EVERYDAY ELECTRONICS

APRIL 1988

INCORPORATING ELECTRONICS MONTHLY

£1.30

LOW FUEL ALERT

PIPE & CABLE LOCATOR

STEREO NOISE GATE

FREE INSIDE! DATA CARD

24 page GREENWELD Spring Catalogue Supplement

The Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PACKS

Price per pack is £1.00. Order 12 you may choose another free. Items marked (sh) are not new but guaranteed ok.

1 - 5 13 amp ring main junction boxes
2 - 5 13 amp ring main spur boxes
5 - 3 flush electrical switches
7 - 4in flex line switches with neons
8 - 2 80 watt brass cased elements
9 - 2 mains transformers with 6V 1A secondaries
10 - 2 mains transformers with 12V ½ A secondaries
11 - 1 extension speaker cabinet for 6½" speaker
12 - 5 octal bases for relays or valves
13 - 12 glass reed switches
14 - 4 OCP 70 photo transistors
16 - 4 tape heads, 2 record, 2 erase
17 - 1 ultrasonic transmitter and 1 ditto receiver
18 - 2 15000 mfd computer grade electrolytics
19 - 2 light dependent resistors
20 - 5 different micro switches
21 - 2 mains interference suppressors
22 - 2 25 watt crossover units 2 way
23 - 1 40 watt 3 way crossover unit
28 - 1 6 digit counter mains voltage
30 - 2 Nicad battery chargers
31 - 1 key switch with key
32 - 2 humidity switches
34 - 96 x 1 metre lengths colour-coded connecting wires
36 - 2 air spaced 2 gang tuning condensors
37 - 2 solid diaelectric 2 gang tuning condensors
38 - 10 compression trimmers
41 - 6 Rocker Switches 10 amp mains SPST
43 - 5 Rocker Switches 10 amp SPDT Centre Off
44 - 4 Rocker Switches 10 amp DPDT
45 - 1 24 hour time switch mains operated (s.h.)
46 - 1 6 hour clock timeswitch
48 - 2 6V operated reed switch relays
49 - 10 neon valves - make good night lights
50 - 2 x 12V DC or 24V AC, 4 CO relays
51 - 1 x 12V 2C O very sensitive relay
52 - 1 12V 4C relay
55 - 1 locking mechanism with 2 keys
56 - Miniature Uniselector with circuit for electric jigsaw
57 - 5 Oolls' House switches
60 - 5 ferrite rods 4" x 5/16" diameter aerials
61 - 4 ferrite slab aerials with L & M wave coils
62 - 4 200 ohm earpieces
63 - 1 Mullard thyristor trigger module
64 - 10 assorted knobs ¼ spindles
65 - 5 different themostats, mainly bl metal
66 - Magnetic brake - stops rotation instantly
67 - Low pressure 3 level switch
69 - 2 25 watt pots 8 ohm
70 - 2 25 watt pots 1000 ohm
71 - 4 wire wound pots - 18, 33, 50 and 100 ohm
73 - 4 3 watt wire wound pots 50 ohm
77 - 1 time reminder adjustable 1-60 mins
78 - 5.5 amp stud rectifiers 400V
85 - 1 mains shaded pole motor ¾" stack - ¼ shaft
86 - 2 5" ali fan blades fit ¼" shaft
87 - 2 3" plastic fan blades fit ¼" shaft
88 - Mains motor suitable for above blades
89 - 1 mains motor with gearbox 1 rev per 24 hours
91 - 2 mains motors with gearbox 16 rpm
93 - 4 11 pin moulded bases for relays
94 - 5 B7G valve bases
95 - 4 skirted B9A valve bases
96 - 1 thermostat for fridge
98 - 1 motorised stud switch (s.h.)
101 - 1 2½ hours delay switch
103 - 1 6v mains power supply unit
104 - 1 4½ V mains power supply unit
105 - 1 5 pin flex plug and panel socket
107 - 1 5" speaker size radio cabinet with handle
109 - 10 ¼" spindle type volume controls
110 - 10 slider type volume controls
112 - 1 heating pad 200 watts mains
114 - 1 1W amplifier Mullard 1172
115 - 1 Wall mounting thermostat 24V
118 - 1 Teak effect extension 5" speaker cabinet
120 - 2 p.c.b. with 2 amp full wave and 17 other recs
122 - 10 mtrs twin screened flex white p.v.c. outer
132 - 2 plastic boxes with windows, ideal for interrupted beam switch etc
156 - 3 varicap push button tuners with knobs
188 - 1 plastic box, sloping metal front, 16 x 95mm, average depth 45mm

5A BATTERY CHARGER KIT

All parts, including case, only £5 plus £1 postage

243 - 2 speakers 6" x 4" 15 ohm 5 watt made for Radiomobile
266 - 2 mains transformer 9V ½ A secondary split primary so OK also for 115V
330 - 2 6V 0.6V mains transformer .3a p.c.b. mounting
350 - 40 double pole leaf switches
365 - 1 7uf 660V 50hz metal cased condenser
453 - 2 2¼ in 60 ohm loudspeakers
454 - 2 2¼ in 8 ohm loudspeakers
464 - 2 packets resin filler/sealer with cures
465 - 3 5A round 3 pin plugs will fit item 193
466 - 4 7 segment l.e.d. displays
470 - 4 pc boards for stripping, lots of valuable parts
498 - 4 1000uf 25V axial electrolytic capacitors
504 - 1 Audax PM 8" speaker 15 ohm 5 watt rating
515 - 100 4BA 1½" cheesehead plated screws and 100 4BA nuts
541 - 1 pair stereo tape head as in cassette recorder/players
546 - 1 bridge rectifier 600V International rectifier ref 3SB100
548 - 2 battery operated relays (3-6v) each with 5A c/o contacts 2 pairs
563 - 2 lithium 3V batteries (everlasting shelf life)

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

THIS MONTHS SNIP

3½ floppy Disk Drive, made by the Chinon Company of Japan. Beautifully made and probably the most compact device of its kind as it weighs only 600g and measures only 104mm wide, 162mm deep and has a height of only 32mm, other features are high precision head positioning - single push loading and eject - direct drive brushless motor - Shugart compatible interface - standard connections - interchangeable with most other 3½ and 5¼ drives. Brand new with copy of makers manual. Offered this month at £28.50 post and VAT included.

CASE - adaptable for 3" or 3½" FDD, has room for power supply components price only £4 includes circuit of PSU. Our Ref 4P8.

POWER SUPPLY FOR FDD 5V and 12V voltage regulated outputs, complete kit of parts will fit into case 4P8 price £8 or with case £11.

MULLARD UNILEX AMPLIFIERS

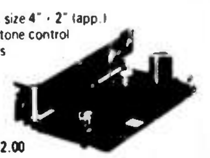
We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules - i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for £6.00 plus £2 postage. For prices of modules bought separately see TWO POUNDERS.

CAR STARTER/CHARGER KIT

Flat Battery! Don't worry you will start your car in a few minutes with this unit - 250 watt transformer 20 amp rectifiers, case and all parts with data case £17.50 post £2.

MINI MONO AMP on p.c.b. size 4" × 2" (app.)

Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or £13 for £12.00



LIGHT BOX

This when completed measures approximately 15" x 14". The light source is the Philips fluorescent 'W' tube. Above the light a sheet of fibreglass and through this should be sufficient light to enable you to follow the circuit on fibreglass PCBs. Price for the complete kit, that is the box, choke, starter, tube and switch, and fibreglass is £5 plus £2 post, order ref 5P69.

TANGENTIAL HEATERS

We again have very good stocks of these quiet runnng instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1.2kw, 2kw, 2.5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post £1.50 per heater if not collecting.

CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram, 50p for 2kw, 75p for 3kw.

FANS & BLOWERS

5" £5 + £1.25 post. 6" £6 + £1.50 post
4" x 4" Muffin equipment cooling fan 115V £2.00
4" x 4" Muffin equipment cooling fan 230/240V £5.00
9" Extractor or blower 115V supplied with 230 to 115V adaptor £9.00 + £2 post.
All above are ex computers but guaranteed 12 months.
10" x 3" Tangential Blower. New. Very quiet - supplied with 230 to 115V adaptor on use two in series to give long blow £2.00 + £1.50 post or £4.00 + £2.00 post for two

9" MONITOR

Ideal to work with computer or video camera uses Philips black and white tube ref M24/306W. Which tube is implosion and X-Ray radiation protected. VDU is brand new and has a time base and EHT circuitry. Requires only a 16V dc supply to set it going. It's made up in a lacquered metal framework but has open sides so should be cased. The VDU comes complete with circuit diagram and has been line tested and has our six months guarantee. Offered at a lot less than some firms are asking for the tube alone, only £16 plus £5 post.

LOW COST OSCILLOSCOPE - kit to convert our 9" monitor into an oscilloscope with switched time bases to allow very high and very low frequency waveforms to be observed and measured. Signal amplitudes from as low as 10mV and as high as 1kV can easily be observed and measured. Ideal for servicing, also for investigating TV, radio and audio circuits.

Kit containing all the parts for the conversion and the power supply to operate from mains £25 our ref 25P3.

TELEPHONE LEAD

3 mtrs long terminating one end with new BT, flat plug and the other end with 4 correctly coloured coded wires to fit to phone or appliance. Replaces the lead on old phone making it suitable for new BT socket. Price £1 ref BD552 or 3 for £2 ref 2P164.

COMPACT FLOPPY DISC DRIVE EME-101

The EME-101 drives a 3" disc of the new standard which despite its small size provides a capacity of 500k per disc, which is equivalent to the 3½" and 5¼" discs. We supply the Operators Manual and other information showing how to use this with popular computers: BBC, Spectrum, Amstrad etc. All at a special snip price of £27.50 including post and VAT. Data available separately £2, refundable if you purchase the drive.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, shop, work room etc. Makes you feel better and work harder - a complete mains operated kit, case included. £11.50 + £3 P&P.

J & N BULL ELECTRICAL

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

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted: Brighton (0273) 734648 or 203500.

NEW ITEMS

Some of the many described in our current list which you will receive with your parcel.

POWERFUL 12V MOTOR - was intended for Sinclair electric car, rating approx ⅓h.p. Price £15. Ref. 15P8.

BURGLAR ALARM BELL - 6 inch gong. OK for outside use if protected from rain. Mains or 12V battery operated, state which required. Price £8. Ref. 8P2

24 HOUR TIME SWITCH - 16A changeover contacts, up to 6 on/offs per day. Nicely cased, intended for wall mounting. Price £8. Ref. 8P6

CAPACITOR BARGAIN - axial ended, 4,700μF at 25V. Jap made, normally 50p each, you get four for £1. Our Ref. 613.

AGAIN AVAILABLE 12" mini fluorescent tubes - Price £1 each. Ref. BD314.

POWER PACK OR AMPLIFIER CASE - Size approx 10" x 8¼" x 4¾" plated steel - with ample perforations for cooling. Front panel has on/off switch and E.E.C. mains inlet plug with built in RF filter - undoubtedly a very fine case which would cost at least £50 from regular sources, our price is £5 each and £3 post. Ref. 5P111.

MINIATURE BCD THUMB WHEEL SWITCH - Matt black edge switch engraved white on black - gold plated, make before break contats - size approx. 25mm high 8mm wide 20mm deep - made by the famous Cherry Company and designed for easy stacking - Price £1 each. Ref. BD601.

EDGE METER - miniature, whole size approx 37mm x 13mm 100 ua fsd - centre zero scaled 0 to - 10 and 0 to + 10. Price £1 each. Ref. BD602.

CLEANING FLUID - Extra good quality - intended for video and tape heads - regular price £1.50 per spray can - our Price - 2 cans for £1. Ref. BD 604.

DON'T FREEZE UP! - We have had the strongest winds for over 200 years and who knows we may be in for the coldest winter, so if you have not already protected your water pipes you should do so now - our heating wire wound around the pipes will do this and will cost only about 50p per week to run - 15 metres (minimum length to connect to 230/240 v mains). Price £5. Our Ref. 5P 109.

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 it is ideal for computer and instrument cooling. Price is only £1 each. Ref BD605.

SPRING LOADED TEST PRODS - heavy duty, made by the famous Bulgin company. Very good quality. Price four for £1. Ref. BD599.

CURLY LEAD four core, standard replacement for telephone handset, extends to nearly two metres. Price £1 each. Ref. BD599.

TELEPHONE BELLS - these will work off our standard mains through a transformer, but to sound exactly like a telephone, they then must be fed with 25 hz 50v. So with these bells we give a circuit for a suitable power supply. Price 2 bells for £1. Ref. BD600.

ULTRA SENSITIVE POCKET MULTIMETER - 4k ohms per volt - 11 ranges - carry one of these and so be always ready to test ac/dc volts to 1000, DC milliams and have an ohms range for circuit testing - will earn its cost in no time. Price only £7. Ref. 7P2

BLOW YOUR ROOF OFF 140 watt speaker systems - new type you must not hide! they have golden cones and golden surrounds and look really "Bootiful" 12" Woofer, Midrange and Tweeter and comes with a crossover at a special introductory price of £49, carriage paid. Two sets for £95 carriage paid. 140w Woofer only £35 carriage paid.

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 2 for £1. Ref. BD582.

COMPUTERS

Big consignment of computers expected in , various makes and numbers, write or phone for details.

NOVEL NIGHT LIGHT - plugs into a 13A socket. Gives out a surprising amount of light, certainly enough to navigate along passages at night or to keep a nervous child happy. Very low consumption, probably not enough to move the meter. Price £1. Ref. BD563.

CASE WITH 13A PRONGS - to go into 13A socket, nice size and suitable for plenty of projects such as car battery trickle charger, speed controller, time switch, night light, noise suppressor, dimmers etc. Price - 2 for £1. Ref. BD565

SPEAKER EXTENSION CABLE - twin 0.7mm conductors so you can have long runs with minimum sound loss and for telephone extensions or burglar alarms, bells, intercoms etc. 250m coil only £3 plus £1 post. Ref. 3P28.

ALPHA-NUMERIC KEYBOARD - this keyboard has 73 keys with contactless capacitance switches giving long trouble free life and no contact bounce. The keys are arranged in two groups, the main area field 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.

TELEPHONE EXTENSIONS - it is now legal for you to undertake the wiring of telephone extensions. For this we can supply 4 core telephone cable, 100m coil £8.50. Extension BT sockets £2.95. Packet of 500 plastic headed staples £2. Dual adaptor for taking two appliances from one socket £3.95. Leads with B.T. plug for changing old phones. 3 for £2.

MODULAR SWITCH - Panel mounting highest quality and ideal where extra special front panel appearance is required, can be illuminated if required d.p.d.t. and latching. Price - 2 for £1. Ref. BD607.

WIRE BARGAIN - 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 + £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 DC 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.

TRANSMITTER SURVEILLANCE (BUG) - tiny, easily hidden, but which will enable conversation to be picked up with FM radio. Can be housed in a matchbox, all electronic parts and circuit. Price £2. Ref. 2P52.

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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

ABC

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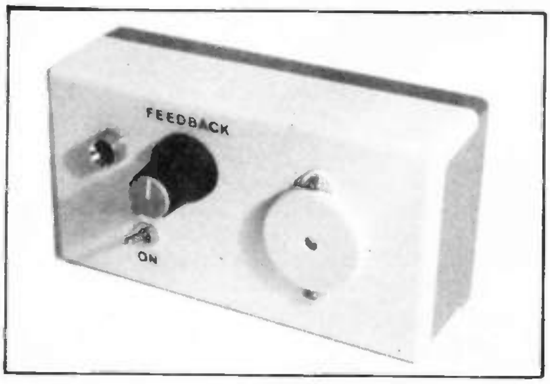
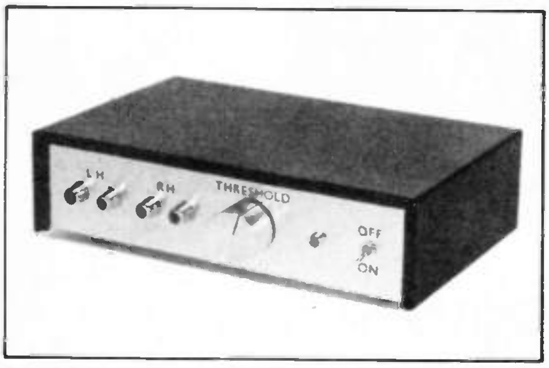
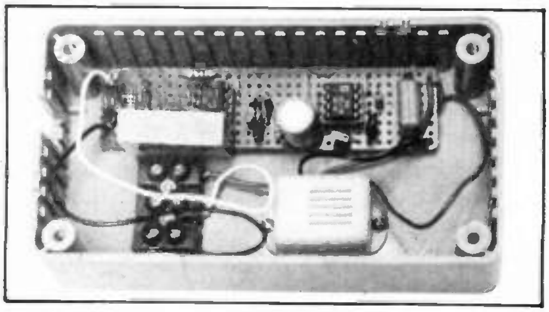
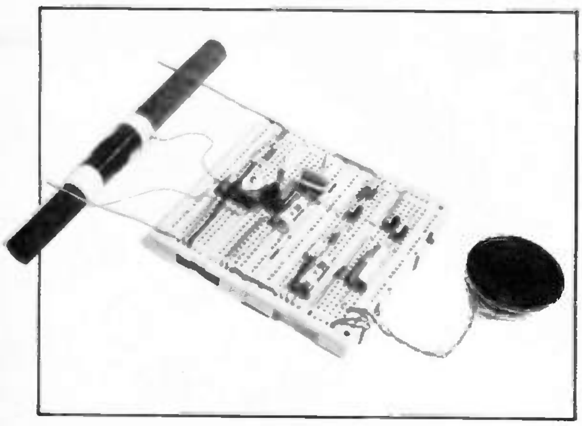
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Projects

Series

Features

FREE

GREENWELD 24-page Spring Catalogue Supplement
Between pages 224 and 225

DATA CARD

Our may 1988 issue will be published on Friday, 31 March 1988. *See page 249 for details.*

BI-PAK BARGAINS

BI-PAK

THE UNDISPUTED PACK KING FOR OVER 20 YEARS, we offer you the very best in Electronic Components and Semiconductors that your money can buy. Look at our lists and prices, they are unbeatable in value and quantity and you always have our "Satisfaction or money back guarantee". For 1988 we offer more and more Super Value Packs. All goods advertised in stock at time of going to press. **Please note our new mail order address: BI-PAK, PO BOX 33, ROYSTON, HERTS SG8 5DF. Telephone orders: 0763-48851.**

RESISTORS

Pak No	Qty	Description	Price
VP1	300	Assorted Resistors, mixed values & types	£1.00
VP2	300	Carbon Resistors, ¼-½ watt, pre-formed, mixed	£1.00
VP4	200	½-1 watt Resistors, mixed values and types	£1.00
VP16	50	Wirewound Resistors, mixed watt values	£1.00
VP140	50	Precision Resistors, 1% tolerance	£1.00
VP181	100	1 and 2 watt Resistors, assorted values	£1.00
VP287	100	Close tolerance Resistors, .05-2%, 10-910 ohms, mixed	£1.50
VP288	100	Close tolerance Resistors, .05-2%, 1K-820K, mixed	£1.50
VP289	100	Metal oxide high stab. Resistors, ¼w 2%, mixed values	£1.50

CAPACITORS

Pak No	Qty	Description	Price
VP5	200	Assorted Capacitors, all types	£1.00
VP6	200	Ceramic Capacitors, Min. mixed values	£1.00
VP9	100	Assorted Polyester/Polystyrene Capacitors	£1.00
VP10	60	C280 Capacitors, metal foil, mixed values	£1.00
VP11	50	Electrolytics, all sorts	£1.00
VP12	40	Electrolytics, 0.47mf-150mf, mixed volts	£1.00
VP13	30	Electrolytics, 150mf-1000mf, mixed volts	£1.00
VP14	50	Silver Mica Caps, mixed values	£1.00
VP15	25	.01/250v Min. Layer Metal Caps	£1.00
VP180	25	Tantalum Bead Caps, assorted values	£1.00
VP182	4	1000uf 50v Electrolytics	£1.00
VP192	30	Min. Electrolytics, mixed values, 0.47mf-1000mf 6/16v	£1.00
VP193	6	Sub Min. Electrolytics, 2 x 1000/2200/3300mf 10/16v	£1.00

OPTOS

Pak No	Qty	Description	Price
VP24	10	.125" clear showing Red LEDs	£1.00
VP25	10	Mixed shape and colour LEDs	£1.00
VP26	15	Small .125" Red LEDs	£1.00
VP27	15	Large .2" Red LEDs	£1.00
VP28	10	Rectangular .2" Red LEDs	£1.00
VP57	25	Opto special pack. Assorted. Super Value	£1.00
VP130	6	RED 7 Seg. CC 14mm x 7.5mm RDP FND353 LED Display	£2.00
VP131	4	GREEN 7 Seg. CA .6" LDP XAN6520 LED Display	£2.00
VP133	6	RED Overflow .6" 3 x CA 3 x CC 6630/50 LED Display	£2.00
VP134	5	GREEN Overflow .6" CA XAN6530 LED Display	£2.00
VP138	20	Assorted LED Displays. Our mix, with data	£5.00
VP147	1	Pair Opto Coupled Modules	£1.00
VP199	4	LD707R LED Displays CA	£1.00
VP203	15	Triangular shape LEDs. Mixed colours	£1.00
VP204	10	Large Green LEDs, 5mm	£1.00
VP205	10	Small Green LEDs, 3mm	£1.00
VP206	10	Large Yellow LEDs, 5mm	£1.00
VP207	10	Small Yellow LEDs, 3mm	£1.00
VP208	10	Large LEDs clear showing Red, .2"	£1.50
VP241	2	ORP12 Light Dependent Resistor	£1.50
VP242	4	Tri-colour LEDs, 5mm Dia., 5mA 2v R.G.Y.	£1.00
VP243	3	Tri-colour LEDs. Rectangular 5mm R.G.Y.	£1.00
VP266	10	Orange LED's, 5mm large	£1.00
VP267	8	Stackable LED's, Rectangular, mixed, R.G.Y.	£1.00
VP268	15	LED Panel Mounting Clips, metal and plastic, 3-5mm	£1.00
VP269	2	Red Flashing LED's, 5mm	£1.00
VP284	2	Opto-isolator IL74-4N27, single	£1.00
VP285	1	Dual Opton-isolator ILD74	£1.00

DIODES AND SCRS.

Pak No	Qty	Description	Price
VP29	30	Assorted volt Zeners 50mw-2w	£1.00
VP30	10	Assorted volt Zeners 10w, coded	£1.00
VP31	10	5A SCRs T066, 50-400v, coded	£1.00
VP32	20	3A SCRs T066, up to 400v, uncoded	£1.00
VP33	100	Sil. Diodes like IN4148	£1.00
VP34	200	Sil. Diodes like 0A200/BAX13-16, 40v 200mA	£1.00
VP35	50	1A IN4000 Diodes, all good, uncoded 50v min	£1.00
VP49	30	Assorted Sil. Rectifiers 1A-10A, mixed volts	£1.00
VP141	40	IN4002 Sil. Rectifiers 1A 100v, preformed pitch	£1.00
VP142	4	40A Power Rectifiers, silicon, T048 300 PIV	£1.00
VP143	5	BY187 12kv Sil. Diodes, in carriers, 2.5MA	£1.00
VP184	3	4A 400v Triacs, plastic	£1.00
VP187	10	SCRs 800MA, 200v, 2N5064, plastic, T092	£1.00
VP194	50	OA91 point contact germ. Diodes, uncoded	£1.00
VP195	50	OA47 gold bonded germ. Diodes, uncoded	£1.00
VP196	50	OA70-79 detector germ. Diodes	£1.00
VP197	50	OA90 type germ. Diode, uncoded	£1.00
VP198	40	BA248 Sil. Diodes, 350v 2A, fast recovery	£1.00
VP222	20	3A Stud Rectifiers, 50-400v Assorted	£1.00
VP274	12	SCR's (Thyristors) 1A 100-400v, TO 39	£1.00
VP275	3	5A 400v SCR's, T0220, TIC106D	£1.00
VP276	5	SCR's standard type, 5-16Amp to 400v	£1.00
VP277	4	Triacs 2Amp 400v TO-39	£1.00
VP278	4	6Amp 1000v plastic Silicon Rectifiers	£1.00
VP283	5	Diac BR100, triac trigger	£1.00

TRANSISTORS

Pak No	Qty	Description	Price
VP38	100	Sil. Trans. NPN plastic, coded, with data	£3.00
VP39	100	Sil. Trans. PNP plastic, coded, with data	£3.00
VP47	10	Sil. Power Trans. similar 2N3055, uncoded	£1.00
VP48	5	Pairs NPN/PNP plastic Power Trans. 4A, data	£1.00
VP50	60	NPN Sil. Switching Trans. T0-18 and T0-92	£1.00
VP51	60	PNP Sil. Switching Trans. T0-18 and T0-92	£1.00
VP60	100	All sorts Transistors, NPN/PNP	£1.00
VP150	20	BC183B Sil. Trans. NPN 30v 200mA Hfe240 + T092	£1.00
VP151	25	BC171B Sil. Trans. NPN 45v 100mA Hfe240 + T092	£1.00
VP152	15	TIS90 Sil. Trans. NPN 40v 400mA Hfe100 + T092	£1.00
VP153	15	TIS91 Sil. Trans. PNP 40v 400mA Hfe100 + T092	£1.00
VP154	15	MPSA56 Sil. Trans. PNP 80v 500mA Hfe50 + T092	£1.00
VP155	20	BF595 Sil. Trans. NPN eqvt BF184 H.F. T092	£1.00
VP156	20	BF495 Sil. Trans. NPN eqvt BG173 H.F. T092	£1.00
VP157	15	ZTX500 series Sil. Trans. PNP plastic	£1.00
VP158	15	ZTX107 Sil. Trans. NPN eqvt BC107 plastic	£1.00
VP159	15	ZTX108 Sil. Trans. NPN eqvt BC108 plastic	£1.00
VP161	25	BC183L Sil. Trans. NPN 30v 200mA T092	£1.00
VP162	6	SJE5451 Sil. Power Trans. NPN 80v 4A Hfe20 +	£1.00
VP163	2	NPN/PNP pairs Sil. Power Trans. like SJE5451	£1.00
VP164	4	2N6289 Sil. Power Trans. NPN 40v 7A Hfe30 +	£1.00
VP165	6	BFT33 NPN Sil. Trans. 80v 5A Hfe60-200 T039	£1.00
VP166	5	BFT34 NPN Sil. Trans. 100v 5A Hfe50-200 T039	£1.00
VP167	1	BUY69C NPN Trans. TO3 VCB 500, 10A, 100w, Hfe15 +	£1.00
VP168	10	BC478 eqvt BCY71 PNP Sil. Trans. TO18	£1.00
VP169	10	BX521 eqvt BC394 NPN Sil. Trans. 80v 50mA TO18	£1.00
VP170	10	Assorted Power Trans. NPN/PNP coded and data	£1.00
VP171	10	BF355 NPN TO 39 Sil. Trans. eqvt BF258 225v 100mA	£1.00
VP172	10	SM1502 PNP TO 39 Sil. Trans. 100v 100mA Hfe100 +	£1.00
VP200	30	OC71 type germ. AF Transistors, uncoded	£1.00
VP201	25	OC45 germ. RF Transistors	£1.00

TRANSISTORS (cont).

Pak No	Qty	Description	Price
VP261	4	Programmable Unijunction Transistors, MEU22	£1.00
VP270	10	FET's UHF/VHF Amplifiers, switching & choppers, data	£1.00
VP271	10	FET's general purpose like 2N3819-2N5457, data	£1.00
VP272	10	MOS-FET's Signetics, SD304	£1.00
VP280	12	ZTX300 NPN Silicon Transistors	£1.00
VP290	15	MPSA06 Sil. Transistors, NPN 80v 500mA HFE50 + T092	£1.00
VP428	10	AC128K PNP Germanium Transistor, 1A 32v	£1.00
VP429	10	AC176K NPN Germanium Transistors, 1A 32v	£1.00
VP430	4	2N3055 Sil. Power Transistors, full spec	£2.00
VP431	25	PNP Sil. Transistors, T0 39 like 2N2905A	£1.00

I.C.S.

Pak No	Qty	Description	Price
VP40	40	TTL I.C.s all new gates – Flip Flop – MSL Data	£4.00
VP54	20	Assorted I.C. DIL Sockets, 8 – 40 pin	£2.50
VP59	20	Assorted I.C.s linear, etc, all coded	£2.00
VP209	12	74LS00	£2.00
VP210	12	74LS74	£2.00
VP211	10	CD4001B	£2.00
VP212	10	CD4011B	£2.00
VP214	10	CD4069B	£2.00
VP215	10	741P 8 pin	£2.00
VP216	10	555 Timers 8 pin	£2.00
VP223	50	Asst 74 TTL I.C.s "ALL GATES" new and coded our mix 7400-7453	£6.00
VP224	100	Asst 74 TTL I.C.s "ALL GATES" new and coded our mix 7400-7453	£10.00
VP282	1	Prog. Sound Gen. Chip, AY-3-8912	£3.00
VP291	1	Z80ACPU Microprocessor, 40 pin DIL	£2.00
VP292	1	Z80AP10 Parallel Interface Controller, 40 pin DIL	£2.00
VP293	1	Z80ACTC Counter Timer Circuit, 28 pin DIL	£2.00
VP294	1	2732D 32K Eprom	£3.00
VP295	1	6821P Peripheral Interface Adaptor (PIA)	£1.50
VP296	6	LM324 14 pin DIL Quad Op Amp	£2.00
VP297	5	CA3130E MOS-FET I/P, CMOS O/P, Op-Amp	£2.00
VP298	3	MC1310P Stereo Decoder, 14 pin DIL	£2.00
VP299	3	CA3085 Pos. Volt. Regulator, 1.7v-46v, 8 pin TO5	£2.00
VP400	1	27128 128K Eprom	£2.50
VP401	2	LM317T Adjst. Voltage Regulator, 1.5A	£1.00
VP402	1	2114 4K Static Ram	£2.00
VP403	1	TA7204 Audio Amp I.C. 4.2w, 13v, 2-4 ohms	£1.00
VP404	1	TBA461 Audio Power Amp, 4.5w	£1.50
VP432	8	CD4016B	£2.00
VP433	6	CD4017B	£2.00
VP434	10	CD4024B	£2.00
VP435	10	CD4028B	£2.00
VP7413	4	7413 Dual Nand Schmitt Trigger, 4-input	£1.00
VP7440	4	7440 Dual 4-input, Positive Nand Buffer	£1.00
VP7470	4	7470 And gated Positive edge-triggered Flip Flop with preset	£1.00
VP7480	4	7480 Gated full Adder	£1.00
VP7481	4	7481 16 bit Random Access memories	£1.00
VP7490	4	7490 Decade Counter	£1.00
VP7491	4	7491 8-Bit Shift Register	£1.00
VP7492	4	7492 Divide by 12 Counter	£1.00
VP7493	4	7493 4-bit Binary Counter	£1.00
VP7494	4	7494 4-bit Shift Register	£1.00
VP7495	4	7495 4-bit Shift Register	£1.00
VP74111	4	74111 Dual J-K Master Slave, Flip Flop	£1.00
VP74141	4	74141 BCD – Decimal Decoder/Driver	£1.00
VP74151	4	74151 1 of 8 Data Selectors/Multiplexers	£1.00
VP74153	4	74153 Dual 4 line to 1 line Data Selectors/Multiplexers	£1.00
VP74164	4	74164 8-bit Parallel Output Serial Shift Registers	£1.00
VP74167	4	74167 Synchronous Decade Rate Multipliers	£1.00
VP74174	4	74174 Hex D type Flip-Flops	£1.00
VP74181	4	74181 Arithmetic Logic Units/Function Generators	£1.00
VP74193	4	74193 Synchronous Up/Down Dual Clock Counters. Binary Clear	£1.00
VP74279	4	74279 Quad S-R Latches	£1.00
BPX6	1	TTL Data Book 74 Series, including "LS". Complete with Pin out diagrams. 7400-74670. TTI interchangeability guide. Function selection guide and explanation of function tables. "NO VAT"	£1.00
BPX5	1	IC555 PROJECTS BOOK (TIMER). 167 pages. Over 50 project circuits to build and other information on IC555 Timers. Plus FREE with our compliments, 3 x IC 555 Timer, worth 80p "NO VAT". Special offer price just	£2.95
BPX4	1	INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE. Babani Publishing's latest edition BP85, plus FREE with our compliments, 10 popular Silicon Transistors, worth £1.00. "NO VAT". Special offer price just	£3.50

MISC.

Pak No	Qty	Description	Price
VP17	50	Metres PVC single strand Wire, mixed colours	£1.00
VP18	30	Metres PVC multi strand Wire, mixed colours	£1.00
VP19	40	Metres PVC single/multi strand Wire, mixed colours	£1.00
VP22	200	Sq. inches total copper clad board	£1.00
VP23	10	40mm track slider pots 100K Lin	£1.00
VP42	10	Black heatsinks, fit TO3 and TO220, drilled	£1.00
VP43	4	Power-fin heatsinks, 2 x TO3, 2 x TO66	£1.00
VP44	15	Assorted heatsinks, TO1/3/5/18/220	£1.00
VP56	100	Semiconductors from around the world, mixed	£4.00
VP82	1	Electronic Buzzer, 3v, 25MA	£0.95
VP83	1	Electronic Buzzer, 6v, 25MA	£0.95
VP84	1	Electronic Buzzer, 9v, 25MA	£0.95
VP85	1	Electronic Buzzer, 12v, 25MA	£0.95
VP86	1	TECASBOTY Components Pack, semiconductors, caps, wire, etc	£8.00
VP87	1	Telephone pick-up coil with 3.5mm jack plug	£1.25
VP88	1	Pillow Speaker with 3.5mm jack plug	£1.45
VP107	1	Piezo Buzzer, miniature, 12v	£1.25
VP108	1	Piezo Buzzer, miniature, 240v	£1.25
VP113	1	Coax Antenna Switch, 2 way	£4.50
VP114	1	Coax Antenna Switch, 3 way	£4.75
VP115	1	High Pass Filter/Suppressor CB/TV	£0.50
VP116	1	Low Pass Filter, VHS/TV Band	£3.00
VP122	1	Precision Morse Key, fully adjustable	£1.85
VP144	4	100K Lin multi turn Pots, ideal vari cap tuning	£1.00
VP145	10	Assorted Pots, inc, dual and switched types	£1.00
VP148	30	Presets, horizontal and vertical, mixed values	£1.00
VP174	5	DIL Switches, 1 and 2 way slide, 6 way SPST, assorted	£1.00
VP176	30	Fuses, 20mm and 1¼" glass, assorted values	£1.00

MISC. (cont.)

Pak No	Qty	Description	Price
VP177	1	Pack assorted Hardware, nuts, bolts, etc	£1.00
VP178	5	Assorted Battery holders and clips PP3/9, AA/D, etc	£1.00
VP223A	6	Tag Boards, 18 way paxaline	£1.00
VP225	20	DIN Plugs, plastic 2-8 pin, 180°/240°/380° mixed	£2.50
VP226	20	DIN Chassis Skts, metal 2-8 pin 180°/240°/380° mixed	£2.50
VP227	18	DIN In line Skts, plastic 2-8 pin 180°/240°/360° mixed	£2.50
VP228	10	C15 Computer Cassette Tapes, leadless	£3.00
VP232	1	Cassette Head Cleaner/Demagnetizer, in case	£2.00
VP233	1	Revolving Cassette Rack, holds 32, smokey perspex	£2.50
VP244	1	High Power Piezo Electric Siren. Emits earpiercing warbling sound. Ideal alarm. White plastic body with mounting bracket. Power 12vDC 150mA. Output 100db (A) at 1m typ. freq. 2.5KHz. Size: 57 x 42 x 37mm	£6.00
VP260	1	9" x 6" Elliptical 8 ohms 10W RMS Speaker. Freq. Res. 60-10000 Hz. Gauss 10000. Centre HF cone	£4.50
VP260A	1	2¼" Transducer Waterproof Speaker. Polyester film diaphragm. Moisture res. 8 ohms 300mW Freq. Res 20-20000 Hz	£1.00
VP273	10	10K Lin Rotary Potentiometers, slim spindle	£1.00
VP281	4	Plug-in Relays. Mixed volts, etc	£1.00

TOOLS

Pak No	Qty	Description	Price
VP95	1	Plastic Vice, small, with suction base	£1.75
VP97	1	Logic Probe/Tester, supply 4.5v – 18v, DTL, TTL, CMOS	£8.50
VP99	1	Universal Tester, with ceramic buzzer	£5.00
VP103	1	6 pc Stanley screwdriver set, flat and crosspoint	£3.50
VP139	1	Pick-up Tool, spring loaded	£1.75
VP217	1	Helping Hand	£4.00
VP218	1	Watchmakers Screwdriver Set, 6 pieces	£1.75
VP219	1	Miniature Side Cutters	£1.55
VP220	1	Miniature Bent-nose Pliers	£1.55
VP221	1	Miniature Long-nose Pliers	£1.55
VP237	1	Universal Ni-Cad Battery Charger, AA-HP11-HP2-PP3	£8.00
VP238	4	AA Ni-Cad Batteries, 1.25v 500mAh C/R mA	£4.00
VP239	2	C?HP11 Ni Cad Batteries, Rechargeable	£3.50
VP240	2	D-HP2 Ni-Cad Batteries. Rechargeable	£4.00
VP246	1	25w Quality Low Cost Soldering Iron, 240vAC	£3.50
VP247	1	15w "Lightweight" Quality Low Cost Soldering Iron, 240vAC	£3.50
VP248	1	High Suction Desoldering Pump. Teflon nozzle. Auto eject. Heavy duty return spring	£4.80
VP250	1	Long Finger Grip. Soldering Aid. Heavy metal use. Serrated jaws with rev. Tweezer action. Ideal for holding small components. Fully adjustable	£3.00
VP254	1	250 grams Etchant Granules (Ferric Chloride) makes ½ pint	£1.00
VP256	1	Etching Pen. Etch resistant. Spare tip. Blue	£1.00
VP258	1	Multicore Solder. 5m total. 10 and 22 SWG	£1.00
VP259	1	PCB Holder, Fully adjustable from 0-320mm wide and to any angle. Complete with iron stand and sponge. Strong metal construction with rubber feet. Very high quality	£15.00
VP286	2	Etch Resist PCB Transfer Sheets. Asst. symbols/lines	£1.00
VP405	2	Steel Rules 1 x 4", 1 x 10", measuring ins and mm	£1.00
VP406	1	Junior Hacksaw & 3 blades + hobby knife & 2 blades	£1.00
VP407	1	10 Piece Needle File Set	£3.00
VP408	1	4 Piece Stainless Steel Tweezer Set	£4.00
VP409	1	Set of 4 min. low cost Side & End Cutters, snipe & combination Pliers, 5" insul. handles	£4.50
VP410	1	18 Pc Hex Wrench Keys. AF sizes in wallet	£1.50
VP411	1	16 Pc Hex Key Wrench Set, SAE and Metric	£2.00
VP412	1	Crimping Pliers, Wire Strippers & Bolt Cutters	£1.00
VP413	2	IC Extraction Tools, jaw width 18 and 29mm	£2.00
VP414	1	End Action Stripping Pliers. Adjustable jaws	£1.00
VP415	1	5" Grip Locking Pliers	£3.00
VP416	1	6" Long Nose Grip Locking Pliers	£3.00
VP417	1	6" Adjustable Wrench. Forged alloy steel	£2.50
VP418	1	8" Tin Snips. Hardened steel, spring joint	£2.00
VP419	2	"Chubby" Screwdrivers. Crosspoint No 1 and 2	£1.50
VP420	2	"Chubby" Screwdrivers. Flat blade 4.5 and 6mm	£1.50
VP421	1	Screwdriver 400mm long, 6mm flat blade	£3.00
VP422	1	Screwdriver 400mm long, No 2 crosspoint	£3.00
VP423	1	Vernier Caliper-Crosshorns. Depth gauge. Vernier Cap. 4½"/110mm reading 1/128", 1/10mm	£2.50
VP424	1	Helping Hand with Magnifier	£4.50
VP425	1	7 Pc high quality Screwdriver Set	£8.50
VP426	1	7 Pc high quality Screwdriver Set 1000v	£12.50
VP427	1	6 Pc Cushion Grip Screwdriver Set	£4.00

LEADS

Pak No	Qty	Description	Price
VP300	1	10m Speaker Lead 2 pin DIN Plug to 2 pin DIN Skt	£1.00
VP301	1	2m Video Lead Coaxial Skt to Coaxial Skt + 2 adaptors	£1.20
VP302	1	3m 4 core cable indv. screened 5 pin DIN Plug-5 pin DIN Plug	£1.80
VP303	1	TV Ext. Lead. Coax plug to Coax Plug. White	£1.00
VP304	1	1.5m 4 core indv. screen. 5 pin DIN Plug – tinned open end	£1.00
VP305	1	1.5m cable 5 pin DIN Plug – 3.5mm Jack Plug. Pin 1 & 4 connect	£1.00
VP306	1	2m Typewriter/Calculator Lead. 3 pin Plug, angled European IEC configuration	£2.00
VP307	1	60cm Patch Lead. PL259 Plug to PL259 Plug	£1.00
VP308	1	1.2m Patch Lead. PL259 Plug to PL259 Plug	£1.50
VP309	1	1.2m Lead 4 Phono Plugs to 4 Phono Plugs	£1.50
VP310	1	20cm Lead 2 x 2 pin DIN Plug to Stereo Inline Jack Skt	£1.00
VP311	1	2m Lead Scart Plug to 5 pin DIN Plug & 2 BNC Plugs	£8.00
VP312	1	1.2m Video Lead. BNC Plug to Phono Plug	£1.50
VP313	1	3m Headphone Lead. 3.5mm Jack Plug to 3.5mm Jack Skt.	£1.00
VP314	1	2m Coax Lead BNC Plug to BNC Plug. 75 ohms	£3.00
VP315	1	2m Coax Lead BNC Plug to UHF Plug. 75 ohms	£3.00

TELEPHONE ACCESSORIES

Pak No	Qty	Description	Price
VP316	1	5m Telephone Ext. Lead. Plug to Socket	£4.50
VP317	1	10m Telephone Ext. Lead. Plug to Socket	£8.00
VP318	1	3m Line Jack Cord. BT 4 way Plug to 4 Spade Terminals	£1.75
VP319	1	Double Adaptor, One IDC plug. 2 socket	£3.50
VP320	1	IDC Telephone Plug 4 way	£0.50
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ACCENTEO BEAT METRONOME Nov 87	£19.95
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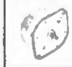

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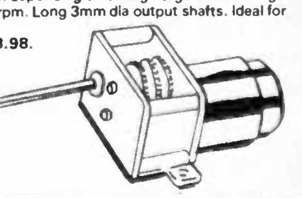

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SPRING

As I write this it is a warm "spring" day in the middle of February and one's thoughts turn to summer projects—we have a couple lined up for later issues so hopefully the sun will shine again later in the year. No doubt by the time you read this there will be snow and gales and you will be happy to stay inside and build a few more projects, or continue learning from our various features and series. At this time of the year we get many letters from G.C.S.E. students requesting designs for their chosen project or requesting very old back issues for a project they have picked out. With the recent change in style of the G.C.S.E. exams no doubt these approaches will cease or at least change in nature.

