should be no problems in obtaining components for the *Heart Rate Monitor Interface* described in this month's *BBC Micro* column.

For best results, it is important that a 5mm "ultra-bright" or "super-bright" l.e.d. be used in this circuit.

Home Security

The only components likely to cause local sourcing problems to readers who wish to construct the *Infra Red Beam Alarm*–this month's *Home Security* project–are the infra red lenses. These were purchased from Maplin and are listed as red plastic lens and cost 48p each, order code FA95D (Plastic Lens).

Locating the components called up for this month's *Exploring Electronics* project–*FET Touch Switch*–and the *I/O Address Select (On Spec)* circuit should be trouble-free and available from any good component stockist.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month, in response to requests from several readers, we shall be taking a look at the Plus-D Disk Interface available from Miles Gordon Technology. For those of you wishing to operate a number of I/O devices simultaneously, we have details of a simple address selector which can greatly simplify the task.

I/O Address Selector

One of the limitations of the Spectrum, at least as far as I/O provision is concerned, is the method of partial address decoding employed within the Spectrum's Uncommitted Logic Array (ULA). This "single-line" address decoding involves sensing the state of individual address lines (A0 to A4 in the case of an unexpanded Spectrum) rather than detecting the presence of a unique address within the lower 256 addresses of the Z80's I/O memory map.

The upshot of this is that external hardware (such as our *On Spec* projects) *must not* respond to a low state on any one (or more) of the address lines A0 to A4 when an I/O operation is to be performed. This unfortunate restriction leaves only three of the lower eight address lines to play with (A5 to A7) and thus a total of only eight further unique I/O addresses is available for the hardware developer to use!

The most effective way of decoding these extra I/O addresses in order to provide the active-low signals required to select or enable external devices is with the use of a three-to-eight line decoder (e.g. 74LS138) as shown in Fig. 1. Readers who are contemplating complex I/O arrangements (as would be required if, for example, several of our *On Spec* projects were to be assembled together to form a single multi-function I/O circuit) should find this circuit a great improvement on employing several address decoders based on conventional logic gates (e.g. typically OR or NAND).

The address decoder provides eight chip select lines (any that are not used can simply be left floating) and a master switch is provided in order to disable all external I/O (useful when developing software routines). The circuit operates according to the truth table shown in Table. 1. As an example, the chip connected to $\overline{CS4}$ will be enabled (assuming, of course, that its chip select line conforms to the usual active-low convention) when an I/O operation (using IN or OUT) makes reference to a port address of 9F hexadecimal (or 159 decimal).

Plus-D Disk Interface

Readers will doubtless already be well aware of the advantages of magnetic disk storage. Amstrad, it appears, have at last acknowledged this fact by incorporating a 3 inch disk unit within the Spectrum Plus-Three. Unfortunately, this device offers rather limited storage compared with other comparable units (approximately 800K of formatted disk storage is now typical for a 3.5 inch or 5.25 inch double- sided drive).

For existing Spectrum owners, the Plus-D interface from Miles Gordon Technology (well known for their Disciple disk interface) provides an arguably better alternative to that of upgrading to a Plus-Three. The Plus-D interface is housed in a neat metal enclosure and is attached to the expansion connector at the rear of the Spectrum. The unit measures 92×108×20mm and is fitted with a "snapshot" push- button (more of this later), l.e.d., and two connectors (one for the Shugart standard floppy disk bus and one for a Centronics printer).

The plus-D interface can be used with a variety of different disk drives (provided they are compatible with the Shugart specification) but drives *must* be double-density types (older single-density drives are not suitable). I tested the Plus-D with a variety of drives including 3.5 inch and 5.25 inch, 40 and 80 track, single and double-sided types and all performed satisfactorily, the only difference, of course, being the amount of storage provided. It is interesting to note that an 80 track double- sided drive (either 3.5 inch or 5.25 inch) will provide 780K of formatted storage per disk (approximately four times that provided by a 3 inch disk using an Amstrad Spectrum Plus-Three!). The Plus-D will support one or two drives, the latter having obvious advantages when copying or transferring files between disks.

Snapshot

The snapshot facility is undoubtedly one of the most valuable assets of the Plus-D (and one which is not available on the Plus- Three unless one cares to invest in some external third party hardware). The snapshot facility (invoked by simply pressing the snapshot button) allows users to freeze the current program and either dump the screen to a Centronics printer (in either 32-column or "large size" modes), save the screen to disk, or save the entire contents of the Spectrum's memory as a 48K (or 128K) snapshot file.

Snapshots allow the user to quickly and easily transfer existing software to disk and I put the Plus-D through its paces by transferring a huge variety of commercial software to disk. Happily, all but one of my

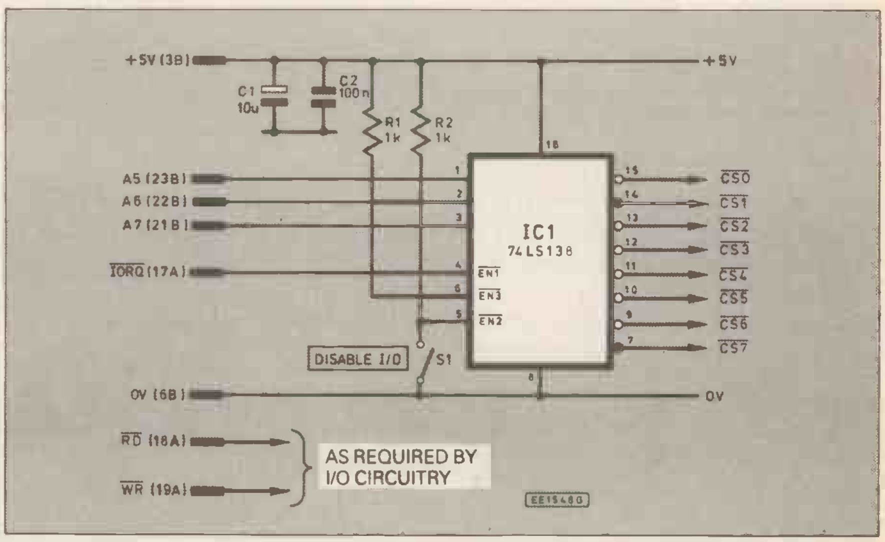


Fig. 1. Complete circuit of the I/O address selector.

Table 1: Truth table for the I/O address selector.

ADDRESS LINES			$\overline{EN2}$	$\overline{IORQ}$	CHIP SELECT LINES								I/O ADDRESS SELECTED	
A7	A6	A5			$\overline{CS7}$	$\overline{CS6}$	$\overline{CS5}$	$\overline{CS4}$	$\overline{CS3}$	$\overline{CS2}$	$\overline{CS1}$	$\overline{CS0}$	HEX.	DEC.
0	0	0	0	0	1	1	1	1	1	1	1	0	1F	31
0	0	1	0	0	1	1	1	1	1	1	0	1	3F	63
0	1	0	0	0	1	1	1	1	1	0	1	1	5F	95
0	1	1	0	0	1	1	1	1	0	1	1	1	7F	127
1	0	0	0	0	1	1	1	0	1	1	1	1	9F	159
1	0	1	0	0	1	1	0	1	1	1	1	1	BF	191
1	1	0	0	0	1	0	1	1	1	1	1	1	DF	223
1	1	1	0	0	0	1	1	1	1	1	1	1	FF	255
X	X	X	1	X	1	1	1	1	1	1	1	1	–	–
X	X	X	X	1	1	1	1	1	1	1	1	1	–	–

personal "top-ten" games and all of my favourite utilities transferred without a hitch. Loading a saved snapshot file takes just a few seconds and the program restarts at the exact point at which it was left (ideal for games addicts!). The snapshot facility copes with both 48K and 128K versions of the Spectrum (the latter taking a little longer by virtue of the larger file size) and up to 16 48K snapshot files can be accommodated on a double-sided 80 track drive.

The Miles Gordon disk operating system (G+DOS) proved extremely straightforward with simple and easily memorised commands for catalogueing, loading, erasing, and renaming files. The usual wild card characters (? and *) are supported and the operating system also recognises Sinclair Microdrive syntax (useful when transferring software designed for use with microdrives).

An excellent configuration and installation program is supplied on cassette. The *only* thing I didn't like about this software was the somewhat nauseating opening screen (which not only offers "congratulations" to the user for purchasing the system but assaults the ear by playing the tune of the same name!). This said, the installation program is a model for all programmers, and one can only hope that other manufacturers will sit up and take note.

One limitation of the Plus-D interface is that it does not provide an extension of the Spectrum's expansion bus for use by other external hardware (such as a joystick interface). Miles Gordon Technology can, however, provide a reasonably priced adapter which will overcome this problem.

Manual

A 32-page A5 format manual accompanies the Plus-D package. This document constitutes a comprehensive guide to installing and configuring the Plus-D system and provides users with a gentle introduction to the Plus-D's command syntax and the process of saving, loading, copying and renaming disk files. Incidentally, to keep faith with software suppliers, the Plus-D will *not* allow users to make copies of snapshot files. The Plus-D manual also deals with configuration of the Centronics printer port and has a section for the more advanced user in which the procedure for reading from and writing to a disk sector is discussed as is the use of streams and channels and the automatic execution of single sector machine code files.

Further support for the Plus-D is forthcoming from an independent user group which caters for Disciple and Plus-D users. This active group, INDUG, provides a regular newsletter which is packed with hints and tips supplied by members. U.K. membership of INDUG is moderately priced at £10 per annum.

During the past three months, I have used the Plus-D with half a dozen different variants of the Spectrum, including an early Issue 3 machine, an Issue 6 Spectrum Plus, and a recent Plus-Two. In all cases the Plus-D behaved impeccably. Furthermore, since the Plus-D has its operating system in ROM, the system is protected against an inadvertent reset (there is no need to reload the system from disk).

In conclusion, I have absolutely no hesitation in recommending the Plus-D as it represents outstanding value for money. Existing users of the Spectrum should take heart as there is no longer any good reason for upgrading to a Plus-Three; at £139.95, the Plus-D and a 3.5 inch 80 track double-sided drive from MGT is a much cheaper *and* more powerful combination.

Miles Gordon Technology is at Lakeside, Phoenix Way, Swansea Enterprise Park, Swansea, SA7 9EH. INDUG can be contacted at 34 Bourton Road, Gloucester, GL4 0LE.

Next month: We shall be taking a look at books on the much neglected Forth programming language. Also, as promised in the August issue, we include two fast machine code routines for those who built the Dual DAC featured in July and August issues.

In the meantime, if you would like a copy of our *On Spec Update*, please drop me a line enclosing a large (250mm×300mm) *adequately* stamped addressed envelope. Mike Tooley, Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

Constructional Project

HOME SECURITY SYSTEMS Part 4

OWEN BISHOP

Part 4 Infra-Red Detector

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

In this, the final part of the series, we look at the construction of an Infra Red Detector which will provide a useful addition to the Home Security System, the unit can also be used as a stand-alone detector.

INFRA-RED DETECTOR

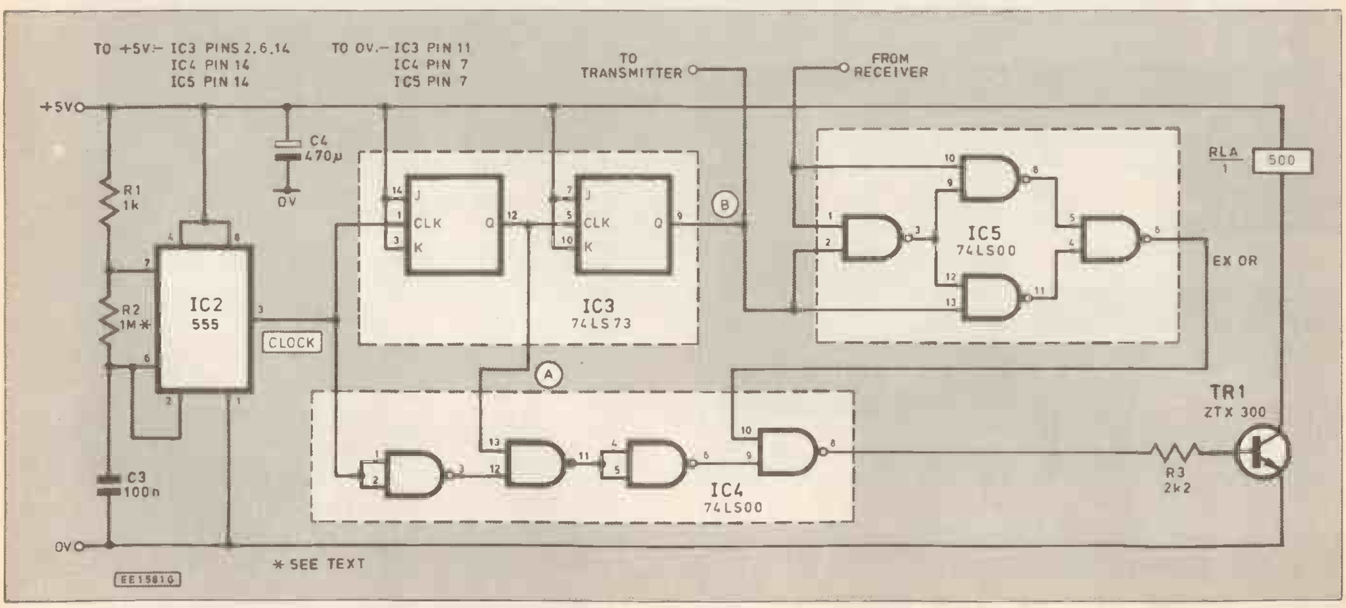
This device depends upon a beam of infra-red being broken by the intruder. Ordinary visible light could be used for such a system but the advantage of using infra-red is that it is invisible to the intruder. The unwelcome visitor is thus more likely to walk into the beam unawares.