May I make the point that we cannot provide individual designs to meet the needs of any reader or organisation and we are also unable to provide information on anything published more than five years ago. Might I also suggest that before building any project from a publication that is more than a couple of years old you check that all the components are available at reasonable prices.

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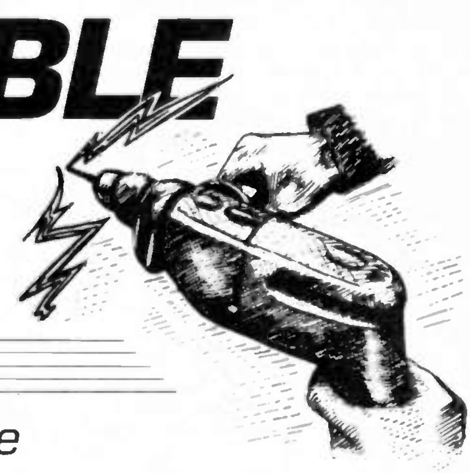
PIPE AND CABLE LOCATOR



ROBERT PENFOLD

Take the guesswork out of finding those hidden electric cables and metal pipes and save yourself from a nasty shock!

MANY people probably think of metal detectors as something strictly for treasure hunters or for the military in mine detection. Metal detectors of various kinds are used in a variety of applications though, including roles as diverse as electronic ignition systems and pipe/cable locators.

It is this second application that almost certainly represents the most worthwhile use for a metal detector in most households. Checking the routing of electric cables and pipes when doing odd-jobs that involve drilling into walls can avoid a lot of expensive damage. It also renders jobs of this type very much safer.

DESIGN

Cable locators are of two basic types; metal detectors and so called "hum" detectors. The latter detect the magnetic field around a cable that is passing current. As the mains supply is an a.c. type, this magnetic field is in the form of a 50Hz signal which can be detected by a coil and then amplified to drive an earphone (or whatever).

This type of detector can work well, but it is only usable with electric cables and is obviously not applicable to gas or water pipes. The metal detector type is suitable for detecting any metal pipes or cables buried in the wall, regardless of their function.

The only proviso is that they must be metal types, and not the plastic types that are sometimes used these days. It is not just pipes that can be located, and any metal reinforcement above doors or windows should show up quite readily, as should any moderately substantial piece of metal.

The only difficulty with a metal detector for this application is in designing one which is easy to use but which also gives good performance. This design is based on a special proximity detector integrated circuit which enables a very simple circuit to be used, but also gives good performance.

Unlike some metal detectors, there is no difficulty in setting up and using this unit. When a metal object is detected the unit emits an audio tone and it also switches on a l.e.d. indicator light.

THE CHIP

There are numerous methods of metal detection, although most of these rely on a search coil or coils which have their characteristics altered in some way by a piece of metal in their proximity. The b.f.o. (beat frequency oscillator) type is perhaps the best known class of metal detector.

These use the search coil as an inductor in a *L/C* oscillator, and the presence of metal near the coil changes its inductance slightly so that a shift in the oscillator's frequency is produced. In order to give a reasonable shift in frequency the oscillator must operate well beyond the upper limit of the audio range, but a second oscillator and the heterodyne technique are used to bring the output down to an audible frequency.

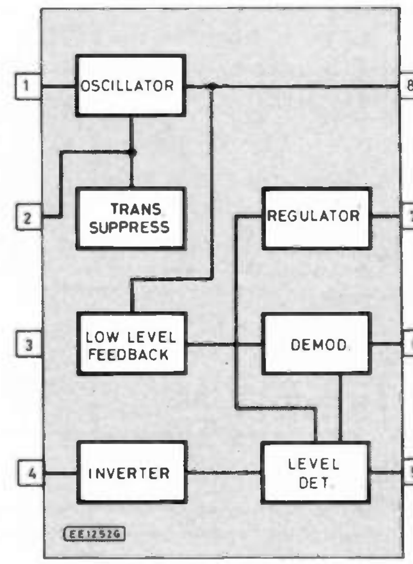


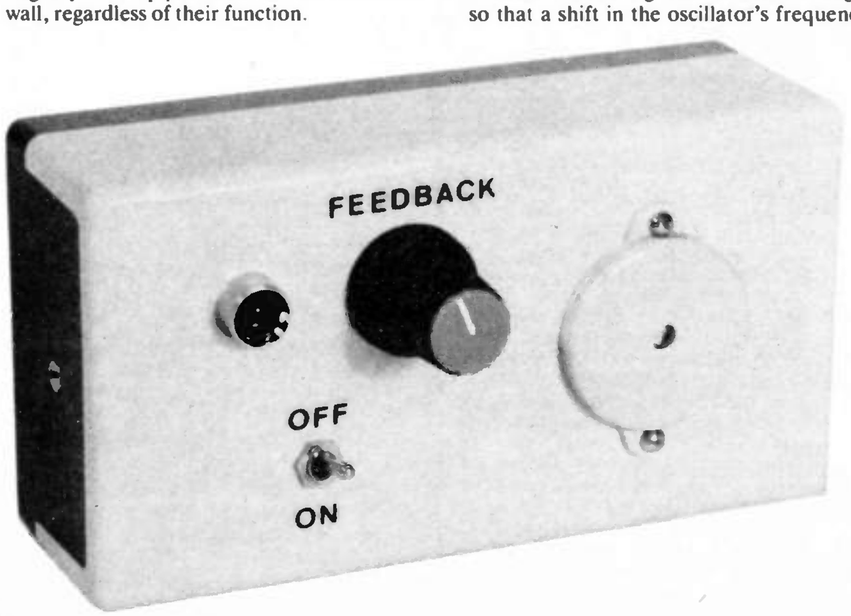
Fig. 1. Internal block diagram for the proximity detector i.c. type CS209.

Units of this type offer good sensitivity and simplicity, but they can be difficult to use. Many people find the small shift in frequency hard to detect, and the presence of walls and other large but non-metallic objects can produce shifts in tone that produce confusing results.

The circuit to be described here is based on the CS-209 proximity detector integrated circuit. A b.f.o. design was originally considered, but on comparing results against a unit based on the CS-209 the latter proved to be much easier to use.

The CS-209 is designed to operate with a search coil, and this is connected as the inductor in a *L/C* oscillator. However, here the similarity with b.f.o. detectors ends, and the output frequency of the oscillator is of little importance in this case. Fig.1 shows the internal arrangement of the CS-209, and this helps to explain the way in which the device functions.

The coil and parallel tuning capacitance connect from pin 2 to earth, and as the unit



operates on a non-frequency dependent principle the exact values used here are far from critical. This is helpful, as it makes construction of a suitable search coil very much easier than it is for many metal detectors.

Oscillation is sustained by a positive feedback circuit connected between pin 1 and pin 8. It is crucial to the operation of the circuit that the level of feedback is carefully adjusted to the point at which strong oscillation is sustained, but there is only just enough feedback to maintain the output at a high level.

The d.c. output signal from the demodula-demodulator circuit. This is an ordinary a.m. type demodulator, and it therefore provides an output level which is proportional to the strength of the a.c. input signal.

The d.c. output signal from the d6mod}lator is coupled to the input of a level detector circuit. Normally this circuit receives a strong signal, and this holds the output transistor in the "on" state (i.e. there is a virtual short circuit from pin 5 to earth). There is between pin 5 and the positive supply rail in an absence of metal near the search coil. In this application it is the output at pin 4 that is needed and this can be used to activate the load when metal is brought close to the search coil.

The CS-209 i.c. has a built-in voltage regulator which supplies the critical stages of the unit. This gives stable operation and avoids the need for frequent readjustment of the feedback level.

CIRCUIT DESCRIPTION

The full circuit diagram for the complete Pipe and Cable Locator is shown in Fig.2. IC1 is the detector chip CS-209, and this has L1 and C3 as the search coil and tuning capacitor respectively. These are fed from IC1 via protection resistor R3.

The level of positive feedback is adjusted using the preset "coarse" control VR2, and front panel mounted "fine" control VR1. For the circuit to give good results it is essential that the feedback level is adjusted very accurately, and it is for this reason that this two stage system is used, with VR1 having a very limited adjustment range. C4 is the filter capacitor in the demodulator section of the unit.

In this application only the normally open output at pin 4 is required, and the other output at pin 5 is just ignored. When the unit is activated the internal *npn* switching transistor at pin 4 switches on l.e.d. indicator D1. Resistor R4 provides current limiting for the l.e.d.

A simple audio oscillator based on IC2 is also switched on when the unit is activated. This oscillator is a standard 555 type, although in this case a low power 555 is used in order to keep the current consumption down to a satisfactory level. The frequency of oscillation is about 300Hz.

The output of the oscillator drives a loudspeaker, which is actually a cased ceramic resonator rather than a normal moving coil loudspeaker. An operating frequency of 300Hz is well below the frequency range where the resonator provides optimum efficiency, but in this application high volume is not really required. The quiet buzzing sound of the unit is much more practical than having a device generate a penetrating high-pitched whistle.

The circuit is powered from a 9V battery, and a small type such as a PP3 is perfectly adequate. The current consumption is only about 6mA under standby conditions, and around 14mA when the unit is activated.

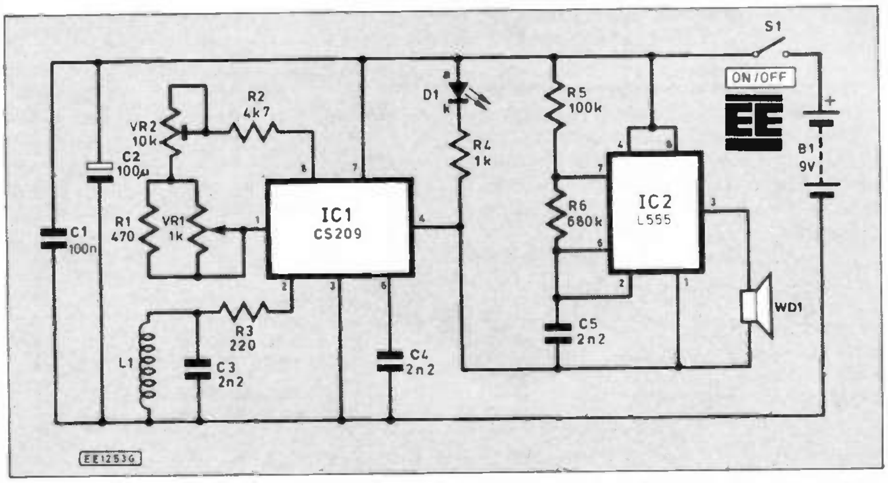


Fig. 2. The complete circuit diagram for the Pipe and Cable Locator. The speaker WD1 is a piezoelectric transducer buzzer (PB2720).

another output transistor at pin 4, but this is driven via an inverter so that it is normally in the off state.

EFFICIENCY

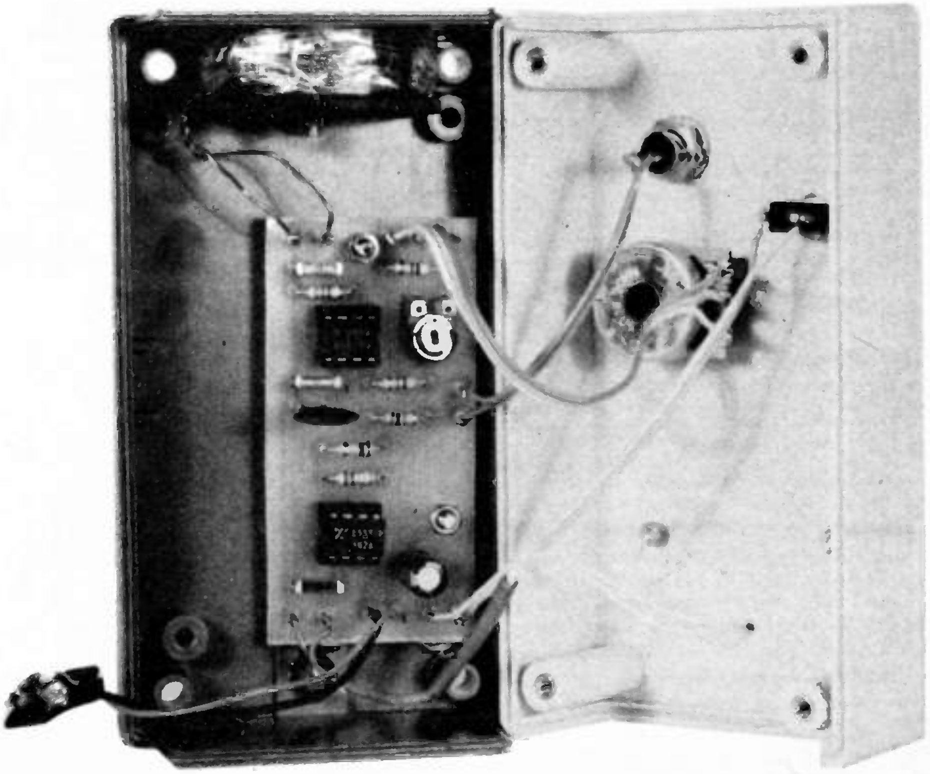
Although there is no obvious way in which this set up provides metal detection, it does in fact do so quite efficiently. The circuit relies on the fact that a metal object near to the search coil will alter its *Q* value.

The *Q* of a coil can be regarded as a measure of its efficiency, and this is a factor which is very much dependent on the core material of the coil. Many r.f. inductors for example, are given ferrite cores in order to give them vastly higher *Q* values than those obtained if they are just left with air cores.

In this case the effect of the change in Q value is to dampen oscillations. They could be damped to the point where they actually cease, but the CS-209 incorporates a low level feedback that prevents this. It maintains oscillation with a much lower output level though. The reason for doing this is not explained in the CS-209 data sheet, but it could be to prevent instability, or (more probably) to prevent the circuit from tending to stay in a non-oscillating state when the metal object is withdrawn.

When the unit is activated the level detector senses the drop in output from the demodulator, and it switches the states of the output transistors. The device can therefore be used to switch on a load connected

The completed "metal detector" showing positioning of components.



CONSTRUCTION

Most of the components are mounted on a single printed circuit board. The component layout and full size copper foil master pattern is shown in Fig.3. This board is available from the *EE PCB Service*, code EE 598.

Construction starts with the printed circuit board. The board is very simple and should not provide any real difficulties even for beginners to electronic construction.

Although IC2 is a CMOS device it has built-in protection circuits that render any antistatic handling precautions unnecessary.

Neither of the integrated circuits are very cheap types, and I would strongly urge the use of 8-pin d.i.l. holders for both devices. Note that IC2 has the opposite orientation to IC1. At this stage only fit single-sided pins to the board at the positions where connections to off-board components will eventually be made.

A plastics case having outside dimensions of 120mm by 65mm by 40mm is ideal as the case for this project, but most cases of around this size should also be suitable. There is the obvious proviso that the case *must not be a metal type*, and would not even recommend the use of a plastic type which has a metal front panel.

SEARCH COIL

The search coil is mounted at one end of the case, but the coil must first be home constructed. The ideal size for the search coil depends on the type of object that is of most interest.

A large coil gives good range with sizeable objects, but poor sensitivity with small pieces of metal. A small coil gives very much better results with little objects, but a relatively small increase in range with large objects.

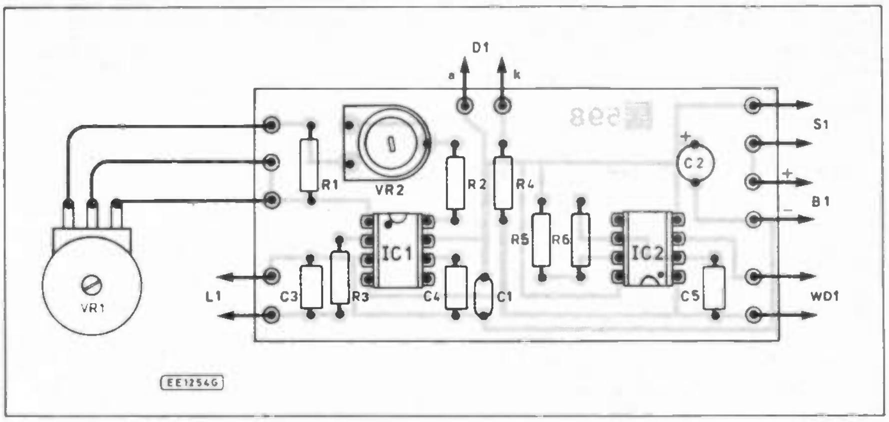
Although pipes and cables are large objects in terms of overall size, they are mostly quite small in diameter which makes them virtually "invisible" to large search coils. A few experiments showed that optimum results were generally obtained using a coil of around 25mm or so in diameter, but the exact size is not critical.

To build the coil a temporary former of around 25mm in diameter is required, and something like a 35mm film container is suitable. The coil consists of 150 turns of 24 to 28 s.w.g. enamelled copper wire "scramble" wound onto the former, leaving leadout wires about 100mm in length.

The leadout connecting wires are twisted together close to the coil to help prevent it from unwinding when it is carefully slipped off the former. At least four bands of tape are then used to bind the coil together and make absolutely certain that it does not start to unwind.

The coil is mounted at one end of the case using the simple method outlined in Fig.4. This may look a little crude, but in practice it is perfectly adequate to hold the coil securely in position. The plastic panel can be a rectangle of plastic cut from an old case, or a piece of printed circuit board with all the copper etched away will do. It should NOT be a metal plate.

Originally a 25mm 6BA cheesehead nylon screw was used to bolt the coil in place. This is not very good in use as it tends to scratch wallpaper and paint-work as the unit is scanned over a wall. Changing to a metal countersunk screw avoided this problem, and did not seem to have any adverse effect on results.



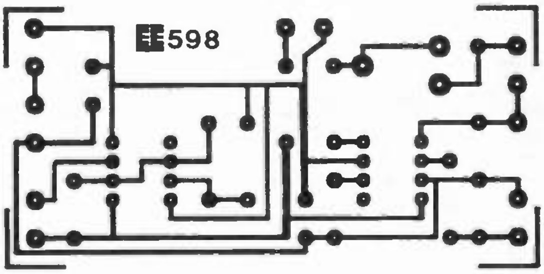


Fig. 3. Component layout wiring details and full size printed circuit board copper foil master pattern.

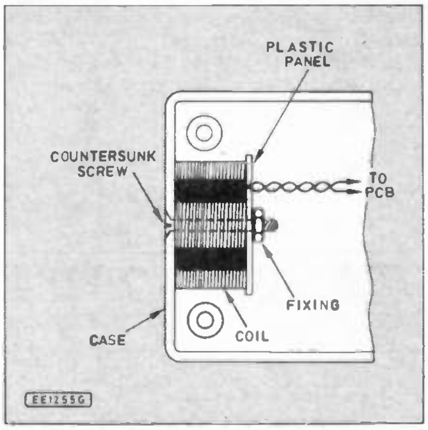


Fig. 4. Suggested method of mounting the search coil in the case.

COMPONENTS

Resistors
- R1 470
- R2 4k7
- R3 220
- R4 1k
- R5 100k
- R6 680k

All 0.25W 5% carbon

Shop Talk
See page 244

Potentiometers
- VR1 1k rotary lin.
- VR2 10k min. skeleton preset

Capacitors
- C1 100n ceramic
- C2 100μ radial elec. 10V
- C3, C4, C5 2n2 poly layer (3 off)

Semiconductors
- D1 Panel mounting l.e.d.
- IC1 CS-209 proximity detector
- IC2 L555 timer (low power)

Miscellaneous
- S1 Sub-min s.p.s.t. toggle switch
- B1 9V battery (PP3 size)
- L1 See text
- WD1 PB2720 ceramic resonator

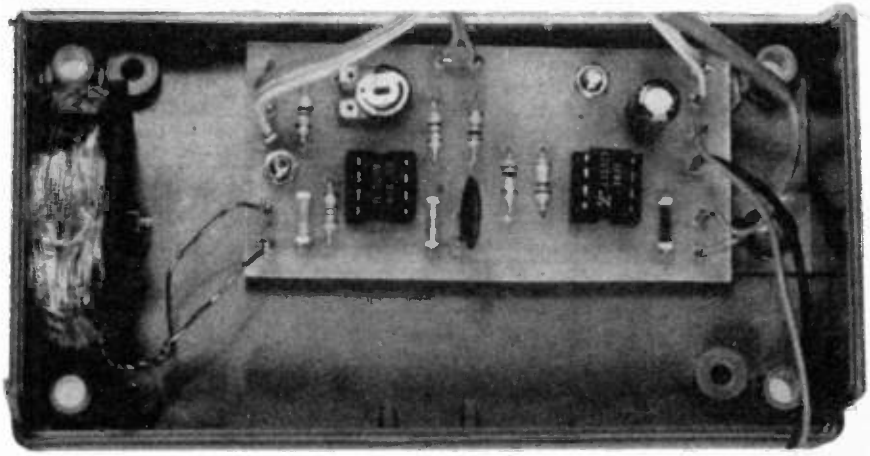
Printed circuit board, available from *EE PCB service*, code EE598; plastic case about 120mm×65mm×40mm, battery connector, control knob, 24, 26, or 28 s.w.g. enamelled copper wire for L1, pins, fixings, connecting wire, etc.

Approx. cost Guidance only £14

WIRING UP

Next the printed circuit is mounted on the base panel of the case using 6BA fixings,

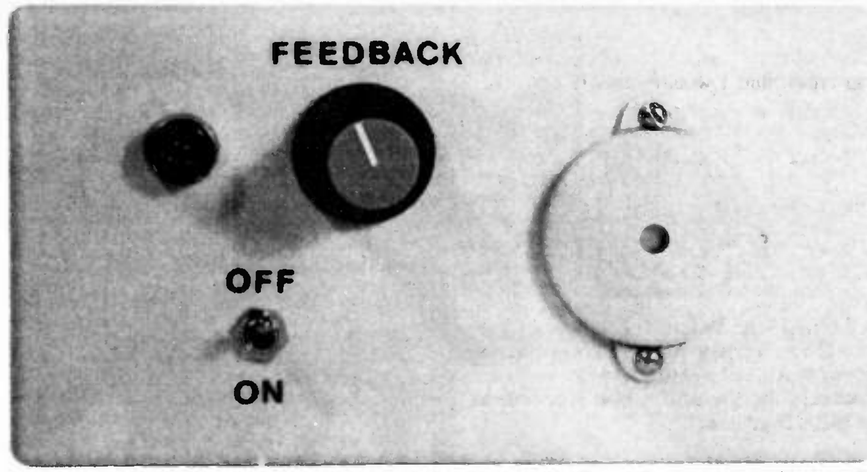
The circuit board should be positioned so that the battery can sit comfortably in the case. The search coil is mounted at one end of the case using a countersunk screw.



making sure that it is positioned where it will leave sufficient space for the battery to fit along side it. The two controls plus l.e.d. indicator D1 and the ceramic resonator (WD1) are mounted on the front panel.

The easiest way of mounting the resonator is to fit it on the front surface of the panel, and it then requires two small (about 2.5 millimetres in diameter) holes for its 8BA mounting screws. A third hole of the same size is needed to provide a route for the two leadout wires to pass through to the interior of the case. WD1 itself can be used as a sort of template when marking out the positions of these holes.

The unit is then completed by adding the hard-wiring. The leadout wires of WD1 are likely to be too short, and insulated extension wires may be needed. Use p.v.c. sleeving to ensure that there can be no short circuit at the point where the extension leads are connected to WD1's leadout wires.



Front panel layout and lettering for the detector. The piezoelectric buzzer is also mounted on the front panel and the connecting wires taken through a small hole in the case top.

ADJUSTMENT AND USE

Set potentiometers VR1 and VR2 at mid-settings initially, and then after a final check of the wiring connect the battery and switch the unit on. By adjusting preset VR2 it should be possible to turn diode D1 and the buzzer on and off. The "coarse" control VR2 should be set precisely at the point where the switchover occurs.

With the front section of the case then screwed in place it should be possible to control diode D1 and the buzzer using the "fine" or feedback control VR1. In order to give VR1 the optimum setting it should first be advanced in a clockwise direction until D1 and the buzzer are switched on. It should then be carefully backed-off just far enough to switch them off again.

Placing the search coil close to any metal object of reasonable size should then result in the unit being activated. If VR1 is backed-off from the switch-on point very carefully it is possible that the unit will latch in the "on" state. VR1 must then be backed off a fraction further, so that D1 and the buzzer switch on and off as the unit is placed near a metal object and withdrawn again. A little experimentation should soon provide a setting that gives good results.

The unit will detect quite small pieces of metal at a range of about 20mm, but due to the small search coil the maximum range with large objects is unlikely to be much more than double this figure.

In use the Pipe and Cable Locator seems well able to detect cables in walls. In fact it is probably the metal conduit through which the cables are run that are detected, rather than the cables themselves. It enabled the route of the electric cables in the author's home to be readily traced, as well as detecting metal reinforcement over the doors plus one or two hidden nails. □

Robot Roundup

NIGEL CLARK

THE Armdroid story continues. One of the pioneer small robot arms refuses to go away despite a couple of temporary disappearances.

The latest twist in this long saga surfaced at the British Education and Training Technology exhibition at the Barbican, London in January when the Scorpion arm was launched by Concorde Robotique of Cardiff. The five-axis articulated arm, which might have to change its name because of a clash with one of Commotion's products, bore a striking resemblance to Armdroid.

"It is an upgraded version," said Chris Magee who runs Concorde. It is the same Chris Magee who ran QTi-Colne which took over the production of Colne products from the Liquidator of Colne Robotics.

The improvements include sturdier bodywork, stronger stepper motors and a metal-reinforced toothed driving belt to reduce stretching. It also has a three-fingered gripper.

With the price set at about £500 Scorpion joins the other Armdroid spin-off, Armtech 2000 from Shesto Tech, in the same price range.

However Shesto, which took on two ex-Colne staff, has an advantage in having produced a work cell with a linear slide base, rotary table and conveyor belt.

VISION

It would appear that Concorde is concentrating on the Colne vision systems, Colvis and Coordinator, which were also at the exhibition. The Colvis 32×32 system is being offered at £995 plus VAT with the Coordinator at £1,295 plus VAT.

The Coordinator allows the Colvis system to control two Scorpions or a conveyor belt and rotary table. Colvis can be upgraded and that is being offered at £300.

There was little that was totally new at the exhibition, which was also less crowded that in its previous guises. However there was one supplier which was new to the kit market, Osmiroid. The Hampshire-based educational supplier has introduced a series of kits known as Teko.

The emphasis has been placed on providing large, easily-handled components, which are robust and can be used with other materials such as old lemonade bottles and yogurt cartons.

There are three main sets from about £40, with the motorised set, including wheels, gears and other components, for about £50. Computer- control is not available at the moment but the makers think that it will not be long before someone supplies the necessary interface.

One of the surprising comments made in the book reviewed in this column last month, *Teaching and Learning with Robots*, was that many teachers preferred Milton Bradley's Robotix kits rather than the more obvious Fischertechnik and Lego sets. They said they were sturdier and could withstand more classroom use. Perhaps this new kit will also answer this need.

LEGO

In the meantime Lego is expanding its range of kits for use in schools' technology. In addition to the system already available for secondary schools it has introduced a new kit in the Technic Control series aimed at primary schools. As with the previous sets there is supporting material for teachers and pupils.

The company says that the aim is to introduce primary children to computer control using control Logo.

There were a number of robotic devices being displayed at the Barbican many of them showing a number of modifications.

The Valiant Turtle from Valiant Technology has been improved so that it is easier to set-up and will work for longer without needing a battery change. The communicator on the infa-red transmission control system has been altered so that it is possible to get started even if the instructions for setting up have not been followed precisely.

The internal processor has been modified so that less power is needed, allowing for a claimed 25 per cent longer working period before the battery runs out. In addition battery charging has been made more efficient.

The new version is available at the old price of about £250. Owners of the previous model can get an upgrade, either in part or in whole with the complete upgrade costing about £60. The company said that not all models could be adapted and advised anyone wishing to have the work done to check with Valiant. They added that machines should not be sent to them as another company was doing the work.

Valiant's Microworld series has proved more difficult to create than had at first been thought. The idea of creating a number of "worlds" around the turtle was first conceived some time ago as a teaching aid for a wide variety of subjects. To date only the Geometry Part 1 has been published, at a price of £5.

The company now says that only another two will be published by Valiant on its own. From then more Microworlds will be developed with the help of the Microelectronics Education Support Unit at the University of Warwick Science Park, including one for special education which is a joint project with SEMERC.

The remaining two from Valiant are Part 2 of Geometry, planned for the spring and Arithmetic Part 1, planned for the autumn.

BEASTY

Commotion was displaying its latest version of the Beasty arm at BETT. The aluminium bars have been replaced by ABS plastic and it has a specially moulded plastic cover. Called the New Beasty Arm Plus it comes in a kit with four servos to power the base, shoulder, elbow and gripper.

The manual has been improved and now includes details of how to build four different arm configurations and a simple plotter. Including the Beasty Plus interface the system costs a total of about £150.

Visitors to the show also got a chance to see the latest development from Cybernetic Applications–the gantry robot arm. The skeleton on view at the Craft, Design and Technology exhibition in Birmingham in October has been fleshed out to include electronics and gripper for a price in the region of £4,000.

It is expected that the software will be developed for the usual range of Cybernetic machines including the IBM PC and BBC series but the launch date has yet to be fixed.

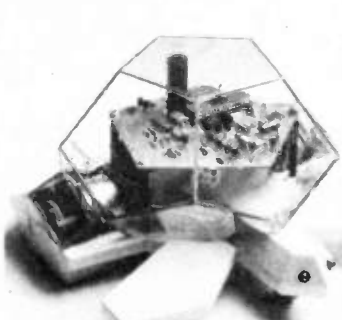
The company is also offering what it calls turnkey systems with its various robots and work cell components joined in a variety of combinations. Prices are available on application to the company.

FIRST TIME

On show for the first time was the RTX-E from Universal Machine Intelligence. Based on the technology of the company's RTX robot arm it was being assessed for future development.

It is a five-axis arm using the vertical movement of the RTX on the horizontal. The price could be in the range of £3,000 but the final details have yet to be decided.

The Valiant Turtle



GETTING RID OF THE HEAT

By Vivian Capel

THE new project worked well, for a short while, then it stopped. A wisp of smoke curled up from an emitter resistor and the associated transistor felt very hot. A test revealed that it was short-circuited, another victim of thermal runaway.

Few constructors have not had this sort of experience, and very disconcerting it can be too. Was there something wrong with the design or the construction? or was it a faulty transistor? Will a replacement be all right or will it go the same way? Why do some transistors have heat sinks while others do not, and what is the meaning of the specifications quoted for them? How can you tell if a heat sink is adequate for a particular job? To take the heat out of the situation we will look at transistor thermal dissipation and how to deal with it.

HEAT GENERATION

Firstly then, why does a semiconductor generate heat? The difference between the emitter and collector voltage indicates that there is a voltage drop across the device. This is the result of the current flowing through the internal resistance. So the voltage dropped muliplied by the current represents a power loss. Now it is a basic law of physics that you cannot "lose" power, it is converted into some other type of energy. In most cases, this appears in the form of heat.

The amount of heat generated is proportional to the voltage drop over the device, times the emitter current. So output transistors that conduct high currents generate a lot of heat, but it should not be overlooked that all transistors that carry current generate heat which must be dissipated somehow.

In the case of a transistor having very little forward base bias, only a small current flows. The internal resistance is high and so there is a large voltage difference between the collector and emitter. The small current produces a minimal drop over the series collector load resistance, hence the collector voltage is nearly that of the supply, However, although the voltage across the device is high, the current is low and the power dissipated is also small.

When a transistor is turned hard on by a large forward base bias, a heavy current flows. But the low internal resistance produces only a small voltage drop across it. So again the power dissipated in the form of heat is low. It should be noted though, that while the heat generated by the device in this condition may not be large, series components such as emitter resistors will be carrying a large current and so must be adequately rated.

AUDIO OUTPUT STAGES

It is when the base bias is such as to operate the transistor at about the midpoint between the cut-off and fully-on state, that both current and voltage drop are sufficient to produce a large power dissipation. This is the situation with class A audio stages with which the signal varies either side of this mid point. The high current passed in output stages generates considerable heat when they are biased to class A.

With true class B each output device is biased to cut-off, so succeeding half cycles of the signal turn each on in turn. Much less heat is thereby produced. In practice, a small standing current is allowed to flow to ease the transition between the half cycles, but this is only partially successful and cross-over distortion consisting of mostly spurious third harmonics is generated.

Class D, or as it is more usually termed, pulse-width modulation, amplifies high frequency square waves of varying width. The frequency is too high for the loudspeaker to reproduce them, but it does respond to their average width. This varies according to the audio signal so the loudspeaker cone moves in sympathy, thereby reproducing the encoded audio. The feature here is that the output transistors are handling only square waves and so are either cut off or hard on. They thus generate very little heat at all. Another feature is the absence of output stage distortion. However there are other snags and although one or two commercial amplifiers using class D have been produced, it has not caught on. Our reason for mentioning it here is that it serves as an example of the effect of hard "off" or "on" transistor operation on heat generation.

THERMAL RUNAWAY

Returning to our opening situation what causes thermal runaway? Heat is produced by the operation of the transistor but it is generated too fast to be dissipated to its environment. So the temperature rises. Now this has the effect of increasing the current which thereby also increases the power loss and produces more heat. A further increase in current results and yet more heat. Once started the process spirals rapidly.

While there are several types of bipolar transistors such as junction, alloy diffused, planar and epitaxial planar, they are all made by diffusing impurities into a base semiconductor material so as to make some form of sandwich. The deeper the diffusions, the thinner the "meat" in the sandwich and the higher the gain; but if the diffusions are taken too far they meet and the device short-circuits. The trick in manufacture is to stop the diffusion just in time.

When a transistor overheats, the diffusions continue and very soon amalgamate resulting in the all-too-familiar burnt out device. Interestingly, a transistor that has been subject to brief overheating which has stopped short of the destruction point may have increased its gain. However this is not an experiment to be recommended unless you have a lot of cheap low-gain transistors you don't mind losing!

There then we have the mechanism whereby a bipolar transistor self-destructs by thermal runaway. The question remains as to how to prevent it. Heat-sinking is the answer, but what size should the heat sink be, and when can it be dispensed with?

THERMAL RESISTANCE

Ideally all the heat should be dissipated into the surrounding free air, but to reach it three barriers have to be crossed. The first is the thermal resistance between the collector junction, where the heat is generated, and the casing of the device. The second is the thermal resistance between the device and its mounting, and the third is that between the mounting and free air. These are designated by θ_j, θ_C, and θ_H.

Thermal resistance is defined as the temperature difference that exists across the barrier for each watt of power produced and is specified in degrees Centigrade per watt, (°C/W).

The maximum junction temperature permissible differs with the type of transistor, but in general it is 100°C for germanium and 150° to 200°C for silicon devices. To keep below those temperatures, we need to know the thermal resistances mentioned above and also the ambient air temperature. The latter will probably be room temperature, but if inside a cabinet other components may produce a higher temperature even though the back is ventilated.

The θ_j junction-to-casing thermal resistance depends mainly on the type of encapsulation, although there are also variations between different devices having the same casing. The following are the range of values which includes most devices in the given encapsulation:

DEVICE

T03	0.5 to 2.5°C/W
TOP3	1.5°C/W
TO5	15 to 35°C/W
T039	4.5°C/W
T0220	3 to 4°C/W

Thermal resistance between the device and its mounting θ_C which is a heatsink if used, is about 0.2°C/W when the contact is direct. If a mica washer is used the resistance is around 0.5°C/W. This can be lowered slightly in both cases by the use of thermal paste.

CHOOSING THE HEAT SINK

The heat sink must be chosen to have a thermal resistance low enough to dissipate the heat generated by the junction fast enough to prevent the junction temperature rising beyond its rated maximum. To do this we must know the maxinum rating and also the ambient temperature of the air in which the device is to work. In the absence of maximum junction temperature information, the above figures can be assumed, using the lower value for safety. For a silicon device we can take it as 150°C, and the ambient temperature as 25°C (77°F), unless the equipment is boxed in with poor ventilation or other heat generating components are nearby. It obviously is best to arrange good ventilation and isolation from other heat sources as this allows a smaller heat sink, so saving space, weight and expense.

We also need to know the thermal resistances of the junction-to-casing θ_j, and the casing-to-mounting θ_C which can be determined from the above table. Finally we have to know what power is being dissipated which is a simple product of the average current passing through the device and the average voltage across it. The formula is:

$$\theta_H \leq \frac{t_j - t_a}{P} - (\theta_j + \theta_C)$$

In which θ_H is the thermal resistance of the heat sink; θ_j the thermal resistance of the junction-to-casing; θ_C the thermal resistance of the casing-to-mounting; t_j is the maximum junction temperature, and t_a, the ambient temperature. P is the power to be dissipated.

EXAMPLE

We will calculate an example to see how it works out. A silicon power transistor having a maximum junction temperature of 150°C working in an ambient temperature of less than 25°C gives a value of 125° for the expression $t_j - t_a$, a figure which holds good in most cases. The emitter current is one amp, and the collector-emitter voltage is 10V. So the power dissipated is 10 watts.

The casing being of the T066 type has a thermal resistance of 4.5°C/W, and it is mounted with a mica washer to electrically insulate the case which is the collector terminal, from the heat sink. This offers a 0.5°C/W resistance. Substituting these values we have:

$$\frac{125}{10} - (4.5 + 0.5)$$

Which is 12.5−5.0=7.5. So the heat sink must have a maximum thermal resistance of 7.5°C/W. As this maintains the junction at its maximum permissible temperature, it is prudent to chose a heat sink that has a lower value to give a safety margin.

The formula can be transposed to determine other parameters. If we wish to discover the maximum power that can be dissipated for given temperatures and thermal resistances we calculate from:

$$P \leq \frac{t_j - t_a}{\theta_j + \theta_C + \theta_H}$$

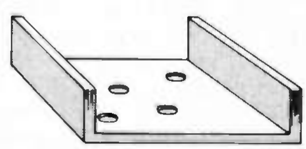


FIG. 1
T03 HEATSINK 14° C/W RATING

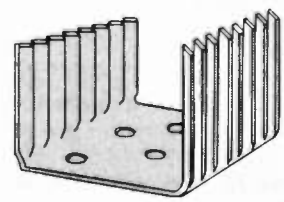


FIG. 2
T03 HEATSINK WITH TWISTED VANES
7·1° C/W

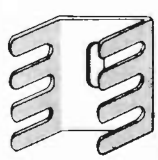


FIG. 3
PLASTIC PACKAGE HEATSINK
24° C/W

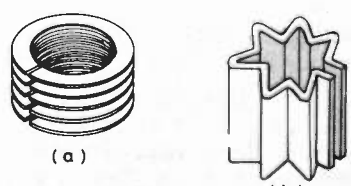


FIG. 4
TO5 & T039 TYPES
(a) 85° C/W (b) 48° C/W

FIG. 5
HIGH POWER TYPE 2·5° C/W

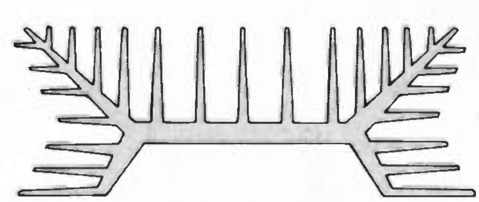


FIG. 6
HIGH POWER TYPE 0·23° C/W

Or if we wish to determine the maximum ambient temperature in which a transistor can be operated at a given power dissipation, we can use:

$$t_a \leq t_j - P(\theta_j + \theta_C + \theta_H)$$

POWER TRANSISTOR HEAT SINKS

Heat sinks are available for many encapsulations and thermal resistances. They are usually finished in matt black paint which increases rediated heat, and all but the smaller high-resistance type have fins or vanes so that heat can be lost through convection. Furthermore the metal is generally aluminium of heavy gauge which facilitates conduction to the chassis, although some are steel.

It is convection that is the principal means of losing heat from sinks rated up to around 7°C/W, so the fins must always be mounted vertically to allow the air to rise freely between them. There should be no obstruction immediately beneath or above the heat sink for the same reason. Above 7°C/W, the sink is likely to be just a slab of metal possibly with two sides turned up to give extra radiating surface area.

There is a large range of thermal resistances available right down to 0.2°C/W. Some of these can be very expensive costing up to £60 each. However, above 1.0°C/W, the cost falls to less than £5, and over 2.0°C/W, under £3. From 4.0°C/W the cost is usually under £1. It can be seen from this why high powered class A amplifiers are not very common!

JUNCTION-TO-AIR-RESISTANCE

Can power transistors ever be operated without a heat sink? Yes, but only for low powers. While values for individual types vary, a typical thermal resistance value from junction to free air of a T03 encapsulated device is around 35 to 40°C/W. As the maximum permissible power from the above formula is the temperature difference between junction-to-ambient (usually 125°) divided by the total thermal resistance, this gives a value of 125÷40≃3 watts.

Such would be a maximum rating of a T03 device mounted on a printed circuit board, but if mounted on a metal chassis member, that would serve as a heat sink and the power rating would be higher.

In the case of a plastic package T0220 transistor, the junction to free air thermal resistance is typically 60 to 65°C/W. So 125÷65≃2 watts is the maximum. Small bolt-on heat sinks for plastic transistors are rated from 10 to 20°C/W. The largest of these plus the θ_j of 4°C/W of the transistor gives a total of 14°C/W, so a rating of 125÷14≃9 watts can be obtained. These assume a maximum junction temperature of 150°C, but many devices will run up to 200°C so this affords an extra safety margin or a somewhat higher power rating.

SMALL TRANSISTORS

The question now arises as to the small wire-ended transistors. These are sometimes seen with heat sinks clamped to them, but more usually they are free. Power is expended not only in the output stages but also the drivers. The drive current required by the output stage is the output current divided by the H_{FE} of the output transistors. As this is usually well below 100, the drive current needed is quite large. To supply this the drivers themselves may be power types and need heat sinking. However, many output devices are now Darlington pairs contained in the one package, and so have a large current gain. High power drivers are not required for these.

For small transistors of the T05 and T039 type, the small surface area offers a high junction to free air thermal resistance of around 400°C/W. This gives a maximum power of about 300mW which is adequate for most small signal applications. For higher powers push-on heat sinks are available. A ribbed cylindrical type has a resistance of 85°C/W so bringing the total to around 100 to 120°C/W, and permitting a power of just under one watt. Another type which has a star shape that allows convention currents to pass through the arms, has a resistance of 40°C/W. With this sink, powers of up to two watts can be obtained.

The parameters of most small transistors are specified for 25°C and if these are not exceeded, no heat sink is required. If the ambient temperature is greater than this, the limits are derated by a stipulated amount per degree, typically 2mW/°C for small transistors. For power transistors the derating is much greater and varies considerably with the device. If larger currents are required, or higher temperatures likely, a heat sink may prove to be the solution although an alternative would be to use a transistor with a larger rating.

While ratings can be increased by heat sinking, this can only be done up to a certain point. Current or voltage above this may damage the device for reasons other than that of excessive temperature. This is the purpose of the absolute maximum ratings sometimes quoted along with the 25°C rating. These should never be exceeded however massive the heat sink.

INTEGRATED CIRCUITS

I.C's are not often seen with heat sinks other than the integrated sinks that come with some power types. They are available though for d.i.l. devices from 14 to 40 pins and can be either bonded or clipped on. The thermal resistance of these is around 24°C/W. If the chip is being operated near its maximum dissipation rating or in high ambient temperatures, it would be prudent to fit a heat sink.

MOS FETs

MOS FET transistors are increasingly being found in the output stages of amplifiers. Among the several advantages they have is that of a negative temperature coefficient. This means that when they get hot, the current *decreases*. The power dissipated is thus reduced and thereby also the heat generated. So thermal runaway is eliminated. It is still necessary to remove heat from the device otherwise it would never reach its full power capability, but the heat sinks can be smaller because there is no safety factor to consider. □

PLEASE TAKE NOTE

The following points concerning past projects have come to our attention:

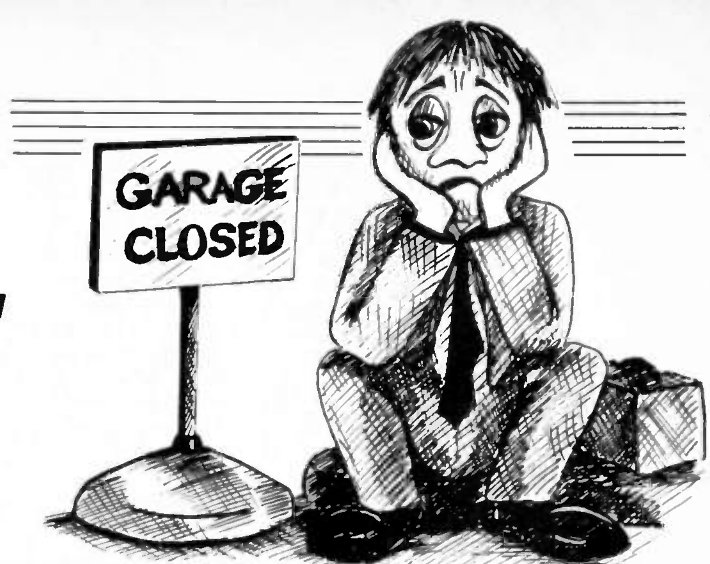
BBC SIDEWAYS RAM/ROM (November 1987)
The instructions in the text should read
* SAVE OFFLOAD 900 9B7
* SAVE ONLOAD 900 9BO
and lines 490 and 530 of program 2 (OFFLOAD source code) should use label loop2.

BBC MICRO (March 1988)
In Fig. 2 R6 and C3 should be transposed.

TWINKLING STAR (December 1987)
It is essential that a completely isolated bulb holder is used. This should be of the type which covers all metal parts of the bulb. The bulb used must be of the type that shorts when it fails–this prevents voltage across the unit from becoming excessive if the bulb fails. Please note that the circuit is at mains potential and proper isolation must be provided by the housing.

Constructional Project

LOW FUEL ALERT



T. R. de VAUX-BALBIRNIE

Avoid an empty petrol tank with this low-cost project.

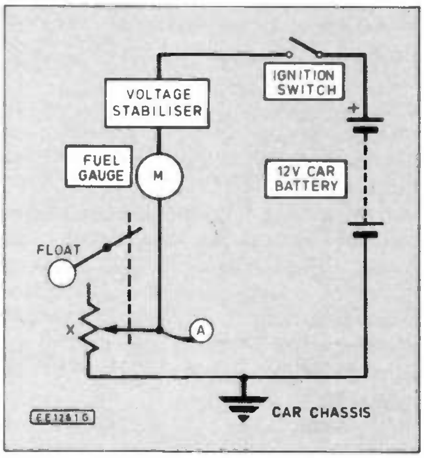
FAILING to notice a low fuel gauge reading soon results in disaster. Where petrol is being used rapidly—when caravanning, perhaps—the problem is more acute. This add-on unit, which is suitable for negative-earth cars with a traditional fuel gauge system, gives a bleeping tone when the fuel falls below a certain level.

A typical fuel guage circuit is shown in Fig.1. X is a float-operated variable resistor (the sender unit) situated inside the tank. One terminal of this is "earthed" to the car chassis (battery negative) while the other is connected to the battery positive terminal through the fuel gauge, voltage stabiliser and ignition switch.

As the fuel level falls, the float alters the position of the sliding contact of X on its track so increasing the resistance. The reduced current flowing through the gauge results in a lower reading. Meanwhile, the voltage across X rises and it is this which operates the additional circuit.

STABILISER

The purpose of the voltage stabiliser is to provide consistent readings despite changes in supply voltage. A typical stabiliser works by repeatedly "making" and "breaking" the current through the guage at a rate which, for a given fuel level, provides a certain average voltage. The gauge itself is usually of the thermal type which responds too slowly for the individual current pulses to be registered.



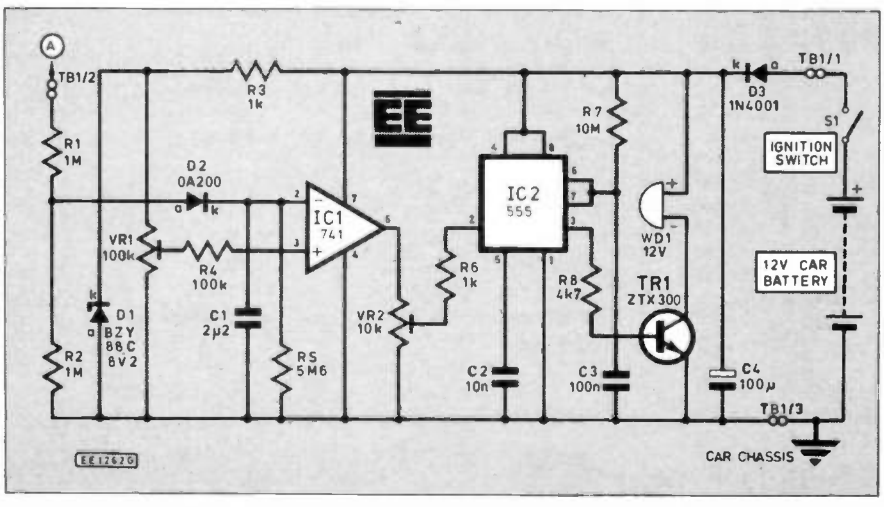
Block diagram for a typical fuel gauge set up.

The circuit should still work where other types of stabiliser are fitted but, in any case of doubt, it would be wise to make a check before commencing construction work. To do this, locate the connector on the fuel tank sender unit. Alternatively, find the corresponding connection at the gauge. This is Point A in Fig.1.

Connect the positive test lead of a volt meter (multimeter set to Volts d.c.) to this point while retaining the existing connection. Connect the negative probe to an earth point (car chassis).

Observe the reading with a full fuel tank and repeat the procedure with a near-empty one. With the type of voltage stabiliser described, the reading will pulse—if this is the case take note of the highest voltage. So long as the "empty" reading exceeds the "full" one by a few volts, the circuit will be suitable.

Fig. 2. Complete circuit diagram for the Low Fuel Alert. The TB numbers refer to a three-way terminal block and aid connection to the vehicle.



CIRCUIT DESCRIPTION

The complete circuit for the Low-Fuel Alert is shown in Fig.2. With each pulse from the stabiliser, current flows through the potential divider consisting of resistors R1 and R2 so approximately one-half of the voltage available at Point A appears across R2 hence across the terminals of capacitor C1. C1 charges up and, due to the large resistance of R1, this happens over several seconds effectively smoothing out voltage fluctuations which occur as the fuel moves in the tank. Diode D2 prevents C1 discharging through the fuel gauge unit.

The very high input resistance of the op.amp IC1 and resistor R5, allow C1 to discharge over a much longer time interval and the combined effect is that some voltage, dependent on the average fuel level, appears across C1. This is applied to IC1 inverting input (pin 2).

Zener diode, D1, together with resistor R3, provide a reference voltage of 8.2V and a fraction of this is selected by VR1 and applied to IC1 non-inverting input (pin 3). With VR1 correctly adjusted and transitory low fuel level (which will occur on cornering or braking when the level is near the critical point) the voltage at the inverting input exceeds that at the non-inverting one. The op-amp is then off with pin 6 low.

This when applied to IC2 pin 2 (trigger input) allows the i.c to act as a monostable and deliver a positive pulse from its output, pin 3. This operates TR1 and hence the audible warning device, WD1, in its collector circuit. The pulse length depends on the values of resistor R7 and capacitor C3—with those chosen it will be approximately one

COMPONENTS

Resistors

R1,R2	1M (2 off)
R3, R6	1k (2 off)
R4	100k
R5	5.6M
R7	10M
R8	4k7

All 0.25W 5% carbon.

Shop Talk See page 244

Potentiometers

VR1	100k sub-min. preset (vertical)
VR2	10k sub-min preset (vertical)

Capacitors

C1	2μ2 (non-electrolytic)
C2	10n ceramic
C3	100n ceramic
C4	100μ 16V elec. radial

Semiconductors

IC1	741 op. amp.
IC2	555 timer
TR1	ZTX300*npn* silicon
D1	BZY88C 8V2 Zener diode.
D2	0A200
D3	1N4001 1A

Miscellaneous

Plastic box size, 112mm×62mm×31mm external; 8-pin d.i.l i.c sockets (2 off); 0.1in. matrix stripboard, 8 strips ×33 holes; WD1, 12V solid-state buzzer; TB1 5A terminal block, 3 sections required. Connecting wire. Auto-type wire and connectors (see text). Fixings. Adhesive fixing pads.

Approx. cost Guidance only £7

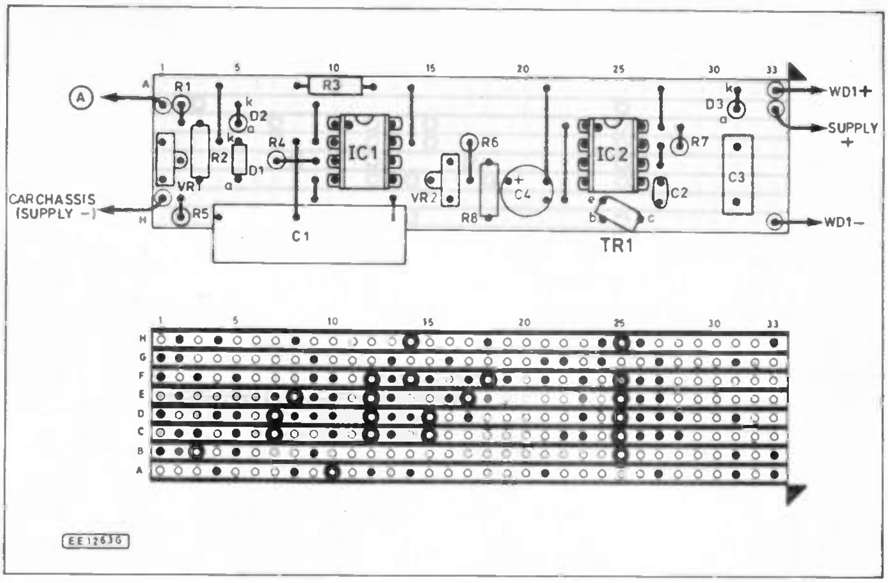


Fig. 3. Stripboard component layout and details of breaks to be made in the underside copper tracks.

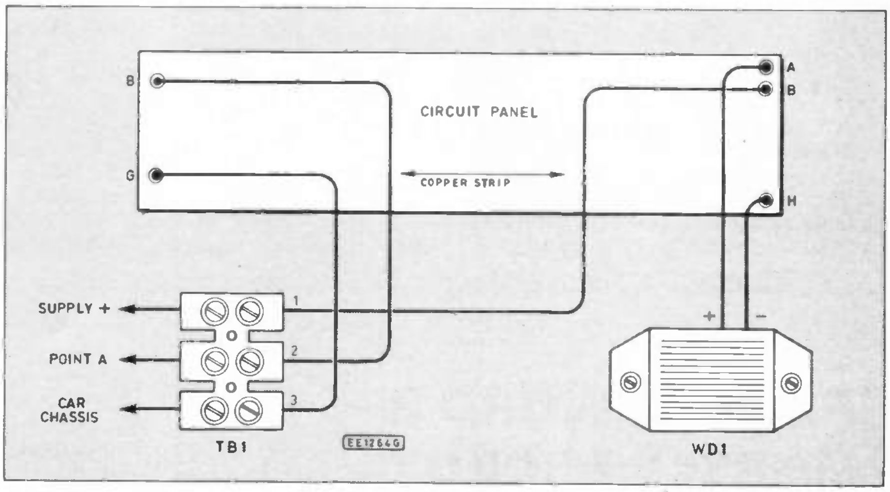


Fig. 4. Interwiring details from the circuit board to the terminal block TB1 and the warning buzzer WD1.

second. When the fuel level falls further, IC1 will trigger continuously and a constant signal will be given.

With a high fuel level, the voltage at IC1 inverting input remains less than that at the non-inverting one so IC1 is on with pin 6 high (positive battery voltage). When this is applied to IC2 pin 2, the device is disabled—TR1 and WD1 then remain off. The preset potentiometer VR2 selects a fraction of the output from IC1 pin 6 and is adjusted to give the correct operating voltage levels for IC2 pin 2.

The reason for stabilising the voltage applied to the op-amp non-inverting input is to prevent false triggering near the operating point when the supply voltage falls slightly as when direction indicators or brake lights are used.

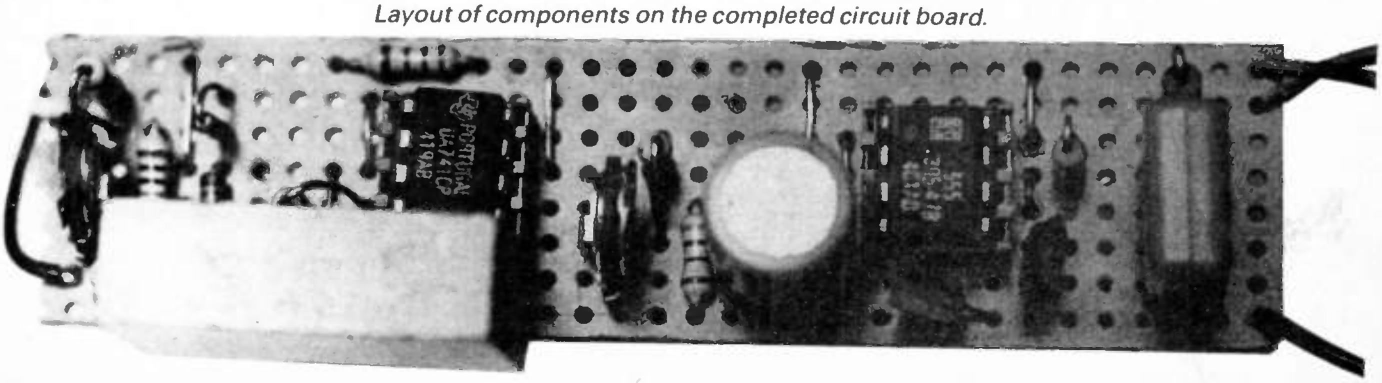
CONSTRUCTION

Construction is based on a circuit board made from a piece of 0.1in. matrix stripboard size 8 strips×33 holes. The component layout and underside view showing breaks to be made in the copper strips is shown in Fig 3. Make the breaks and inter-strip links as indicated then check carefully for errors—particularly for "bridged" copper tracks. Follow with the on-board soldered components but do not insert the i.c.'s into their sockets until the end of construction. Complete the board by soldering 10cm. pieces of light-duty stranded connecting wire to the points indicated.

Prepare the plastics case to receive the circuit panel by drilling mounting holes for WD1 and the terminal block TB1. Make a hole for the external wires to pass through. Attach the buzzer and terminal block using short fixings.

Refer to the interwiring diagram Fig.4 and complete all wiring. It is important to use auto-type wire rated at a minimum of 3A for

Layout of components on the completed circuit board.



connections to the terminal block TB1. Secure the circuit panel to the base of the case using an adhesive fixing pad. Note that no holes are needed for the sound to pass through unless the user requires extra volume.

Leave VR1 sliding contact adjusted fully anti-clockwise (as viewed from the edge of the circuit panel) and VR2 to approximately mid-track position. Choose a suitable place for the unit under the car dashboard.

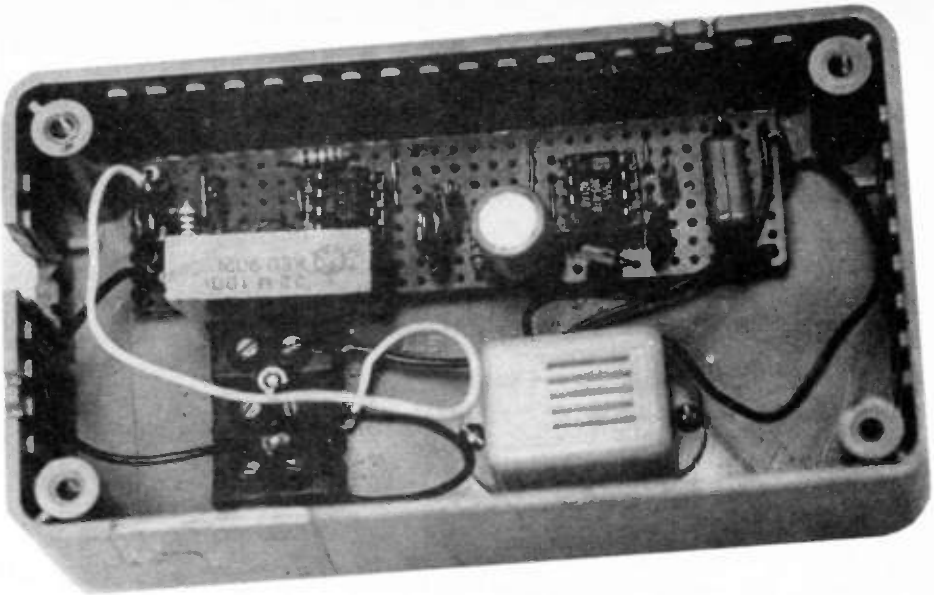
TESTING

Allow the fuel to fall to the low operating level then make the terminal block connections as indicated in Fig.4. Use proper auto-type wire of 3A rating minimum.

The lead from TB1/1 to the vehicle wiring is connected to a fuse which is live only when the ignition is switched on. If possible, make this connection at the fusebox rather than by breaking into an existing circuit. This is because any voltage drop imposed by existing circuits could cause false triggering.

TB1/2 is connected to the fuel gauge sender unit terminal (or made at the fuel gauge itself)—use a proper automotive type fixing and a "piggy back" connector. TB1/3 connects to a nearby earth point (car chassis). *Remember, wherever wires pass through a hole in metal, a rubber grommet MUST be used for protection.*

With the ignition switched on and the engine running (so that maximum operating voltage is developed) rotate VR1 sliding contact clockwise (as viewed from the edge of the circuit panel) until the buzzer just fails to sound. It will be necessary to make small adjustments and to wait several seconds to assess the effect.



Finished Low Fuel Alert showing positioning of components inside the plastic case. The interconnecting wires to the terminal block should be auto-wire rated at 3A minimum.

If difficulty is experienced, VR2 may need adjusting but this is unlikely. Further adjustment to VR1 will be required over a trial period to obtain the correct setting—when the circuit is first used on the road it is likely that the buzzer will sound too early.

In use, single bleeps should occur when the fuel level falls temporarily—when cornering or breaking. After that, they will occur more frequently until, eventually, the buzzer sounds continuously.

Note that a bleep is sometimes given when the ignition is switched on—this is of no consequence and may be regarded as a circuit check. The unit may be secured under the dashboard with adhesive fixing pads.

With the Low-Fuel Alert you should never be left stranded with an empty tank! □

EE CROSSWORD 3— "MOSTLY MICRO"

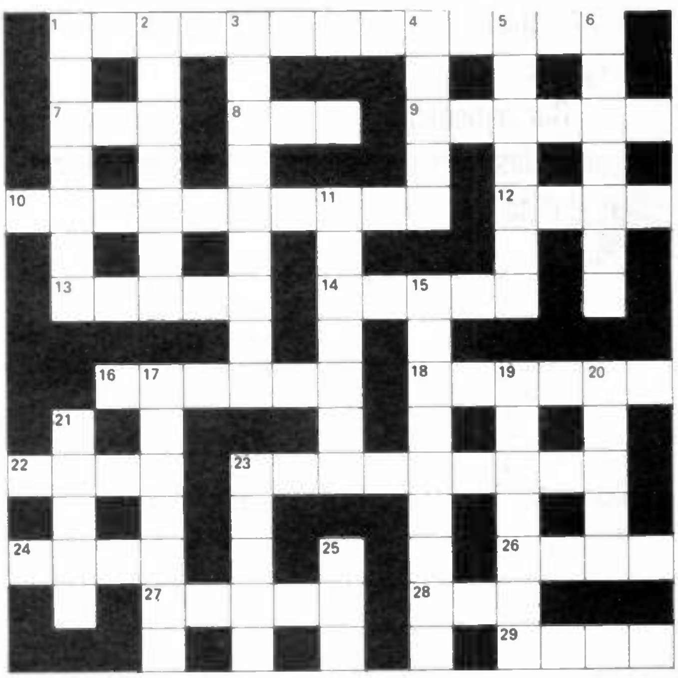
CLUES ACROSS

1 Both letters and numbers. (13)
7 Initially a converter. (1, 1, 1)
8 Instruction to stop a program. (3)
9 An address that connects a subprogram with the main program. (6)
10 Very high speed digital communications. (10)
12 One or more inputs to this circuit but only one output. (4)
13 In a bistable these diodes direct the signal. (5)
14 To restore a memory to a standard state, e.g. zero. (5)
16 To have removed information. (6)
18 To put in current information. (6)
22 Named subdivision of an addressable storage space. (4)
23 Quantities that can assume any one of a given set of values. (9)
24 A sequence of logical records. (4)
26 A particular execution of a program. (4)
27 Magnetic contacts sealed in a glass tube. (5)
28 Number of inputs to an inverter. (3)
29 Examine every reference in a file as part of a retrieval scheme. (4)

DOWN

1 Group of characters that identifies a particular part of storage. (7)
2 Ceramic, plastic and T.O. are types of this. (7)
3 Part of a mask permitting retention of the corresponding data. (9)
4 Electrically alterable memory. (1, 1, 1, 1, 1)
5 A natural whole number. (7)
6 A pad that holds information temporarily. (7)
11 This red cone scrambles information. (7)
15 Simulation in real time. (9)
17 These devices have the capability of sensing or converting data. (7)
19 Removes text held in storage. (7)
20 Data developed specifically to carry out these. (5)
21 Particle size of the phosphor coating. (5)
23 This signal contains luma, chroma and syncs. (5)
25 Initially international standards organisation. (1, 1, 1)

For fun only—answers on page 251.



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INTRODUCING MICROPROCESSORS

MIKE TOOLEY B.A.

Part 6

INPUT/OUTPUT

In part five we described how semiconductor devices provide storage for programs and data within a microprocessor based system. In this part we shall be looking at methods used for input to and output from microprocessor systems. We shall also examine the internal architecture and characteristics of a programmable VLSI device which greatly simplifies the task of microcomputer I/O.

LEARNING OBJECTIVES

The general learning objective for Part Six of *Introducing Microprocessors* is that readers should be able to describe the internal architecture and facilities provided by a typical programmable parallel I/O device.

The specific objectives for Part Six are as follows:

4.1 I/O METHODS

4.1.1 Distinguish between memory-mapped and port I/O techniques.
4.1.2 Draw and interpret the block diagram of a simple memory mapped I/O and state the function of each block.
4.1.3 Draw and interpret the block diagram of a simple port I/O and state the function of each block.

4.2 PROGRAMMABLE PARALLEL I/O DEVICES

4.2.1 Describe and distinguish between serial and parallel data transfer.
4.2.2 Describe the reasons for using parallel I/O devices and explain why they need to be programmed.
4.2.3 Draw and interpret a block diagram to show the simplified internal architecture of a representative programmable parallel I/O device.
4.2.4 State the function of each of the principal internal elements of a representative programmable parallel I/O device.

INPUT AND OUTPUT

All microprocessor based systems require means of inputting and outputting data. The input/output (I/O) provision in a microprocessor based system will obviously be dictated by the application for which it is intended. As an example, a microprocessor based central heating controller might have as its inputs a small keypad together with one or more temperature sensors interfaced to the system by some additional signal conditioning circuitry. The output of the central heating controller might comprise a simple status display using light emitting diodes together with relay outputs for controlling a boiler and a central heating pump.

The I/O provision in a personal computer would be vastly different. User input would be provided via a conventional QWERTY keyboard and joystick port whilst outputs would be provided for a TV or monitor (VDU) and also for a printer using the popular Centronics parallel interface. In addition, an RS-232C serial I/O port may be provided in order to facilitate data exchange with other microcomputers or with a modem.

Despite the obvious differences in the I/O provision of the two systems, it is eminently possible for them to use identical I/O devices (at least as far as the parallel I/O provision is concerned)!

Parallel versus serial I/O

The personal computer mentioned earlier has provision for both parallel (Centronics) and serial (RS-232C) I/O. Parallel I/O involves transferring data one byte at a time between the microcomputer and peripheral along multiple wires (usually eight plus a common ground connection). Serial I/O, on the other hand, involves transferring one bit after another along a pair of lines (one of which is usually a ground connection).

In order to transmit a byte (or group of bytes) the serial method of I/O must involve a sequence or stream of bits. The stream of bits will continue until all of the bytes concerned have been transmitted and additional bits may be added to the stream in order to facilitate decoding and provide a means of error detection.

Since data present on a microprocessor data bus exists in parallel form, it should be apparent that a

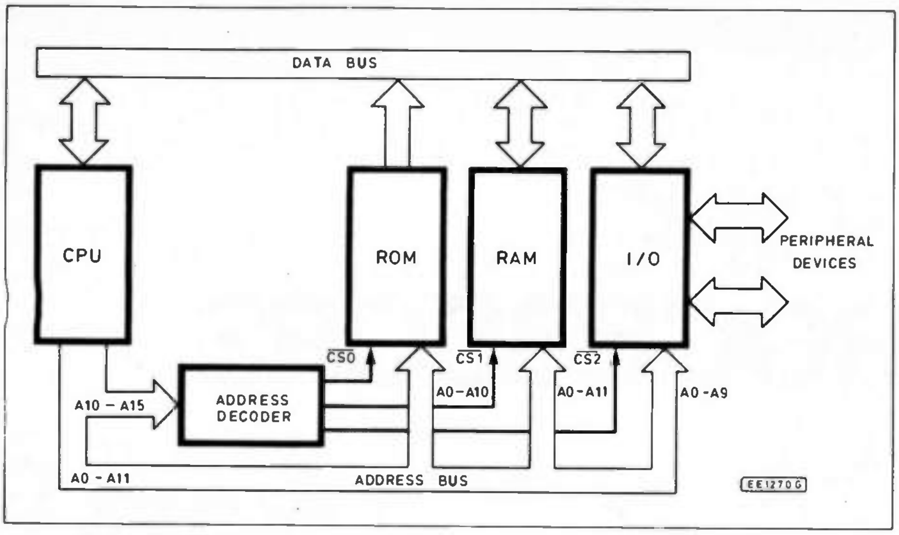


Fig. 6.1. Architecture of a representative microcomputer using memory mapped I/O.

Table 6.1. Truth table for the address decoder in Figure 6.1

A15	A14	A13	A12	A11	A10	CS2	CS1	CS0	Block selected	Address range (hex.)
0	0	0	0	X	X	1	0	1	RAM	0000–0FFF
1	0	0	0	0	0	0	1	1	I/O	8000–8400
1	1	1	1	1	X	1	1	0	ROM	F800 FFFF

means of parallel-to-serial and serial-to-parallel conversion will be required in order to implement a serial data link between microcomputers and peripherals. These topics are dealt with at greater length at Elementary level.

Memory mapped versus port I/O

In the last part we briefly mentioned that I/O can be "mapped" into the address space of a microprocessor based system. In such cases, the processor does not distinguish between memory and I/O when it performs its read and write operations; the processor treats I/O devices in much the same way as RAM and ROM.

Some processors (notably the 8085 and Z80) can make a distinction between memory and I/O devices and have control signals which are used to qualify their read and write operations. In order to make use of this facility, a number of software instructions are provided which deal exclusively with input (read) and output (write) operations to I/O devices. This type of I/O is usually described as "port I/O".

In the case of the 8085, a single control line is used to inform the system whether the current read or write cycle relates to I/O or whether it is directed at memory. Not surprisingly, this line is marked IO/M; the line is taken high to denote an I/O operation and low to signal a memory read or write.

In the case of the Z80, two separate control lines are provided. Both of these lines are active-low (i.e. asserted when taken to logic 0). The Z80's MREQ (memory request) signal is asserted (taken low) when the processor is performing a memory read or write whereas its IOREQ (input/output request) signal is asserted (taken low) when the processor is performing an equivalent operation to a peripheral I/O device.

The architecture of a representative microcomputer using memory-mapped I/O is shown in Fig. 6.1. Note that the six most significant addresses (A10 to A15) are fed to an address decoder, the outputs of which are used to drive the active-low chip select (CS) lines of the ROM, RAM, and I/O devices. The I/O device, for example, is selected (enabled) whenever CS2 goes low. The address decoding is, of course, arranged so that only one of the chip select lines goes low at any time. The action of the address decoder can be explained using Table 6.1.

Problem 6.1

Refer to Fig. 6.1 and Table 6.1.

(a) What is the capacity of the ROM?

(b) How many I/O addresses are provided for?

(c) How much RAM space is provided?

The architecture of a representative microcomputer using port I/O is shown in Fig. 6.1. This system is a little more complex than its memory mapped counterpart and it is important to note that the processor's MREQ and IOREQ control signals are fed to the address decoders and are used in the production of the ROM, RAM and I/O block chip select signals (CS0, CS1, and CS2 respectively). The upper address decoder logic is arranged so that CS0 and CS1 can only be asserted when MREQ is taken low (i.e. when the processor is performing a memory read or write). Note that address lines A10 to A15 are still used by the upper decoder to distinguish between ROM and RAM.

The lower address decoder logic is arranged so that CS2 can only be asserted when the IORQ line is taken low. The internal registers of the I/O device correspond to a set of four unique addresses determined by the state of the two least significant address lines (A0 and A1).

To illustrate the difference between memory mapped and port I/O as far as software is concerned, consider the simple problem of reading a byte from one I/O address and transferring it to another. Let's assume that the memory mapped system has input and output addresses of 8001H and 8003H whilst the corresponding addresses for the port based system are 01H and 03H. Typical assembly language routines for 6502 (memory mapped) and Z80 (port I/O) processors would take the form:

6502 (memory mapped)

```
LDA $8001 ; Load accumulator from input
STA $8003 ; and transfer to the output
```

Z80 (port I/O)

```
IN A,(01H) ;  Read the input port and
OUT (03H),A ; transfer to the output port
```

Readers should compare the foregoing fragments of code noting how the "load from memory" (LDA) and "store in memory" instructions of the 6502 are replaced by the IN and OUT instructions of the Z80. Note also the difference in conventions for expressing hexadecimal numbers (the leading $ and trailing H) and that the port addresses for the Z80 are contained within brackets.

Problem 6.2

Refer to Fig. 6.2 and Table 6.2. What operation is being carried out when:

(a) MREQ is low, IOREQ is high, and A10 to A15 are all low

(b) MREQ is low, IOREQ is high, and A10 to A15 are all high

(c) MREQ is high, IOREQ is low, and A0 to A7 are all low?