The requirements for operating such a system are not quite as simple as they may at first seem. It is not sufficient to have a source of infra-red directing a beam on to an infra-red sensor, and arrange for the alarm to sound when the beam is broken.

Light from most sources of illumination, including incandescent lamps and fluorescent tubes, contains a proportion of infra-red. If lighting levels are high, the sensor may become saturated and the breaking of the infra-red beam will not be detected. If the house is unoccupied, the intruder may switch on room lighting and inactivate the system. Furthermore, an intelligent intruder who spots the sensor, may try to swamp it by shining a bright torchlight at it.

In this system, an *intermittent* infra-red beam is directed at the sensor. The logic circuit confirms that the sensor detects infra-red when the beam is on, and detects the absence of infra-red when the beam is off. If the sensor fails to detect infra-red when the beam is on, this indicates that someone is blocking the beam—the alarm is sounded. If the sensor detects infra-red when the beam is off, this indicates that room lights have been switched on, or that someone is swamping the sensor, or perhaps that an intruder has unwittingly shone a torch at the sensor while investigating the premises, In either case the alarm sounds.

Fig. 4.1. Clock, logic and relay circuits of the Infra-Red Detector



COMPONENTS

Shop Talk
See page 527

Resistors

R1	1k
R2	1M, then 100k
R3	2k2
R4 to R6	15, 0.5W carbon or 0.6W metal film (3 off)
R7	68
R8	33k
R9	4k7
R10	10k
R11, R12	2k7 (2 off)
R13	330k
R14	220
R15	2k7
R16	1k
R17	33k

All ¼W 5% carbon, unless otherwise stated

Potentiometer

VR1	47k horizontal sub-miniature preset

Capacitors

C1	470n polyester layer
C2, C3	100n polyester layer (2 off)
C4	470μ elect. 16V

Semiconductors

D1 to D3	TIL38 high power infra-red emitting diode (3 off)
D4	TIL100 photodiode
D5	TIL209 red l.e.d.
D6	BZY88 Zener diode 4.7V
TR1, TR2, TR4, TR5	ZTX300 *npn* transistor(4 off)
TR3	BD131 *npn* medium power transistor (or ZTX300, see text)
IC1	7805, 5V, 1A regulator
IC2	555 timer
IC3	74LS73 dual J-K flip-flop
IC4, IC5	74LS00 quadruple 2-input NAND gate
IC6	CA3140 MOS-FET op. amp.

Miscellaneous

RLA1 d.i.l. reed relay, single pole make, 5V; 0.1 inch matrix stripboard, 22 strips×38 holes, 8 strips ×11 holes, 11 strips ×24 holes, 13 strips ×24 holes (cut from a piece, 36 strips ×50 holes; 1mm terminal pins (16 off); 14-pin d.i.l. sockets (4 off); 8-pin d.i.l. sockets (2 off); plastic lenses-red, 37mm diam, f=80mm (2 off); cases, black a.b.s 68mm×130mm×42mm (2 off); wire; fixings etc.

Approx. cost Guidance only **£18**

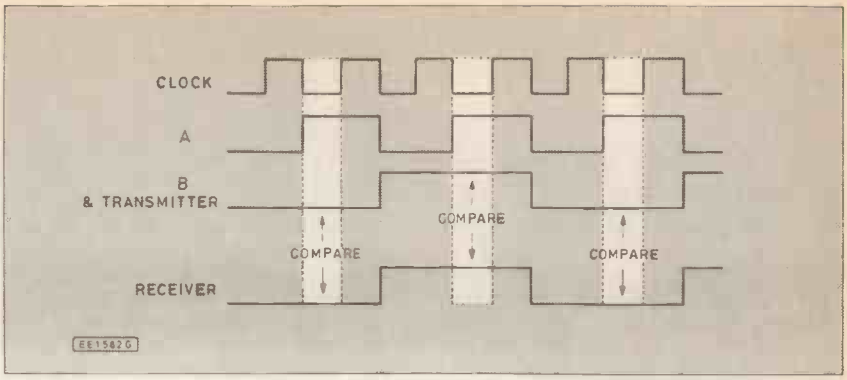


Fig. 4.2. Logic timing diagram

CIRCUIT

The clock, logic and relay circuits employed are shown in Fig. 4.1. The clock operates at about 70Hz, producing a stream of pulses (Fig. 4.2) referred to as CLOCK. These pulses are fed to a J-K flip-flop (IC3) wired with J and K high so that the output Q changes every time CLOCK goes low. This gives a pulse-train A, running at half the frequency of CLOCK. Pulse train A is sent to a second J-K flip-flop, giving a train B which has one quarter the frequency of CLOCK. B is used for driving the transmitter, which switches a set of infra-red l.e.d.s on and off. This produces the intermittent beam referred to above.

The beam is detected by a receiver circuit, which produces a logic high output when the beam is on and a logic low when it is off. If the beam is not broken (output continuously low) and is not swamped (output continuously high), the signal from the receiver should be identical with and in phase with B, as shown in Fig. 4.2. We use an exclusive-OR gate to compare these two signals. Since we need only one EXOR gate it is made from four NAND gates (IC5). As long as the signals are identical, the output from this gate is high. If they differ, it immediately goes low.

If we were to rely simply on comparing the two signals continuously, we could run into trouble owing to response times of the transmitter l.e.d.s and the receiver. Instead we arrange to compare the signals some time *after* the l.e.d.s have been switched off or on. Fig. 4.2 shows that the comparison is made when CLOCK is low and a signal A is high. IC4 provides the necessary logic; the output of pin 6 is high only when CLOCK is low and A is high.

If the output of pin 6 is low, the output of pin 8 is high, no matter what signal is being received from the EXOR gate. However, during the sampling period, pin 6 is high and we find the inverse of the EXOR output at pin 8. Thus, the output at pin 8 is high when the system is functioning normally, but drops to low if the beam is broken or the sensor is saturated. The output from pin 8 drives a transistor TR1 which controls a relay.

The relay is normally closed, but opens in the alarm condition. The relay may thus be wired into the peripheral loop of the security system. Note that with this method of connection, the alarm will also be sounded if the intruder finds and cuts the wires carrying the power supply to the Detector, or between the Detector main unit and the transmitter unit, or the wire of the peripheral loop leading to the Detector.

CONSTRUCTION

Build the 5V regulator board first (Figs. 4.3 and 4.4). Do not mount it in the case yet, as it is much easier for testing to have all the boards laid out on the bench. The 12V supply may be obtained from the p.s.u. of the security system (Part 1, June 1988), or from a low-current transformer unit, such as a 12V "battery eliminator". The Detector normally needs only 200mA, though it could require more if extra-large currents are used for the l.e.d.s (see later).

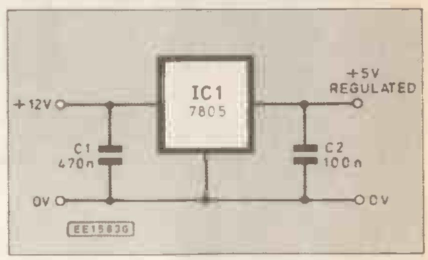
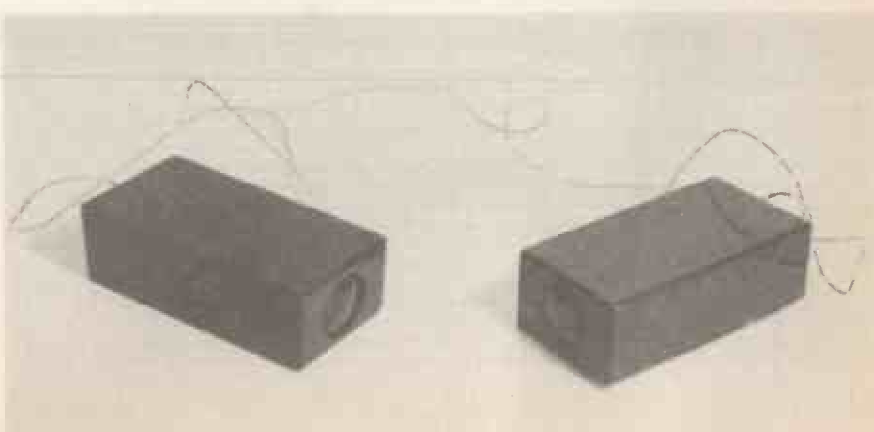


Fig. 4.3. Circuit of the regulated 5V supply



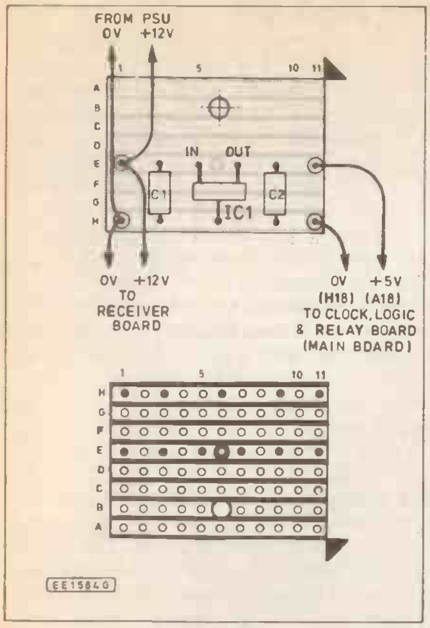


Fig. 4.4. Regulator board construction

Fig. 4.5. Layout and wiring of the main board

The main board is built next and wired to the 5V regulator board (Figs. 4.1 and 4.5) R2 has the value 1M, which gives a clock rate of about 7Hz, to facilitate testing. Substitute a 100k resistor later, when the complete circuit has been tested. For testing this board, temporarily connect the transmitter output (P8) to the receiver input (N26). When the circuit is switched on the output at IC4, pin 8, should remain high. If the connection between P8 and N26 is then removed, the output from pin 8 should go low briefly about twice a second. If the logic appears faulty. check all connections, check that strips that should have been cut really have been cut right across, check that all solder joints are good.

TRANSMITTER

The switching transistors for the transmitter (Fig. 4.6) are also on this board and should be assembled at this stage. The 68 ohm resistor (R7) is optional. Its purpose is to reduce the current to the l.e.d.s to about 50mA (total), which has been found to give an adequate beam for operating the system at distances of two to three meters or more. This distance is suitable for protecting a doorway, a small room or a corridor and there is no point in allowing the l.e.d.s to operate at their maximum rating. The diagram stipulates that TR3 should be a medium-power transistor (BD131) but, if R7 has a value of 68 ohms, a ZTX300 may be substituted here.

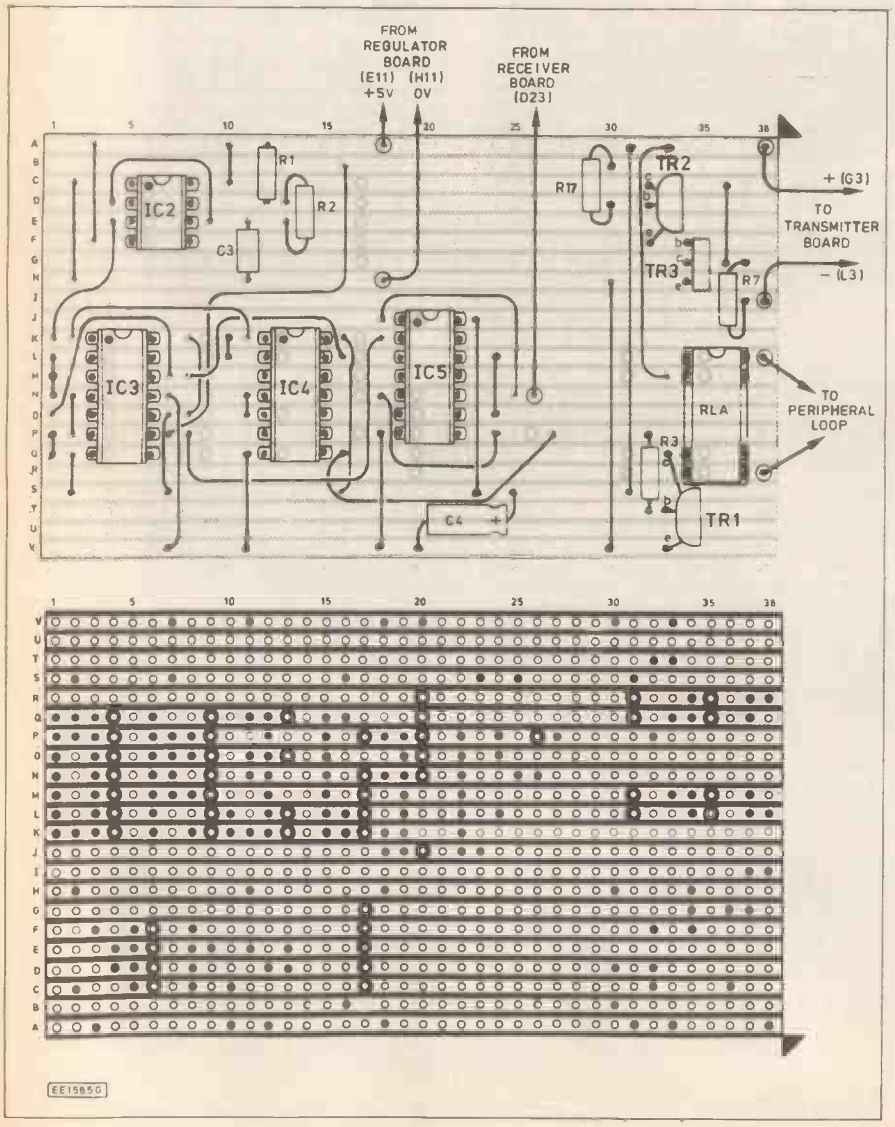
For greater distances, you may find that R7 has to be reduced in value, or even omitted altogether. If R7 is omitted, each l.e.d. passes 150mA, and it is essential to fit a heat sink both to TR3 and to the regulator IC1. With such a large current, a p.s.u. capable of delivering over 500mA is essential. It should be well stabilized, otherwise voltage surges caused by switching the l.e.d.s may affect the operation of the other parts of the circuit. The transmitter board has three infra-red l.e.d.s (Fig. 4.7). One would be sufficient for short distances but three gives a larger region of emission, making it easier to align the system optically. It also caters for applications in which the transmitter is to be a long way from the sensor. The board is cut so as to fit into a slot in the transmitter case (Fig. 4.8).