Parallel I/O devices

Microcomputer I/O is greatly simplified with the use of one or more sophisticated VLSI devices, the operational characteristics of which can

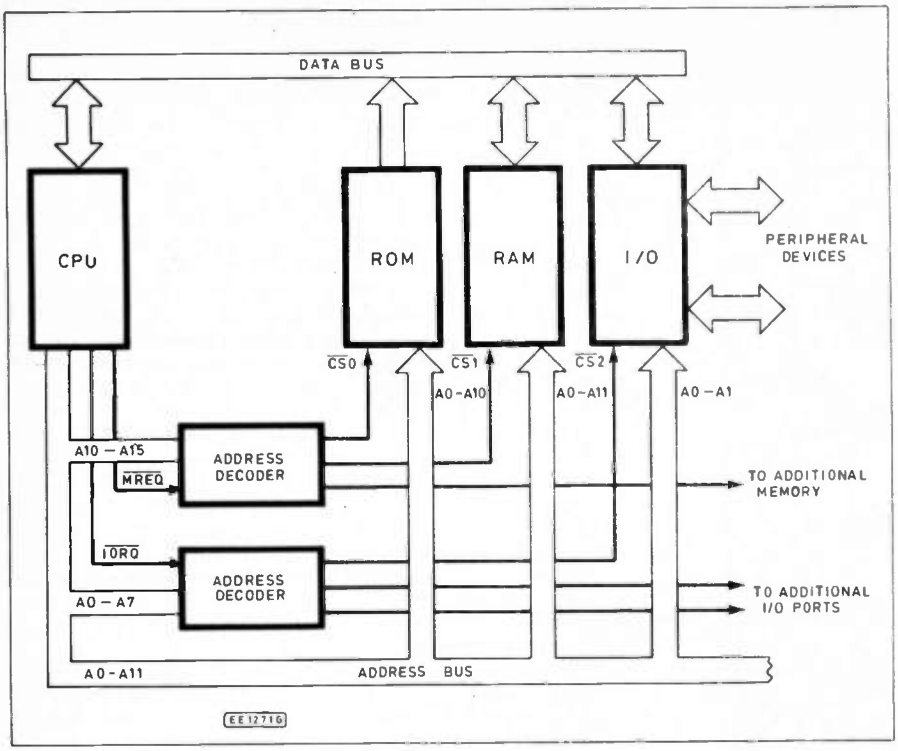


Fig. 6.2. Architecture of a representative microcomputer using port I/O.

Table 6.2. Truth tables for the address decoders in Figure 6.2

A15	A14	A13	A12	A11	A10	MREQ	IOREQ	CS2	CS1	CS0	Block selected	Address range (hex.)
0	0	0	0	X	X	0	1	1	0	1	RAM	0000–0FFF
1	1	1	1	1	X	0	1	1	1	0	ROM	F800–FFFF

X=don't care

A7	A6	A5	A4	A3	A2	A1	A0	MREQ	IOREQ	CS2	CS1	CS0	Block selected	Address range (hex.)
0	0	0	0	0	0	X	X	1	0	0	1	1	I/O	00–01

X=don't care

be established by writing data to one, or more, internal registers. This property is the key to making devices suitable for a wide range of applications and provides the microprocessor system designer with a great deal of flexibility: the I/O configuration of a system may be modified using nothing more than a short sequence of software instructions.

VLSI parallel I/O devices enjoy a variety of names depending upon their manufacturer. Despite this, parallel I/O devices are remarkably similar in internal architecture and operation with only a few subtle differences distinguishing one device from the next (see Data Card No. 6 for details).

The internal architecture of a representative parallel I/O device is shown in Fig. 6.3. Despite the complexity of this diagram, parallel I/O is really quite straightforward. When used for output, the I/O device must latch data from the system data bus into a byte-wide output register. This register will preserve the data written to it so that it can be presented, via a buffer, to the outside world. When used for input, the I/O device must contain an octal tri-state buffer which, when enabled by an appropriate read instruction, will place the data received from the peripheral onto the system bus.

In common with most programmable parallel I/O devices, the chip shown in Fig. 6.3 provides two independent 8-bit I/O ports (labelled A and B). Each port has an Output Register (ORA and ORB), Data Buffer, Data Direction Register (DDRA and DDRB), and a Control Register (CRA and CRB). Interrupt Status Control circuitry is also provided for "handshaking", the aptly named process by which control signals are exchanged between the microcomputer and peripheral devices.

The function of the signals shown in Fig. 3 may be summarised:

CPU SIDE

D0 to D7 System data bus.

CS Active-low chip select line. This line is asserted whenever the CPU wishes to read or write to the I/O device.

RS0 and RS1 These Register Select lines are used to distinguish the internal registers of the I/O device. Note that since the two Register Select lines are connected to two of the address bus lines (usually A0 and A1), the device will occupy four memory locations.

R/$\overline{W}$ Read/Write. This is the standard CPU control signal.

$\overline{IRQA}$ and $\overline{IRQB}$ These two lines are used to provide interrupt request signals for the CPU. Each line is associated with a different port.

$\overline{RESET}$ Active low system reset line. When asserted, this signal places the internal registers of the I/O device in a known state.

PERIPHERAL SIDE

PA0 to PA7 Port A I/O lines; 0 corresponds to the least significant bit (LSB) whilst 7 corresponds to the most significant bit (MSB).

CA1 and CA2 Handshaking lines for port A; CA1 is an interrupt input whilst CA2 can be used as both an interrupt input and peripheral control output.

PB0 to PB7 Port B I/O lines; 0 corresponds to the least significant bit (LSB) whilst 7 corresponds to the most significant bit (MSB).

CB1 and CB2 Handshaking lines for Port B; CB1 is an interrupt input whilst CB2 can be used as both an interrupt input and peripheral control output.

As mentioned earlier, programmable devices can be configured under software control. Several options are normally provided including;

(a) making all eight lines of a designated port inputs
(b) making all eight lines of a designated port outputs
or (c) individually configuring port lines as either inputs or outputs

This process is carried out by sending (writing) a Mode Setting Word to the Control Register. A subsequent word may also be written in order to define the direction of lines within a port and this byte will be placed in the corresponding Data Direction Register.

The bit positions in each Data Direction Register correspond to similarly numbered peripheral lines in the port concerned. A logic 0 placed in a particular position will define the corresponding peripheral line as an input, and vice versa.

The Register Model of the programmable I/O device is shown in Fig. 6.4. Note that this model dispenses with much of the detail shown in Fig. 6.3 and simply treats the I/O device as two groups of three registers. We shall examine the process of programming I/O devices in much greater detail in Part Eight.

NEXT MONTH: We shall be dealing with methods for interfacing microprocessor based systems with such commonplace devices as LEDs, relays, and switches.

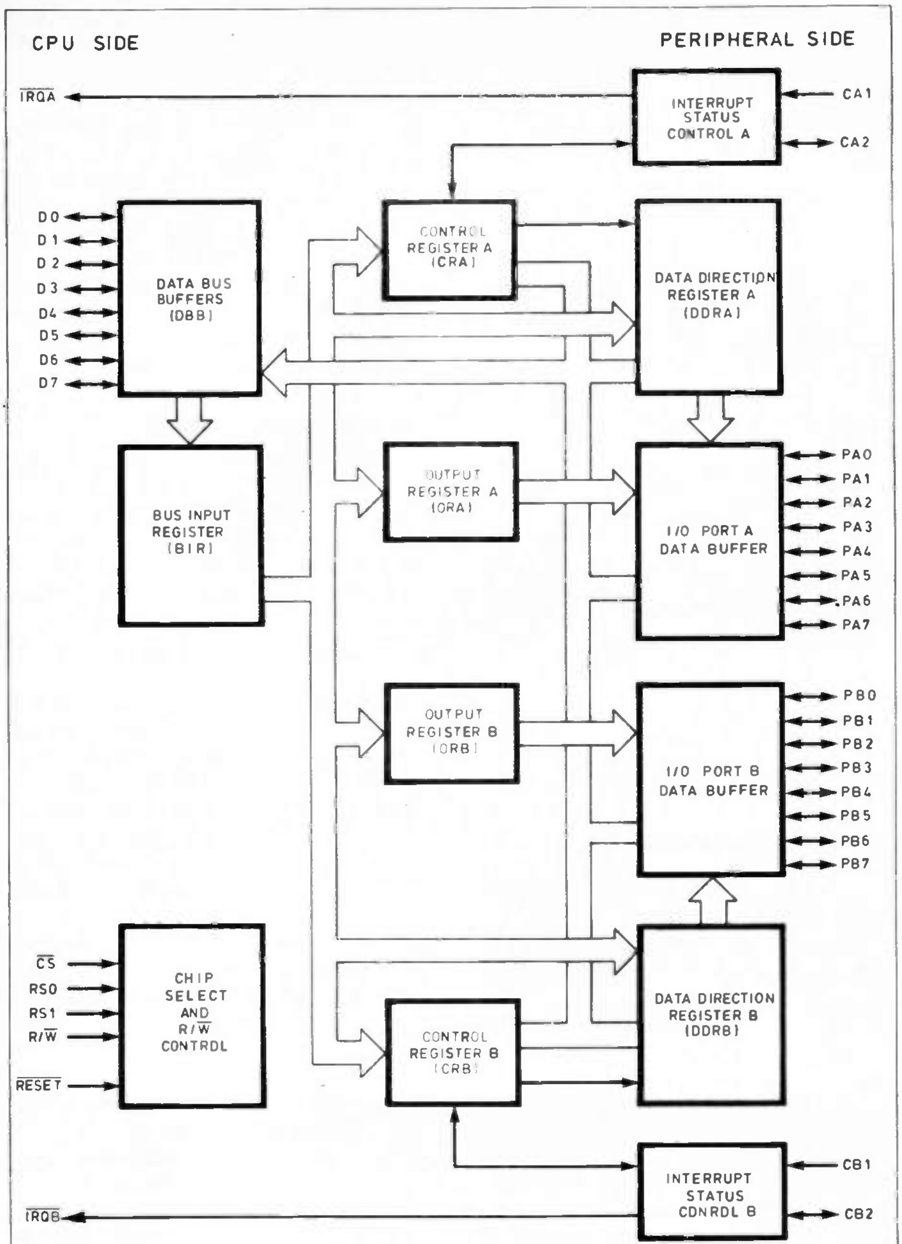


Fig. 6.3. Architecture of a representative programmable parallel I/O device.

BACKGROUND READING

The following background reading is recommended for Part Six:

Chapter 5 (The Microcomputer in Control) of *Beginner's Guide to Microprocessors* by E. A. Parr, (a Newnes Technical Book published by Heinemann-Newnes) ISBN 0 408 00579 3. Available from the *EE Book Service*, see page 246.

Chapter 7 (Input and Output Devices) of *Practical Digital Electronics Handbook* by Mike Tooley, (Published by PC Publishing) ISBN 1 870775 00 7. Available from the *EE Book Service*, see page 246.

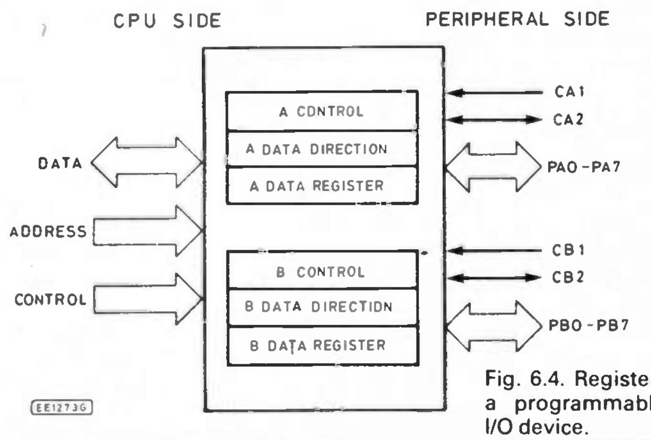


Fig. 6.4. Register model of a programmable parallel I/O device.

GLOSSARY

Keyboard
Group of push button switches used for manually inputting information to a microcomputer system. Most keyboards cater for letters, numbers and punctuation and follow the general layout convention used for typewriters. This is often referred to as a "QWERTY keyboard" by virtue of the position of the keys.

Light emitting diode (LED)
A diode which becomes illuminated when supplied with a specified voltage and current. LEDs are commonly used as indicators and display devices and are also available in "seven segment" format for use as numeric displays.

Parallel data transfer (I/O)
Transmission of data using multiple wires so that 8 bits (representing a byte of information or single character) are transmitted simultaneously. Transmission speed using this technique is usually expressed in characters per second. The popular Centronics printer interface standard uses parallel data transfer.

Port
A point or device within a microprocessor based system which facilitates the connection of external (peripheral) devices so that they may communicate (exchange information) with the system. The configuration of a port is often to be determined by software instructions sent to the programmable I/O device which is used to implement the port.

Programmable I/O device (PIO)
An input/output device (invariably single VLSI chip) which can be programmed by the user to provide an interface with external devices and components (e.g. relays, switches, keyboards, etc.).

Relay
A single or multiple switch which is usually operated by electromagnetism. Relays provide a high degree of electrical isolation between a microprocessor and the circuit which it is being used to control. Relays are also capable of switching currents greatly in excess of those available from a microprocessor system.

Serial data transfer
Data transmission using a single wire (plus ground) so that each bit of a character is transmitted in turn. Transmission speed is usually expressed in bits per second.

CORRESPONDENCE

Comments and queries from readers are welcome and should be sent directly to the author at the following address:

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

Please include a stamped addressed envelope (and be prepared to wait a little!) if you require an individual reply.

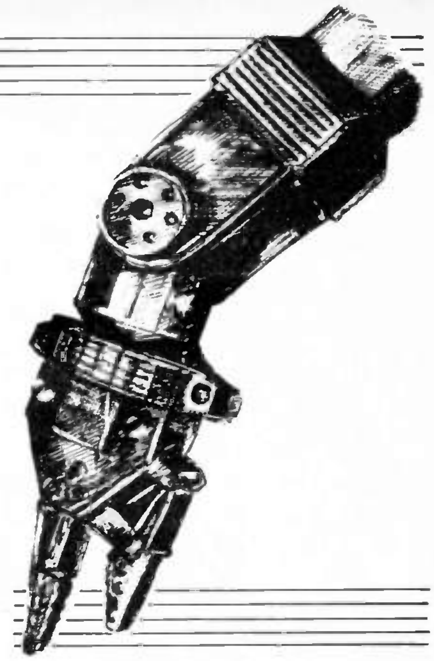
ANSWERS TO PROBLEMS

6.1 (a) 2K bytes
(b) 1K bytes
(c) 4K bytes

6.2 (a) Read or write operation to RAM
(b) Read operation from ROM
(c) Read or write operation to I/O

Constructional Project

INDUCTIVE PROXIMITY DETECTOR



B. J. FROST B.ENG. MIEE

Build an inexpensive inductive proximity sensor

An inductive proximity sensor is a miniature "metal detector" used as a replacement for a mechanical switch where a non-contacting, non-sparking or sealed switch is required. This article describes the construction of a simple sensor which provides an output logic level change when a metal object is detected close to a small readily available sense coil.

Such devices are used widely in industry as replacements for switches and opto-electronic devices where their increased robustness and immunity from interference are highly prized. Supplied as an encapsulated module these units are around £20-£30 each but single units as described in this article can be constructed for a few pounds and use a ready-wound sense coil.

The device is useful for many applications such as automation, robotics, sensing shaft rotation or counting the passage of metallic objects such as coins etc. The sensitivity of the unit is adjustable and it can also be used for analogue distance or thickness measuring applications.

TYPES OF SENSOR

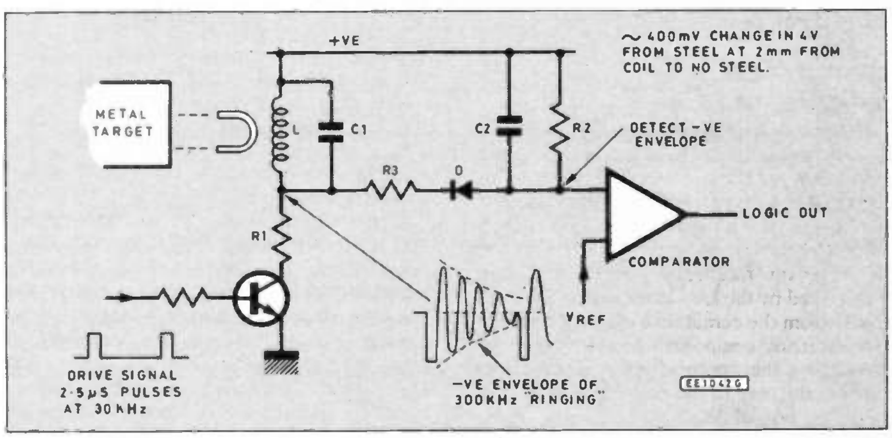
Almost all common inductive proximity sensors provide a logic output which changes state when a metal target is detected at a predetermined point relative to the sensor body. In this function they share a lot of similarity with common metal detectors but are much smaller and have a much faster response.

There are two major styles of sensor as shown in Fig. 1 and 2, that of the "Fork" sensor and the "End" sensor respectively. Although using the same fundamental principle these are different in technique as follows:

The "Fork" Sensor. Fig. 1 shows how the fork sensor operates using two coils mounted on each side of the fork comprising an oscillator and sense loop. The entry of a metal flag into the fork reduces the coupling between the coils until a detection point is reached hence signalling a logic output change.

The style of construction has the advantage that the detection point is sharp and readily identified by the relative coil positions but has the disadvantage that it is a difficult design to produce, requires special body mouldings and coil positioning as

Fig. 3. Principle of operation.



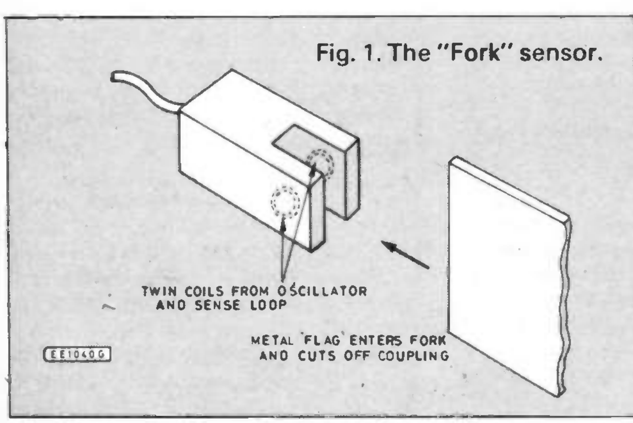


Fig. 1. The "Fork" sensor.

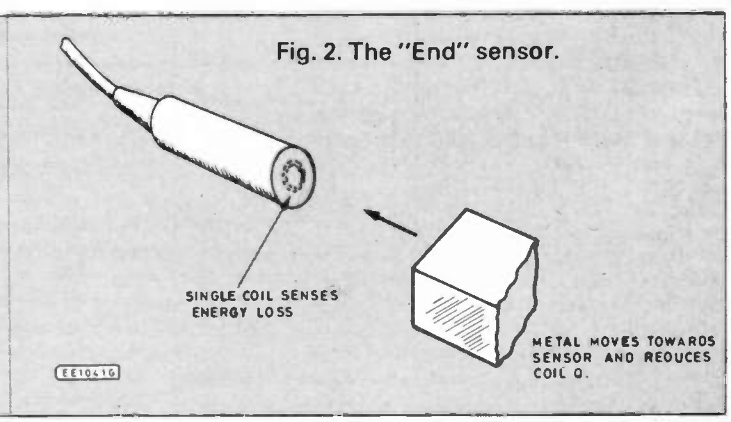


Fig. 2. The "End" sensor.

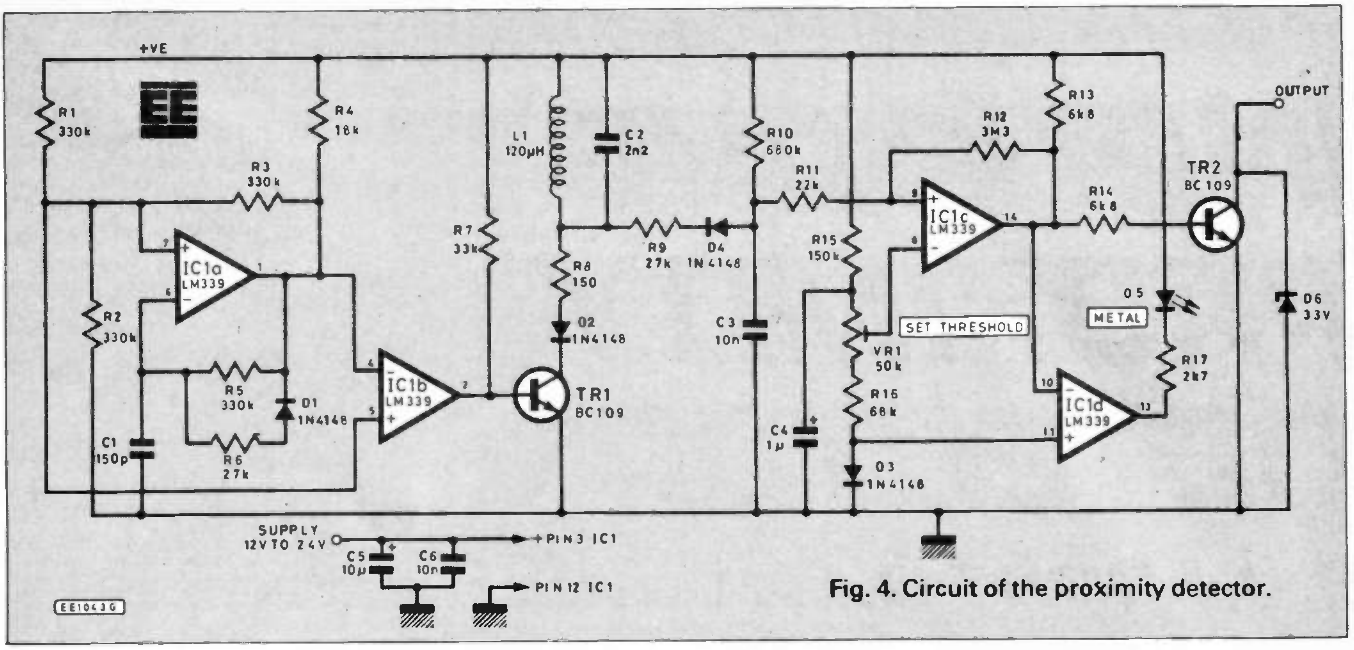


Fig. 4. Circuit of the proximity detector.

well as being limited to objects that can enter the slot in the body.

The "End" Sensor. Fig. 2 shows how the "end" style of sensor is usually made available moulded inside a tubular body with a single sense coil placed up against the end face. An oscillator drives this coil and a detector circuitry monitors its operating waveform. When metal approaches the sensor it becomes mutually coupled to the sense coil and some of the coil waveform energy is lost to it. This change is detected and used to provide a logic output change.

It is this latter principle that is used in the sensor to be described and is much more suitable for construction due to the use of only one readily available single sense coil and straightforward circuitry.

PRINCIPLE OF OPERATION

The principle of operation is shown in Fig. 3. A drive oscillator produces narrow drive pulses that are used to switch short bursts of current into a resonant circuit comprising the sensing coil and a capacitor. Following each current pulse an envelope of "ringing" at the LC resonant frequency decays at a rate determined by the LC circuit losses. This loss results from the cumulative effect of the individual circuit component losses, but is increased by the approach of a metal target towards the core of the coil and results in an increased rate of decay of the ringing envelope.

In the circuit configuration chosen, this ringing envelope is centred around the positive rail, so the detector diode D averages the negative half of the envelope to provide a detected d.c. voltage at one input of the comparator. The detector components are chosen such that the drive signal is averaged in as short a time constant as possible to achieve maximum speed of response.

The comparator is set to change state at the required target distance when the envelope decay has reduced to the point where the detected signal rises higher in voltage than the reference.

It can be shown that as the supply rail varies, the averaged detector level tracks this change very well and thus it is only necessary to provide an adjustable division from the supply rail to form this reference.

As with all circuits that rely on the operation of an inductor and its interaction with other circuit components, the construction of the coil is most important. A coil is required that is wound on a core that presents an open end toward the metal target but in a small size and potted for robustness. In addition, the coil should have a good Q factor to provide good sensitivity to small objects.

Fortunately for constructors like me with fingers that are too large for 30 micron wire this style of construction required is readily available from at least one source as ordinary, low-cost potted inductors, so that no d.i.y. coil construction is required.

THE CIRCUIT

The full circuit diagram of the unit is shown in Fig. 4. The entire system is based around IC1, a single LM339 quad comparator. IC1a forms a schmitt-trigger oscillator which generates narrow pulses of around 2.5µS at a repetition rate of around 30kHz. These pulses are buffered by IC1b before being used to drive the sensing circuit via the switching transistor TR1.

Current pulses into the resonant sensing circuit are determined by R8, and D2 allows the resulting ringing envelope to exceed the supply rail if necessary. C2 together with the inductor allows the resonant frequency decay envelope to be fitted into one period of the pulse repetition rate such that any given envelope reduction will produce the maximum change in detected voltage at the averaging of D4, R9, R10 and C3.

Comparison of this detected signal against a reference level set by VR1 is performed by IC1c which is provided with some positive feedback (hysteresis) by R12 about which more later. Its output drives the output transistor TR2 directly with enough base current to sink around 100mA of the output current if required.

The indicator l.e.d. is driven by IC1d. At first sight it may seem that the l.e.d. and output transistor could both be driven by IC1 alone, but the use of a separate l.e.d. driver isolates its effect from the output voltage of IC1c that would otherwise alter the hysteresis via R12. Of course this also allows the l.e.d. operation to be inverted at will. Note that there is nothing devious in the connection of D3 to IC1d pin 11, D3 simply provides a convenient threshold voltage without

COMPONENTS

Resistors

R1 to R3, R5	330k (3 off)
R4	18k
R6, R9	27k (2 off)
R7	33k
R8	150
R10	680k
R11	22k
R12	3M3
R13, R14	6k8 (2 off)
R15	150k
R16	68k
R17	2k7

All ¼W 5% carbon

Shop Talk See page 244

Potentiometer

VR1	50k multiturn preset

Capacitors

C1	150p ceramic
C2	2n2 polyester
C3, C6	10n polyester (2 off)
C4	1µ tantalum 35V
C5	10µ tantalum 35V

Semiconductors

IC1	LM339 quad comparator
D1 to D4	1N4148 (4off)
D5	l.e.d.
D6	33V 400mW Zener diode
TR1, TR2	BC109 (2 off)

Miscellaneous

L1 144HT-121 Toko coil; printed circuit board, available from the *EE PCB Service*, order code 574; plastic case approx 75×55×35mm; 14 pin d.i.l. i.c. socket; fixings, wire, solder etc.

Approx. cost Guidance only **£7.00**

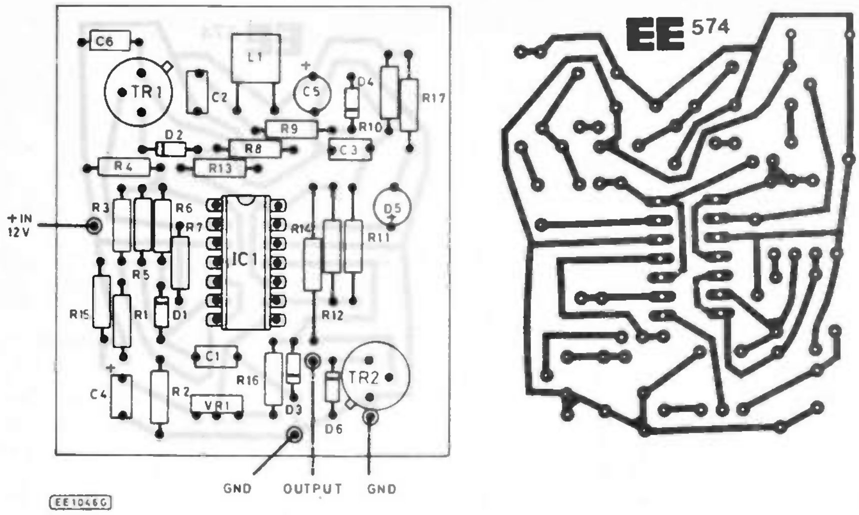


Fig. 5. Printed circuit board layout and wiring of the proximity detector. Construction of the prototype unit—a p.c.b. was later designed.

extra supply rail divider components.

Note the use of a 33V Zener diode D6 across the output transistor collector-emitter. This replaces the usual clamp-diode returned to the supply rail that is used to suppress the inductive voltage spike that occurs when TR2 switches off an inductive load such as a relay. Use of a clamp diode implies pre-knowledge of the output load supply voltage whereas use of an ordinary Zener diode simply clamps the voltage spike to a non- destructive level of its Zener voltage, still protecting TR2 and allowing the use of any external load supply rail up to this voltage.

The circuit shown is intended for a supply voltage of 12-15V but can be adjusted to operate from 9V to 24V. If required, the l.e.d. current can be altered or its operation inverted by swapping the inputs of IC1d. Currently the l.e.d. will be 'on' when a metal target is detected.

CONSTRUCTION

During construction the only important point to consider is the mounting of the sensing inductor. Since it will exhibit maximum sensitivity if it is removed from surrounding metal as far as possible, the whole sensor could either be constructed in a small plastic case where the problem does not arise, or if a metal case is to be used, the inductor should be situated centrally within a clearance hole of some 10mm or more in diameter by using a rubber grommet or non-metallic blanking plate. (A 15mm rubber grommet fits the Toko inductor quite well). This will ensure that the inductor is as responsive as possible to externally approaching metal rather than the case itself.)

Electrically the circuit is not particularly critical, but do not omit the decoupling capacitors which should be close to TR1 and the i.c. Although not shown on the circuit, a small 100mA regulator such as the 78L12 should be used to "clean up" the supply if it is inherently noisy or is to be shared with noisy items such as electric motors.

FAULT-FINDING AND SETTING UP

The unit is adjusted for a particular metal target as follows: Adjust the sensitivity control VR1 with a falling voltage on its wiper until the l.e.d. comes on. Now reverse its direction and find the point at which the l.e.d. goes out. This may require several turns depending on the hysteresis of the comparator. Place the metal target up against the coil and the l.e.d. should come on. but when the target is removed it may not go out. In this case continue adjusting VR1 with a rising voltage until the l.e.d. does go out at the most remote target distance required. The l.e.d. should now come on when the target is adjacent to the coil and go off as it is moved away.

If it is not possible to find both of these points then the comparator operation will have to be checked, since it is likely that the detector circuitry is providing an output voltage that is outside the adjustment range, possibly due to the mounting of the sensing coil or the characteristics of the coil itself. This can be checked as follows: Put a high-impedance voltmeter (greater than one megohm) across the detector reservoir capacitor C3. The voltage should be around 4 to 5V with a 12V supply and should increase by around 1V when a piece of steel is placed up against the sensing coil. If the voltage change is satisfactory, check the voltage on the wiper of VR1 and investigate its maximum and minimum that can be achieved with the adjustment and which should be from about 3.5 to 5.5V. If the measured detector voltage lies outside of this range then either there is too much hysteresis via R11 and R12, or VR1 will need to be given a greater control range. To provide the necessary voltage, substitute either R15 or R16 until VR1 spans the required voltage range with the minimum voltage drop across itself, this will give the greatest adjustment sensitivity.

If there was little or no change in the detector voltage the oscillator and driver circuit must be checked. Remove D2 from the collector of TR1 and connect a 1k resistor between its collector and the supply rail. Lift D1 out of circuit to force the oscillator into a 50:50 mark-space ratio. If the oscillator and driver stages are functioning, approximately half the supply rail voltage will be measured at pin one of IC1 and at the collector of TR1. Note that this is a good check of the oscillator operation but not of its frequency.

If this is satisfactory and the detector voltage is still not correct, check the pedigree of the coil and its associated components.

SENSITIVITY—HYSTERESIS

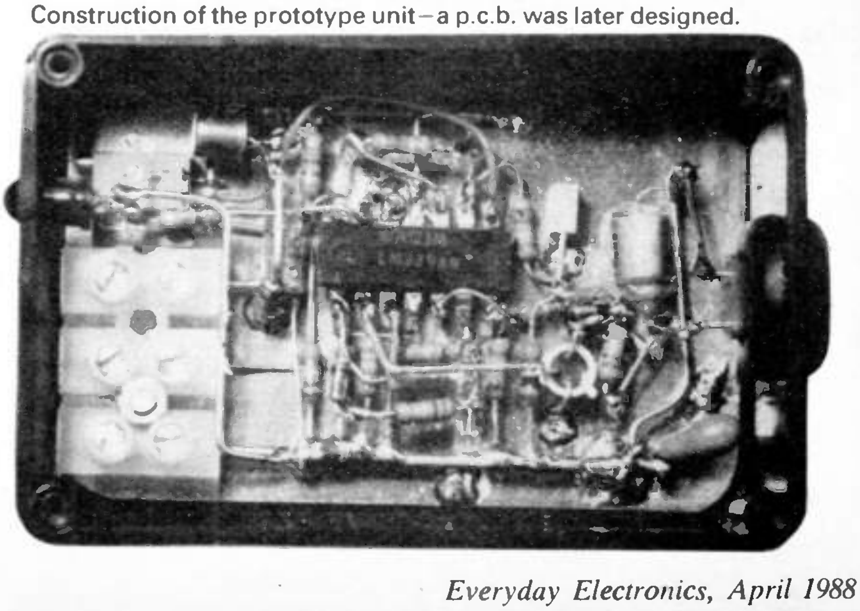
To suit particular targets or to change the sensitivity, the hysteresis of the comparator can be changed if required, so it is worth reviewing the reasons for hysteresis and the considerations involved.

Hysteresis is the process by which the output can be made to give a "clean" transition instead of a noisy or "fuzzy" changeover if the metal target is approaching the actual threshold point slowly and is provided by a controlled amount of positive feedback or "hysteresis". This is the electrical analogue of the "snap-action" of most mechanical switches and is about the only time that positive feedback is of benefit outside of an oscillator!

Two resistors are used to alter the actual threshold voltage at the "+" terminal of the comparator in such a way that it actually becomes two thresholds, one for each state of the output. These are designed spaced apart by a voltage that is chosen to just exceed the expected level of input noise or jitter which may be only a few millivolts up to several volts.

On the diagram of Fig. 6 these two levels are shown as V_U and V_L for the upper and lower thresholds respectively, and the input waveform is shown containing various unwanted noise "glitches". With no positive feedback there would be only one threshold level and the output would contain extra unwanted transitions due to the "glitches". With the hysteresis effect creating the two levels shown, the comparator responds only to the transitions associated with the basic waveform period. Immediately the input waveform reaches whichever of the levels is "active" the output of the comparator flips its own input to establish the other input level which now holds the comparator in this new state until the input goes beyond this

Construction of the prototype unit—a p.c.b. was later designed.



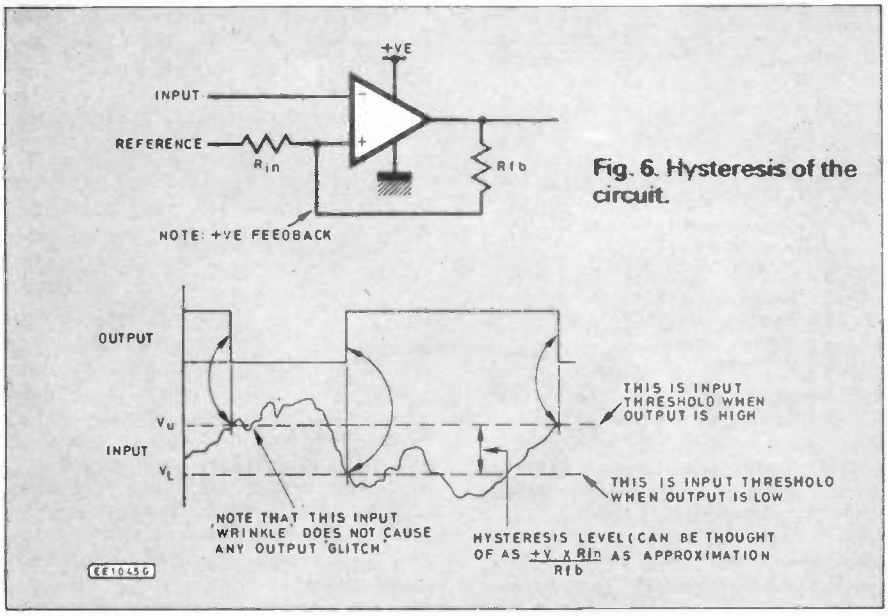


Fig. 6. Hysteresis of the circuit.

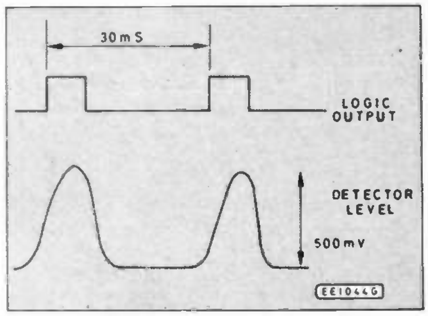


Fig. 7. Maximum operating speed.

new level. Of course the intention is to set the levels apart by an amount in excess of the noise that would otherwise cause interference.

Having shown the advantage of such a technique it is worth adding that use of too much positive feedback eventually causes the comparator to remain in only one state since the thresholds have now exceeded the actual circuit change to be detected, so there is a limit on the application of the principle.

PERFORMANCE

The circuit as shown will operate from around 9V up to 24V without modification other than to re-adjust the l.e.d. current for satisfactory brightness and the sensitivity control for the detection threshold. The current consumption is around 8 to 10mA plus any l.e.d. current. Operation from supplies as low as 5V is possible but the sensitivity of the detector is lower at this voltage.

When using the sensor to sense moving objects or the rotation of a shaft it is important to know the response time that can be achieved. Fig. 7 was measured using the rotating blades of a fan as a convenient "target" and shows that the response time is around 10mS giving a maximum operating frequency of around 30Hz. This speed is limited by the time constant of the detector smoothing that is nesessary to average the drive pulse repetition rate. It follows that an improvement in operating speed can be gained by increasing this drive rate and reducing the detector time constant. As a matter of interest, simple immunity to false operations on slowly moving objects can be gained by increasing this detector time constant until it is approaching the object rate.

APPLICATIONS

As well as its intended use as a non-containing switch, the device can also be used for measurement. If the output of the detector is buffered and taken to a voltmeter or a computer A/D input it will be found that the change in d.c. voltage is a very sensitive function of target distance within some 5mm. of the coil. The voltage changes about 1V over this distance and although it is not a linear relationship, it can be measured and used to control either small distance motions or used to measure the thickness of non-metallic material by sandwiching the material between the sense coil and a steel reference plate. This technique can measure small thicknesses in a very sensitive manner. □

Actually Doing it!!

IF YOU take a look through a few electronic component catalogues, one category of component that seems to take up a large amount of space in most of them is connectors. In one or two catalogues there seems to be more space devoted to various types of plug socket than to the range of semiconductors. This is perhaps a rather surprising situation, as on the face of it, a few types of connector are all that should be needed in order to accommodate all normal requirements. It is also a potentially confusing situation for beginners. If you have a project that requires a two way socket, you would probably find a choice of about one or two dozen different types in one of the larger component catalogues!

In this month's Actually Doing It article we take a look at the various types of connector currently available, paying particular attention to their suitability (or lack of it) for a variety of applications.

PHONO

Phono connectors are a simple two way type intended for audio applications. They seem to have become the nearest thing to a standard type of connector for hi-fi systems, which is perhaps a little odd as they can only carry a monophonic signal. Stereo is accommodated by having separate connectors and leads for each channel, although the leads are often combined into a twin (figure of 8 style) cable. Phono connectors are not only suitable for hi-fi systems, and they are often used for other low frequency applications such as audio frequency test equipment. They even seem to be used for some higher frequency applications, including video connections to computer monitors.