This design uses inexpensive red plastic lenses to focus the radiation into a roughly parallel-sided beam. The focal length of these lenses is about 80mm for infra-red, so the l.e.d.s should be 80mm behind the lens. The board is a little further back than this and the leads of the l.e.d.s bent so that they are the correct distance from the lens and are grouped around its optic axis.

A hole 32mm diameter is cut in one end of the case and the lens is glued in place. When you have completed the transmitter board, solder two wires about 2m long to it (you can increase the length later), slot it in place, run the two leads out of the hole at the back and screw down the lid.

RECEIVER

The receiver circuit (Fig. 4.9) uses a reverse-biassed infra-red diode to detect incident radiation. When infra-red is received, the increased reverse-current through D4 causes a reduction in potential between R8 and D4. This reduces the base current to TR4, so reducing the current through R9, and hence the potential between TR4 and R9. The operational amplifier (IC6) is wired so that changes in the input potential (at TR4/R9) are amplified and inverted. Thus, the reduced input potential when infra-red is detected gives an increased output from the op. amp. The output from the op. amp. swings sharply between 0V and about 9V (relative to the 0V rail), in phase with the incident infra-red beam.



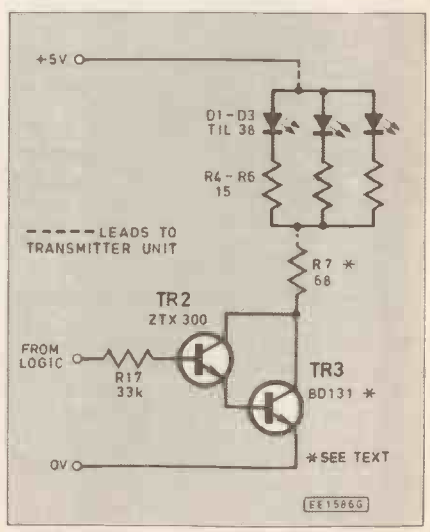


Fig. 4.6. Circuit of the infra-red transmitter

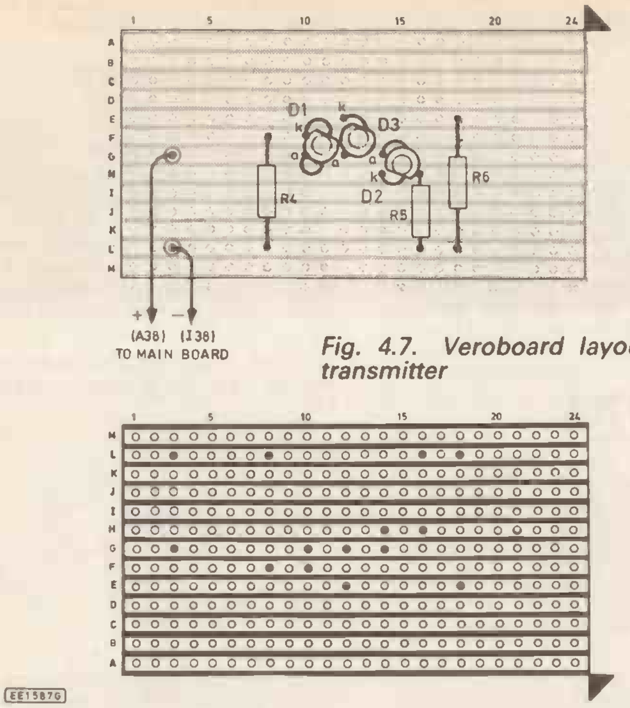


Fig. 4.7. Veroboard layout of the transmitter

SETTING UP

When the receiver circuit is assembled, slot it in position in its case. Connect it to the 12V supply (Note: NOT the 5V supply) and switch on. With the case open and exposed to normal room artificial lighting, adjust VR1 until the l.e.d. just comes on, but goes out again when you shade the sensor with your hand. Then put the lid on the case.

Connect the transmitter board to the terminal pins on the main board (A38, I38). When the 5V supply is switched on, use a voltmeter to monitor the voltage across R7. It should be pulsating regularly at about 2Hz, indicating that the l.e.d.s are being switched on and off as a result of signal B.

Align the transmitter and main cases as in Fig. 4.8, with about 5cm between the lenses. The l.e.d. on the receiver board (D5) should begin to flash regularly at about 2Hz. Place your hand so as to interrupt the beam; the l.e.d. goes out. Remove the lid of the main case, or shine a bright light into it through the lens; the l.e.d. stays on. It may be necessary to adjust VR1 slightly but, usually, the correct position is found first time. Repeat the above tests, measuring the output from the op. amp. (not yet connected to IC5 on the main board). This output should alternate between 0V and 4.7V as the l.e.d. goes off and on.

Now connect the receiver output to IC5 (terminal pin N26 on the main board). Moni-

The output is clipped, using a TR5 as an emitter-follower, so that the output of IC6 appears also across R16 but is limited to a maximum of 4.7V by the Zener diode D6. This limited voltage, suitable for TTL inputs, is then fed to the logic circuit. The output state is indicated by the red l.e.d (D5), which is useful when setting up the system. The main case has a lens fitted as in the transmitter case.

The receiver circuit is assembled on a piece of board (Fig. 4.10) that slots into the main case in a similar way to the transmitter board (Fig. 4.8). The sensor diode is mounted on its long leads so that its position may be adjusted to bring it to the focal point of the lens. A hole cut in the side of the case opposite to D5 allows this l.e.d. to be viewed when the case is closed.

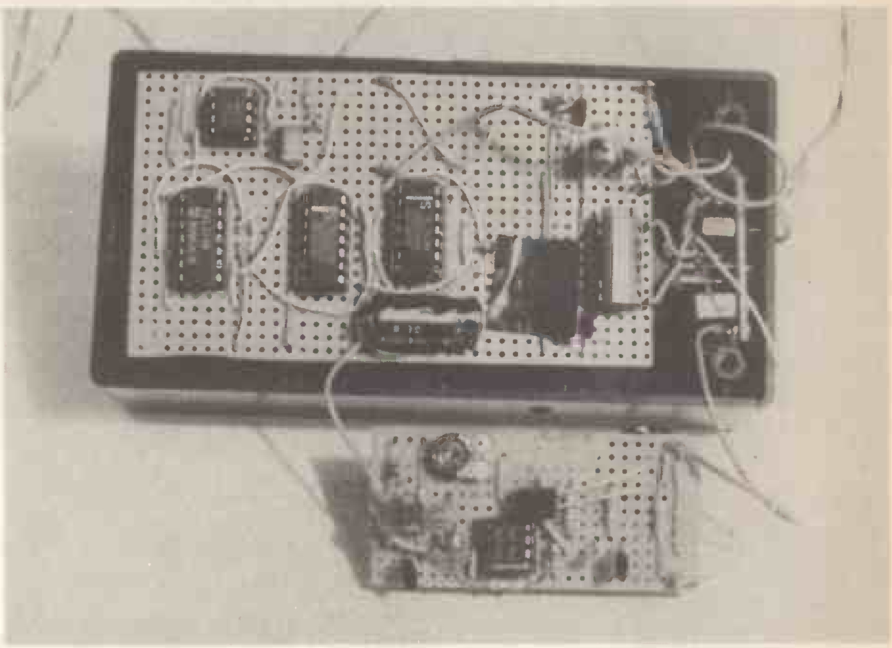
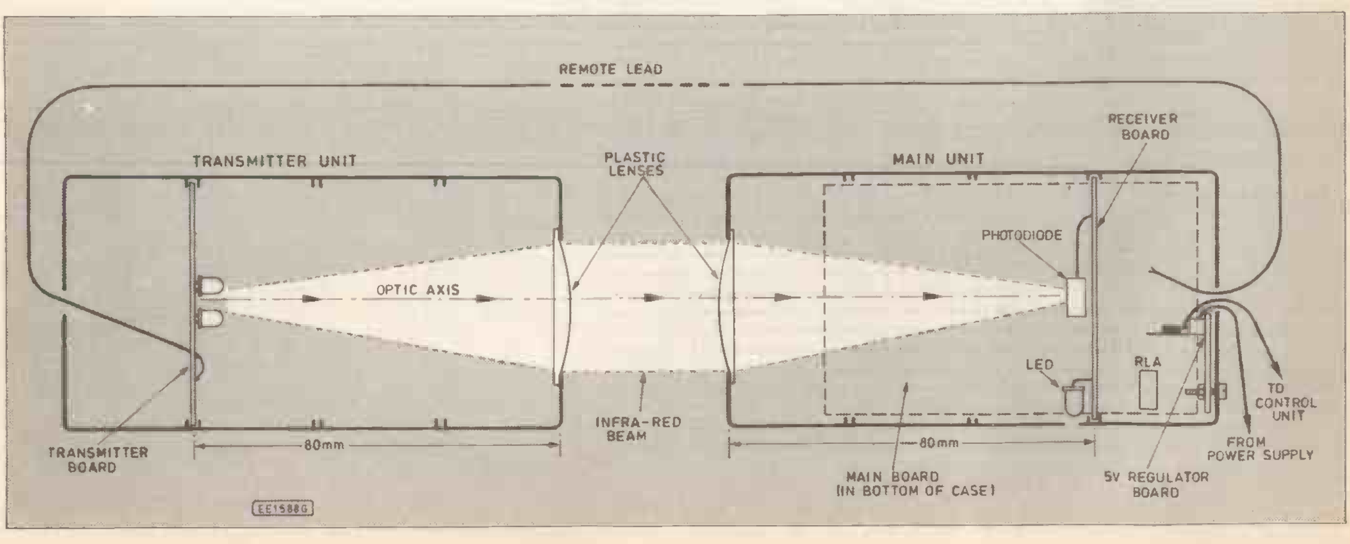


Fig. 4.8. The optical system and general layout



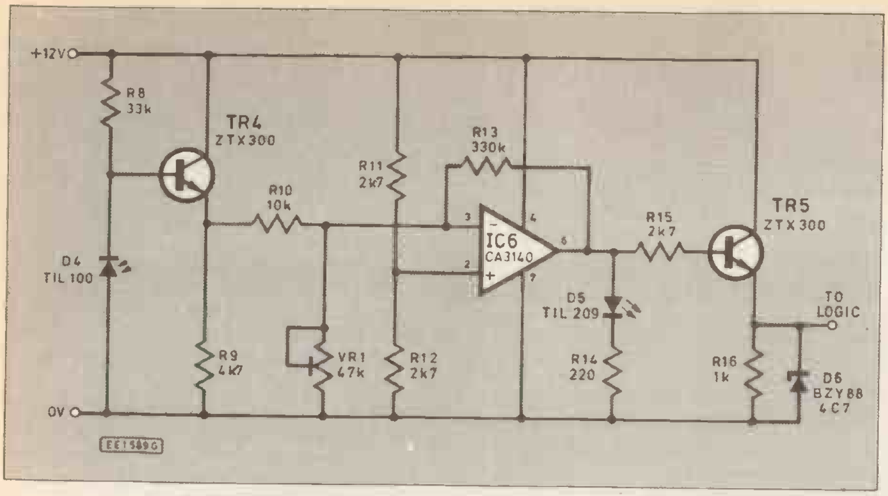
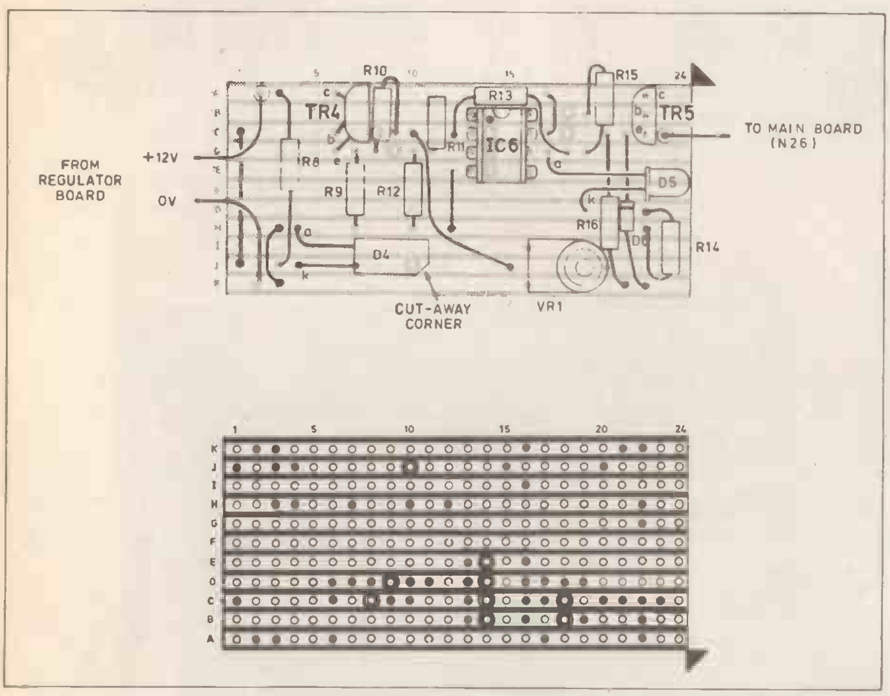


Fig. 4.9. Receiver circuit diagram



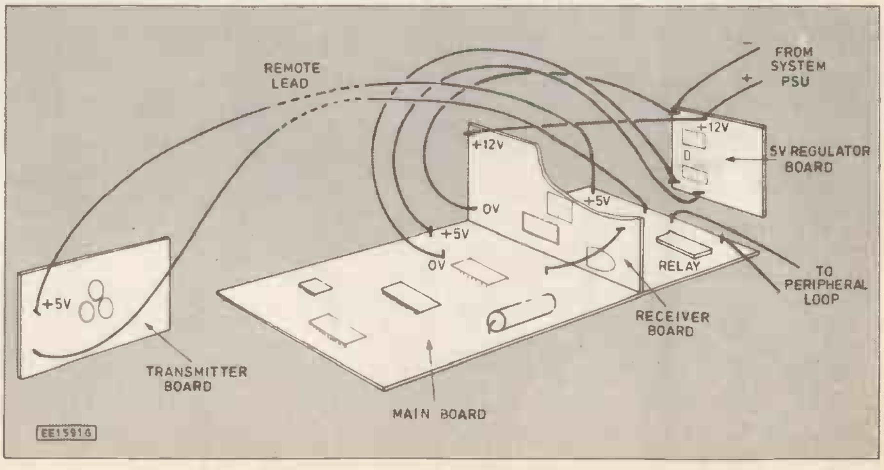
tor the output from pin 8 of IC4, or connect an ohmmeter across the relay contacts. With an uninterrupted beam, the output of pin 8 stays high and the relay contacts are closed. Interrupt the beam: after a delay of a fraction of a second, the output begins to fall repeatedly to 0V, and the contacts repeatedly open. The delay is due to the time taken to reach a "compare" stage (Fig. 4.2). When you are certain that the circuit is operating correctly, replace R2 with a 100k resistor; the clock runs 10 times faster and this delay is not noticeable.

MOUNTING

A compact way of fitting the boards into the main case is to mount the main board in the bottom, with the receiver board across it, in its slot (Fig. 4.11). The region of the main board from columns 27 to 29 has been left clear of components to allow the receiver board to rest on the main board. The main board is the full width of the box and the top of the receiver board comes flush with the top of the box, so the boards are held in place when the lid is fitted. If the case or boards are of other dimensions it will probably be necessary to secure them with bolts.

Fig. 4.10. Layout and wiring of the receiver board

Fig. 4.11. Positioning and interwiring of the various circuit boards



The regulator board is bolted beside the hole in the end of the case. The inter-board wiring is then completed as in Fig. 4.11.

INSTALLATION

The two cases are mounted on either side of the doorway or room. Normally the beam is horizontal and about 75cm above the floor. This ensures that it will be broken by an intruder, but pets will pass under it freely. There is the problem of the intruder who locates the cases and then either crawls under the beam or steps over it. Conceal the cases as far as possible, possibly behind curtains or actually inside furniture or partition walls.

If the system is being used to protect the doorway of a room, the cases are mounted so that they cannot be seen until the room has been entered and the beam has already been broken. The main case must be positioned so that it is directed towards a darker part of the room, not at a window or lighting fitting.

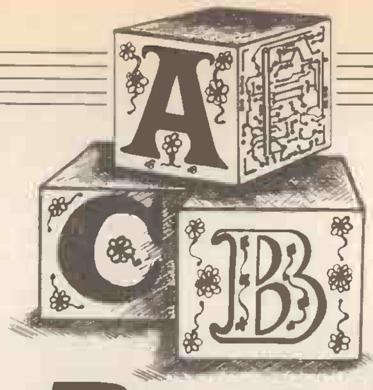
Before finally mounting the cases in position, check the operation of the circuit. Switch on and observe the flashing l.e.d. (D5). Align the cases so that the l.e.d. flashes regularly. If no response is obtained, check the positioning of the infra-red l.e.d.s and sensor to make certain that they are at the focal points of the lenses. If D5 is on continuously, the sensor may be swamped by room illumination. A tube, painted matt black inside, and placed in front of the lens will help narrow the field of view of the sensor. If D5 is continuously off and the distance between the cases is more than 3-4 metres, try reducing the value of R7 to 56 or 47 ohms, to increase the current through the l.e.d.s. When the system is working properly, fix a piece of black insulating tape over the spy-hole in the main case, to prevent the flashing l.e.d. from giving away the fact that a security system is operating.

STAND-ALONE DETECTOR

The detector can be used as a stand-alone device as already explained for the *Temperature Monitor* (Fig. 3.9). The difference is that this circuit normally has the relay contacts closed and opens them in the alarm condition. Instead of the relay specified, use a relay with normally-closed contact that open when the coil is energised. Such relays are not readily available in d.i.l. packaging, but you can use a small 6V change-over relay, mounted off-board, wiring to the appropriate pair of contacts. □

Constructional Project

AUDIO MINI-BRICKS



JOHN BECKER

Part 4

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

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

A USEFUL add-on for our Envelope Shaper (details last month) is a note or level triggered pulse generator. This enables a pulse to be generated by a musical instrument, such as a guitar.

The simple Level Triggered Pulse Generator circuit shown in Fig. 4.1 does this in response to input level changes. When a note is played on an instrument, unless it is an organ or similar, there will be an increase in its level. If the note is fed to diode D5, the rising level will pass through and charge capacitors C8 and C9.

However, as resistors R19 and R20 are of different values, capacitor C8 will charge faster than C9. An imbalance between the two inputs of IC2a will result. Consequently its output will be tripped into its high state.

If the note is held, eventually the charge on capacitor C9 will rise above that on capacitor C8, and so IC2 will be tripped down again. Thus a pulse is generated, and is suitable for controlling an envelope shaper or other circuits.

Diode D8 ensures that the minimum output level of IC2a, which is somewhat above ground level, does not adversely affect the controlled circuit. Resistor R54 ensures a grounded reference level. With this circuit it is possible to play notes at a fairly fast rate since the level will normally decay slightly between each one, so allowing the trigger points to reset.

The pulse generator in use with a signal pre-amp and an Envelope Shaper plus VCA is shown in Fig. 4.2. With this set up once the Envelope Shaper is triggered it will normally need to follow through its full cycle. It cannot be forced into a fast decay by the pulse generator.

VOICE OPERATED FADER

A combination of several circuits so far described, including a variation on the pulse generator, can be used as a Voice Operated Fader (see Fig. 4.3). This is of particular interest for disco control, and for recording home movie or video commentaries with music. The microphone provides both the voice and the trigger source.

When speech starts, the level of the music fed into a second input is automatically reduced, so giving priority to the commentary. The pre-amp shown serves both for raising the mic level, and also acts as a buffer to the trigger stage. This is similar to Fig. 4.1, except that the controlling capacitors are kept charged for as long as speech continues.

Short speech pauses are ignored, but after a longer pause, the capacitors start to dis-

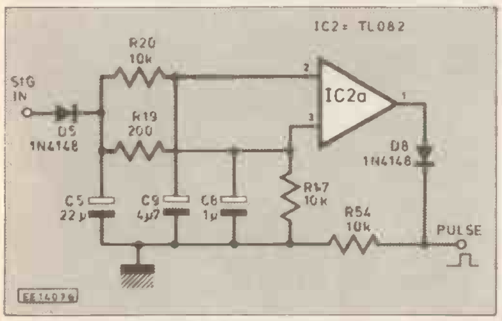


Fig. 4.1. Circuit diagram for a simple Level Triggered Pulse Generator.

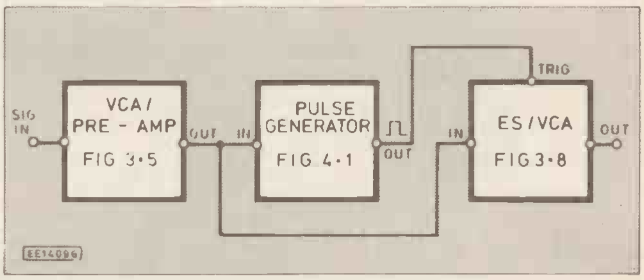
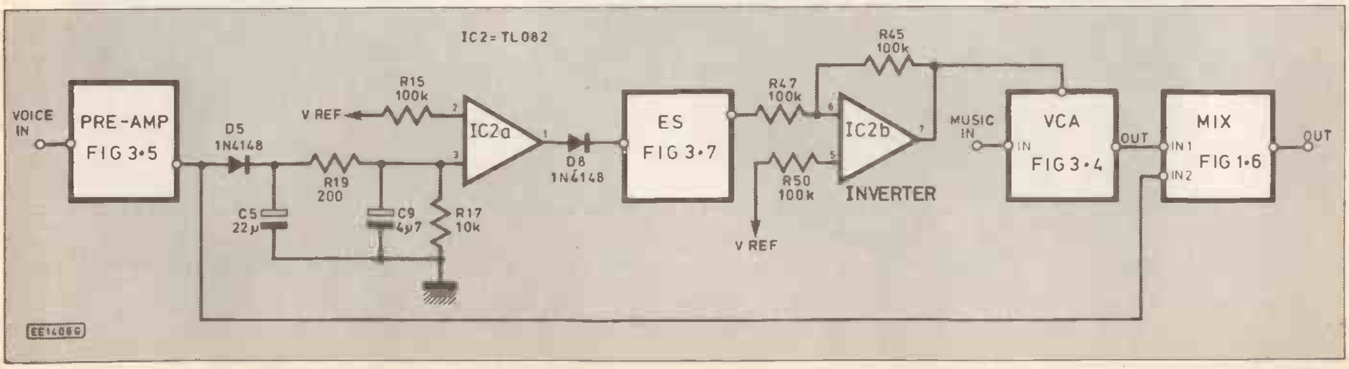


Fig. 4. 2. Note triggered envelope shaper.

Fig. 4. 3. (below) Arrangement for Voice Operated Fader.



charge until the threshold level of comparator IC2a is reached, at which point the output state falls allowing the Envelope Shaper to start its decay. Since the trigger levels need to reduce the music volume rather than increase it, the Envelope Shaper output is inverted prior to the VCA.

Both music and voice signals are combined at the two input mixer. The composite mix can be fed to an amplifier or recorder in the normal way.

AUTOWAH

The block diagram for a note triggered Wah-Wah unit is given in Fig. 4.4. The music comes in through the buffering pre-amp. The split signal goes to the VCF in one direction, and to the pulse generator in the other.

This is triggered by note level changes, and controls the envelope shaper. In turn, this sets the response of the VCF, and wah effects are produced during the envelope swing. The effect is most pronounced with harsher input sounds in the upper frequency regions.

COMPRESSOR

With signals having a wide dynamic range, it is often desirable to restrict the range to a more even level. This enables speech for example to be evened out for such purposes as commentary recording, or radio transmission.

It also helps reduce the possibility of signal overload when high level peaks occur. The compression function of the transconductance amplifier (TCA)chip IC1 was described earlier, but that method is less controllable than the circuit in Fig. 4.5. This automatically compresses the level to an amount set by the variable limiting control.

To avoid overloading the signal source a buffer, such as the pre-amp from Fig. 3.5, should be used immediately prior to capacitors C14 and C20. The signal is then split into two directions. The first route takes it through a VCA where the gain can be changed in response to the level detected. The second route takes it to be rectified by diode D12.

Capacitor C22 charges to the maximum level passed, which is then picked up by the inverting amplifier IC2b, the gain of which can be set by potentiometer VR14. The resulting output swing is sufficient to change the current going to the VCA control node via the level trimmer preset VR4.

When the signal level rises above approximately 4.5V as seen at capacitor C22, the output of IC2b starts to fall. As it does so the current reaching the node of IC1c also falls.

This fall progressively closes the VCA as the swing increases. Consequently the VCA output also falls, thus resulting in signal compression. Graph 7 shows the response curves for various settings of potentiometer VR14.

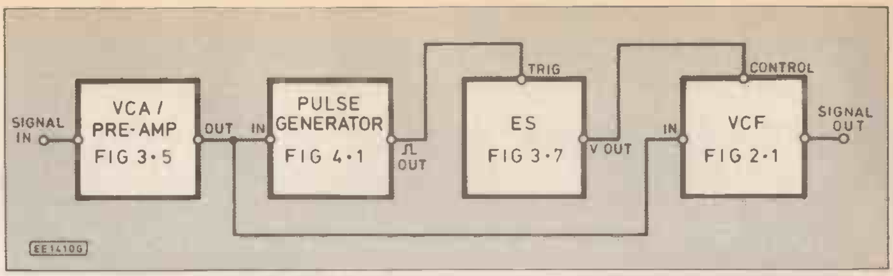


Fig. 4. 4. Auto-triggered Wah-Wah set up.