The old style phono sockets have from one to about half a dozen sockets fitted on a panel made from an insulating material. Mounting these requires a cutout of about 9.5 millimetres in diameter for each socket, plus two or more smaller holes for M3 size mounting bolts. More recent types are neater and somewhat easier to use. They are single types, and require just one mounting hole (usually 6.35 millimetres in diameter). The connection to the outer conductor (which connects to the braiding of screened cables) is by way of an out-sized solder tag held in place by the fixing nut.

The only problem I have encountered when using these is that with use they can tend to work loose. They still seem to be better than the older style, and I would certainly recommend the use of the single-hole fixing variety wherever possible. In the past phono plugs have tended to be almost impossible to wire to cables, but again, modern components seem to be much improved and are unlikely to give any real difficulty in this respect.

THE DIN

There is a range of DIN plugs and sockets from simple two way connectors through to at least 13 way types. However, only DIN connectors from two to eight ways seem to be readily available. These are primarily intended for audio use, but they are well suited to any low frequency low power applications. They are used as the standard connectors for the MIDI interfaces now fitted to many electronic musical instruments for example. The two way type is specifically intended for connecting loudspeakers to audio power amplifiers, but only low and medium power units (up to 25 watts r.m.s.). They have not proved to be particularly popular in this application, and in my experience have not provided a particularly reliable method of connection. Screw terminals, as used on higher power amplifiers, now seem to be quite common on lower power units. The other DIN connectors are only intended for low level signals.

Fig.1 shows the pin layouts for DIN connectors from two to eight ways, and as will be apparent from this, there are three different five terminal types and two different eight way types. I am not sure why this should have been deemed necessary—perhaps so that different connectors can be used on different categories of equipment. Anyway, any three to eight way DIN connector having a sufficient number of ways should be suitable for any low power, low frequency application.

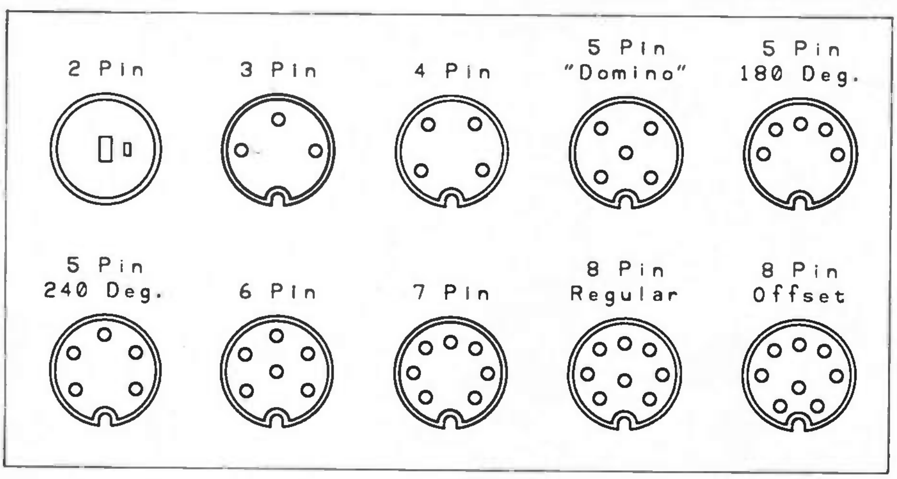


Fig. 1. ten readily available styles of DIN connector.

Printed circuit mounting DIN sockets can now be obtained, but the chassis mounting type are the ones most frequently used in projects. These are quite easy to mount, and they require a 12.5 millimetre main cutout plus two smaller holes for the 6BA (or similar) mounting screws. The plugs having five or more terminals can be a bit awkward to wire up. This task is very much easier if the plug can be fixed in a vice. As when doing any wiring of this general type, the terminals and ends of leads should be tinned with solder prior to making the connections.

With most modern plugs a certain amount of care needs to be taken in order to avoid accidental short circuits, and this is certainly the case with multi-way DIN plugs. Remember to fit the plastic covers onto the cable before wiring up the plugs, otherwise you will be unable to fit the covers in place.

There are a couple of metal grips on each plug which can be crushed onto the cable using a pair of pliers, and these provide simple but effective strain relief. When using a screened cable, if the cable is left uninsulated at the point where it is gripped by the plug, this will provide a connection between the screen and the metal shell of the plug (it is a good idea to reinforce this connection with a generous helping of solder). This method of strain relief is sometimes used with other types of plug incidentally, including some phono types.

JACK

This is another form of audio connector, and there are three sizes available. These are 6.35, 3.5, and 2.5 millimetres (which is the diameter of the barrel section of the plug). Originally these were only two way connectors, but there are now stereo versions in all three sizes. In their mono form the 6.35 millimetre variety are mainly used for audio connections in electronic music and P.A. systems, and they are used in both forms for headphones (depending on whether the application requires stereo or mono use). The smaller types are also primarily used with headphones and earphones, but on miniature equipment such as radios and personal stereo units.

A jack socket is the obvious choice for an earphone or headphone output on a project, or for a microphone input. They are also very useful as general purpose two or three way connectors for low frequency applications which involve modest currents. They are inexpensive, easy to use as the sockets are all single-hole fixing types, and the plugs are easy to wire up. Their only slight drawback is that the plugs are sometimes a slightly loose fit in the sockets, and they can tend to pull out of the sockets easily. The early miniature types gained a bad reputation as there seemed to be no standard barrel length, and some plugs literally jumped out of incompatible sockets. There seems to be no problem of this kind these days.

COAXIAL

Coaxial (or just plain "coax") connectors are a two way radio frequency (r.f.) type which are primarily intended for connections to television aerial leads and similar applications. They are sometimes used as an inexpensive alternative to BNC connectors for radio frequency test gear, and seem to be well suited to this application. At a glance BNC and coaxial connectors look very similar, but a closer examination will reveal that the BNC type are higher in quality, and lock together with bayonet style mechanism. For something like a television aerial amplifier or simple test equipment coaxial connectors are the obvious choice, but for high quality test equipment such as an r.f. signal generator or an oscilloscope the BNC type are probably worth the extra money.

Coaxial connectors can be quite awkward to connect to the special coaxial (75 ohm) screened cable. The outer braiding is not usually a problem as the connection to it is made via a simple grip mechanism which tightens as the plug's cover is screwed in place. The inner connector must have a long piece of insulation removed so that it can be pushed right into the central connector of the plug, and soldered at the far end. Plenty of solder must be applied to the joint, and preferably some of the solder should go well down into the plug to make a really strong connection. On the other hand, excess solder may make it impossible to fit the plug in the socket, and the connection has to be made reasonably quickly in order to avoid melting the plastic insulation around the central connector. I have yet to come across anyone who finds connecting this type of plug anything other than irksome, and it is noticeable that some recent high quality types have a grub screw to permit a painless connection to the central prong of the plug!

Note that the plugs and sockets used for car radio aerial connections are not of the standard coaxial variety, but would seem to be a form of connector produced specifically for this task. Apart from a project such as a car radio aerial amplifier there would seem to be little point in using these. Another form of coaxial connector is the 50 ohm impedance variety, and these are a high quality locking type. They are normally only used for transmitters and you are unlikely to use them unless you are a CB amateur radio enthusiast.

HIGH CURRENT

The connectors discussed so far are not well suited to high current applications, such as at the outputs of bench power supplies. The usual choice for this type of application are four millimetre connectors. These are single way connectors, and the plugs are very simple split-pin types. There are very basic sockets, and the "terminal post" variety. The latter can function as ordinary sockets, but the front section can be unscrewed slightly to reveal a hole through the metal part of the socket. The bare end of the lead can be threaded through the hole, and then the front part of the terminal is screwed down onto it to provide a very secure and low resistance connection.

Four millimetre connectors are popular for use on power supplies, multimeters, and for aerial connections on short wave radios. There are smaller one and two millimetre versions that are useful for applications, such as aerial connections, where a simple one way low current connector is required. For loudspeaker outputs on power amplifiers a more popular choice is either simple spring loaded terminals which connect to the bare ends of the speaker leads, or screw terminals. These screw terminals can be connected direct to the leads, but it is neater (and more reliable) if the proper "spade" terminals are used instead. Screw terminals probably represent the most reliable form of high current connector, but they are really only suitable for "Connect it and forget it" applications such as speaker connections in hi-fi systems.

These connectors are all very low technology types having their origins in the early days of electronics, and they should not be difficult to use. One point that I must stress is that it is important to use these heavy duty connectors for applications that involve currents of more than a few hundred milliamps. Miniature jack sockets etc., could easily burn out if subjected to high currents, and would not give reliable results.

THE FIELD

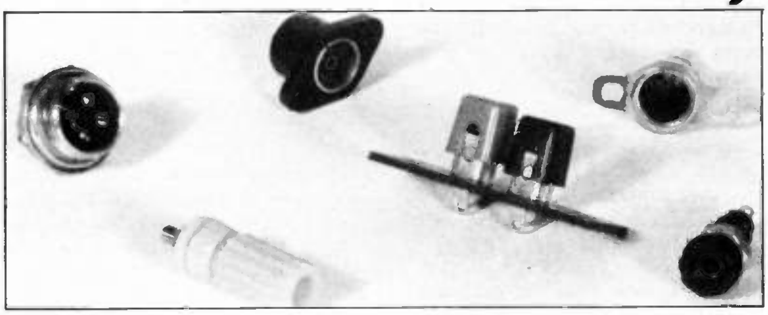
We have covered the main types of plug that you are likely to use, but there are several other types available. One of these is the audio locking range of connectors. These are mainly used as microphone connectors for CB radios, PA systems, and other applications where rugged construction and locking capability is advantageous. It is worth noting though, that locking versions of some other types of audio connector (including certain jack and DIN varieties) are now available, and these might be more convenient in some cases. Note that in order to obtain a locking action, both the plug and the socket must be locking types.

XLR connectors are very high quality three way audio types intended for use in professional grade equipment. Their ratings of 15 amps at 120 volts a.c. with a maximum contact resistance of five milliohms seems more appropriate to power connectors than audio types. They are little used in electronic projects due to their cost. A plug and socket costs about as much as a small project!

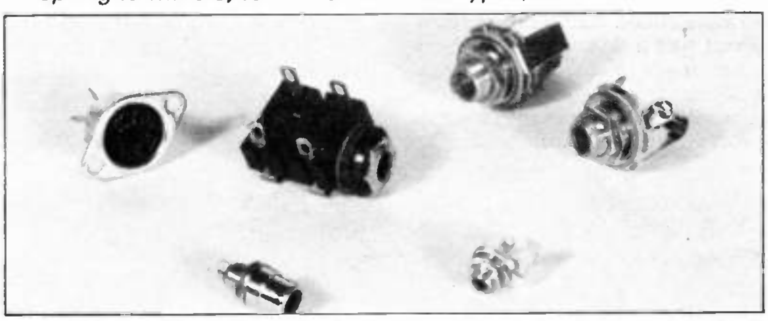
So-called "power" plugs and sockets are potentially useful to the home constructor, but seem to be little used. They are intended for the connections between mains adaptors and items of equipment such as portable cassette recorders and radios. These connectors are available in a bewildering array of sizes and types, and this lack of standardisation has possibly led to them being "cold shouldered" by many electronics hobbyists.

This accounts for all the common types of connector, apart from special varieties such as computer types—but that's another story.

Robert Penfold



A selection of sockets (locking, 4mm terminal post, coax, spring terminals, car radio and 4mm types).



Audio sockets (5 way DIN, phono, standard (enclosed and switched) jack, standard open mono jack, and 3.5mm (switched) jack).

A plug assortment (2 pin DIN, 4mm, stereo jack [rear], BCN [front], 2.5mm jack and 6 way DIN).

Constructional Project

STEREO NOISE GATE

ROBERT PENFOLD

Clean up your act and make sure you get your message across to your audience loud and clear

A NOISE gate is extremely simple in essence, and the basic idea is to have an electronic switch which enables the input signal to pass through to the output, but cuts the signal path when no signal is present. Units of this type are normally used on signals which contain a fair amount of noise, either in the form of background "hiss" or mains "hum". The noise would tend to be very obtrusive during pauses in the main signal, and switching it out during these periods can therefore make a worthwhile improvement in the subjective quality of the signal.

Noise gates are used in various applications, but are mainly used in communications systems to clean-up noisy voice links, or in electronic music systems. In the case of the latter they are often needed to combat the mains "hum" that is present on the output of some instruments, or which occurs due to "earth loops" which prove to be difficult to eradicate, but may also be used to combat tape noise or "hiss" type noise from other sources such as certain types of effects unit.

Noise gates are sometimes utilized as a form of effects unit themselves, and can be used to give an abrupt cut-off to an instrument which has a long decay time. In this role the unit is really operating as an envelope modifier rather than as a noise gate, although it is still the noise gate name which is normally applied to units of this type.

ZERO POINT SWITCHING

Although simple in theory, some noise gate designs are quite complex. It is one of those things where a basic design can be built using a handful of components, but one which gives really good results needs to be much more involved.

The main problem with very basic types is that they tend to generate switching "clicks" as they switch on and cut off again. The importance of this depends on the application, but a design which does not generate these "glitches" will almost invariably sound noticeably better that one which does, and in some electronic music applications the difference can be very noticeable indeed.

There are two main approaches to avoiding the switching glitches, and these are predictive switching and zero point (or "crossover") switching. With predictive switching the gate appears to predict that the signal is about to commence, and switches on just before it does so.

What is actually happening is that the switch is being activated in the normal way by detecting the commencement of the input signal, but the signal to be gated is fed to the switch via a delay line so that the switch has time to close before the signal reaches it. This system can still produce a switching glitch when the signal is cut off, although in most cases the signal is not switched off until it has decayed to a very low level, and any switching glitch is then likely to be so small as to be unnoticeable.

This noise gate design uses the alternative of zero point switching which is slightly more simple and less expensive to implement, and which seems to give better overall results. With this method it is accepted that by the time the circuit has detected the start of an input signal it will have already reached the electronic switch, but switching glitches are avoided by holding off the switching on of the gate until the signal passes through the zero volts crossover point.

The waveforms shown in Fig.1 helps to explain the way in which this eliminates the switching "clicks". In Fig.1(a) there is no zero point switching, and the gate actually switches on at the worst possible time, which is at the peak of a half cycle. This gives a signal which rises almost instantly to the peak level, and in doing so it produces strong high frequency components which give the switching "click"sound.

With a combination of high amplitude and high frequency components this glitch will stand out clearly against most types of signal. Of course, the signal will not always be switched on when it is at or near its peak level, but in practical tests with a variety of signals a simple noise gate was found to generate strong switching glitches far more times than they were very weak or absent.

With the zero point switching waveform of Fig.1(b) the switch-on has been held off until the end of the half cycle, so that the output signal from the gate starts at the beginning of a half cycle. There is no sudden rise in the signal to a high level, and no "click" will be evident on the output signal. This system is less than perfect in that a few milliseconds at the beginning of the signal are lost, but in practice it is highly unlikely that this would ever be noticeable.

Switching glitches can also occur when the signal is switched off again. These are caused by a similar effect, with the output signal suddenly being switched from (possibly) a high amplitude to zero. Often the signal will be at a low level by the time it is switched off, but ideally the zero point switching should also be active at switch-off so that a high cut off threshold can be used if desired, without the risk of any significant switching glitches.

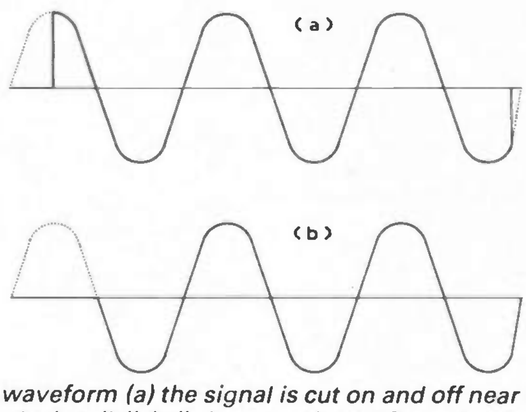


Fig. 1. In waveform (a) the signal is cut on and off near its peak level, producing "clicks" that are absent from the waveform shown in (b).

SYSTEM OPERATION

The block diagram of Fig.2 shows the general arrangement utilized in the Stereo Noise Gate, and although this looks rather involved, the basic means of operation is actually quite straightforward.

Each channel has an electronic switch which is used to switch the input signal through to the output, or to block its path, depending on the input signal level. A buffer amplifier ahead of each switch provides the unit with a reasonably high input impedance while a buffer stage following each switch gives the unit a low output impedance.

The basic function the noise gate must provide is to generate a signal to turn on the switches if the input exceeds a certain threshold level, or to switch them off if the signal is below this level. With a stereo noise gate it is normal for the two channels to be switched in unison as the action of the unit becomes much more apparent if they operate independently. Therefore, the output of each input buffer amplifier is coupled to a mixer stage, and the gating signal is derived from the output of the mixer.

With this system there is actually no rigidly defined level at which the gate is activated in the sense that the threshold level is the sum of the input levels, rather than at a certain level on one or other of the inputs. This gives perfectly good results in practice though, and helps to simplify the unit slightly.

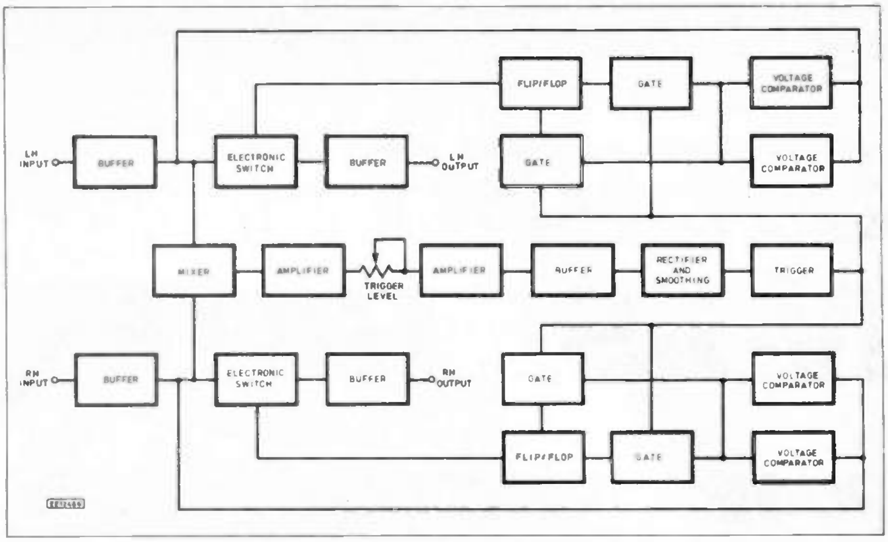


Fig. 2. The block diagram for the Stereo Noise Gate. Although it looks quite complex the actual operation is quite straightforward (see text).

AMPLIFIER

It will often be necessary for the gate to be activated at quite low signal levels of around −40dB or less, and a large amount of amplification is needed after the mixer in order to produce a strong enough signal to drive the switch control circuits properly. Two stages of amplification are used, with a gain control fitted between these two stages. This acts as the trigger level control.

A buffer stage follows the second amplifier, and the purpose of this is to provide a very low output impedance so that the next stage can be driven properly. This stage is a smoothing and rectifier circuit, and the low drive impedance permits a very rapid attack time of under a millisecond to be achieved.

A very fast attack time is essential in this application in order to ensure that an insignificant amount of signal is lost before the electronic switches are closed. The decay time must be somewhat longer so that the unit responds to the overall amplitude of the input signal, and not to individual half cycles (which would result in severe "chopping" of the signal).

TRIGGER LEVELS

The smoothing circuit feeds into a trigger circuit which provides two functions. Firstly, it provides a logic compatible output from the input signal which will be at non-logic voltage levels and will vary relatively slowly rather than cleanly switching between two levels.

Secondly, it introduces a small amount of hysteresis, which simply means that the threshold level at which the unit switches to the "on" state is higher than the one at which it reverts to the "off" state. This reluctance to change state avoids having the unit rapidly switching between the two states when the input signal drops close to the cut off point.

With a simple noise gate the output from the trigger circuit would be used to directly drive the electronic switches, but in this case the switches must be driven via zero crossing detector and control logic circuits. Each electronic switch is driven from a flip/flop circuit, and these are of the basic S/R (set/reset) type.

A flip/flop of this type has two inputs called the "set" and "reset" inputs, and there are two outputs called the "Q" and "not Q" outputs. The outputs always have the opposite states to one another, and in this case only the "Q" outputs are used. These are set high by a positive pulse to the set input, and set low again by a positive pulse to the reset input. In this case, the set pulses close the electronic switch, and reset pulses open it again.

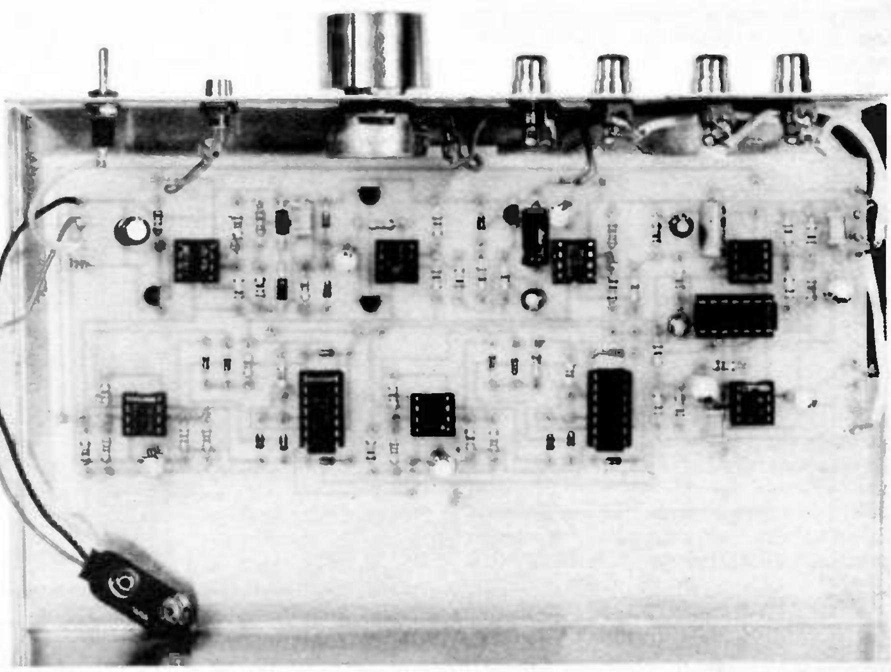
VOLTAGE COMPARATOR

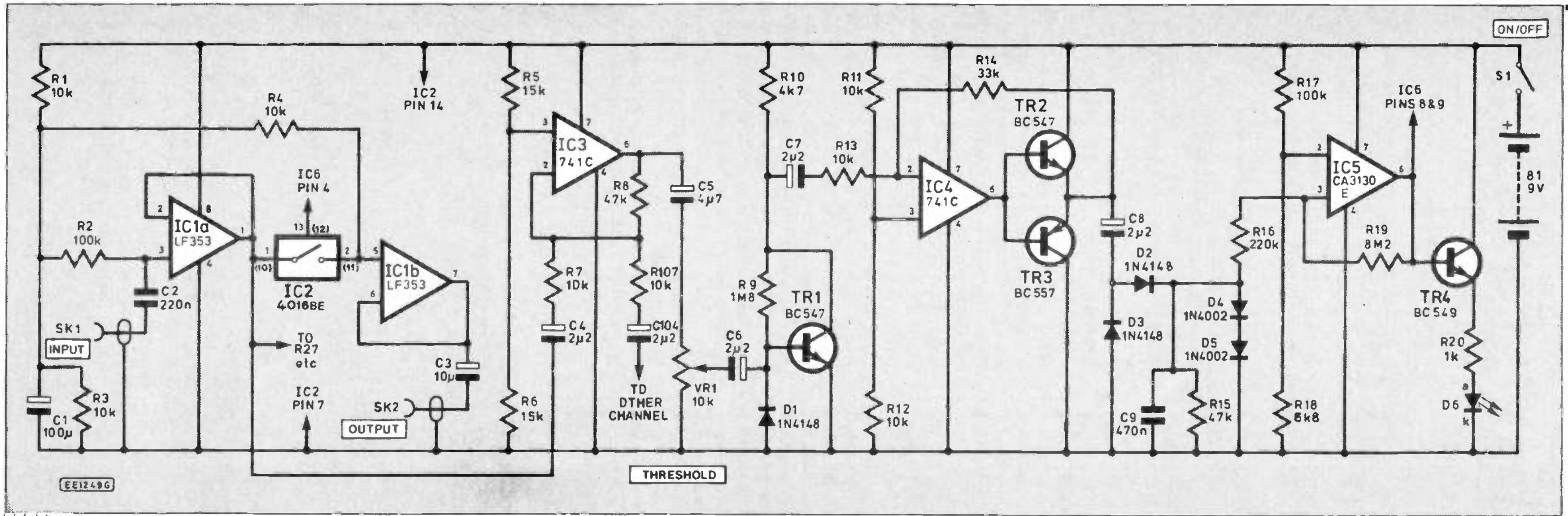
Two voltage comparators provide zero crossing detection, and these are set up in such a way that both their outputs go high if the input voltage is within a few millivolts of zero volts. The two outputs are fed to a gate circuit, along with the output from the trigger circuit.

The gate is designed to provide a positive output only if all three inputs are high, and it provides the set signal for the flip/flop. In other words, the desired action is obtained, with the trigger output going high, but the electronic switch not being activated until the signal reaches the zero crossover point and the outputs of both comparators go high as well.

The reset pulse is produced by a second gate circuit, and it is fed from the same sources. However, it differs from the other gate in that it generates a high output level when the outputs of the voltage comparators are high, and the trigger output is low (not high). Thus the electronic switch is turned off when the trigger output goes low, but only when the comparators detect that the input signal has entered the zero crossing zone.

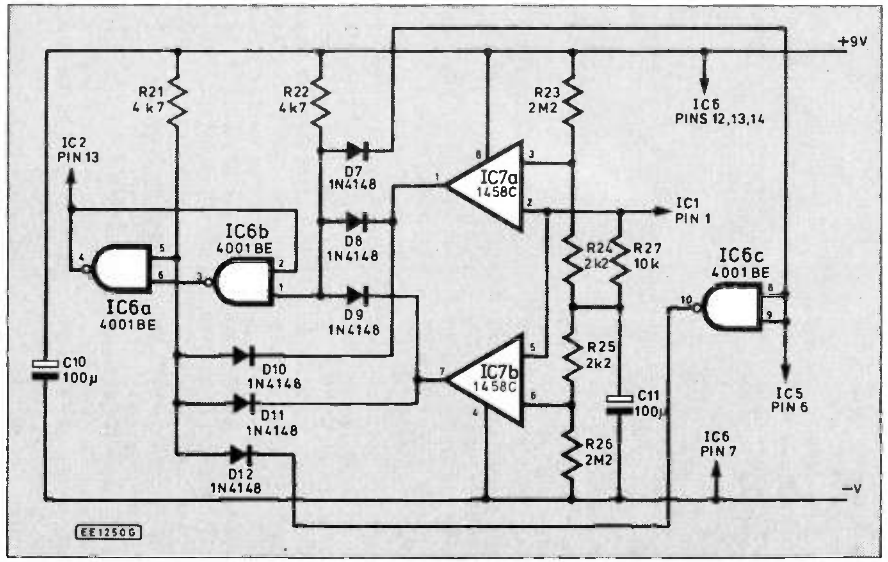
As the signal in each channel will normally be different, a separate zero crossing detector and control logic circuit is needed for each channel. This means that the two channels will not be switched precisely in unison except when the two signals just happen to pass through the zero point simultaneously. However, the time difference between the two channels switching will usually be no more than a few milliseconds, and is unlikely to be noticeable.





STEREO NOISE GATE

Fig. 3 (above). The main circuit diagram for the Stereo Noise Gate.
Fig. 4 (right). Circuit diagram for the zero crossing detector, gate and flip/flop stages. This circuit is repeated for the stereo channel.



COMPONENTS

Resistors

R1, R3, R4, R7, R11, R12, R13, R27, R101 R103, R104, R107, R127	10k (13 off)
R2, R17, R102	100k (3 off)
R5, R6	15k (2 off)
R8, R15	47k (2 off)
R9	1M8
R10, R21, R22, R121, R122	4k7 (5 off)
R14	33k
R16	220k
R18	6k8
R19	8M2
R20	1k
R23, R26, R123, R126	2M2 (4 off)
R24, R25, R124, R125	2k2 (4 off)

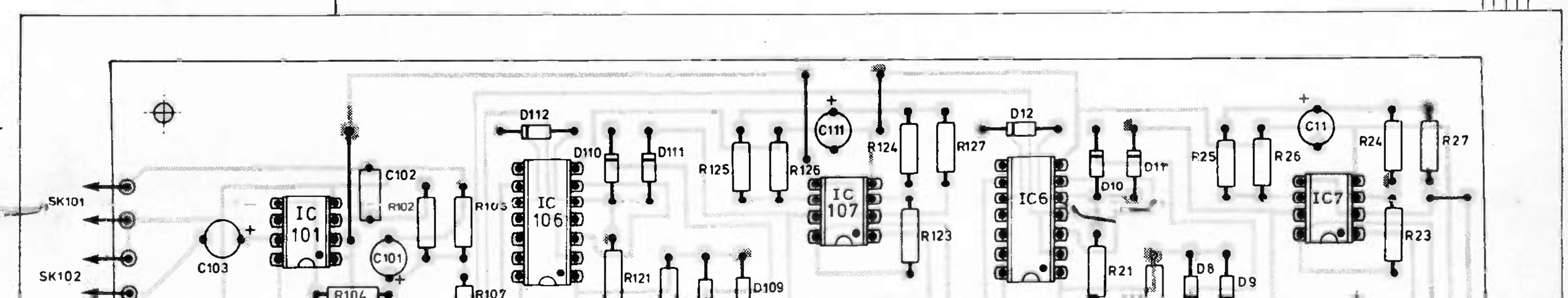
All 0.25W 5% carbon

Capacitors

C1, C10, C11, C101, C110	100µelec. 10V (5 off)
C2, C102	220n polyester layer (2 off)
C3, C103	10µ elec. 25V (2 off)
C4, C6, C7, C8, C104	2µ2 elec. 63V (5 off)
C5	4µ7 elec. 63V
C9	470n polyester layer

Shop Talk
See page

Potentiometer



Potentiometer

VR1	10k log.

Semiconductors

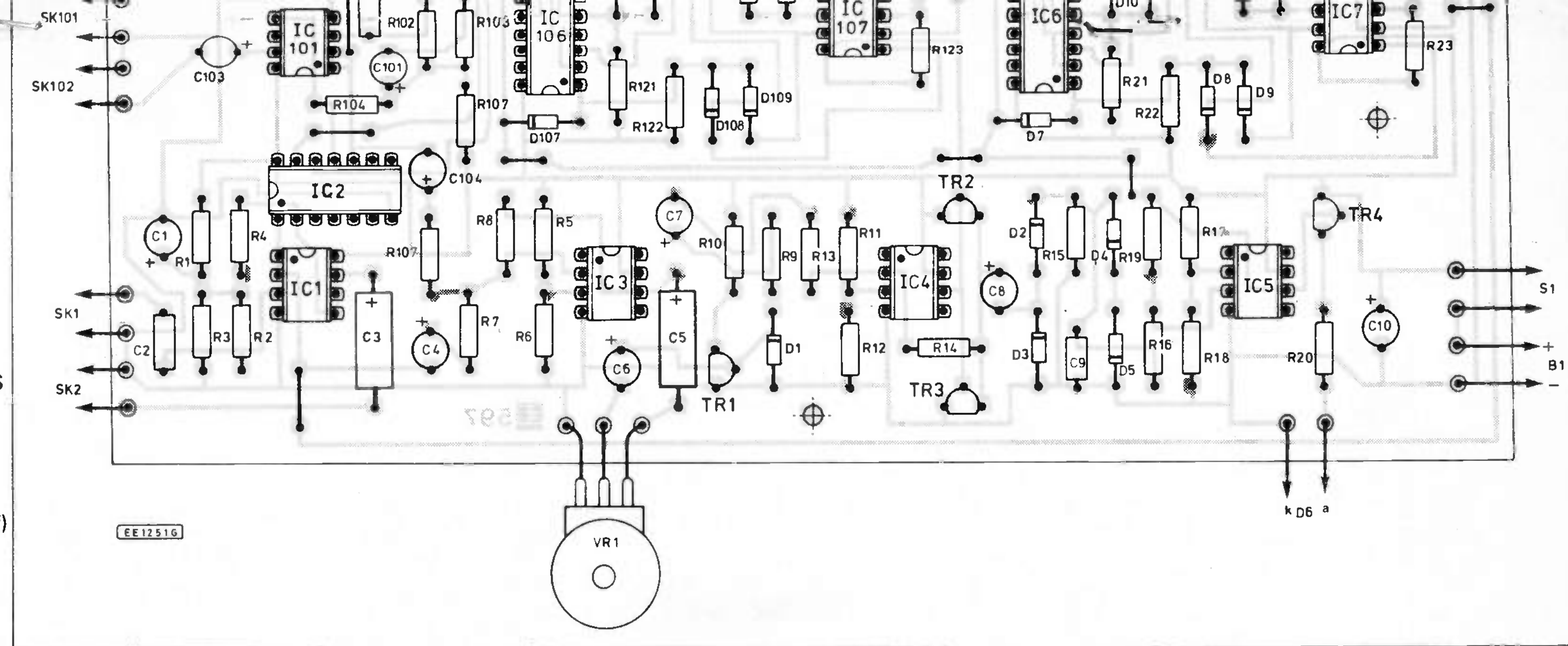
IC1, IC101	LF353 dual op-amp (2 off)
IC2	4016BE CMOS analogue switch
IC3, IC4	741C op-amp (2 off)
IC5	CA3130E CMOS op-amp
IC6, IC106	4001BE CMOS NOR gate (2 off)
IC7, IC107	1458c dual op-amp (2 off)
D1, D2, D3, D7-D12 D107-D112	IN4148 silicon diode (15 off)
D4, D5	IN4002 rectifier diode (2 off)
D6	Red panel l.e.d.
TR1, TR2	BC547 silicon *npn* (2 off)
TR3	BC557 silicon *pnp*
TR4	BC549 silicon *npn*

Miscellaneous

B1	Six 1.5V HP7 cells in plastic holder (see text)
SK1, SK2 SK101, SK102	Phono socket (4 off)
S1	s.p.s.t. sub-miniature toggle

Instrument case about 203×127×51mm; printed circuit board, available from *EE PCB Service*, code EE597; control knob; battery connector (PP3 type); 8-pin DIL i.c. holder (7 off); 14-pin DIL i.c. holder (3 off); pins, wire, solder, etc.

Note: Components with one hundred added are for the second channel.



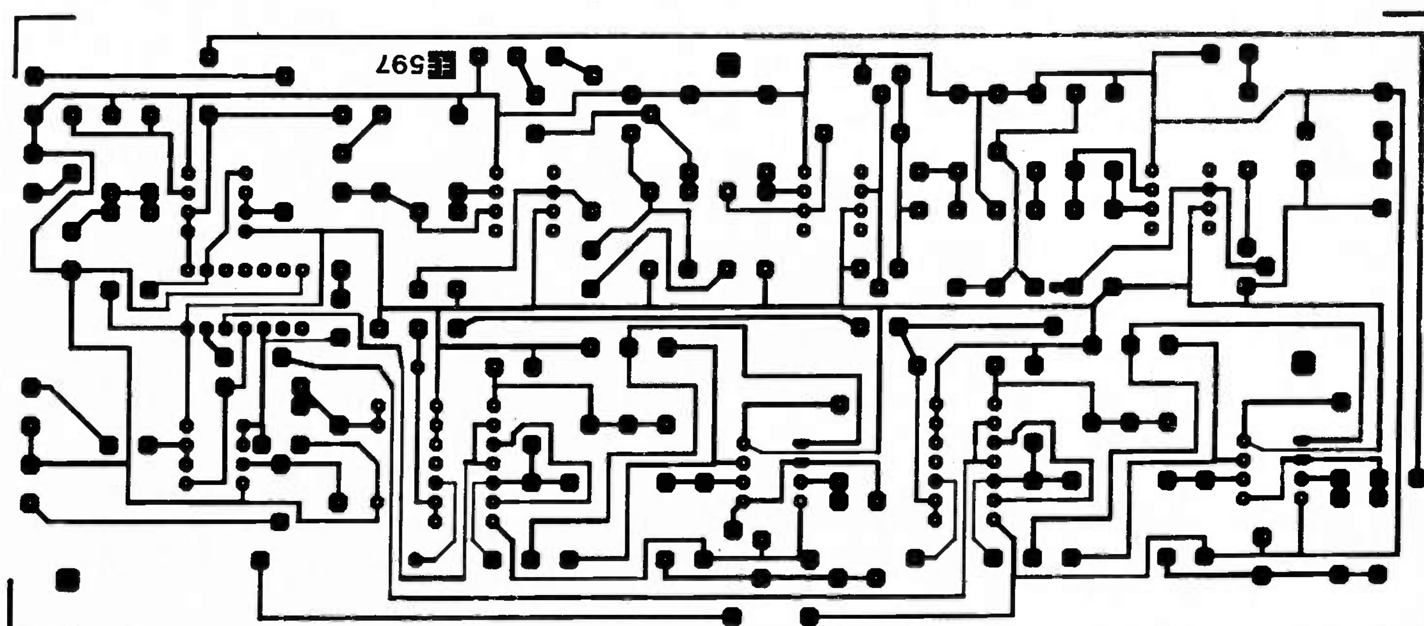


Fig. 5. Component layout and full size printed circuit board copper foil master pattern for the Stereo Noise Gate. The components with annotations of one hundred added are for the second channel.

CIRCUIT OPERATION

The main circuit diagram of the Stereo Noise Gate appears in Fig.3, with the zero crossing detector gate circuit shown separately in Fig.4 Note that this circuit is for ONE channel only, and that for stereo operation much of the circuitry is duplicated in the second channel.

The input and output buffer amplifiers IC1a and IC1b (Fig.3) are both standard non-inverting types. The input impedance of the unit is nominally 100k. IC2 is the "electronic switch", and this is a CMOS 4016BE quad s.p.s.t. type. One of the four switches is used in the other stereo channel, but the other two are simply ignored.

The input of IC1b must not simply be left floating when IC2 is switched off, as it would almost certainly drift away from the normal bias level, and this would cause a switching "click" each time the switch was activated. Resistor R4 is therefore used to bias IC1b's input to half the supply voltage during the periods when IC2 is open.

The mixer stage IC3 is a conventional summing mode type. It is designed to have a certain amount of gain though, and it therefore doubles as the first of the amplifier stages.

The potentiometer VR1 is the "Threshold" control, and this feeds into the second amplifier which is a high gain type which has TR1 operating in the common emitter mode. This amplifier will often be considerably overloaded, and diode D1 is needed to prevent this from driving the biasing well off its correct level, which could cause the circuit to occasionally malfunction.

The buffer amplifier uses IC4 in the inverting mode with TR2 and TR3 as a discrete class-B output stage which gives the circuit a high drive current capability. The circuit does exhibit a small amount of voltage gain, but only about 10dB (just over three).

DECAY TIME

Diodes D2 and D3 are the rectifier circuit, and capacitor C9 is the smoothing capacitor. Resistor R15 sets the decay time, and with the specified value this is quite short (less than 100ms). The decay time can be altered by changing the value of R15 though, or a potentiometer could be used here to give an adjustable decay time. The decay time is proportional to the value of R15.

Diodes D4 and D5 limit the voltage produced across capacitor C9 to no more than about 1.3V, and this helps to give consistent results. Without this limiting some signals would generate a very strong voltage on C9 which would take a long time to fall to the switch-off threshold voltage, and this would give inconsistent decay times.

IC5 operates as the trigger circuit with positive feedback and hysteresis introduced by resistor R19. The l.e.d. indicator D6 is driven from the output of IC5 by way of emitter follower buffer TR4, and D6 indicates when the gate has been activated.

ZERO CROSSING DETECTOR

Focussing our attention on the zero crossing circuit, Fig.4, IC7 is a dual operational amplifier but in this circuit both sections are connected to act as voltage comparators. The resistor/capacitor network (R23 to R27 plus C11) provides suitable reference voltages, but note that the circuit is not strictly speaking a true zero crossing detector. What it is really detecting is when the signal voltage is close to its quiescent bias level, which is about half the supply voltage.

The two gates are both 3-input AND types formed from three diodes and a resistor. In the case of the gate that generates the reset signal, the input that is fed from the trigger circuit's output is preceded by an inverter (IC6c), so that when the trigger provides a low output level the input to the gate goes high and generates the reset pulse.

The flip/flop is a conventional CMOS type formed by cross coupling a couple of 2-input NOR gates, IC6a and IC6b. One of the other gates in IC6 is used as the inverter mentioned above, but the other gate is left unused.

The current consumption of the circuit is about 18mA when in the stand-by state, and around 25mA when activated (and the l.e.d. indicator switches on). Power is supplied by a fairly high capacity 9V battery, such as a PP9 type or six HP7 size cells held in a plastic battery holder.

CONSTRUCTION

Apart from the usual off-board components such as the sockets and the controls, the components are all mounted on the printed circuit board, as detailed in Fig.5. This board is available from the *EE PCB Service*, code EE597. There are quite a few components to fit onto the board, but provided things are taken steadily with no undue rushing there should be little difficulty in constructing the board successfully.

Be careful to fit the electrolytic capacitors and semiconductors the right way round, and bear in mind that IC2, IC5, and IC6 are MOS input types. These require the normal antistatic handling precautions, and the most important one of these is to use sockets for these devices and not to plug them into the circuit board until all other construction is completed.

A number of link wires are required, and these can be made from about 20s.w.g. tinned copper wire, or trimmings from the resistor leadouts are suitable if suitable wire is not to hand. Fit pins to the board at the points where connections to the off-board connections will eventually be made.

With this project we are using the convention of having the component numbers in the second stereo channel equal to those in the first channel but with one hundred added. Of course, many of the components in this case are common to both channels, and therefore only appear with their basic indentification numbers. If a monophonic noise gate is required, build up the board in the normal way but omit any components which have identification numbers more than one hundred.

CASE

An instrument case having dimensions of about 203mm by 127mm by 51mm is used as the housing for the prototype, but any case of around the same size would probably be equally suitable. Bear in mind though, that the board is almost 190mm wide, and the width dimension of 203mm represents something approaching the minimum that is usable.

The printed circuit board is mounted on the base panel of the case, and I used self-adhesive nylon supports, but obviously conventional mounting pillars or spacers and mounting bolts can be used if preferred. Fit the board well forward so that there is sufficient space for the battery at the rear of the unit, but leave enough room to accommodate front panel mounted components. The sockets specified in the components list are phono types, but an alternative audio connector may well be more convenient with your particular set up, and the sockets should be changed to a more suitable type if necessary.

There is little in the way of hard wiring, and there should be no real problems in completing this. Ideally, the leads from the board to the input and output sockets should be screened, but this is not essential provided these leads are kept reasonably short.

IN USE

With the Threshold control VR1 well backed-off the effect of the unit should be readily apparent with the signal being coupled through to the output only when at a fairly high level. If VR1 is set in a fully anticlockwise direction the signal should be continuously cut off. D6 should switch on and off in sympathy with the signal being cut on and off. With VR1 well backed-off the unit is only really usable as a musical effects unit, and it would not normally be set up in this way for true noise gate applications.

To adjust the unit for use as a noise gate the unit must first have the signal source connected to its input. There should be no signal present though, just the background noise that must be suppressed.

With the Threshold control VR1 well advanced D6 should light up. VR1 should then be backed-off just far enough to switch-off D6, or if D6 does not switch on even with VR1 fully advanced, then VR1 should be left fully advanced.

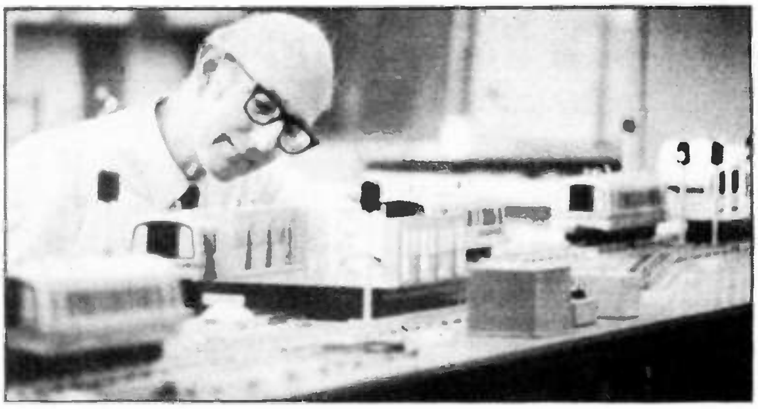
Subjectively, results might be better with VR1 backed-off slightly from the point where the unit only just cuts off the signal before it fully decays. It is worthwhile experimenting a little with the setting of VR1 to determine the setting which gives the best results in practice. □

NEWS ... from the world of electronics

"STEAM-UP" FOR SINGAPORE

A TRAIN set—made in the UK—that would be every boy's dream is being used to train engineers in the Far East.

With a price tag of £650,000 it's obvious that this is no ordinary train set that Dad could play with in the loft or the spare room. It is a railway simulator built for Westinghouse Signals at Chippenham as part of a £45 million contract for supplying signalling and other equipment for Singapore's Mass Rapid Transport system.



Project engineer, Geoffrey Smith, operating the £650,000 model train set built for Westinghouse Signals.

The computer controlled layout is used for training Singapore workers who will run the new railway, which will be one of the most modern in the world. Two Westinghouse engineers went to Singapore to train instructors at the training school, set up for the country's new system.

Geoffrey Smith, project engineer and Duncan Chaddock, senior engineer, with three software engineers at Westinghouse worked on the layout for two years. The inch-and-a-half gauge "model railway" itself was made for Westinghouse by Bassett Locke of Northampton.

Eight of the 41 stations on the 66km long computer-controlled rail system were included in the layout. There are 18 coaches, each representing a six-car train.

Full-size control equipment operates the model system so that staff will be familiar with the feel of it when they use it on the real railway.

Geoff Smith says that when the initial training of staff was completed and the railway operational, the simulator would remain in use.

"New staff will always need training and the system can also be used as an analytical tool to recreate and investigate failures and incidents which may occur on the full size railway", he says.

The simulator has already revealed prospective problems which would not have normally been discovered until the real system was running.

An electric model of a diesel loco, which runs at half the speed of the trains, was specially made for use on the simulator to create the real life problems of a slow train clogging up the system.

Charges for British Telecom inland private circuits have just been revised. Rentals will rise by an average of 5 percent, and connection charges for analogue private circuits, Access Lines and KiloStream digital circuits will be increased by an average of 50 per cent.

Even after the revised increases come into effect, BT claim that the private circuit charges will remain among the cheapest by far in comparison with Europe and North america.

Radio, Electronics and Hobbies Fair

The Swindon & District Amateur Radio is to hold a "Radio, Electronics and Hobbies Fair" at the Science Museum, Wroughton, Swindon, Wilts, on Sunday 22 May 1988 from 10 a.m.

The Science Museum at Wroughton has a large collection of aircraft, agricultural equipment, fire engines, hovercraft and much more. The stands and exhibitors displays will be set out with the Museum exhibits as a backdrop.

With this move the club hope to expand their annual Radio and Electronics Rally into a much bigger event and in addition to the radio rally they are inviting applications for space from the modelling world.

It is planned to have a "Model Railway Swopmeet", model aircraft show and flying display, model boat show and a R/C pond. Also to be included will be a model steam engine rally and a model car meet.

*The venue is well sited for access from the M4 motorway, which is only two or three miles away, and will have the AA signs from the motorway and around the area to direct traffic. For further information contact: **Mr K. A. Saunders (Event Organiser), Tamarisk, Tetbury Lane, Leighterton, Glos. GL8 8UP. Tel 066 689 307.***

RADIO DATA SYSTEM

Recently BBC engineers completed the installation, ahead of schedule, of Radio Data System (RDS) equipment at all of its Network and Local Radio VHF-FM transmitters serving England. These RDS signals will allow the "intelligent" receiver to automatically tune to the best signal, give a visual indication of the station name, and display time and date.

The RDS data is carried on an inaudible 57kHz subcarrier on every VHF-FM transmitter serving England. It will be extended to Scotland, Wales and Northern Ireland in an installation programme during 1988. The codes being transmitted conform to the European Broadcasting Union (EBU) specification, and consist of PI (Programme Information), PS (Programme Service), AF (Alternate Frequency), ON (Other Networks Information), and CT (Clock Time and Date).

SOFTWARE FOR THE HANDICAPPED

In association with the Scottish Spastics Trading Co., Special Needs Software have launched a range of easy-to-use computer software for the physically handicapped. The software was developed by the Scottish Council for Spastics and will be made available worldwide during the coming months. Mr Ron Lander, Chairman of Special Needs Software, said:

"My colleagues and I have worked closely with the Scottish Council for Spastics to produce this range of switch-controlled software which may also be operated by trackerball or via a standard computer keyboard. Three titles are now available: 'Electra Pen'—an art and painting package; 'CAD Master'—a computer aided drawing and graphics program; and 'Storybook Generator'—a program which enables production of switch-controlled, audio-visual reading packages."

Mr Lander indicated that experts from various parts of the world had already previewed the first three programs and their verdicts had been enthusiastic.

At present, the programs run on Acorn's BBC Master computers but work is about to begin on adapting them so that IBM PCs and compatibles can be used.

NEW NEW NEW NEW NEW NEW PRODUCTS NEW NEW NEW NEW NEW NEW

ULTRA CLEAN

FOLLOWING several phone calls recently requesting information on ultrasonic cleaners, we have found that a range of "personal" ultrasonic cleaners are being marketed by **Cobonic Ltd.**

The EcoClean EC150 to EC400H housing is made from stainless steel and three bath sizes are available, 1.5, 2.5 and 4 litres. The timer is standard but the bath heater with thermostat is, however, an optional extra.

The radio frequency interference, RFI, is suppressed in accordance with the demanding German standards and can, therefore, be used in residential areas, such as jewellery shops, dental laboratories or to clean personal items.

Prices of the EC range from £248 to £407 and further details may be obtained from:

Cobonic Ltd., Dept EE, 32 Ludlow Road, Guildford, Surrey GU2 5NW. ☎0483 505260

FOLDING MULTIMETER

A NEW range of four high accuracy, robust folding multimeters from **Megger Instruments** have joined the AVO M2000 advanced analogue/digital line-up.

The unique folding case design is claimed to allow the highest display-to- instrument-size ratio of any instrument on the market. The "lid" section, which can be set at viewing angles to suit the user and lighting conditions, is dedicated to providing a clear display of test information enhanced by a zoom facility on an analogue scale of at least 60 divisions.

When folded shut the instrument display and switches are fully protected. All the instruments in the range have 0.05 percent basic accuracy and current measurements to at least 15A.

The M2035 is a general purpose laboratory instrument providing range, data and peak hold functions with autoranging voltage to 1000V. A diode test/continuity bleeper is also incorporated. The top-of-the-range M2042 measures current to 20A; provides true r.m.s. readings of a.c. and a.c.+d.c. quantities; and the maximum zoom facility of eight stages to a factor of 500.

For further information and details of nearest stockists contact:

Megger Instruments Ltd., Dept EE, Archcliffe Road, Dover, Kent CT17 9EN. ☎0303 202620

EXPLORING MICROS

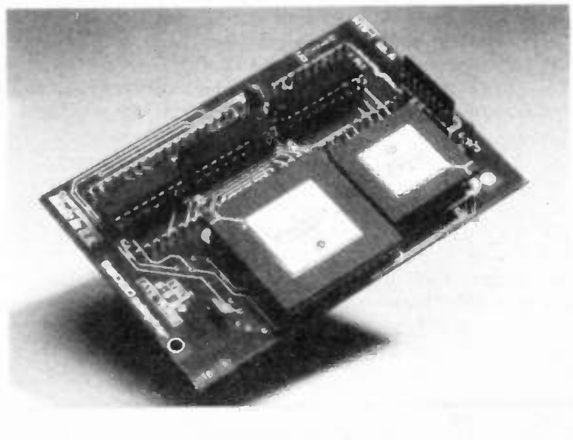
AN UPGRADE package for its popular 68000 microprocessor trainer has been launched by **Flight Electronics.** They have also included a socket on the add-on board allowing the optional 68881 maths co-processor to be explored.

The upgrade 68020 package allows Flight-68K users to gain experience with the latest microprocessor technology. Housed on a high-quality multilayer p.c.b. the 68020 is a plug-in replacement for the 68000, with custom interface circuitry. The board allows access to all the original features of the 68K trainer. Two upgraded systems ROMs and a comprehensive manual are included in the package.

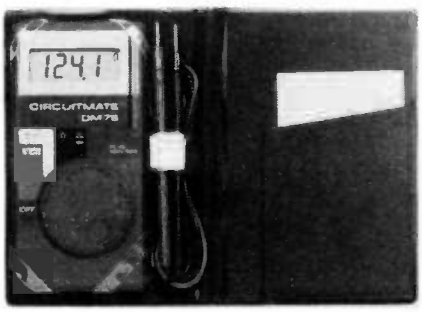
It is claimed that hardware and software for control applications can be designed using the system, without the user having to be expert in BASIC. Also, teaching of microprocessors from the introductory level through to advanced applications is possible. Standard Motorola "S" files are accepted allowing program development through an intelligent terminal or a host system.

Features offered by the 68020 include: 32-bit data and address buses; virtual memory, five control registers, seven data types and 18 addressing modes. For further information contact:

Flight Electronics Ltd., Dept EE, Ascupart Street, Southampton SO1 1LU. ☎0703 227721



SMALL MEASURE



A MINIATURE autoranging digital multimeter, small enough to slip into a shirt pocket, has been introduced by **Beckman Industrial** at a price of only £24.50 (plus VAT).

Designated the DM78, the 3½ digit meter has five functions which can measure up to 250V a.c. in four ranges; 250V d.c. in five ranges; 20Megohm in six ranges, and check diodes and continuity with an audible bleeper. D.C. volt accuracy is 1.3 percent ±4 digits.

The autorange feature automatically sets the optimum measuring range to simplify operation and avoid overloads. Measuring 4.25×2.13×0.40in, the meter is supplied in a neat wallet together with the test leads. For details of nearest stockists contact:

Beckman Industrial Ltd., Dept EE, Temple House, 43/48 New Street, Birmingham, B2 4LJ. ☎021 643 8899

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 22 Integrated circuit radio

THE DEVELOPMENT of the art of designing and manufacturing integrated circuits makes it possible to produce all kinds of specialised circuits on a single chip. This month we base our project on a chip that carries most of the circuitry of a radio receiver.

SIMPLE I.C. RADIO

The complete radio tuner can be built by using a single integrated circuit, the ZN414 and a few additional components. You then need only a few transistors to make the amplifier and you have a set able to receive most medium-wave and long-wave stations with good volume, and without the need for an "outside" aerial.

HOW IT WORKS.

The block diagram for the radio is shown in Fig. 22.1. The full circuit diagram for the Simple I.C. Radio is shown in Fig. 22.2 and has four main sections or stages: power supply; tuned circuit; radio chip and amplifier.

The power supply provides a 6V supply to the amplifier and 1.9V to the radio i.c. Resistors R1 and R2 act as potential dividers.

The tuned circuit stage consists of a variable capacitor (VC1) and an inductance coil (L1). The inductance is a coil wound on a ferrite rod, which acts as an aerial. We have used a tuned circuit of this type in previous projects (*EE* July '86 and December '86).

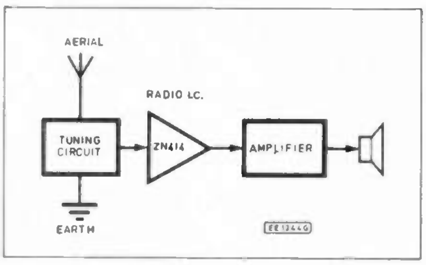
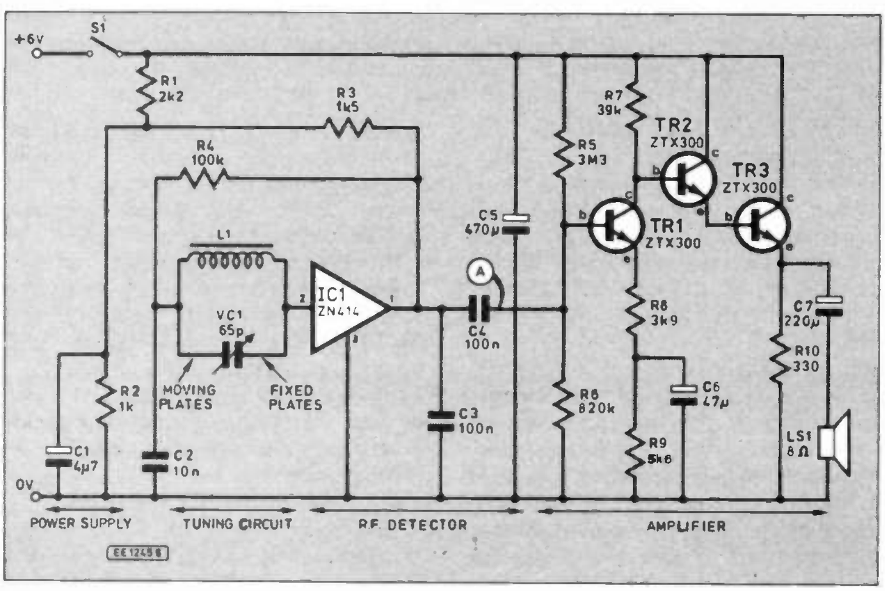


Fig. 22.1. Simplified main block diagram for the I.C. Radio.

Fig. 22.2. Full circuit diagram for the Simple I.C. Radio showing the four main sections.



COMPONENTS

Resistors

R1	2k2
R2	1k
R3	1k5
R4	100k
R5	3M3
R6	820k
R7	39k
R8	3k9
R9	5k6
R10	330

All 0.25W 5% carbon

Shop Talk
See page

Capacitors

C1	4µ7 elec.
C2	10n polyester
C3, C4	100n polyester (2 off)
C5	470µ elec.
C6	47µ elec
C7	220µ elec.
VC1	5p5 to 65p variable miniature trimmer capacitor

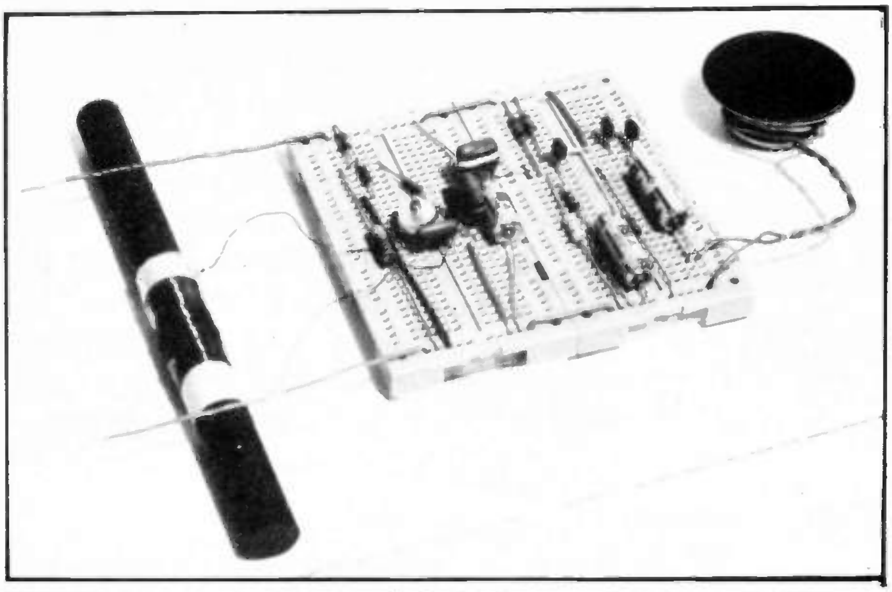
Semiconductors

TR1-TR3	ZTX300 *npn* transistor (3 off)
IC1	ZN414 radio i.c.

Miscellaneous

L1 for Medium Wave Ferrite rod, approx 120mm long, 12mm dia.; approx 2m of 28s.w.g. enamelled copper wire.
L1 for Long Wave Ferrite rod, up to 200mm long, 10mm dia.; approx 8m of 40s.w.g. enamelled copper wire.
Breadboard (e.g two Veroblocs) or 0.1in matrix stripboard, 18 strips×30 holes (Vero 10346); LS1 8 ohm miniature loudspeaker; connecting wire and 6V supply

Approx. cost Guidance only **£10**



For long wave reception (optional) use a longer ferrite rod, (up to 20cm long). On this wind a coil of 300 turns of 40 s.w.g. enamelled copper wire. Note that this is wound in a compact way, to make a short, fat coil, as in Fig. 22.3

To try out long wave reception, you can temporarily wind this coil on one end of the rod you are using for the medium wave coil. Changing wavelength is a matter of disconnecting one coil and connecting the other. A neat way of doing this is to use switches, but you can plug in the coils one at a time.

CONSTRUCTION–BREADBOARD

The radio can be built up on two demonstration breadboards, the tuning and r.f. detection/amplifier stages on one board and the a.f. transistor amplifier on the other board. Both boards are inter-locked together.

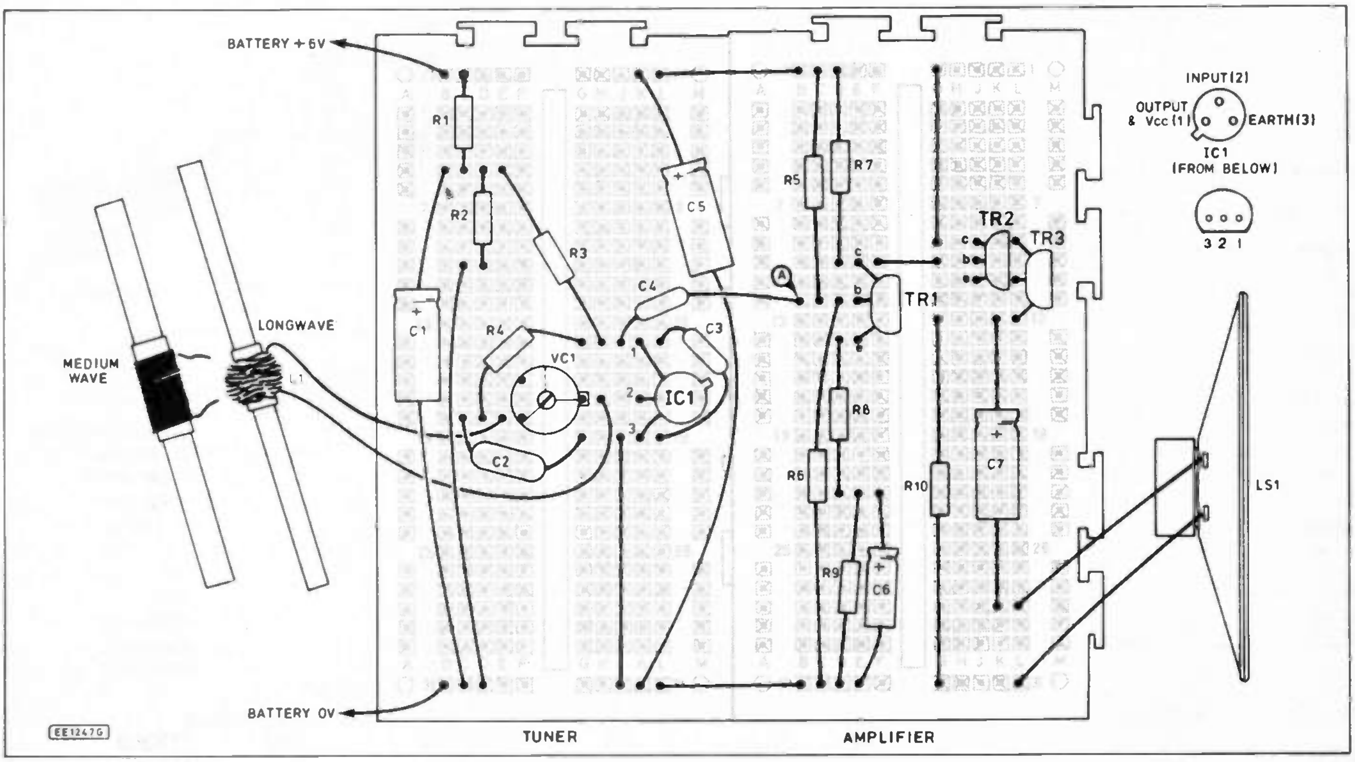


Fig. 22.3. Demonstration breadboard (2 off) component layout for the I.C. Radio. Pinning details for both types of i.c. packages are shown top right. Try to keep the leads from capacitor C3 as short as possible.

ZN414 RADIO I.C.

The ZN414 radio chip is a 10 transistor t.r.f. (transmitted radio frequency) receiver and contains an r.f. amplifier, detector and a.g.c. circuit. The i.c. detects and amplifies the radio frequency (r.f.) signal from the tuned circuit, producing an audio frequency (a.f.) signal–the programme from the received station.

The audio signal is fed from the output of IC1, via capacitor C4, to the transistor amplifier. Once the signal has been "boosted" by the amplifier circuit–TR1,TR2,TR3–it should have sufficient power to drive the small loudspeaker LS1.

CONSTRUCTION–AERIAL

For medium wave reception, wind a coil on a ferrite rod as follows. Wrap a piece of paper around the ferrite rod and fix it with sticky tape. Then wind the coil of enamelled copper wire on the paper sleeve, until you have 70 turns. Each turn should touch but not overlap its neighbours.

When you have finished winding, fix the ends of the coil in position by wrapping a piece of tape around each end and twist the wires together. Allow about 10cm of free wire at each end of the coil. Scrape the enamel from the ends of these wires. If you still have the coil you wound for the project in July 1986, you can use it again here.

The "test-bed" component layout and wiring for the Simple I.C. Radio is shown in Fig. 22.3. Try to keep all leads around IC1 as short as possible, particularly the decoupling capacitor C3.

It is best to begin by setting out the amplifier circuit and making sure that this works. Build the complete circuit, including capacitor C4. Switch on the battery and then touch side *A* (see Fig. 22.2) of C4 to the 6V line and 0V line in turn. You should hear loud clicks from the speaker if the amplifier is working properly.

When wiring up the tuning and r.f. detection sections of the circuit, follow the layout shown in Fig. 22.3 as closely as you can. Check carefully that you insert the correct pins of the i.c. in the sockets *before* you switch on, otherwise the i.c. may be destroyed.

If you examine the variable capacitor VC1, you will be able to see which terminal is connected to the set of *fixed* plates and which is connected to the set of *moving* plates. Connect VC1 the correct way round, as indicated in Fig. 22.2. Note that the aerial rod should not be placed near any large object made of metal.

When all is ready *and checked again* for proper connections, switch on. You will probably hear a station straight away—you may even hear several at once! Adjustment of VC1 will bring one station into tune.

Except in the evenings when foreign stations may cause some interference, you should have no difficulty in tuning to all the main BBC stations on medium wave, including local radio stations. If you receive nothing, check your connections again.

If you have difficulty in receiving any particular station, try turning the ferrite rod to point in various directions. This increases the strength of some stations while reducing others.

If this fails, it may be that the station you are seeking is beyond the range to which your circuit can be tuned. Experiment by removing a few turns from the coil. Alternatively, try the effect of adding a fixed capacitor of small value *in parallel with* VC1. The added capacitor should be about 50 picofarads (pF).

–STRIPBOARD VERSION

This project is a good one for building into permanent form and the stripboard component layout and wiring is shown in Fig. 22.4. Make sure that you make all the breaks in the copper strips as indicated.

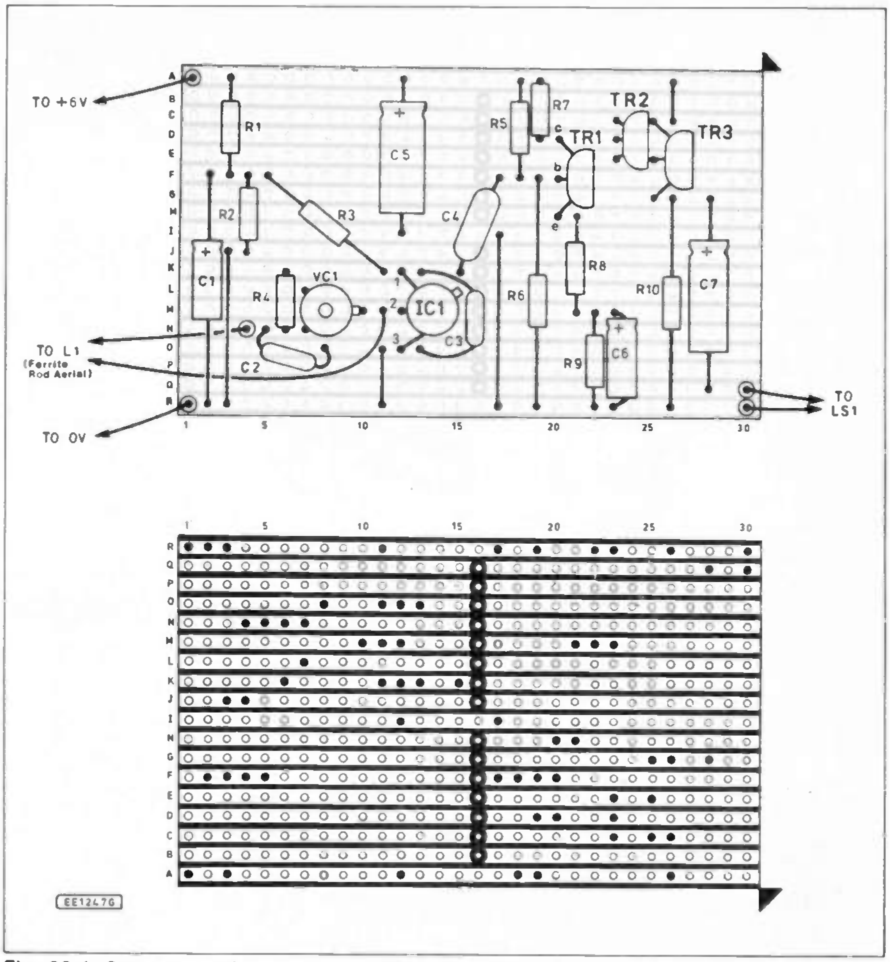
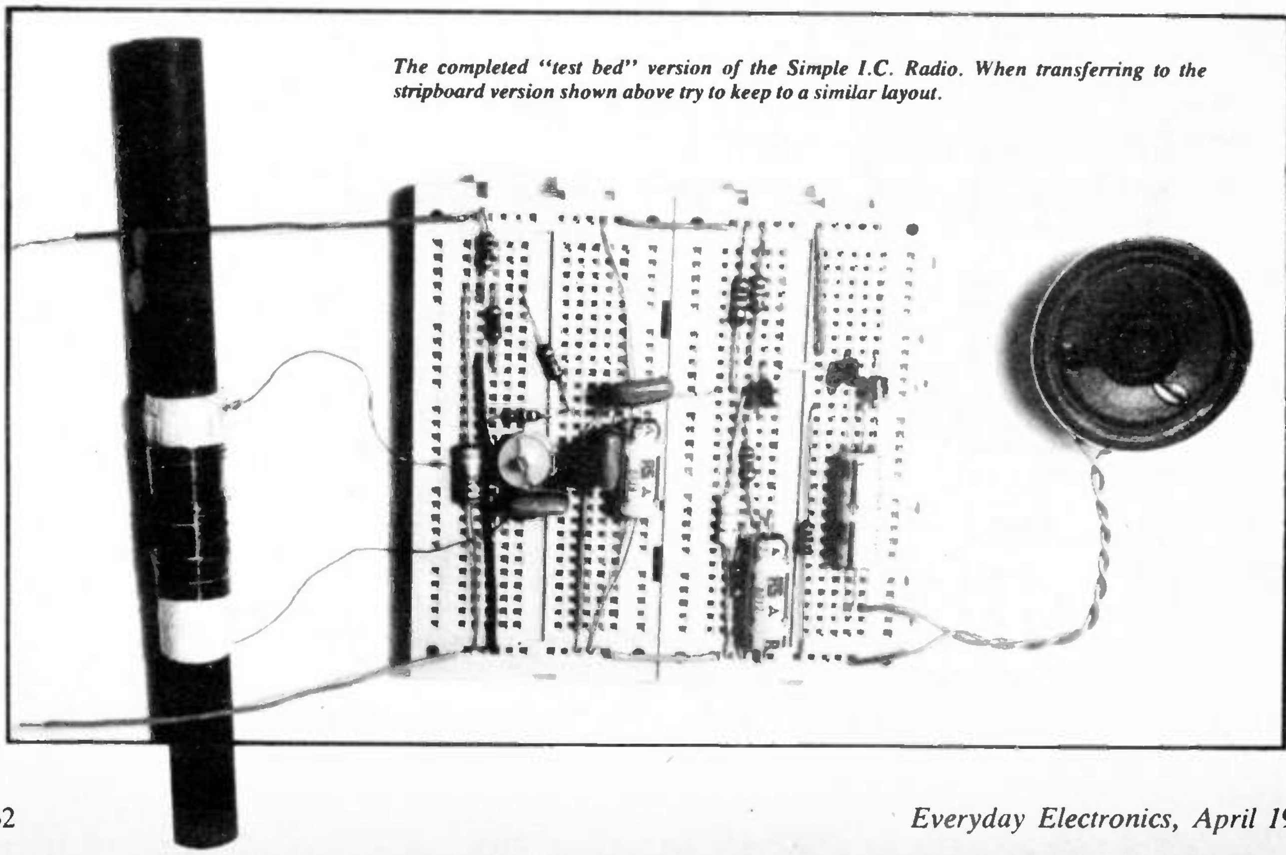


Fig. 22.4. Component layout and details of breaks to be made in the underside copper tracks. These can be made using a small twist drill.

When you are transferring it to a permanent stripboard try to keep to the same layout. In particular capacitor C3 must be soldered as close as possible to the earth (Gnd) and output (Op) pins of IC1.

Use a heat shunt when soldering IC1 and the transistors. Also be sure to turn the power supply off while soldering, as this i.c. may easily be damaged if you try to solder while power is on.

Next Month: We investigate the Op. Amp Summer and demonstrate a simple Digital-to-Analogue Converter.



The completed "test bed" version of the Simple I.C. Radio. When transferring to the stripboard version shown above try to keep to a similar layout.

... Parallel-to-Serial Conversion ... Dual Port Converter ...

IN THE last *Beeb Micro* article our discussion of the BBC computer's serial port reached the stage where data could be sent in serial form, and converted into eight bit parallel bytes to control user add-ons. In this month's article we will look at the problem of using the serial port to read parallel data from user add-ons. With some simple hardware the RS423 serial port can be used to act as an eight bit parallel input port, and with a little further circuitry it can be expanded to 16 lines or more.

In common with the serial to parallel converter unit described previously, this unit should work with any computer that has a standard RS232C or RS423 serial port, and it is far from restricted to operation with only the BBC machines. Much of the information here should therefore be of interest to owners of other computers, but obviously a few points of detail are specific to the BBC machines.

Basic Conversion

The circuit diagram of Fig.1 is for a basic parallel to serial converter. Like the basic serial to parallel converter circuit described in last month's article, this circuit is based on a UART (universal asynchronous transmitter/receiver). In the earlier design the receiver section was used, and in this circuit it is the transmitter section that is utilized.

It is perfectly possible to have serial to parallel and parallel to serial converters based on the same UART, but there are a few points that should be borne in mind. The main one is that the inputs used to program the word format are common to both sections of the unit. Consequently, the unit must use the same word format for transmission and reception. This should not be a major drawback if the unit is used with the BBC computer, where there would seem to be little point in using anything other than the default word format of one start bit, eight data bits, and one stop bit with no parity. This is the word format obtained with the program inputs connected as shown in Fig.1. See the previous *Beeb Micro* article for details of how to obtain other formats.

The 6402 (IC3) has separate receive and transmit clock inputs, and (like the BBC computer) it could be used with split baud rates. In most cases there would be no point in using different transmit and receive baud rates, and a single clock generator circuit could be used to drive both pin 17 (the receive clock input) and pin 40 (the transmitter clock input). In this circuit the clock generator is based on TR2 and IC2. It gives a baud rate of 9600, and it is identical to the clock generator in the receiver circuit. Therefore, it will not be discussed further here.

Speed

Note that 9600 baud is the highest rate at which the BBC computer is guaranteed to work. There are operating system commands to set both receive and transmit rates of 19200 baud though, and my BBC model B has always seemed to work perfectly well at this rate on the few occasions that I have tried it. 9600 baud allows just under one thousand bytes per second to be read, which should be adequate for most applications. Using a BASIC program it would almost certainly be the execution speed of the program rather than the speed of the serial port that would be the limiting factor governing the rate at which data could be read.

A UART does not automatically send a continuous stream of data. A low level on the TBRL (transmitter buffer register load) input causes the parallel data on the inputs to be transferred to the transmitter buffer register. The TBRL input going to the high state then causes data to be transferred to the transmitter register, and transmitted together with start and stop bits. If the transmitter register is full, data transfer to this register is held-off until the byte it contains has been sent (and further pulses on the TBRL input are ineffective).

In this circuit a simple 555 oscillator based on IC1 is used to provide a continuous stream of pulses to the TBRL input of IC3, and data is transmitted at something approaching the maximum rate possible at 9600 baud. This method is adequate for most purposes, but if necessary an output line controlled by the computer can be used to activate IC3 as and when required. This output line could conveniently be one from the serial to parallel converter circuit described last month. Note that if a different baud rate is used, the operating frequency of IC1 should be speeded up or slowed down in proportion. The operating frequency of IC1 is inversely proportional to the value of C1. An excessive trigger rate is unlikely to cause any problems with corrupted data though, as IC3 will almost certainly just ignore any excess trigger pulses.

Supply

To produce a "Proper" RS232C/RS423 output signal it is necessary to have a negative supply, since the nominal voltage levels used by these signals are plus and minus 12 volts and plus and minus five volts respectively. In practice the interface may often be used in applications where no negative supply rail is available. It is not too difficult to derive a negative supply rail from a +5V supply, but this is not really necessary.

Most serial inputs seem to respond perfectly well to 0 and 5 volt signal levels, although with these reduced voltage levels it is presumably not possible to use the very long connection cables that are possible with true RS232C and RS423 drive levels. This should not really be a restriction in the vast majority of applications where connecting leads a few hundred metres long are unlikely to be required anyway!