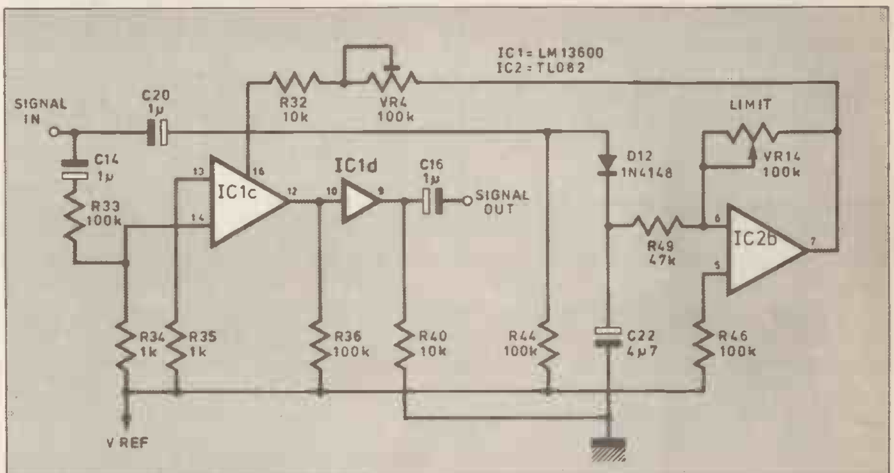
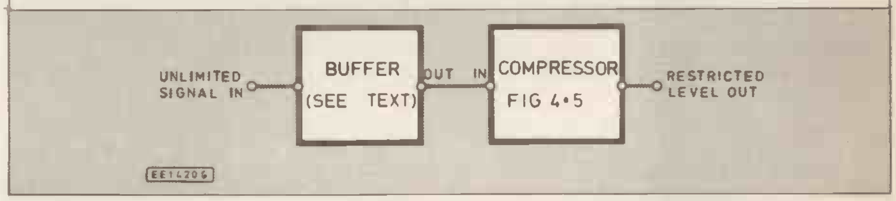
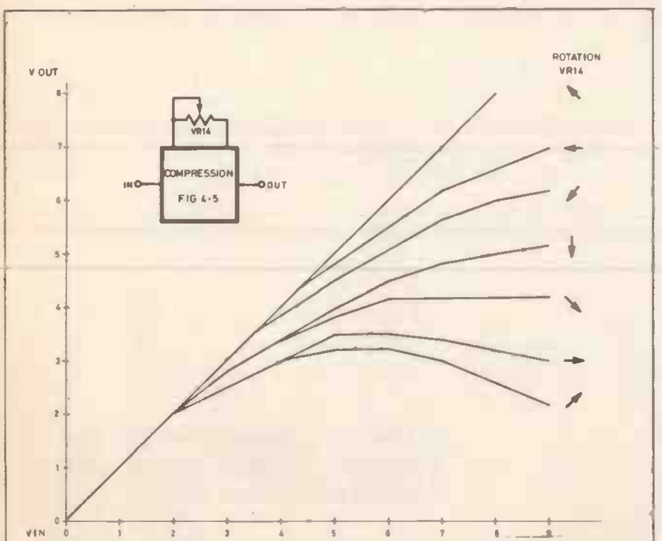
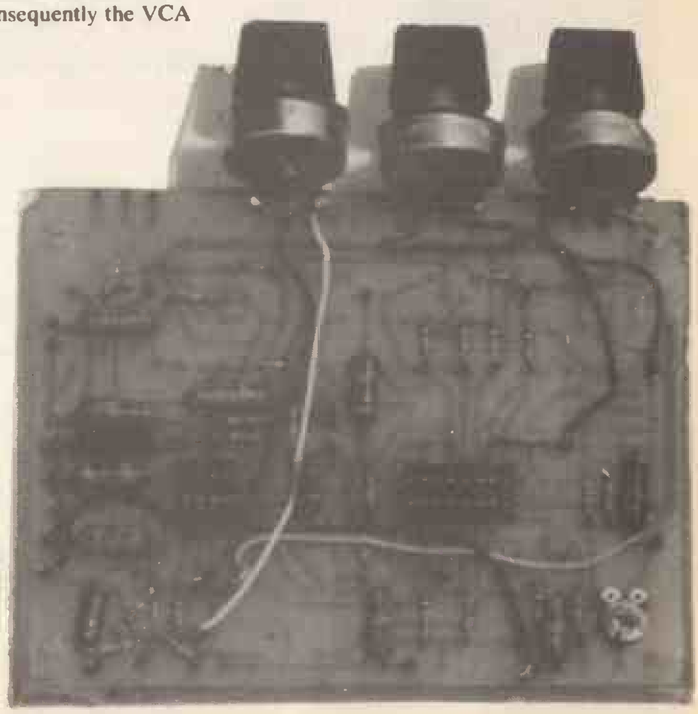


Fig. 4. 5. Circuit diagram for a Compressor. The block diagram below shows where the Compressor might fall in the "chain" of signal processing.





Graph. 7. Typical response or "compression" curves for various settings of VR14.



COMPONENTS

PULSE GENERATOR & COMPRESSOR

Resistors

R2-R4, R17, R20, R32, R39, R40, R54	10k (9 off)
R6, R23, R33, R36, R44, R46	100k (6 off)
R19	200
R28, R29, R53	4k7 (3 off)
R34, R35	1k (2 off)
R49	47k

All 0.25W 5% carbon

Potentiometers

VR4	100k skeleton
VR6, VR11	1M mono rotary (2 off)
VR14	100k mono rotary

Capacitors

C2, C8, C10 C14, C16, C20, C25	1μelect. 63V (7 off)
C5, C11	22μ elec. 16V (2 off)
C9, C22	4μ elec. 63V (2 off)
C23	100n polyester

Semiconductors

D5, D8, D12	1N4148 signal diode (3 off)
IC1	LM13600 trans-conductance op. amp
IC2	TL082 dual BIFET op. amp

Shop Talk
See page 527

Miscellaneous
Printed circuit board, 255A; p.c.b. clips (4 off); 8-pin i.c. socket; 16-pin i.c. socket; knobs (3 off); connecting wire; solder etc.

Approx. cost Guidance only **£15**

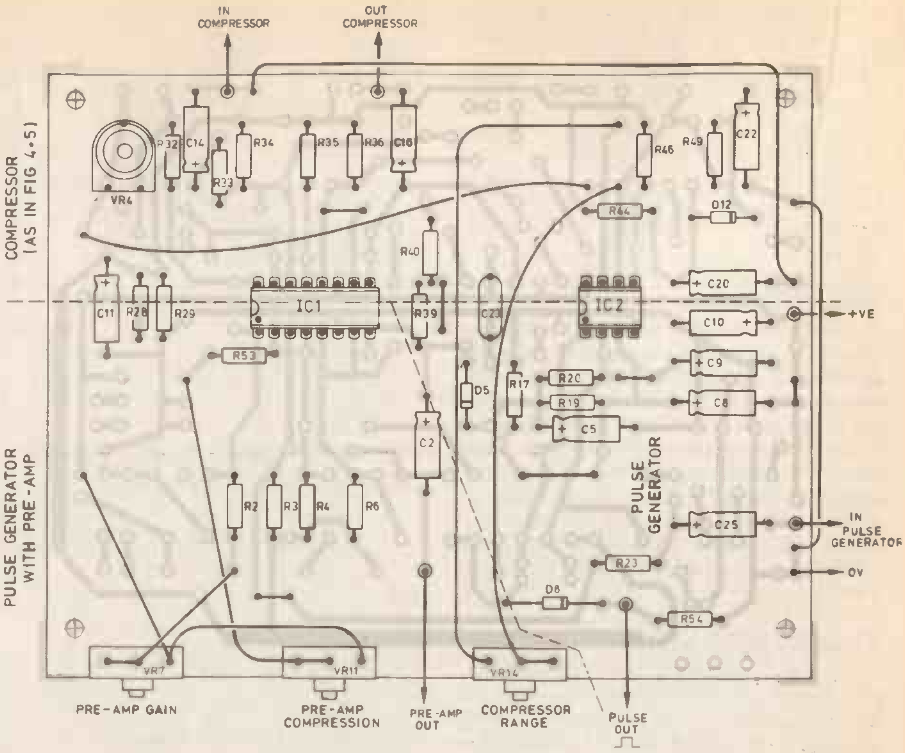


Fig. 4. 6. Pulse Generator and Compressor component layout on the master printed circuit board. –Plan F.

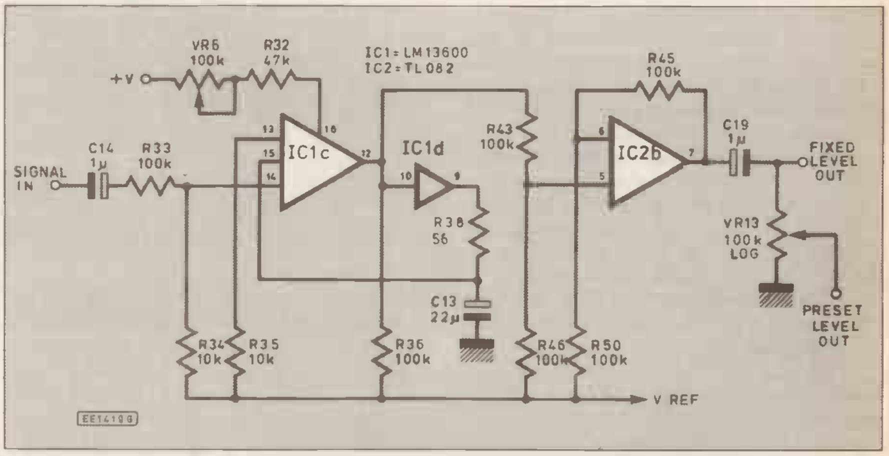
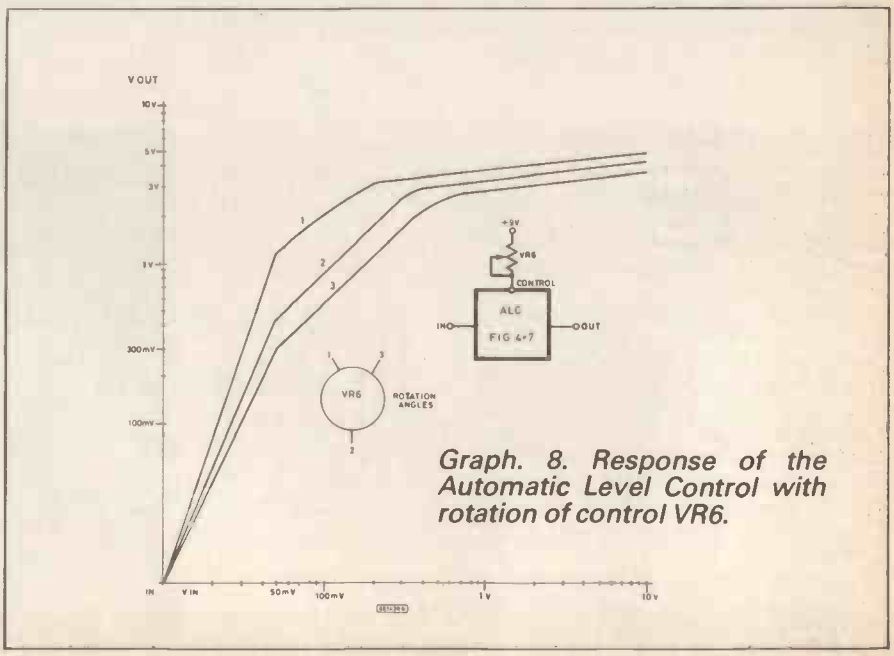


Fig. 4. 7. Circuit diagram for the Automatic Level Control (ALC).



Graph. 8. Response of the Automatic Level Control with rotation of control VR6.

CONSTRUCTION –PLAN F

The printed circuit board component layout for the pulse generator from Fig. 4.1, the pre-amp (Fig. 4.3 and Fig. 4.2), and also the compressor (Fig. 4.5) is shown in Fig. 4.6. The full size copper foil master pattern was given in Part One, Fig. 1.1 (June '88).

AUTOMATIC LEVEL CONTROL

Compression restricts the upper ranges of an input signal. Whereas the use of an Automatic Level Control (ALC) ensures that the overall output signal is maintained at a set level, whether the original is above or below that point.

The one shown in Fig. 4.7 also behaves in a manner similar to a noise gate, as it automatically reduces the response for signals below a threshold point. Typical response curves are given in Graph 8.

The input signal goes to the VCA IC1c. Unlike most other signal inputs, the level here is only attenuated to one tenth. Potentiometer VR6 sets the gain response and the signal passes through to the buffer stage IC2b.

The signal also goes to IC1d. Internally this is a Darlington transistor high impedance stage and will only conduct when the signal level exceeds the transistor gate voltage. This is about 1.5V above the output voltage at IC1d.

As the signal passes the gate level, IC1d conducts and capacitor C13 charges for the duration of the gate excess. The compression input of IC1c is controlled by the voltage at capacitor C13. As it increases, so the TCA compresses the gain. When the voltage falls, so the compression is reduced.

The end result is that for signals above the threshold level, a constant output amplitude is maintained. The final level sent to other circuits can be restricted by the volume control VR13.

NOISE GATE

Still in the same vein of level control, a Noise Gate is shown in Fig. 4.8. These are useful when background noise from a microphone or effects circuit exists.

Under normal signal level conditions, the noise will usually be disguised by the main signal. However, during quiet passages, or when no main signal is present, the unwanted noise can be a distraction.

Using a gate of this nature, the full strength signal is permitted to pass through, but as it falls, so the gain reduces by an amount proportional to the level. The effect is that the low level noise signal is reduced at a greater rate than the main signal. Finally, at a preset threshold point, the gate closes entirely.

This is an extremely useful facility in many applications, as for example, keeping speaker systems mute when not needed. It should though be used with care for speech, as the rise and fall of background noise during short pauses can sometimes be more noticeable than the constant background from ungated signals.

The most usual place for a noise gate is immediately before the final amplification stage, as shown in Fig. 4.9.

CIRCUIT OPERATION

Circuit operation of the Noise Gate Fig. 4.8 is quite simple. The input signal is fed to the VCA IC1a and IC1b. It also goes to the high gain stage IC2a which amplifies by around 100 times. The output goes to a diode and capacitor network.

During high signal level passages, capacitor C6 is kept fully charged, and so the VCA is held open. As the signal strength falls below threshold levels, the charge on C6 reduces, and so the VCA gain is progressively lowered.

Eventually the charge falls to below the VCA sustaining level, and the gate closes. When the signal recommences, capacitor C6 recharges almost instantaneously, so rapidly opening the gate.

Despite the speed though, very fast opening transients may have their attack rate slightly dampened. Gate threshold levels are given in Fig. 4.10.