The line driver in this circuit is a simple common emitter switch based on TR1. R1 provides output current limiting to protect TR1 in the event of the output of this unit being accidentally connected to another serial output line.

Battery operation of the unit is quite feasible as the current consumption of the circuit is only about 10 milliamps. This assumes that a low power 555 timer device is used in the IC1 position. The current consumption will be increased by approximately four milliamps if a standard 555 is used here.

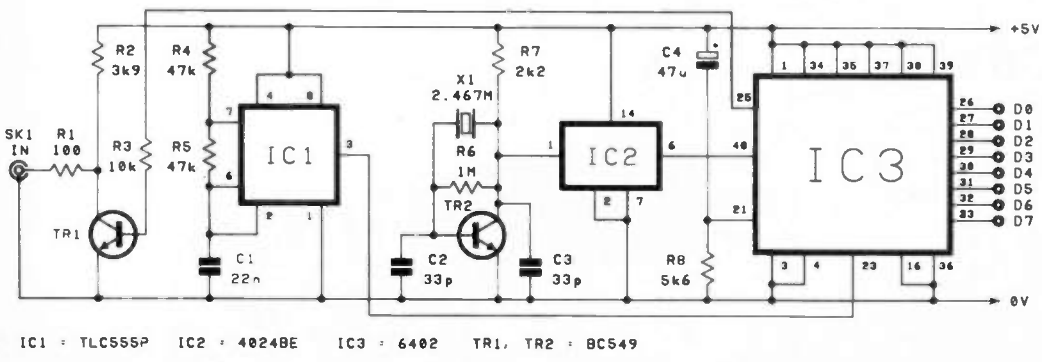


Fig. 1. The parallel to serial converter circuit

In Use

The receive baud rate of the BBC computer is set using the ***FX7,X** command, where "X" is the correct value for the required baud rate (see page 424 of the User Guide). For a rate of 9600 baud the command ***FX7,7** is required. The receive register of the BBC computer's 6850 serial interface device is at address &FE09. This simple routine will set the baud rate to 9600 baud and continuously read data from the serial port:—

```
10 *FX7,7
20 PRINT ?&FE09
30 GOTO 20
```

If the parallel to serial unit is working correctly, the returned values should reflect the levels fed into its parallel input, and should almost instantly respond to any changes made to the input levels.

There is a potential flaw when using this interface, and this is due to the buffered receive register of the BBC computer's 6850. When a byte is received it is fed from the receive register to a buffer, and it is from here that it is read. Once it has been read, the next byte (if there is one) is transferred from the receive register to the buffer. The potential problem surfaces if the serial port is only read infrequently. The byte that is read from the port will be the next one received after the previous reading was taken, and as such it is an old value that might not match the last one sent by the converter. The easiest way around this is to take two readings, but to discard the first of them. The second reading should be a recent one, and therefore a valid reading.

When using assembly language and frequent reading of the port there is a risk of reading the same byte of data twice. This can be avoided using a timing loop to ensure that an adequate delay is left between readings, or a bit of the 6850's status register at ?&FE08 can be used. The relevant bit is bit 0, which can be read by taking the value from ?&FE08 and ANDing it with 1. This gives an answer of 1 if there is a fresh byte of data available, or 0 if there is not.

More Inputs

The method of obtaining more outputs on the serial to parallel converter does not really apply itself well to this unit. I suppose that an equivalent system would be possible, with data from two input ports being fed through to the UART alternately. It would be difficult to get the interface properly synchronised with the computer initially, and to then keep it properly synchronised. It is probably more practical to sacrifice one or two outputs from the serial to parallel converter, and to use these to control a standard multiplexer circuit. The required port is then selected by setting the control output or outputs to the correct state, after which a value is read from it.

The circuit of Fig.2 shows how a single output line can be used to control a 16 line to eight line multiplexer. IC4 and IC5 are octal transceivers, but in this circuit they are both permanently wired in the "receive" mode, and they really just act as octal tristate buffers. To activate one of these devices its pin 19 must be taken low. Pin 19 of IC4 is driven direct from the control line, but IC5 is controlled via an inverter (IC6). Therefore, only one or other of these buffers will be activated, depending on the state of the control line. More specifically, a low level selects port A, while a high state selects port B.

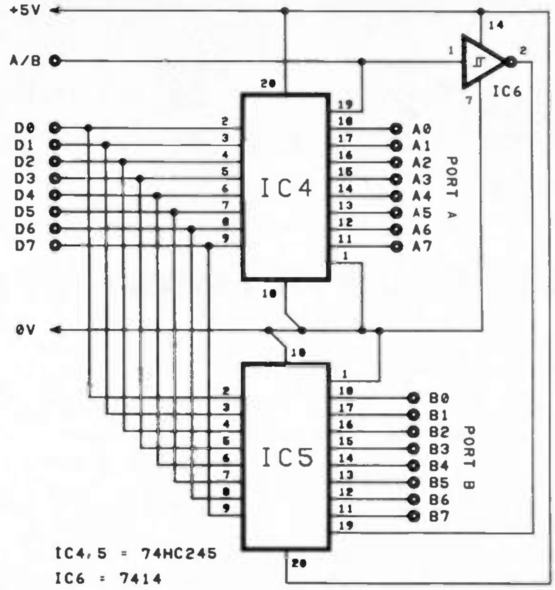


Fig. 2. Adding an extra port to the converter

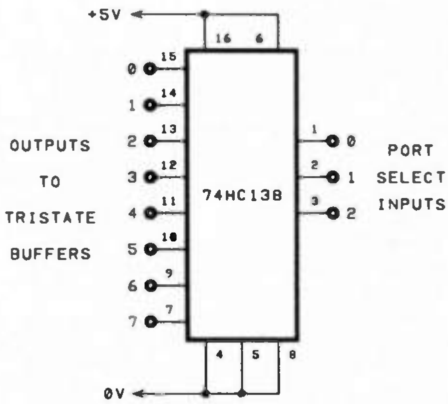


Fig. 3. A circuit to control up to eight input ports

Sixteen input lines are sufficient for most purposes, but further ports are easily added if desired. It is just a matter of adding further 74HC245s, with some control circuitry to feed pin 19 of each device. This control circuit must only take one pin 19 low at any one time. A 74HC138 three to eight line decoder is well suited to this application, and connection details for this device are provided in Fig.3.

The three "enable" inputs of this device are wired to the appropriate supply rails so that it is permanently enabled. One of its eight outputs (and only one) will always be at the low state. The binary value on the three inputs sends the corresponding output low (011 would set output "3" low for example).

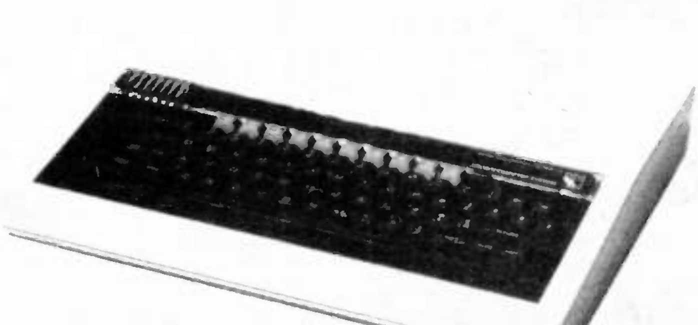
By feeding three port select lines to the inputs of the 74HC138, it is therefore possible to use the outputs to select one of up to eight 74HC245 buffers. This gives a maximum of 64 input lines, and enormous potential.

However, care must be taken to ensure that readings are from the port you think they are from! For good reliability in this repect it is advisable to output the appropriate value to the port select lines, read the interface, and discard this value which is probably erroneous, and then read the interface again to obtain a valid value. Another point to bear in mind is that the more ports you use, the less frequently each one can be read.

If only four or less outputs of the 74HC138 are used, input "2" will not be needed, and it should be connected to the 0 volt supply rail. Do not simply leave it floating as it will almost certainly assume the high state.

Potential

Although serial ports have been little used for computer projects in the past, they certainly have good potential in this area. An advantage of using a serial port is that, as far as the hardware is concerned, it makes a project largely machine-independent. There are few computers that do not have an RS232C compatible port, or which cannot be equipped with one. Possibly this factor will lead to serial ports featuring more prominently in computer projects in the future. If the RS423 port of your BBC computer is otherwise unused it is certainly worth considering its potential for user add-ons, especially if the 1MHz Bus and User Port are getting rather over-utilized!



Constructional Project

UNIVERSAL MONITOR

A. H. ROBSON

This simple unit can be used to monitor the movements of old people, to keep an "eye" on children in bed or to detect the presence of intruders.

As THE population of this country grows older, more and more pressure is put on couples with families to look after ageing parents. Confined to a room, unsure in their movements, old people can stagger and fall, and possibly lie on the floor unable to summon help.

This device reduces the risk of accidents passing unnoticed, and keeps the family in touch with the movements of an old person who lives alone in another part of the house. It also has obvious applications as an intruder detector or as a child monitor.

OPERATION

Three pressure mats placed near to the bed are connected to a console which is monitored by the family. When one mat switch closes a visual warning is given, and if more mats operate buzzers are sounded, indicating that the person may have fallen to the floor.

The circuit is based on two CMOS i.c.s, namely a NE555 and a 4017 decoder. The 4017 drives a series of five l.e.d.s which flash in sequence at a slow rate when on standby.

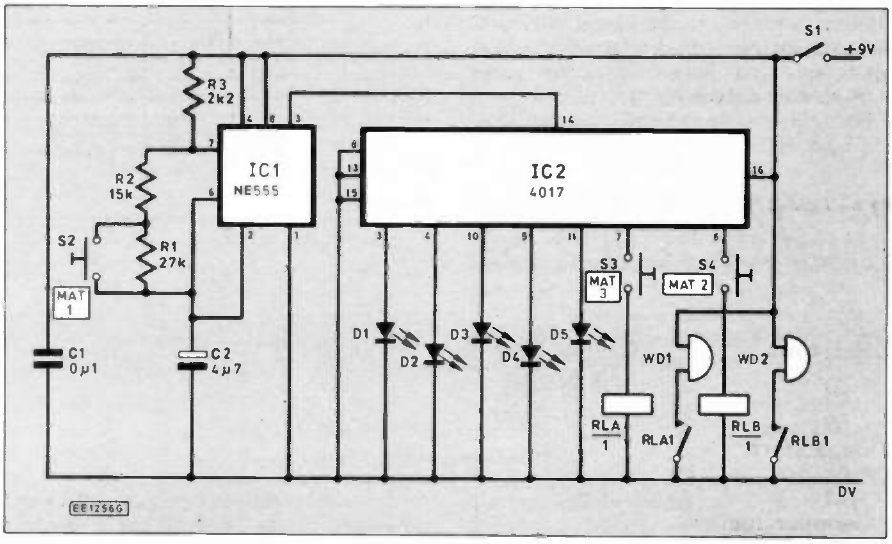
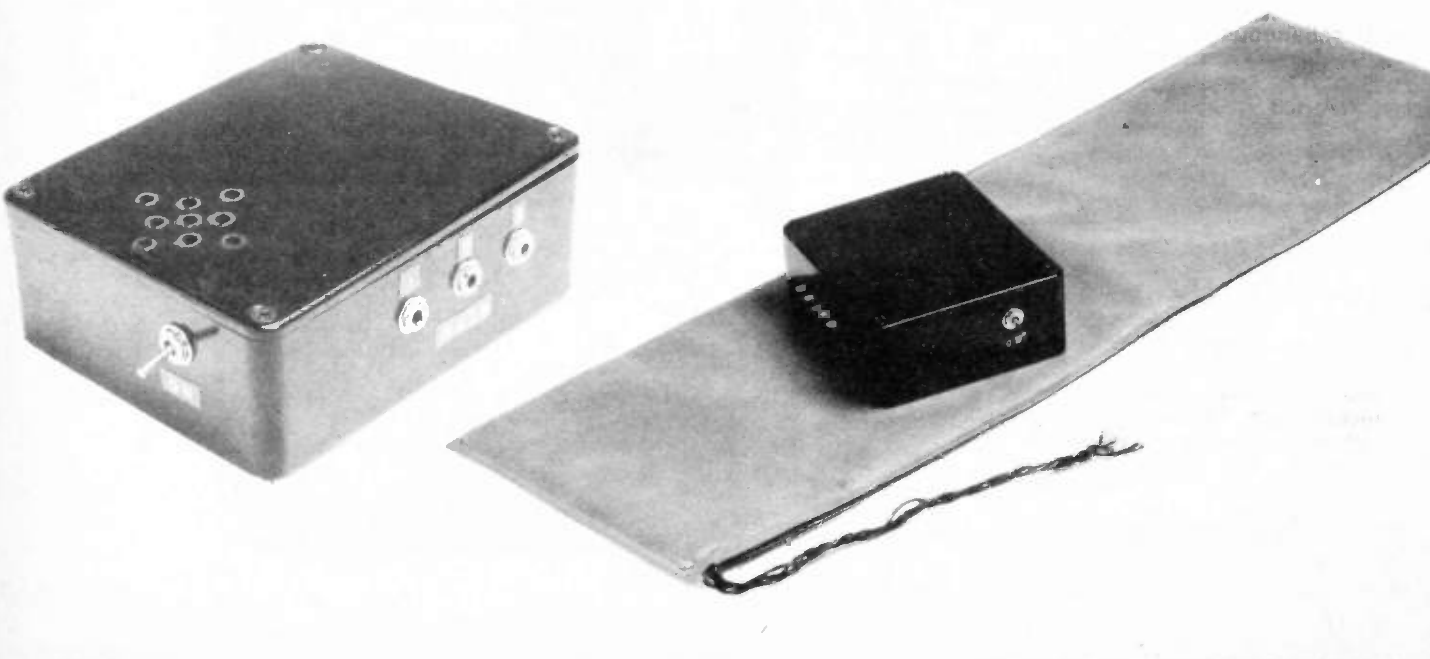


Fig. 1. Complete circuit diagram of the Universal Monitor.



When the mat nearest to the bed is switched on the array speeds up, indicating that the occupant has stepped out of bed. As the other mats switch on, the buzzers operate, showing that steps are being taken across the room. However, should the l.e.d. sequence stay at fast speed and one or more buzzers function, then it is probable that the occupant is lying on the floor.

CIRCUIT CONSTRUCTION

The components are mounted on Veroboard except for the l.e.d.s, battery and buzzers which are fixed separately inside the plastic case. The i.c.s are mounted on low-profile sockets. The wire prongs of the encapsulated reed relays fit conveniently onto the 0.1 inch Veroboard.

The l.e.d.s are mounted on the outside of the case through holes drilled in the plastic. Ensure that they are connected in the order given in the circuit diagram, when they will flash in the correct sequence. Holes must also be drilled for the sockets which take the plugs leading to the mats.

USING THE MONITOR

Locate the mats near to the bed with the visual display mat close to the bed frame. If required, other mats can be added which should be connected in parallel to the existing mats, or wired to the vacant 4017 outputs, via additional reed relays. For a neat wiring job, run ribbon or similar cable between mats and console.

Place the console in a prominent position where it can be seen and heard by the family. And for night surveillance run the cables to a bedroom so that someone can be alerted in case of an emergency.

To use the unit as an intruder detector the mats could be placed around windows or doors. It is also possible to add a personal call button simply wired in parallel with RLA1 or RLB1. In this way a buzzer can be sounded by pushing the button. □

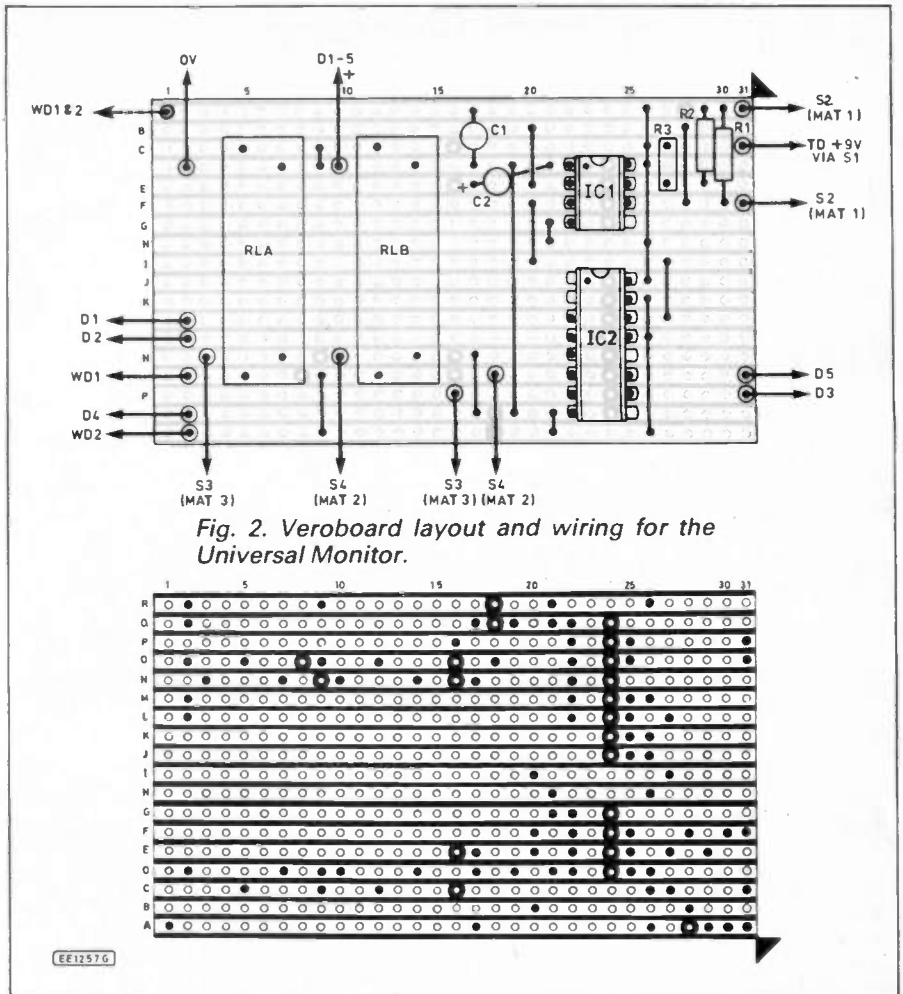


Fig. 2. Veroboard layout and wiring for the Universal Monitor.

COMPONENTS

Shop Talk
See page 244

Resistors

R1	27k
R2	15k
R3	2k2

Capacitors

C1	0µ1
C2	4µ7 elect. 40V

Semiconductors

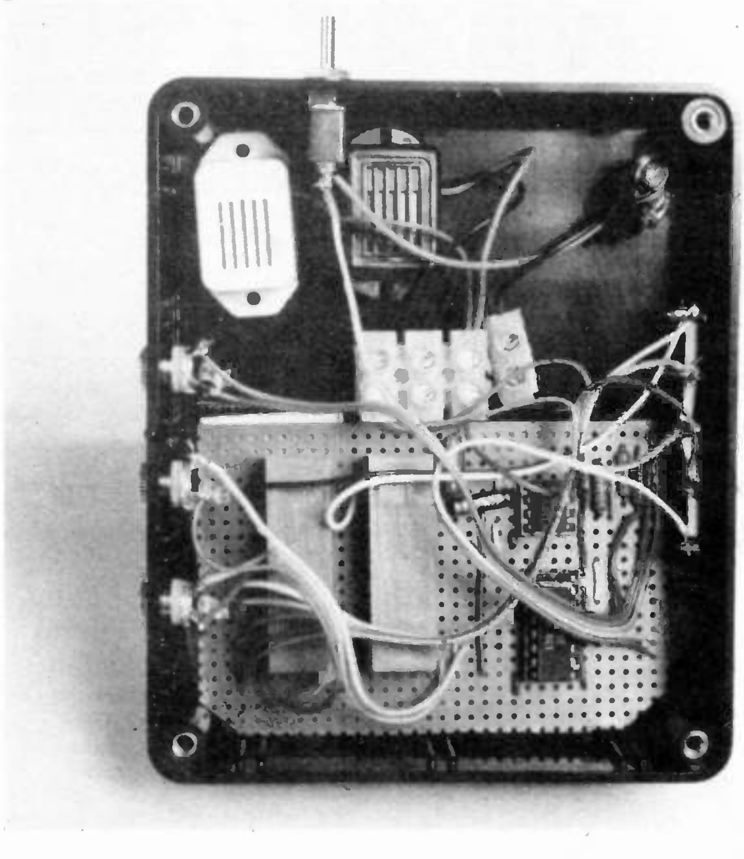
IC1	NE555
IC2	4017
D1 to D5	yellow l.e.d.s (5 off)

Miscellaneous

S1	s.p.s.t. toggle switch
RLA, RLB	Encapsulated reed relay, 700ohm, green body, 6-9V operating (2 off)
S2 to S4	pressure mats (3 off)

4-pin and 8-pin low-profile i.c. sockets; buzzers, solid state, 450Hz, 9V, (2 off); Veroboard, 0.1 inch matrix, 80mm×50mm; plastic case, 120×100mm; PP3 long-life or rechargeable battery; miniature jack plugs, (3 off); miniature jack sockets (3 off); ribbon or similar cable as required.

Approx. cost Guidance only	£20 including mats



...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

HF PROPAGATION

Listeners to short-wave transmissions will be aware that on particular bands conditions are sometimes good, with many stations coming through, and sometimes bad, with few if any signals to be heard. Radio conditions vary from band to band at different times of the day, different times of the year, and at different times during the eleven year sunspot cycle—and within these cyclic patterns events occur resulting in conditions often opposite to those expected!

When amateurs talk about the "HF" bands they usually mean the frequency spectrum 1.8MHz to 30MHz, which contains nine bands of frequencies available for amateur operation, each band having its own characteristics. For h.f. communication, amateurs depend on the existence of the ionosphere, which comprises two distinct sections, the "E" layer and the "F" layer (divided during the day into the *F*1 and *F*2 layers).

These layers reflect radio signals back to earth to be received at distant points on the earth's surface. The ability of these layers to reflect signals depends on their degree of ionization, which is believed to be caused by ultra-violet radiation from the sun.

The greater the ionization of a layer the more the path of a radio wave striking it is bent. The bending or reflection also depends on the wavelength. The longer the wave, the more the path is bent for a given degree of ionization, so that low-frequency waves, e.g, at 3.5MHz or 7 MHz, are more readily reflected than the higher frequencies of 14-30MHz. On occasions, the ionization is so low there is insufficient refraction to return the higher frequencies to earth.

ABSORPTION

Apart from reflecting signals, the ionospheric layers absorb some of the energy of the radio wave. Absorption is greater at low frequencies. It also increases with the intensity of ionization and with the density of the atmosphere in the ionized region.

Apart from the *E* and *F* layers, which have heights of approximately 70 and 175 miles, there is a lower ionized area, the "*D*" region, in the daytime which almost completely absorbs signals at 1.8MHz and 3.5MHz. Only high-angle signals have any chance of being reflected by the *E* layer above. Lower-angle radiations have a longer path through the *D* region and therefore suffer greater absorption

Amateurs trying to obtain long distance communication use antennas designed to provide low-angle radiation of their signals (*see EE December 1987*). The lower the angle at which the signal leaves earth the less bending is required to bring it back down, and the greatest distance occurs between the point where it leaves earth and the point where it returns.

Nearer contacts require high-angle radiation to ensure that the signal comes down at some not too distant point. Apart from ionospheric reflection, the signal is also radiated by "ground wave", which extends for a few miles around the antenna.

The area between the end of the usable ground wave and the beginning of ionospheric-wave reception is called the "skip zone", as no signals can be received in this area. The distance from the transmitter to the nearest point where the skywave returns to earth is the "skip distance".

Changes in ionospheric conditions result in the skip zone varying constantly. When higher layers are reflecting there are longer skip distances for the same angle, and the opposite with lower layers. At any given time, over a specified distance, there is an upper limit to the frequency which can successfully be used over that distance—known as the maximum usable frequency (m.u.f.).

MULTI-HOPS

Sometimes signals follow a multi-hop path, reflecting up and down between ionosphere and earth several times. This results in very long distance propagation but, inevitably, both ground and ionosphere absorb some of the energy on each reflection, normally making the received signal weaker the greater the number of hops.

Fading is a common phenomenon arising from several causes. Two or more parts of a wave can follow slightly different paths to the receiving point. The different paths may cause a phase difference to exist at the receiving antenna with changes in the paths causing the difference to vary in such a way as to aid or oppose the signal over a period of time. Slow fading occurs in relatively stable conditions while rapid fading results from rapidly changing conditions in the ionosphere.

Some sunspot activity causes disturbances in the ionosphere known as ionospheric storms, characterised by a considerable increase in absorption. This makes radio conditions poor, with only the lower frequencies usable for communication.

The opposite effect occurs arising from sporadic-E ionization, when patches of relatively dense ionization appear at heights approximately the same as the E-layer, allowing communication over distances not normally attainable at the time of their appearance. Tropospheric propagation, arising from changes in the temperature and humidity of the lower air masses, permits working over greater than normal ground-wave distances on 28MHz and higher.

FORECASTS

So how does the radio amateur know when is the best time to go on the air, and which is the best band to use to communicate with particular parts of the world? Some make a study of propagation and provide their own forecasts.

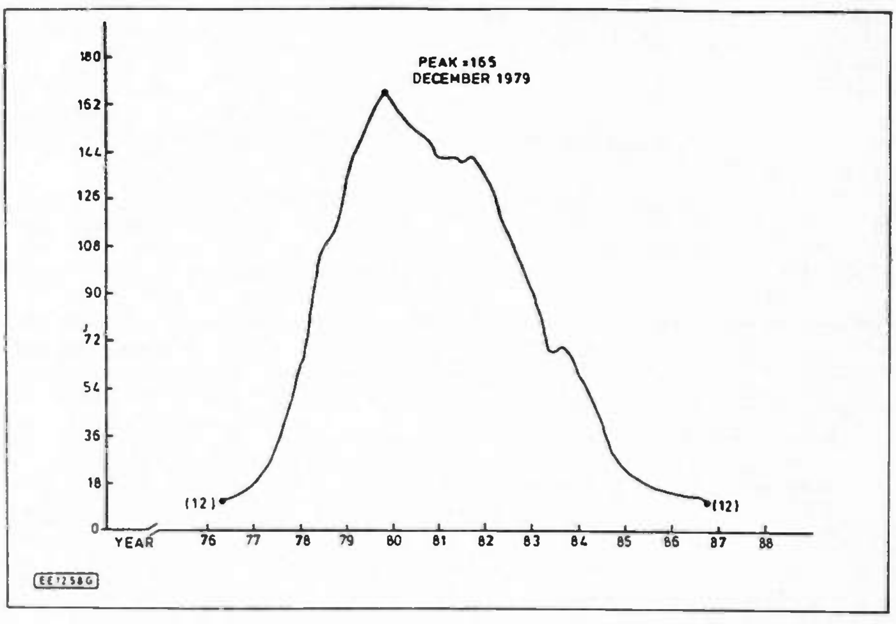


Fig.1. Smoothed sunspot count, Cycle 21, June 1976 to September 1986.

These are based on observed conditions and on information about sunspot activity published by scientific institutions in a number of countries.

Some magazines publish monthly propagation forecast tables, and *Radio Australia* transmits useful propagation reports, including 24-hour forecasts, six days a week which can be well received in the UK. There is, therefore, quite a lot of information available if one is able to use it.

If an amateur is restricted in his or her operating times by domestic or other circumstances, however, then it is just a question of getting on the air whenever possible to see what's coming through! You don't have to have a propagation forecast to work Australia, but your chances of success are probably greater if you do have one and can be guided by it!

SOLAR ACTIVITY

There was a period of very low solar activity as the last sunspot cycle, No.21, neared its end (this occurred in September 1986, see Fig 1.) and the new cycle, No.22, began. There is general lethargy during sunspot minima. Long distance (dx) communication is at a low level and shorter distance working, mainly on the lower frequency bands, is the order of the day.

Conditions improve as the new cycle progresses and suddenly it is possible to work the world again with "flea-power" and the proverbial piece of wet string as an antenna. Countries you have forgotten ever existed produce daily contacts and the excitement of new achievements spurs one on with conditions getting better all the time.

The upsurge period of a new solar cycle is definitely a good time to be a radio amateur!

MARKET PLACE

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WANTED to buy or borrow circuit diagram etc., for ITT Metrix miniature oscilloscope, Model 101B. L. Bailey, 1 Longmere Crescent, Carnforth, Lancashire, LA5 9EW

WANTED urgent memory unit for communication receiver FRG7700 to convert RFG7700M. Mr. Balmforth, Tel. Stonesfield 337.

WANTED service manual for Sensors and Systems Micro 8 central heating controller approx 6/8 years old. N.B. Hateley, 0740-30025.

HISTORIC EKCO eliminator circa 1928 3 Hts–5G.Bs and L.T. to 6V with Vernier and meter £25. J. Wilmot, 0424-221636.

FREE. 250 1/2W. 2% resistors plus 40 metal polycaps full leads. Wife forces clear out. £1. post & packing, D.M. Evans, Pentre Gwyn, Tyn-Y- Cefn, Corwen, Clwyd LL21 0ER.

3 SPECTRUM power supplies 9V 1.4A. Commodore 64K power supply £2 each plus postage. Joe Bakewell, 21 Newbarns Road, Barrow in Furness, Cumbria LA13 9SF

CONN Strobotune Organ Keyboard Tuner with MIC £25. Tel 041-429 1303 Mr. Frank Brown.

ELECTRONIC mags. most years and names from 1973. All mint, offers the lot. Enterprise 64 computer new £40. Phone Mr. Pearce 0703 788278.

OFFERS please Everyday Electronics March 1979 to November 1985 inclusive. August 1981 missing. Tel Mr. Lancaster, 0695 622522.

OHIO Superboard Computer mint condition runs Basic and 6502 machine code £55. Phone Mr. Houghton 0423 330620.

IBM PC-XT hardware service manuals 2 vols. plus Dianostic Diskette £30 o.n.o. new. Mr. Daniels 0332 880061.

SPECTRUM Power Pack cases, slightly dirty, no fixing screws, ideal for small projects. 20p P & P free. Mr. J. Norman, 25 Milton Road Corby, Northants NN17 2NY.

WANTED: Circuit diagrams or service manual for Ramtek Monitor Chassis used in arcade video game. S. Timmons, 6 Compley Avenue, Poulton L· Frylde, Lancs FY6 8AL.

TWIN BSR turntables with ceramic cartridges ideal for disco replacement, good condition only £20. Richard Kind, 0777 701040.

WANTED u.h.f expander 430X unit for FDK 750 rig plus circuit diagram—George Tel. 02-300-1649.

DRAPER rechargeable soldering iron boxed, brand new £10. Tel. 0408 21870, after 6 p.m. please.

WANTED: Chromatheque Disco Lights Controller. Complete, busted p.c.b. only? even p.c.b. foil, anything considered. Mr. Taylor 0253 695778.

WANTED: record player for 78's with suitable cartridge. Amplifier not essential. Surrey or S.W. London. Tel 0306-730188.

COMPONENTS, Boxes, p.c.b's speakers, power supply, meter, books & lots more, for sale £35.00 o.n.o. Mr. T. Dougan, 55 Greenan, Shaws Road, Belfast BT11 8LX.

PROFESSIONAL or amateur, help required. Repair electronic piano Southampton Area. Mr. A. Browne, 111 Mortimer Road, Southampton S02 7HT. Tel. 0703 444742.

ENTERPRISE 64 brand new in box, used twice includes Basic cartridge. Offers over £40. S. Timmons, 21 Howarth Crescent, Poulton Le Fylde, Blackpool FY6 7JG. 892327.

WANTED: Very early transistor types in any condition. Wanted: list and prices available on request. Andrew Wylie, 5 Lyncroft Gardens, West Hampstead, London NW6 1LB.

WANTED: Sinclair ZX81 16K computer in good working order. Fair price given. Write to Mr. T. Puttick, 5 Brookview, Coldwaltham, Pulborough, W. Sussex RH20 1LU.

WANTED: Operation instruction and circuit diagram for the "Horizan System" 2 channel radio control unit. Mr. N.L. Davison, 188 Galsworthy Road, South Shields, Tyne & Wear NE34 7RE.

SONY SQD 2010 4 track quadrophonic decoded £50. Radford v.h.f. stereo valve tuner £20. Tel Coleshill 62308.

WANTED single trace oscilloscope, good condition for birthday/Christmas present. Mr. Boothby Tel 01-670-0794.

Name & Address:			

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EE MARKET PLACE APRIL '88

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Crossroads

British broadcasting is at a crossroads. The Government (the DTI and Home Office) is looking at ways of creating more TV channels by using terrestrial transmitters. Obviously this is cheaper than launching satellites into space.

But widening the choice of programmes cheaply available from terrestrial transmitters pulls the rug from under existing plans for direct broadcasting by satellite. It will cost BSB, the consortium licensed by the Independent Broadcasting Authority to provide a DBS service, around £200 million to start the service. Break-even is not expected until at least £600 million has been spent. And that figure assumes no extra competition from terrestrial services.

Much has been written about the politics of this dilemma but relatively little about the technology. This is doubtless because it is quite difficult to get nitty gritty answers to burning questions.

Subscription Service

The BBC has already started to experiment with "downloading". Programmes are transmitted during the dead night hours, in scrambled form, for reception by video recorders with a built-in descrambler. The idea is to run a subscription service. Only subscribers get the descrambler.

The first programmes will be medical information material, aimed at doctors. But the BBC clearly intends to expand and transmit premium entertainment like feature films.

Already both the BBC and IBA are transmitting scrambled, "closed user group", teletext. Large department stores feed data, for instance on tomorrow's price for baked beans, into the BBC or IBA's teletext systems.

This data is interleaved with normal Ceefax and Oracle teletext, but it is coded so that conventional receivers ignore it. Subscribers, e.g. store branches around the country, use modified receivers to display the data.

Legality

Technically there are no problems. But what about legality? The BBC is bound by the *Telecommunications Act 1984* and the IBA by *Broadcasting Act of 1981*. Both are similarly worded. They put the transmission of scrambled programmes, for reception by subscribers only, right on the borderline between legality and illegality.

The crucial words in the Acts are that broadcasts must be " *for general reception.* "Otherwise they become telecommunications. So the BBC, ITV stations and Channel 4 cannot transmit a programme which some people are barred from viewing or hearing.

At first sight, this makes scrambled subscription TV and closed user group teletext illegal. The counter argument—so far accepted—is that anyone can buy a decoder if they want to.

It will be interesting to see what happens if someone pushes the point, and makes a test case by demanding that they be allowed to buy a decoder to receive closed user group teletext signals. What will happen, for instance, if one chain of groceries demands the right to receive pricing information transmitted by a rival?

Fifth TV Channel

The BBC and IBA have already told the Goverment that, with careful frequency planning, there will be room for a fifth TV channel in the UHF band, reaching around 70 per cent of the population from 14 transmitters.

These would share two u.h.f. frequencies, channels 35 and 37, which are currently used for airport radar. Channel 36 will stay in use for radar—because the airports need some u.h.f. frequencies to give long distance cover—and channel 38 will remain in use for radio astronomy.

The island of four unused frequencies in the middle of the u.h.f. band is peculiarly British. The rest of the Continent uses them for TV. But whereas the BBC and IBA currently manage to provide a four station network, with 44 channels (by re-using the same frequencies on average over 70 times across the country, and sometimes over 100 times) the Continent manages to provide only three networks with the full u.h.f. band.

Obviously it will be very cheap for both the broadcasters and viewers to create a fifth network TV station, by using channels 35 and 37. The extra transmitters will cost only around £20 million. Viewers will at best have only to tune a fifth preset on their sets; at worst they will need a slightly different u.h.f. dipole, tuned to the new channel group—a small price for a fifth channel.

VHF Reception

The other idea is to use some of the VHF bands I and III. These were released when the last 405-line transmitter closed down in January 1985.

At first the Goverment thought it a good idea to give all the Band I and III frequencies to public mobile radio; now it is having second thoughts and may give some of the frequencies back to TV broadcasters. Britain is the only country in Europe not now using VHF for TV.

For Britain the special snag is that allocations for public mobile radio were made without any consideration given to broadcasting needs. These allocations could well effectively sterilise other parts of the band—because TV needs much broader channels than mobile radio. The Government would have to pay heavy compensation if it took back frequencies previously allocated for mobile radio.

Yes, say IBA engineers at the Winchester research laboratories, it would be possible to have a combined u.h.f. and v.h.f. aerial, with tricks like inductive loading to reduce the size. Provided that the v.h.f. TV transmitters were co-sited with existing u.h.f. transmitters, households could then receive all stations with one aerial.

But, warn IBA engineers, there is no getting round the laws of physics. A small v.h.f. aerial would be very inefficient; and thus susceptible to interference. This would not only make the pictures unwatchable, but destroy the encryption keys which are an essential part of broadcasting scrambled subscription programmes. Also combined aerials would be expensive.

Confusion

There is a surprising amount of confusion over exactly what frequencies in Bands I and III have or have not been allocated and thus what compensation the Goverment would have to pay if some v.h.f. frequencies were given back to the TV broadcasters. Here, straight from the DTI horse's mouth is a guide

Around 10 per cent of Band 1, which spreads from 41–68MHz, has been allocated to services which are either already in existence or about to come on stream. Long distance burglar alarms and cordless telephones operate at 47MHz, and short range on-site paging is at 49.0–49.5MHz.

There are some general speech and non-speech uses at 49.82–49.98 and amateur radio "hams" have a band at 50–50.2MHz. There are also two spot frequencies allocated for experimental and scientific work.

A June 1985 policy document from the DTI, with Geoffrey Pattie then the minister, promised the remainder for public mobile radio.

Band III spreads from 174–225MHz, and is divided into three sub-bands; lower, middle and upper. The mid sub-band, 192–205MHz, is already in use for public mobile radio. This sub-band has space for around 500 PMR speech channels. Each channel is made up from two half portions, each 12.5kHz wide and separated by 8MHz, e.g. one channel of incoming and outgoing speech will be at 190MHz and 198MHz, the next at 190.025MHz and 198.025MHz, and so on.

The lower sub-band of Band III is earmarked for future PMR and the upper sub-band is earmarked for advanced forms of PMR, e.g. digital communication systems. Already trials are under way. There are some "temporary and transitional users" in the lower sub-band, for instance radio mikes in theatres, but these will be cleared out as soon as the frequencies are allocated to TV.

One snag with v.h.f. TV reception, is that the aerials are larger than for u.h.f., because the frequency is lower and the wavelength longer. Band I aerials are around twice the size of band III, which is why most countries in Europe use Band III for television, rather than Band I.

It remains to be seen whether the lower and upper sub-bands of Band III remain on offer to PMR, or are snatched back and given to broadcasters.

Satellite Broadcasting

So what about satellite broadcasting? The IBA knows full well that when DBS transmissions begin, they will be flooded with enquiries from members of the public who have tried to erect a dish, and found out the hard way that signals from a satellite hanging over the Equator come into Britain at a low angle, will not get through the leaves of a tree and can only produce clear pictures if the dish is aligned with an accuracy of around one degree.

The plus point is that, provided it is properly mounted, a DBS dish can be smaller than a v.h.f./u.h.f. rod array. There is also the advantage of wider bandwidth. This is what makes it possible for direct broadcast satellites to use the new MAC TV system.