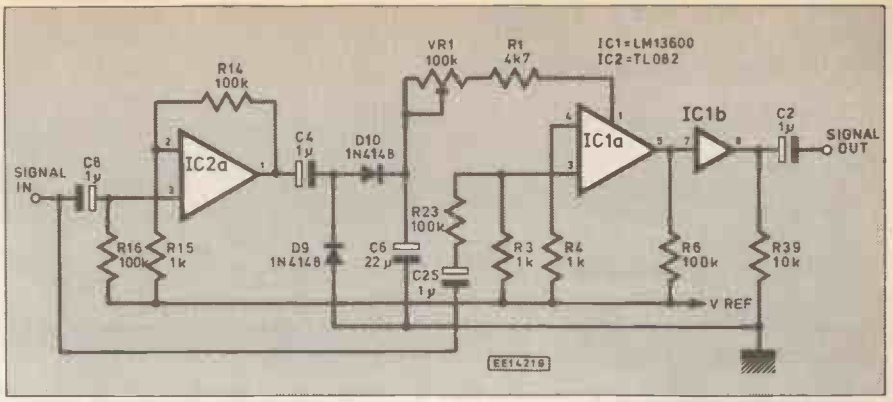


Fig. 4. 8. (above). Circuit diagram for a Noise Gate.

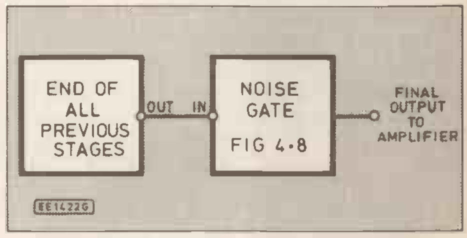


Fig. 4. 9. (right). The Noise Gate as a final signal stage.

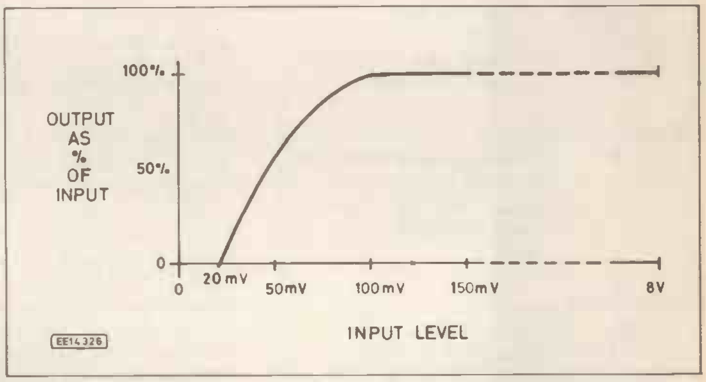


Fig. 4. 10. Typical threshold level to be expected from the Noise Gate.

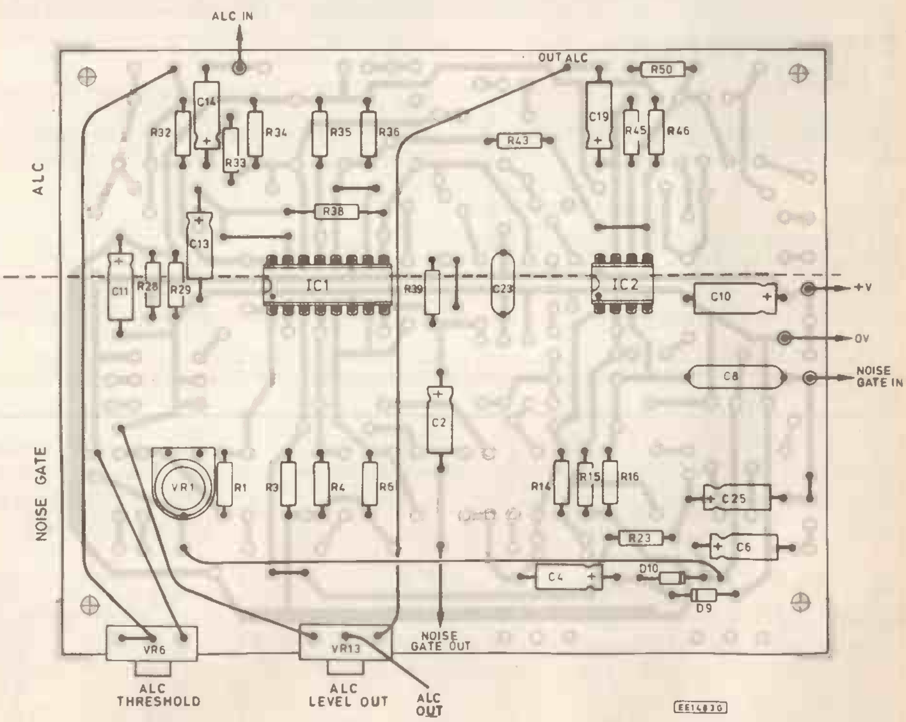


Fig. 4. 11. Printed circuit board component layout for the Automatic Level Control and the Noise Gate. –Plan G.

COMPONENTS

NOISE GATE & ALC

Resistors

R1, R28, R29	4k7 (3 off)
R3, R4, R15	1k (3 off)
R6, R14, R16, R23, R33, R36, R43, R45, R46, R50,	100k (10 off)
R32	47k
R34, R35, R39	10k (3 off)
R38	56

All 0.25W 5% carbon

Potentiometers

VR1	100k skeleton
VR6	100k mono rotary
VR13	100k log mono rotary

See page 527

Capacitors

C2, C4, C8, C10, C14, C19, C25	1µ elec. 63V (7 off)
C6, C11, C13	22µ elec. 16V (3 off)
C23	100n polyester

Semiconductors

D9, D10	1N4148 signal diode (2 off)
IC1	LM13600 trans-conductance op. amp
IC2	TL082 dual BIFET op. amp

Miscellaneous

Printed circuit board, 255A; p.c.b. clips (4 off); 8-pin i.c. socket; 16-pin i.c. socket; knobs (2 off); connecting wire; solder etc.

Approx. cost Guidance only **£14**

CONSTRUCTION —PLAN G

The printed circuit board component layout for the ALC and the Noise Gate is shown in Fig. 4.11.

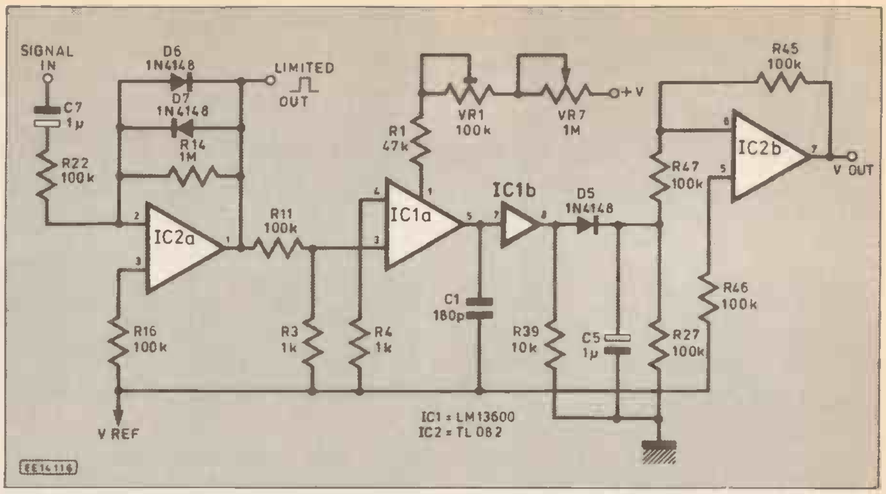


Fig. 4.12. Circuit diagram for a Frequency to Voltage Converter. (Tachometer.)

FREQUENCY TO VOLTAGE

The rate at which a capacitor is allowed to charge can form the basis of a Frequency to Voltage conversion unit. The circuit in Fig. 4.12 is suitable for simple control of other functions or as a rate tachometer. Its response curves are in Graph 9.

The input frequency can come from a variety of sources such as a musical instrument, from an oscillator, or even batch counting detectors. The actual source is irrelevent as long as the frequency remains constant long enough for the converter to sample it.

The input frequency comes to the level clipping stage IC2a. The gain is set by the values of resistors R14 and R22. Diodes D6 and D7 limit the swing to about 1.4V peak-to-peak to standardise the waveform level.

An additional output is provided here so that the limited waveform can be fed to other circuits, either as a signal or pulse source. An example will be seen later with the Sample and Hold in use.

At IC1a the signals pass through to charge capacitor C1 at the rate set by the control current via preset VR1 and variable potentiometer VR7. The former presets the range, and the latter gives manual control over the response width.

The level to which capacitor C1 rises is proportional to the frequency, though it contains a residual ripple waveform. Passing through diode D5 the voltage is smoothed by capacitor C5. Lower frequencies will charge capacitors C1 and C5 at a rate faster than high ones, so C5 is followed by an inverting stage to produce a rise in voltage from a rise in frequency.

A possible use of the converter for setting the response of a voltage controlled unit is shown in Fig. 4.13. Fig. 4.14 shows it in use as a simple frequency meter.

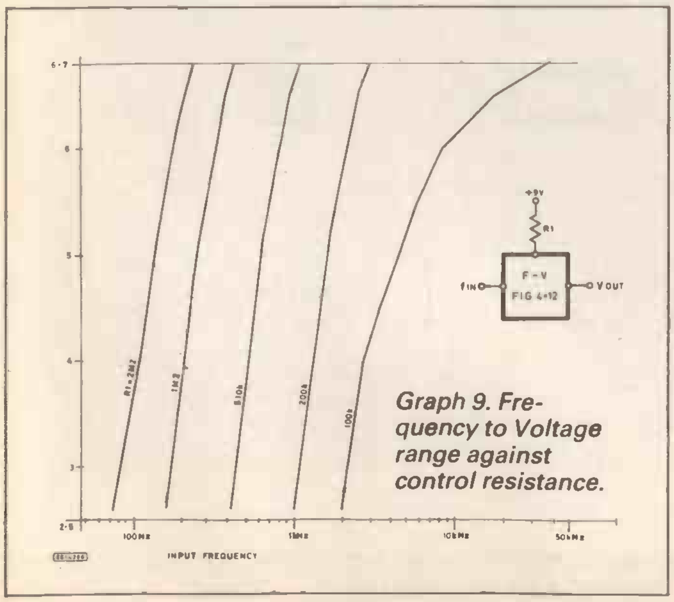
SAMPLE AND HOLD

It is sometimes necessary to sample an event at a point in time, and to store the result for further use. A basic Sample and Hold circuit is shown in Fig. 4.15. Once again this consists of a TCA and a capacitor.

The signal presented to IC1a can be a d.c. or a.c. voltage. When a positive level is supplied to the TCA control node, capacitor C15 is allowed to charge to the level present at the input. When the control level goes, the sample is held by C15.

IC1d buffers the charge to minimise the rate at which it leaks away. It is inevitable that the charge will drift as the buffer does not have an infinitely high impedance, and the capacitor itself will have a leakage factor. The useful storage time though can still be several minutes.

Increased capacitance values will extend the hold time, but electrolytics should be avoided as their leakage rate is usually quite high. The output can be fed to any of the voltage control nodes described in this series of articles, or to other external units.



Graph 9. Frequency to Voltage range against control resistance.

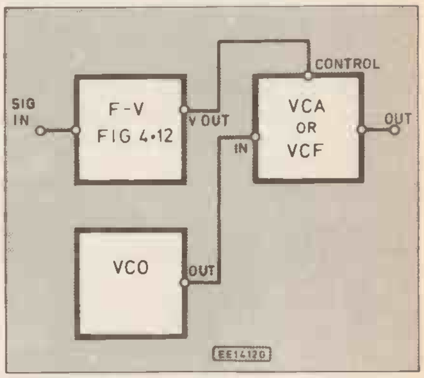


Fig. 4. 13. (right) Frequency control of VCA or VCF. VCO may also be similarly controlled.

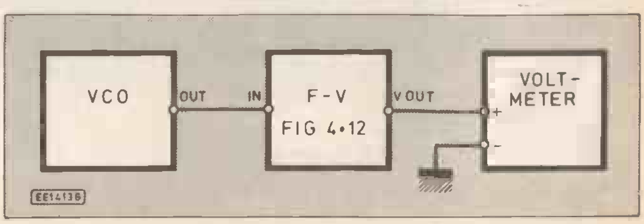


Fig. 4. 14. (below) Simple Frequency Meter block diagram.

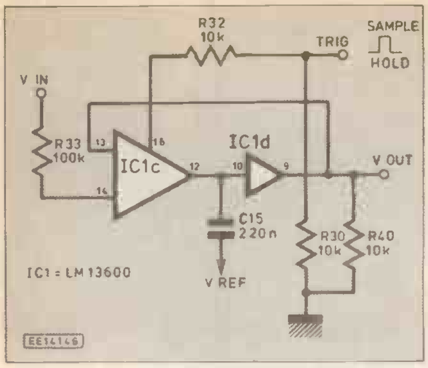


Fig. 4. 15. Sample and hold circuit diagram.

FREQUENCY CHANGER

One use of the Sample and Hold unit is shown in Fig. 4.16. Here it is part of a frequency changing circuit.

The signal is converted to a voltage which is sent to the S & H, the output of which controls an oscillator frequency. The limited trigger signal from the F-V is doubly amplified by IC1b and IC1a to generate a full level trigger control for opening both the S & H, and the VCA Envelope Shaper.

While the VCA is held open the VCO output is passed through and is the replacement frequency. Once the original ceases, the S & H will hold the last level received.

The Envelope Shaper then allows the VCA to close at a set decay rate. This should be timed for a smooth fade out before the S & H charge has signicantly decayed. The VCO output frequency can be selected for any waveform, so that a tonal change as well as frequency change can be made.

A unit like this is quite fun to use with a musical instrument as the source. It may not be harmonically precise, but it is an interesting gimick.

The block diagram in Fig. 4.17 shows how the control voltage and trigger pulse from a keyboard source can be used to generate envelope shaped notes.

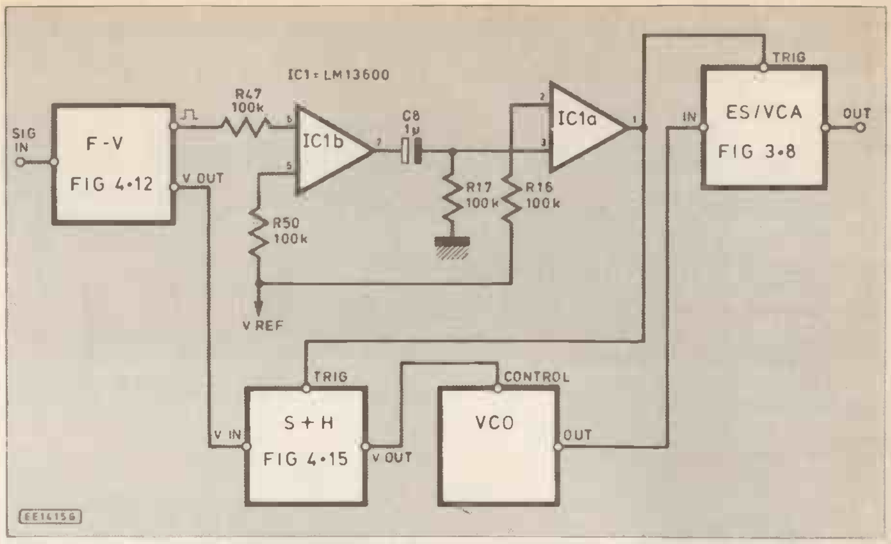


Fig. 4. 16. Circuit arrangement for a Frequency Changer with output gate.

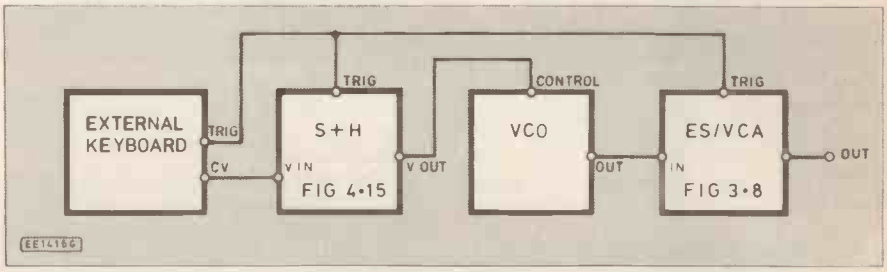


Fig. 4. 17. Block diagram for external control of VCO and VCA.

COMPONENTS

F-V CONVERTER & SAMPLE HOLD

Resistors

R1	47k
R3, R4	1k (2 off)
R11, R16, R22	
R27, R33	
R45–R47	100k (8 off)
R14	1M
R28, R29	4k7 (2 off)
R30, R32	
R39, R40	10k (4 off)

All 0.25W 5% carbon

Potentiometers

VR1	100k skeleton
VR2	1M mono rotary

Capacitors

C5, C7,	
C10	1µ elec. 63V (3 off)
C11	22µ elec. 16V
C15	220n polyester
C23	100n Polyester

Semiconductors

D5–D7	1N4148 Signal diode (3 off)
IC1	LM13600 transconductance op. amp
IC2	TL082 dual BIFET op. amp

Miscellaneous

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

Approx. cost Guidance only **£12**

CONSTRUCTION —PLAN H

Both the Sample and Hold, and the Frequency to Voltage converter can go on the same circuit board. The printed circuit board component layout is shown in Fig. 4.18.

Next Month: Delay Module, Reverb, Echo, Double Tracking and Flanging.

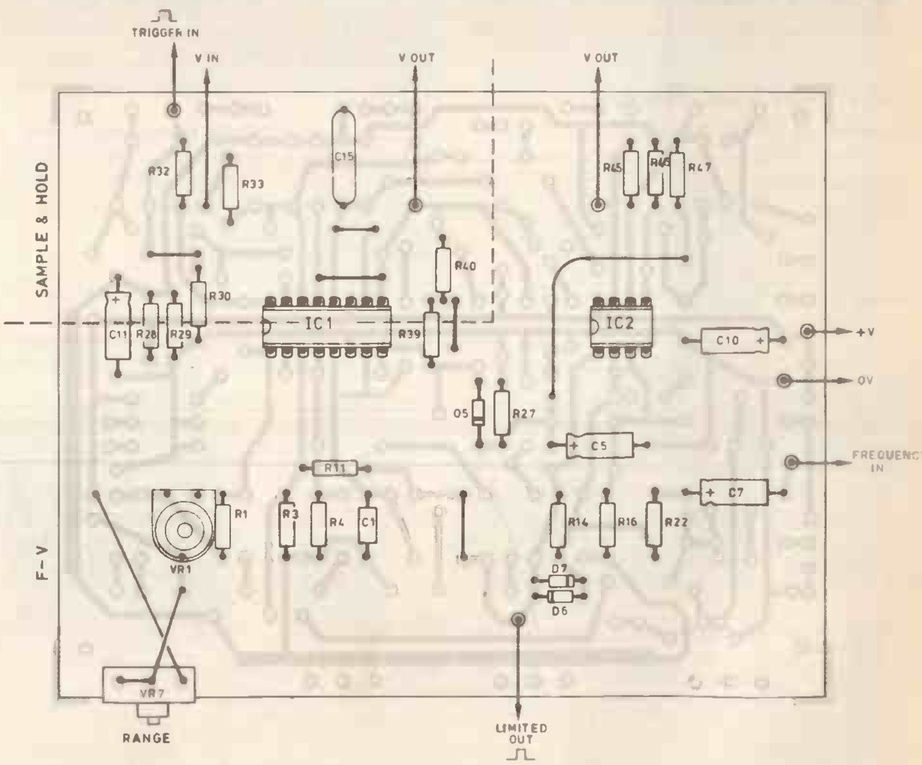


Fig. 4. 18. Printed circuit board component layout for the Sample and Hold and the Frequency to Voltage Converter. —Plan H.

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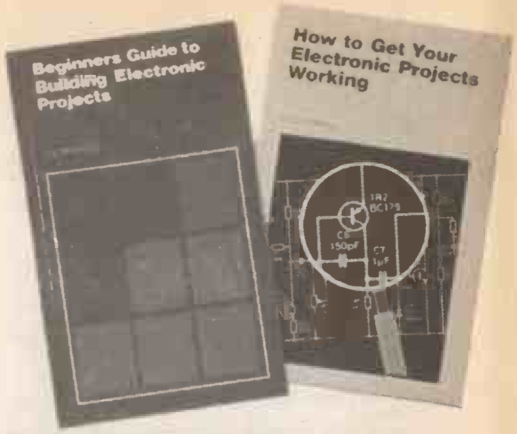

PROJECT CONSTRUCTION

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R. A. Penfold
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Furthermore, information has been included so that the circuits can readily be modified and extended by readers to meet their own individual needs. Related circuits have been grouped together and cross-referenced within the text (and also in the index) so that readers are aware of which circuits can be readily connected together to form more complex systems. As far as possible, a common range of supply voltages, signal levels and impedances has been adopted.
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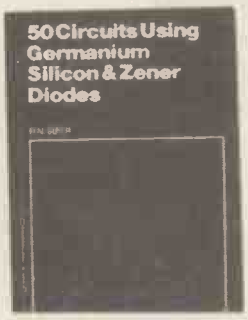

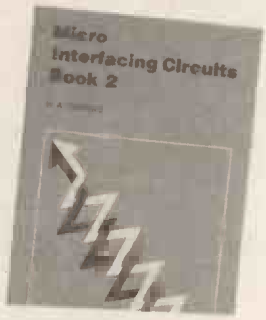

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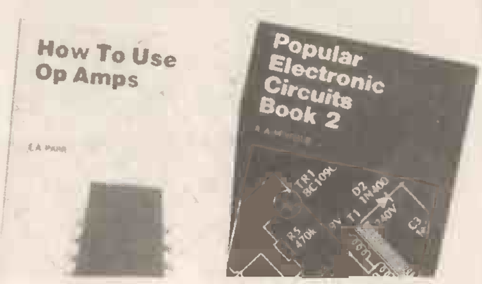

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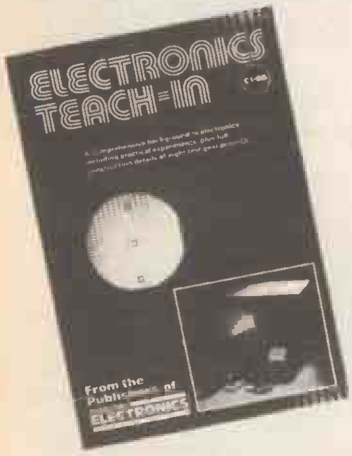

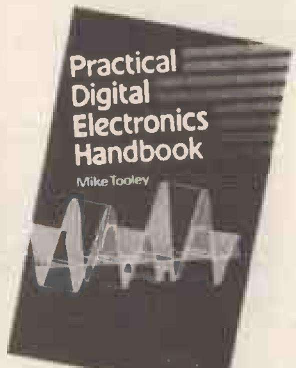

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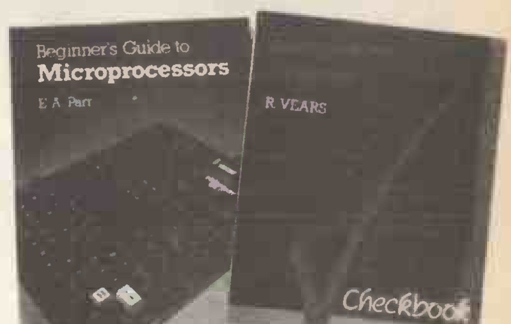

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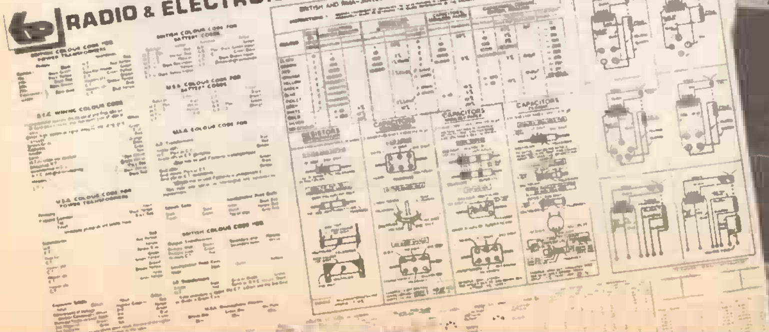

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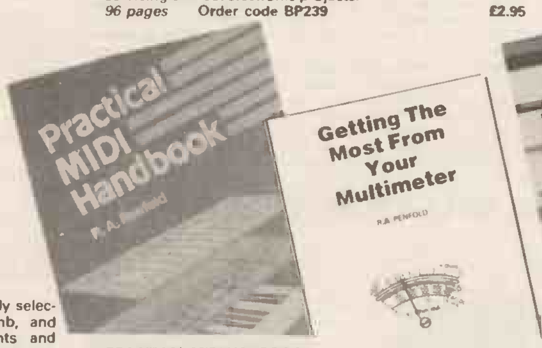

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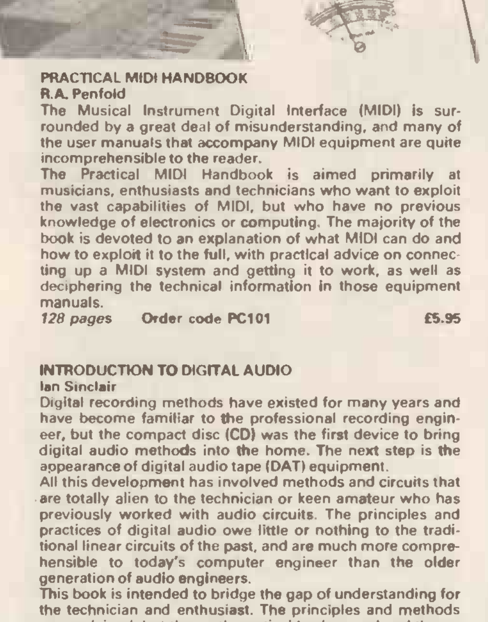

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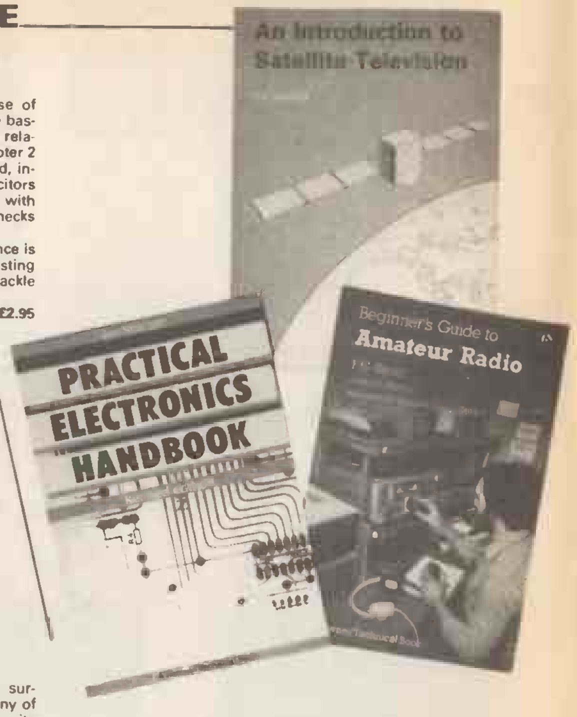

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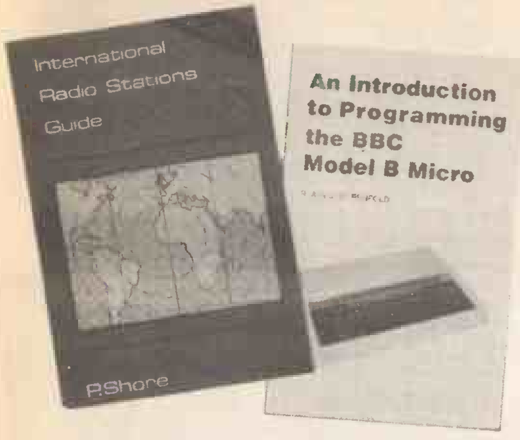

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DOWN TO EARTH

BY GEORGE HYLTON

IT ALL started when we watched *"Tomorrow's World"*. They showed this gadget for locating the faulty bulb in the string of Christmas tree lights. You just held it against one lamp after another until it gave an indication.

"That's clever!"

–"Reckon I could make one of those myself."

"Why don't you, then? Our lights are always going out and it takes you half an hour to find the trouble." So there I was, lumbered.

HIGH IMPEDANCE

My rash claim stemmed from the fact that I was in the middle of some work using CMOS inverters. These have extremely high input impedance (virtually infinite for most purposes). Consequently, as you quickly discover when you try to cash in on this, they pick up stray mains voltages from the work bench or your own hands.

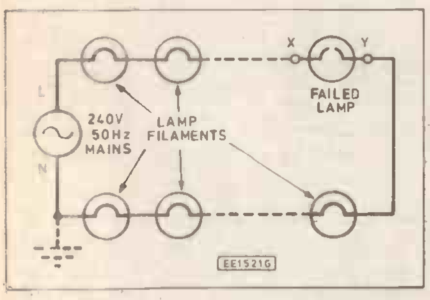

Fig. 1. When one lamp in a string fails there is mains voltage on one side (X) but not the other (Y). Detecting the difference identifies the failed lamp.

CMOS gates, which are built up from inverters, have this same property. The failed-lamp detector evidently made use of it. A capacitive probe placed near the live side of a failed lamp (Fig. 1, point *X* would pick up some voltage resulting from the minute leakage current through the insulation of the mains cable. However, at *Y*, on the other side of the broken filament, the cable is effectively earthed via the lower string of lamps and the mains neutral connection *(Overseas readers please note: YOUR mains may not have a neutral like this)*. In a word, there should be mains leakage to a probe held near *X* but not Y.

Some back-of-an-envelope calculations showed that the scheme should work. If the capacitance from mains to probe via the cable insulation were a plausible 1pF and the input to the CMOS gate looked like 10pF then one eleventh of the mains voltage should reach the gate, or about 22V r.m.s., 31V peak. More than enough to turn the gate on and off.

For indication I could either hang a l.e.d. on the gate output or rig up some sort of audible indication. I decided on sound rather than light because that would leave my eyes free to position the probe. Using a quadruple NAND gate (4011) I would have (Fig. 2) one gate for the leakage detector, two for a simple audio oscillator and the fourth for gating the oscillation to a piezo sounder or crystal earphone.

After settling down the leakage currents apportion V_{CC} between the stray capacitances C1 and C2. If the d.c. leakage is such that there is insufficient voltage across C2 to turn on the gate then the output stays high. Hence the latch-up.

Having seen the problem, the solution was simple. Instead of connecting the detector output directly to the audio gate, use a *CR* coupling as shown dotted (see Fig. 2). The resistance then ties one gate input to 0V. This holds the gate off unless positive half cycles arrive from the detector and turn it on. This happens when the probe picks up enough mains leakage, and bursts of tone from the oscillator then reach the sounder.

SCREENING

I wasn't yet out of the wood. When transferred from work bench to Christmas tree a fresh defect showed up. The detector was too sensitive. It went off when the probe was anywhere near a live mains lead. I needed something which would pinpoint a failed bulb.

Inspection of Fig. 2 shows that sensitivity can be reduced by adding to C_{in}, but this still leaves the full length of the probe to receive leakage.

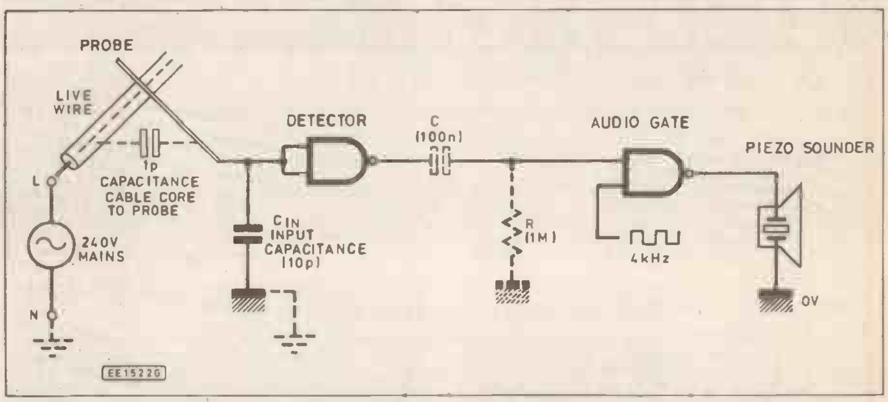

Fig. 2. Principle of live conductor detection. When the probe is in contact with the insulation of a live wire enough leakage flows to set up a detectable voltage across a very-high-impedance load such as the input of a CMOS gate.

D.C. LEAKAGE

My circuit failed: It simply "latched up". The detector output went high and stayed high, opening the audio gate all the time and so giving a continuous sound output irrespective of where the probe was.

Why? Quiet contemplation, aided by a glass of "Christmas" port, suggested that the answer probably lay in the internal arrangements of a CMOS gate chip (Fig. 3). This varies from maker to maker, but the one shown here is common.

Protection diodes D1 and D2 are reverse biassed by the d.c. supply V_{CC}. They do, however, pass tiny leakage currents, as each diode is shunted by a stray capacitance of a few pF.

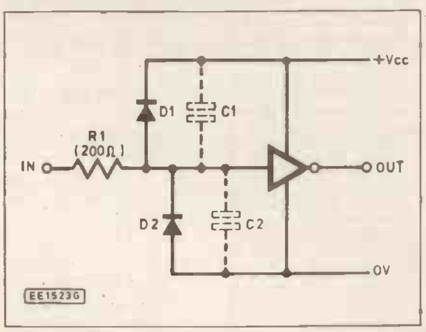

Fig. 3. If the input of a CMOS inverter is left floating d.c. leakage charging the input capacitances C1 and C2 may set up enough voltage to turn the inverter on or off.

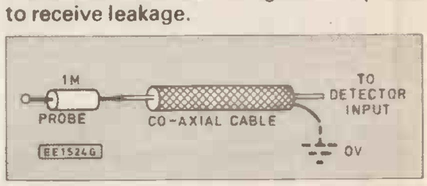

Fig. 4. Screened probe made from co-axial cable. The 1M safety resistor has no effect on operation.

A neater method is to use a short length of coaxial cable (TV downlead) as the probe, with the outer screen earthed to the 0V line. A 1M resistor soldered to the inner (Fig. 4) then provides a short probe with protection for both user and CMOS in case of accidental contact with the mains.

The earthed outer prevents leakage to the main part of the probe from reaching the detector. Only leakage to the probe tip gets through.

The capacitance of the co-ax adds to C1 and reduces sensitivity so a crude adjustment of sensitivity can be made by trying different co-ax. I started with 400 mm of semi-airspaced coax thinking to chop bits off to increase sensitivity, but it worked all right as it was. It gave a *"live"* reading with the probe held against one side of a two-core mains flex and a *"dead"* reading on the other side, indicating not only that the cable was live but showing which side the live conductor was on.

The circuit proved more difficult to use on the Christmas tree lights themselves. Mine have TWO strings of bulbs in parallel. When one fails but the other stays alight capacitive leakage from the working string to the failed string can give false indications.

The answer is to squeeze the cable firmly with the fingers and make probe tests near the squeezed point. The body then "earths" the cable-to-cable leakage and only the real live strand shows up.

In the same way (Fig. 5), if you use this sort of detector to search out a hidden break in a plain live cable core-to-core coupling can make the neutral leg appear live. Connecting a load (e.g. a lamp) to the end of the cable improves matters by making the neutral really live right up to the break. This gives a more abrupt change when the probe crosses the break point.

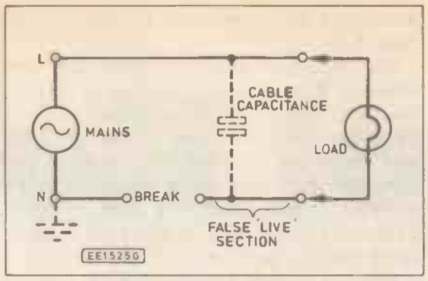

Fig. 5. Leakage via the conductor-to-conductor capacitance of a mains cable can give false readings from one section of the neutral leg.

MAGNITUDES

These experiments demonstrate how even minute leakage currents can have marked effects in high impedance circuits. A capacitance of 1pF would normally be regarded as a complete block to 50Hz signals, since its impedance is about 3000 megohms.

However, 1pF can transfer significant voltage at 50Hz to a really high impedance load. In audio circuitry where even a few millivolts can cause objectionable hum the importance of good screening is obvious.

Robot Roundup

NIGEL CLARK

ROBOT servants are feasible. Advances in technology combined with different ways of looking at the uses to which it can be put should result in useful robots around the house in the not too distant future.

That is the view of Richard Pawson and he has backed his faith by setting up a robot research company called Personal Robots, the company which has been selected to lead the feasibility study for the domestic applications group in the Department of Industry's Advanced Robotics Initiative.

His company is already working on robots to help with vacuum cleaning, security and mowing the lawn, and he is sure that once the study gets under way many more applications will come to light.

"In the last five years technology has moved on and we are a long way from the early attempts at personal robots which were fairly simple devices," he says.

"Processing power has seen a major revolution and has become very, very cheap indeed. People have also started to realise that the old approach of getting a machine to model its environment is not necessary. All that is needed is a robot which can react to its immediate environment".

Warming to his subject he points out that although human beings have large brains it does not mean that the whole of the brain is being used to carry out a particular task. In fact it is probable that only a small part is used most of the time. On that basis robots do not need large brains. He added that it would be better to model robots on less complicated life forms such as insects.

LAWN-MOWER BRAIN

To back up his argument he gives an example of mowing the lawn as an activity in which the brain is rarely troubled to perform anything complicated. While cutting, the only thinking involved is in keeping the mower at the edge of the previous cut. The most complex thought is needed when turning round or when an obstacle is encountered.

The robot would have no difficulty following a line and during the more difficult procedures it would be moving slowly enough to give it time to work out the necessary moves.

Pawson bases his views on an involvement with new technology in one form or another for many years. After gaining an engineering degree he was European software manager for Commodore, editor of three computer magazines and wrote The Robot Book.

Personal Robots was created when he joined with a former computer magazine colleague, Julian Allason, with venture capital backing from City institutions. The company now has a 12-strong development team working on a variety of projects.

PET

Among the group's completed projects is a robot pet, 'Scamp', for a major toy company. According to Pawson it is much more sophisticated than the Petster type of toy, having its own personality, but as fashion moved away from electronic toys the toy company decided not to go ahead with it. Scamp now sits on a shelf at Personal Robots waiting for fashion to change again.

Personal Robots is also interested in modular technology, creating building blocks which can be used in a variety of ways by other robot builders to create different robots. The system, which is complete, is centred on a file of standardised software around which the robots are built using standardised electronics and mechanics. Called Robokit Professional, the collection of blocks is being offered at about £2,000.

As a spin-off, Atari has asked the company to develop a less expensive version to be known as Atari Robokit, containing software and electronics for driving a variety of robots built from Lego and Fischertechnik parts. It should be available soon.

BRAINSTORMING

The DTI feasibility study will fit in with all this work with a report promised in the spring of next year. It will involve brainstorming sessions with other members of the domestic group, seeing what work is being done throughout the world and watching how technology is advancing.

The resulting ideas will then be sifted on the basis of whether they are technically possible, if they can be produced at an economic cost and whether there will be a demand. The result will be three ideas and the group will then decide if it is worthwhile taking any of these to the next stage of development. That work would require outside funding as the DTI pays for only 50 percent of that cost.

Pawson said that part of the feasibility study would be involved in identifying possible sources of funding. He added that at the moment the people involved in the domestic group did not have the resources to provide the cash. "For example no major domestic appliance manufacturer is involved at the moment," he said.

He did not wish to pre-empt the conclusions but he thought that vacuum cleaning, security and lawn mowing uses would be featured as part of the study. He added that price was an important factor and his own view was that an appliance should cost no more than £300.

ALL PURPOSE

The cost contrasts with the path being followed by Joe Engleberger in the States who is looking at producing an all-purpose robot at a cost of about $50,000. They are being aimed at people buying new homes in the $250,000 price bracket, a market which is said to be quite large.

The emphasis on new homes is important because certain conditions have to be built into the homes so that the robots can be used. For example no steps and no thresholds on the doors.

The theory is that a limited number of people will buy them, enough to cover costs, but the lessons learnt in their operation will allow costs to be cut, therefore, expanding the market. Thus, the robot will eventually become a mass market product.

Pawson is persuasive about the possibilities of domestic robots and has become experienced in dealing with those, like myself, who have reservations. However, he sometimes feels that he cannot win.

He tells the story of suggesting a use in the kitchen where the robot could be told to take a convenience meal from the freezer, put it in the microwave and have it ready by a particular time. He is then accused of advocating living off convenience food when his intention was to explain how the convenience of convenience food could be increased. He did not think that it should exclude other forms of food preparation.

I look forward to the group's conclusions with interest.

Richard Pawson behind two of the prototypes produced by Personal Robots.

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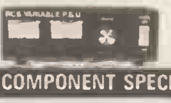

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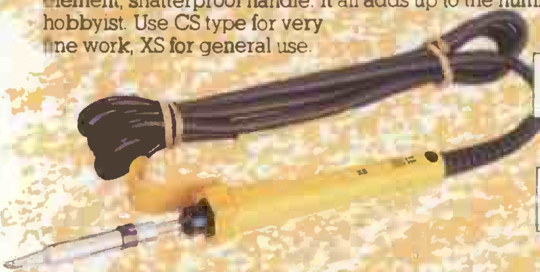

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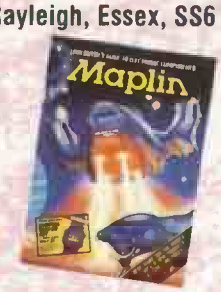

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