The snag here is that the Continent has gone for D2-MAC and Britain for D-MAC. The British D-system matches video bandwidth (8.5MHz) with digital data rate (8.5MHz carries 20.25 Mbit/second bursts of duo-binary code to give eight full bandwidth sound channels).

D2 halves the data rate to bursts of 10.125 Mbit/second which, with duo-binary coding, squeeze into a transmission bandwidth of around 4.25MHz. The vision signal is trimmed to match, to around 5MHz.

The advantage is that this D2 signal will go through an existing cable network. The disadvantage is the loss of four sound channels and some picture clarity.

ITT on the continent makes D2 chip sets, but these will not receive D-MAC signals. Plessey, Mullard and Nordic VLSI are making a multi-standard chip set which will receive D or D2. But the chip set is not yet ready or priced.

So far there are no D2 receivers available on the Contiment, but this does not matter, because the German satellite *TV SAT*, which should by now already be broadcasting D2-MAC signals, is not working properly. The launch of France's sister satellite, *TDF-1*, has now been delayed while engineers look for design faults.

Meanwhile, there are trade rumours of poor reliability in the ITT D2 chip set. The medium-powered *Astra* satellite, to be put up by a Luxembourg consortium, will broadcast 16 channels—but no one yet is sure whether it will use D or D2 MAC. What a muddle!

If engineers round Europe had their way, D2 would now be scrapped so that Europe could standardize on a common system—D-MAC with room for eight sound channels or vast quantities of teletext and business data. A common European standard would help satellite broadcasters in Britain, who otherwise will be out on a limb using the better, but different system.

High Definition TV

In the future, the use of MAC by satellite opens the door to high definition television (HDTV). The Japanese have developed their own system, based on wide screen pictures, built up from 1,125 lines running at 60 interlaced fields a second. In Europe a Eureka project has brought competing manufacturers and broadcasters together, to develop a system better suited to the European 50Hz field rate.

The Eurek HDTV system is also based on a wide screen picture, but with 1,250 lines and 50 interlaced fields per second. Before transmission, the picture information is divided by four, and converted to 625-line MAC standard.

The transmitted picture is thus compatible with ordinary MAC receivers. They just display the centre part of the wide screen area. High definition MAC receivers will effectively multiply the signal by four again, under the control of digital codes broadcast in the data channels.

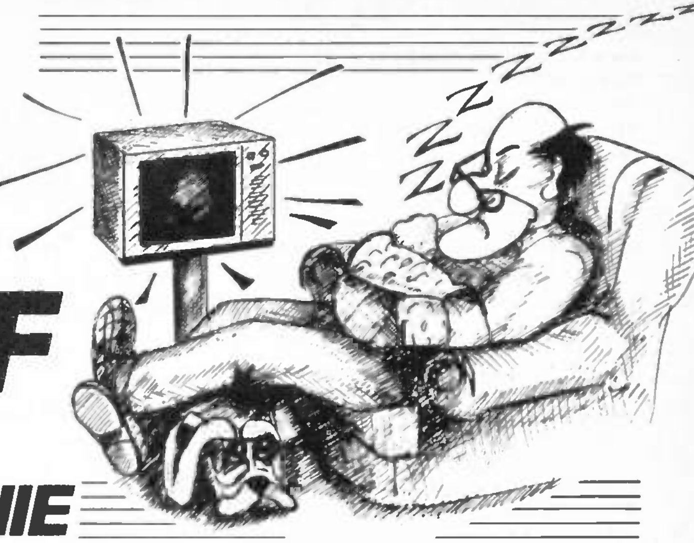
These HD Eureka sets will display the full wide screen area, double the line structure to 1,250 and double the effective picture rate by a technique known as sequential display—each field is stored in memory and displayed twice, to give 50 full interlaced 625-line pictures a second.

There is not enough bandwidth available on terrestrial TV channels to transmit MAC, and thus the only real hope of transmitting high definition TV is to use the satellite channels.

As a halfway stage, before high definition broadcasts begin, a future generation of High *Resolution* MAC receivers will artificially enhance the D-MAC picture by sequential display. The difference between the same picture displayed on a 625-line interlaced set, and on a 625-line set with sequential display, is quite remarkable.

Our eyes are used to seeing 50 half pictures a second each made up from 312.5 lines, which interlace on screen into 25 full pictures. Even though the eye is getting no more information from sequential scan, the display of 50 full 625-line pictures a second creates the illusion of greatly enhanced resolution.

Constructional Project



AUTO POWER-OFF

T. R. de VAUX-BALBIRNIE

Prevent unnecessary use of electrical appliances

THIS device will be of interest to long-suffering readers whose thoughtless offspring (or even other forgetful residents!) leave electrical appliances switched on needlessly. Examples of such equipment include radios and televisions, lights, small heaters and musical instruments. It has been found particularly valuable in controlling soldering irons since these are easily forgotten and left switched on for days. It can be used with a bedside reading lamp and will switch it off soon after the user has fallen asleep.

The Auto Power-Off is a mains-operated timer which cuts off the supply after a preset time in the range three to 30 minutes. In use, the appliance is plugged into a socket on the unit and a push-button (MAINS ON) switch used to begin the timing process. A push-button (RESET) switch may now be used to re-start the cycle at any time. If the RESET button is not pressed within the preset time, the device switches off. The appliance may thus be kept switched on continuously by pressing the reset switch at intervals and this is the way the circuit will normally be used.

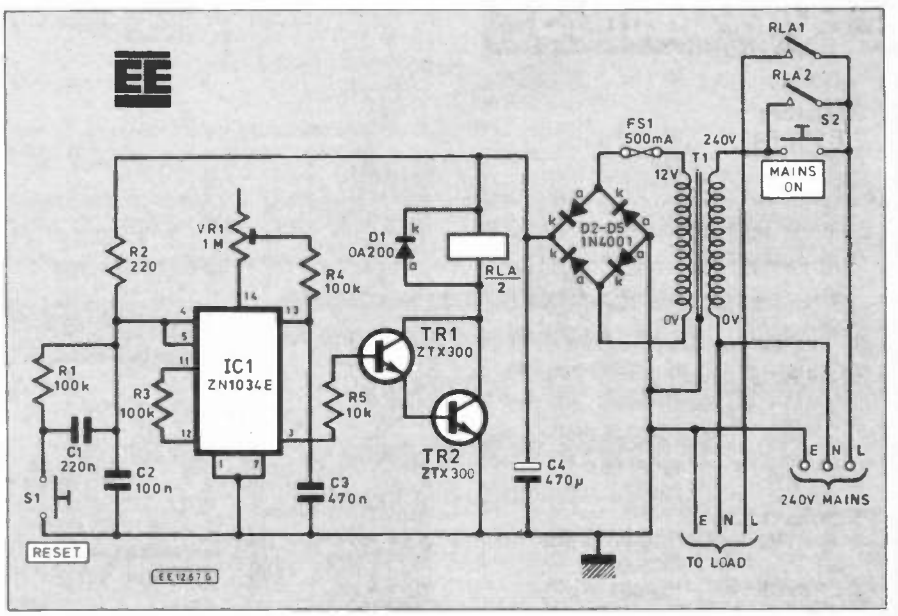
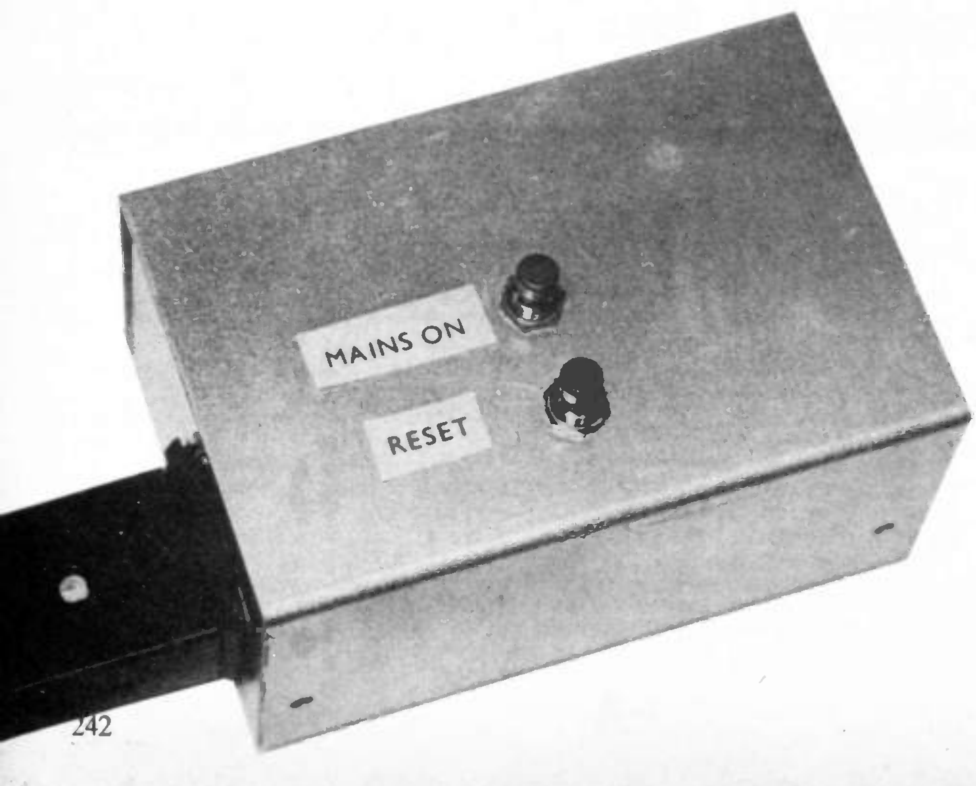


Fig. 1. Complete circuit diagram of the Auto Power-Off.



The unit has a flying lead to plug into a standard 13A mains outlet. The output socket is mounted on the case and is of the shuttered Euro-type. The appliance to be controlled is fitted with a matching plug and this prevents the user from bypassing the unit by simply plugging the appliance into the mains *direct*. The maximum current which may be handled is 3A corresponding to a power of 720W on 240V mains.

CIRCUIT DESCRIPTION

The complete circuit for the Auto Power Off is shown in Fig.1. The principle component is IC1—an integrated circuit timer. C3, in conjunction with R4 and VR1, set the timing period. With VR1 adjusted for minimum resistance, C3 charges through R4 alone giving an interval of three minutes approximately. With VR1 adjusted for maximum resistance, timing is increased to approximately 30 minutes.

A conventional arrangement of mains transformer T1, fuse FS1, bridge rectifier D2 to D5 and smoothing capacitor, C4 provide a 12V output for the circuit. Timing begins when the supply is switched on. Thus, when push-to-make switch S2 (MAINS ON) is operated momentarily, current flows through T1 primary winding to establish the supply. IC1 then begins timing–pin three goes high and reverts to low when the cycle is complete. While high, Darlington pair TR1/TR2 switch on and operate relay RLA–this has two pairs of "make" contacts. Contacts RLA2, bypass S2 and serve to maintain the supply when this switch is released. Contacts RLA1, supply current to the appliance.

When timing is complete, the contacts part–the appliance and circuit supply then switch off. If S1 (RESET) is pressed during timing, IC1 pins four and five go low. This resets the i.c. and the cycle starts again. While S1 is being pressed, pin three goes low and reverts to high on release. Thus, operating S1 would normally switch the circuit off. The inclusion of C1 overcomes the problem by allowing pins four and five to go low only for the time taken for C1 to charge through R2. With the value chosen this is a matter of microseconds and resets IC1 without allowing time for the relay contacts to open.

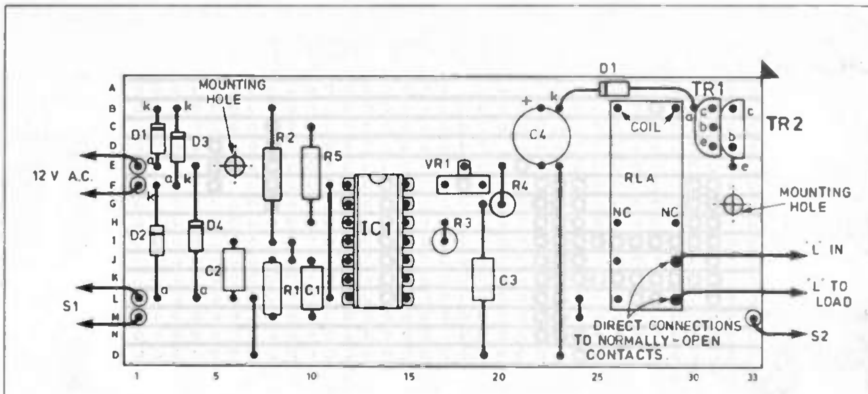
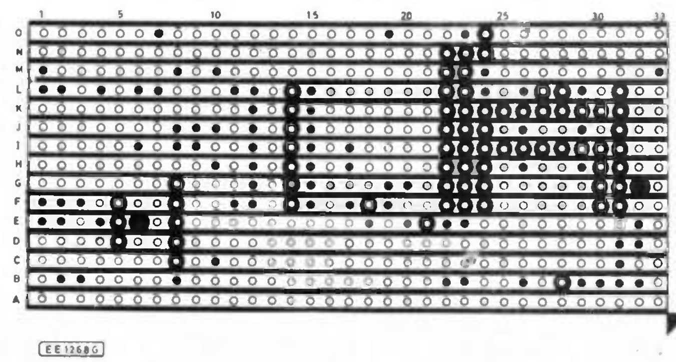


Fig. 2. veroboard layout and wiring.



COMPONENTS

Resistors

R1,R3,R4	100k (3 off)
R2	220
R5	10k

Fixed resistors 0.25W±5%

Potentiometer

VR1 1M sub-miniature vertical preset

Shop Talk See page 244

Capacitors

C1	220n
C2	100n
C3	470n
C4	470μ elect 40V

Semiconductors

TR1,TR2	ZTX300 (2 off)
D1	OA200
D2 to D5	1N4001 (4 off)
IC1	ZN1034E

Miscellaneous

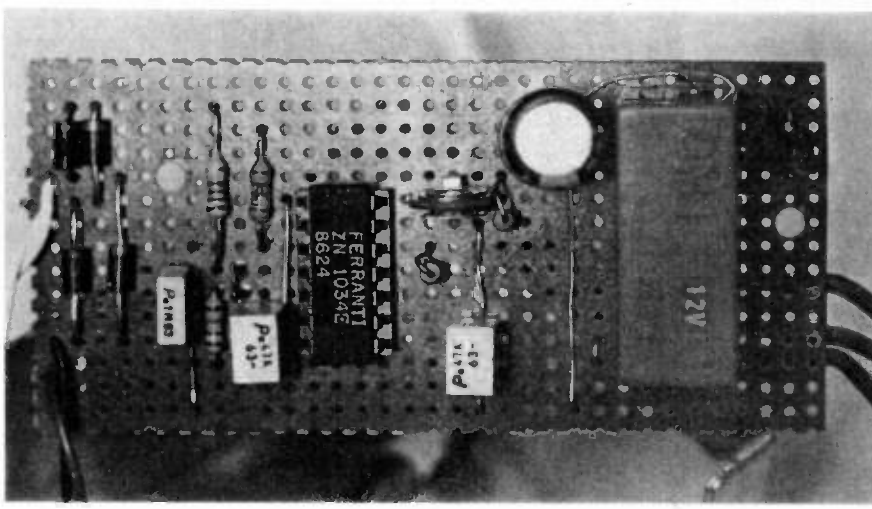
T1 Mains transformer with 240V primary and 12V secondary winding rated at 100mA

RLA Miniature double-pole relay with 5A mains rated contacts and 12V 200 ohm coil.

S1,S2 Push-to-make switches with 1A minimum mains-rated contacts.

0.1 in. matrix stripboard size 15 strips by 33 holes; 14-pin d.i.l integrated circuit holder; 20mm chassis fuseholder with 500mA fuse; aluminium box size 102×64×51mm; 3A terminal block–3 sections required; 18 s.w.g. sheet aluminium size 90×35mm; small fixings; stand-off insulators; solder tag; 3A mains wire; European-type 3-pin mains chassis socket–6A rating with matching line plug.

Approx. cost Guidance only £14·50



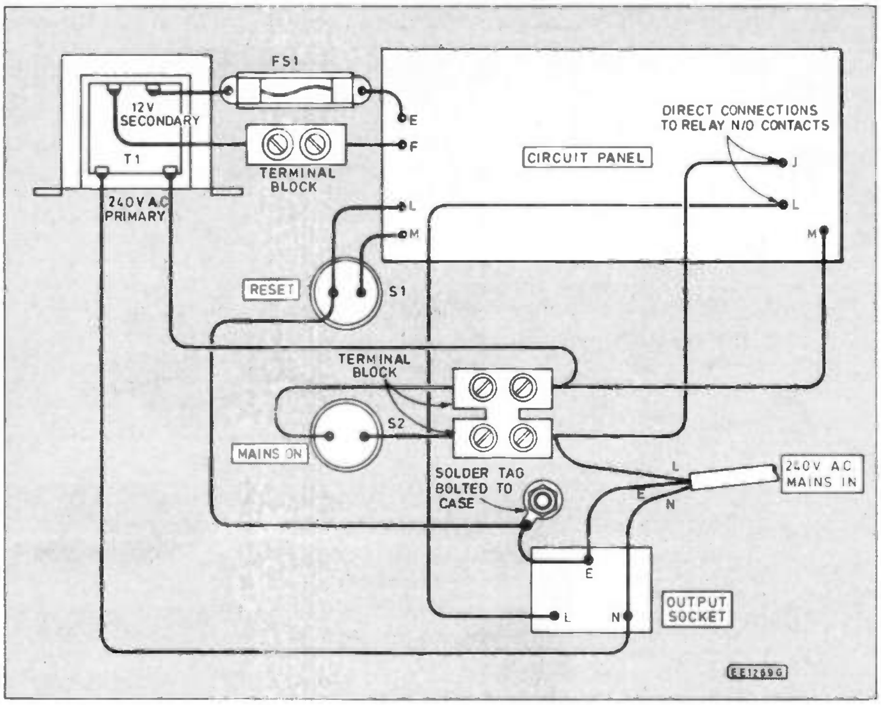
CONSTRUCTION

This circuit must be built into an ***earthed metal box.*** Since there are mains connections to make, any reader who is unsure of being able to make a safe job must seek professional advice. It is assumed that a standard mains plug fitted with a 3A fuse is being used to plug the unit into the supply. In other cases, a fuse of 3A rating should be fitted inside the case.

Begin by constructing the main circuit panel shown in Fig.2. This uses a piece of 0.1 inch matrix stripboard size 15 strips by 33 holes. Cut this to size, drill the two mounting holes and make the breaks in the copper tracks as indicated. ***Note that for safety reasons it is essential to break the tracks completely around the relay position.*** Solder the inter-strip link wires in position and follow with the on-board components. Take care to observe the polarities of C4 and of all diodes. Solder 10cm. pieces of light-duty stranded connecting wire to strips E, F, L and M on the left-hand of the panel also 10cm piece of *mains* wire of 5A rating direct to the normally-open relay contacts. Use a similar piece of wire for the connection between S2 and the circuit panel.

Drill holes in the case for mains input wire, output socket, switches, fuseholder, transformer and solder tag. Fit the input wire hole with a rubber grommet. Cut a piece of thin sheet aluminium size 90×35mm and drill holes in it to correspond with those in the circuit panel. Mount the circuit board to the aluminium panel using stand-off insulators on the fixings. Make certain that the stand-off insulators are long enough to keep all connections on the copper strip side well clear of the metalwork–this applies especially to the mains wiring from the relay contacts. Attach the circuit panel assembly to the case as shown in the photograph.

Check that the wires leading from the relay contacts are not trapped and that the metalwork cannot cut the insulation. Refer to Fig. 3, mount the remaining components and complete all wiring. Fit the mains input



lead with a strain relief clamp. Note that mains wire of 3A rating must be used for all S2, output socket and solder tag connections. Extend the wires leading from S2 with pieces of 3A terminal block as necessary. Adjust VR1 fully clockwise (as viewed from the top edge of the circuit panel).

File down the heads on fixings which would otherwise prevent the lid from fitting properly. Check that when the lid is in position, no wires are trapped—this could easily happen when such a small case is used. Fit the base of the box with self-adhesive feet to prevent damage to work surfaces.

TESTING

Fit a reading lamp with the correct type of plug and insert this into the socket on the unit. Plug the unit into the mains and press the MAINS ON button. The lamp should light and remain on for approximately 3 minutes. Repeat the procedure but this time press the RESET button at intervals of less than 3 minutes. The lamp should now stay on continuously.

Potentiometer VR1 may be adjusted to increase the time interval if required. Note that, for safety reasons, the lid must remain on whenever the unit is plugged into the mains. Note also that it is normal for the case to become warm in prolonged operation. □

SHOP TALK

BY DAVID BARRINGTON

Pipe and Cable Locator

The only source we have been able to locate for the proximity detector i.c., type CS209, used in the *Pipe and Cable Locator* is from Maplin Electronic Supplies. When ordering this device quote order code, UH59P (CS209).

We have been unable to locate a supplier for the "low power" timer chip type L555 from, we think, RCA. However, the TLC555C low power Lin CMOS timer i.c. should work quite happily in this circuit and is stocked by most of our advertisers. Another alternative, though not tried, might be the ICM7555.

Note that it is important, for best results, to use "low loss" polyester layer type capacitors where specified in this circuit. The printed circuit board for this project is available from the *EE PCB Service*, code 598 (see page 000).

I.C. Radio

This month's *Exploring Electronics* project is an easy-to-build *I.C. Radio* built around the ZN414 radio chip. Although the author's radio shows the chip in a TO "metal" encapsulation we were unable to locate a metal device and so we used a "plastic" package (TO18) in our model. The plastic version is the common outline stocked by nearly all our advertisers and should not cause any buying problems.

Suitable ferrite rod aerials specified for the radio are currently listed by **Cirkit** and **Maplin Supplies**. They also supply ferrite rods so that the constructor can wind his own aerial.

The small "Preset" type trimmer capacitor used for tuning should be generally available. If readers do have difficulties in trying to buy this capacitor similar types are stocked by the above mentioned companies.

Universal Monitor

There was a time when most of our advertisers carried stocks of the "Pressure Mats" called for in the *Universal Monitor* project. However, it would seem that the increasing crime rate over the years has taken its toll and had a drastic effect on the supply of these items and they now appear to be in short supply.

The security specialists, **Riscomp** is one company that certainly carry stocks of suitable pressure mats for this versatile project. They produce two types: the "door mat" pressure sensor, as used in the prototype model, code PP2926 (£2.82) and a "stair" mat sensor, code PP2216 (£2.01).

A suitable encapsulated reed relay should be available from most component suppliers, but if any readers do experience purchasing problems the one used in the author's model was bought from Maplin, code FX50E.

Stereo Noise Gate

All the components required to build the *Stereo Noise Gate* appear to be standard devices and should not cause any undue purchasing difficulties as they seem to be stocked by most of our advertisers.

The printed circuit board for the Noise Gate is available from the *EE PCB Service*, code 597.

Low Fuel Alert

Practically all of the components required to build the *Low Fuel Alert* should be available as "off-the- shelf" items and should not cause problems.

Looking through our catalogues for a suitable non-electrolytic capacitor for C1, we have found that the "metallised" polyester range are the only ones which list types with the required value of 2μ2. The auto- connectors and wire should be available from any good motor spares shop.

Inductive Proximity Sensor

The only component called for in the *Inductive Proximity Sensor* that is likely to be difficult to locate is the Toko coil L1.

The coil used in the prototype model is a miniature 120μH choke and was purchased (22p) from **Cirkit**. When ordering quote part number 144HY-121. Note that VAT and a p&p charge of 70p must be added to your order.

The multiturn potentiometer used in the prototype was an RS type but the only possible restriction on using a different "multiturn pot" is the spacing of the solder pads on the p.c.b. You could, of course, use solder pins and wire from the pot tags to the pins.

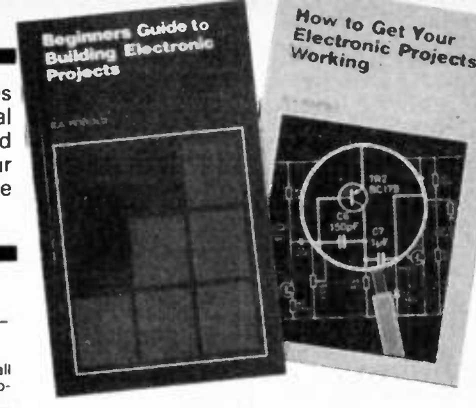
The printed circuit board for this project is available from the *EE PCB Service*, order code EE574 (see page 254).

Auto Power-Off

We cannot foresee any component buying problems for the Auto Power-Off project. It is most important that a metal case be used and it is well "earthed".

BOOK SERVICE

The books listed on these three pages have been selected as being of special interest to our readers, they are supplied from our editorial address direct to your door. Full ordering details are given on the last book page.



PROJECT CONSTRUCTION

HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. Penfold
We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.
96 pages **Order code BP110** **£1.95**

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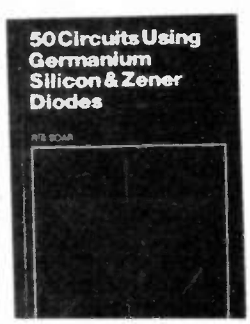

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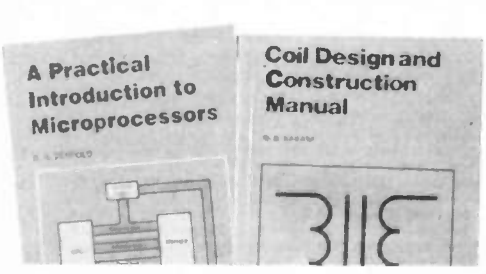

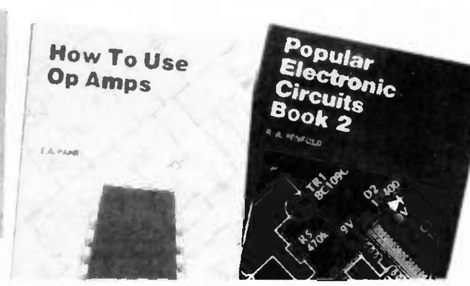

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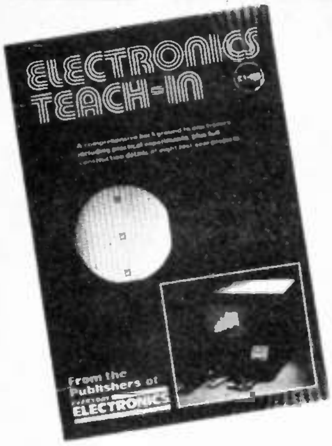

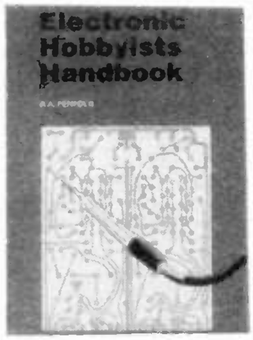

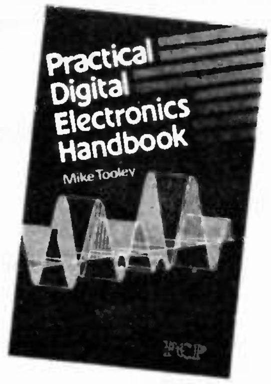

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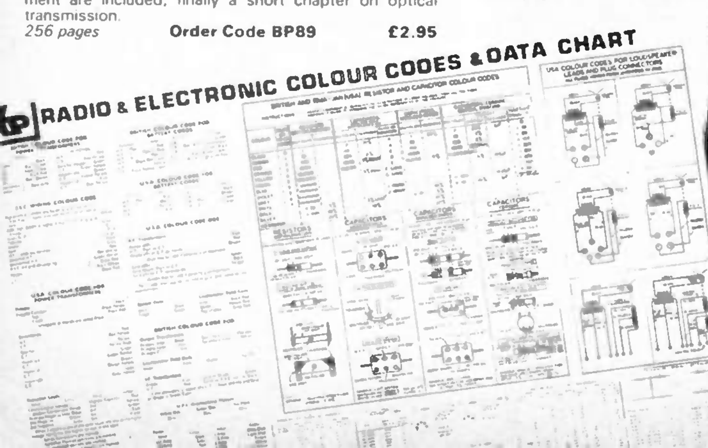

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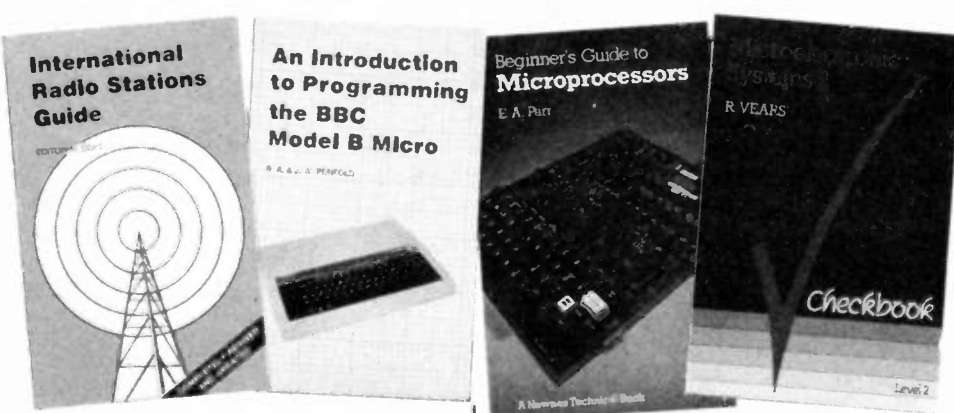

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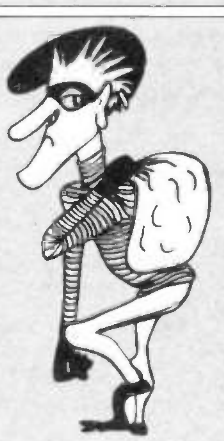

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a regular feature for the Spectrum Owner...

by Mike Tooley BA

HOPEFULLY, there's something for everyone this month! We shall be describing the procedure for testing our versatile Add-on I/0 Port (described last month), taking a look at an alternative to ZX-BASIC, and discussing a number of interesting points raised by readers.

Getting into Print

Firstly, a big "thank you" to several readers who wrote in with solutions to the problem of connecting the popular Amstrad DMP-2000 printer to an Opus Discovery disc interface. Apparently, the necessary connecting cable is readily available from Boots as well as several other sources.

Before using the BASIC LPRINT and LLIST commands it is necessary to enter the BASIC commands:

CLOSE#3: OPEN#3;"t"

To send output to the printer (other than via LPRINT or LLIST), a BASIC statement of the form:

PRINT#3 a$

will be required.

Finally, to send control codes (rather than ASCII text) to the printer it is necessary to use the Discovery's "b" (byte) channel rather than the "t" (text) channel. Otherwise the procedure is the same as before. In either case, it is important to CLOSE any previously OPENed channels after use.

Microdrive Utility

Bernard Cromarty has written with details of a useful program which he has developed in order to catalogue the contents of microdrive cartridges. The program can store the catalogues of up to 80 microdrive cartridges on a single cartridge, with tape back-up facility. Various menu options are provided including Catalogue, Search, Format, Save, Change Drive, Printer, Erase, and Move.

Bernard is willing to provide readers with copies of his program (called CAT-FILE) at a very modest £1.50 (for readers supplying a blank, formatted microdrive) or £2 (for a cassette tape version of the program). Doubtless, in either case, Bernard would appreciate a stamped addressed envelope with enquiries. Bernard can be contacted at: *56 Ranson Street, Farnworth, Lancashire, BL4 7RJ.*

Interrupts Revisited

Ian Tomey has taken me to task over the item on interrupts which appeared in January's issue. Ian rightly says that the Z80 can support up to 256 interrupt service routines (not 128, as stated) furthermore, I failed to mention that the demonstration routine will not operate correctly if certain items of external hardware are present.

My demonstration program assumes that the data bus supplies a byte of FFH when an interrupt occurs. This will always be the case with an unexpanded Spectrum but various items of proprietary external hardware do make use of interrupts and supply their own data bytes for vectoring to interrupt service routines.

Where this type of external hardware is present and the demonstration routine is to be tested, it would be necessary to set up a complete vector table in memory so that any vector would point to the start of the demonstration service routine. To quote from Ian's letter:

"This is why some of the older 48K games do not work on the 128. The original Spectrum ROM has locations 386EH to 3CFFH filled with FFH. A saving of 256 bytes can be achieved by placing the interrupt vector table at 3900H, always pointing to FFFFH.

A placement of a JR at this location and the next which is at 0000H (the PC overflows) corresponds to JR-13. Then a simple JP instruction jumps to the service routine.

The problem with the 128's is that the ROM was re-written with the keyboard handling routines in the unused area (even in 48K mode). This means that any interrupt jumps to the wrong place in memory, thus knackering the program!"

Keyboard Problems

Geoff Marshall writes from Southall to ask for some assistance interfacing a Saga 2001 infra-red remote control keyboard with a 128K Spectrum (not a +2). The keyboard fails to work correctly in both 128K and 48K modes and Geoff has tried hard-wiring the IORQULA connection (missing from the 128K's edges connector) without success.

If anyone can throw some light on this problem or who is successfully using a 2001 keyboard with a 128K machine please drop me a line so that I can pass the information on to Geoff.

Amstrad Connection?

Ron Wundram writes from South Australia to pose an interesting question. Ron has become very familiar with Sinclair BASIC, as witnessed by a neat little program called "*Dream Island*" (included in our current *Update*).

Unfortunately, Ron has had problems with the +2 keyboard and is thinking of upgrading to an Amstrad machine. Ron says that a 16K sideways ROM can be attached (from 49152 decimal) via the machine's extension bus and wonders whether anyone has attempted to interface a Spectrum ROM in this manner.

This is not quite such a far fetched proposition as it might seem. After all, at least one company (Robtek) has demonstrated that it is eminently feasible to make an Atari-ST machine emulate an Apple Macintosh by attaching a Macintosh ROM set to the ST's expansion ROM port. Anyone feel like having a go?

Testing the Add-On I/O Port

The Add-On I/O Port (described last month) is selected whenever an I/O read or write operation is performed in which address line A7 is taken low. In order to avoid conflicts with the Spectrum's existing I/O provision, it is necessary to ensure that address lines A0 to A4 all remain "high" and thus the address lines A5 and A6 have been used for selecting the 8255's internal registers, as shown in Fig. 1.

The 8255 provides three distinct modes of operation. In Mode 0, each group of twelve I/O lines may be programmed in sets of four to be inputs or outputs. In Mode 1, each group may be programmed to have eight lines of input. Three of the four remaining lines in each group are then used for handshaking and interrupt control.

In Mode 2, Port *A* provides eight bidirectional bus I/O lines and five of the Port *C*

ADDRESS										8255 REGISTER SELECTED
A7	A6	A5	A4	A3	A2	A1	A0	DECIMAL	HEX	
0	0	0	1	1	1	1	1	31	1F	PORT A
0	0	1	1	1	1	1	1	63	3F	PORT B
0	1	0	1	1	1	1	1	95	5F	PORT C
0	1	1	1	1	1	1	1	127	7F	CONTROL

EE 1259G

Fig. 1. 8255 addresses.

SK1 (Port *A*)		SK2 (Port *B*)		SK3 (Port *C*)	
PIN No.	SIGNAL	PIN No.	SIGNAL	PIN No.	SIGNAL
1	0V	1	0V	1	PC0
2	PA0	2	PB0	2	PC1
3	PA1	3	PB1	3	PC2
4	PA2	4	PB2	4	PC3
5	PA3	5	PB3	5	PC4
6	PA4	6	PB4	6	PC5
7	PA5	7	PB5	7	PC6
8	PA6	8	PB6	8	PC7
9	PA7	9	PB7	9	+9V
10	+5V	10	+5V	10	+9V

Fig.2. Port connecting data.

lines are used for handshaking. To keep things simple, our interface uses Mode 0 since this mode does not introduce the complication of handshaking and data can simply be written to or read from any of the 8255's ports.

Port *A* is used for input (the DIL switch bank is fitted to this port). Port *B* can be used for either input or output (TTL compatible), whilst Port *C* will be used solely for output (the Darlington output driver is fitted to this port). Fig.2 shows the pin connections used for the 10-way I/O sockets.

Control Word

In order to establish the 8255's mode of operation, it is necessary to write a Control Word to the 8255's Control Register at I/O address 7FH (127 decimal). The composition of the Control Word is shown in Fig.3. Note that the most significant bit (D7) must be set in order to signal a mode setting operation.

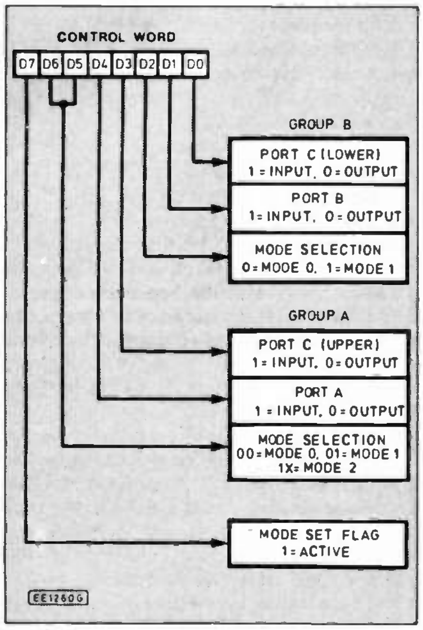

Fig 3. 8255 Control Word.

To select Mode 0 operation using the configuration discussed earlier, and with Port *B* as an output port, the following Control Word is required:

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	1	0	0	0	0

Had we decided to make Port *B* an input rather than an output port, the Control Word would have to be modified to:

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	1	0	0	1	0

The Control Word is sent to the 8255 using a BASIC statement of the form:

```
10 OUT 127,BIN 10010001
```

Having established the mode of operation we can read from or write to a specified port using simple BASIC statements incorporating IN and OUT respectively.

As an example, to read data from the DIL switch bank fitted to Port *A* into a variable x, we can make use of a line of the form:

```
20 LET x=IN 31
```

Alternatively, to write data to Port *C* (illuminating the l.e.d. bar display) we can make use of a line of the form:

```
30 OUT 95,x
```

A simple test routine can be put together simply by combining the previous lines in an infinite loop (use BREAK to escape):

```
10 OUT 127,BIN 10010000
20 LET x=IN 31
30 OUT 95,x
40 GO TO 20
```

By introducing an extra line within the loop, the status of the DIL switch bank can be displayed on the screen:

```
10 OUT 127,BIN 10010000
20 LET z=IN 31
30 OUT 95,z
40 PRINT AT 0,0;z; "        "
50 GO TO 20
```

Finally, the following program shows how a binary count can be produced on the l.e.d. display:

```
10 OUT 127,BIN 10010000
20 FOR x=0 TO 255
30 OUT 95,x
40 PAUSE 5
50 GO TO 20
```

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

Next Month: We shall show how the 8255's bit set/reset facility can be used to produce some practical I/O control routines for use with our versatile Add-On I/O Port. We shall also provide details of the minimal additional circuitry required to drive high-current d.c. and mains connected a.c. loads.

Life Beyond BASIC

Many readers will be aware that Pascal has become increasingly popular as a vehicle for teaching structured programming techniques. It was, therefore, heartening to learn that Mira Software has produced an inexpensive Pascal compiler for the Spectrum.

Mira's Pascal compiler is supplied on either cassette or microdrive and complies with the requirements of level 1 of BS-6192. The cassette version is identical to that supplied on microdrive with the exception that internal files (and some file handling commands) are not implemented.

The compiler produces stand-alone machine code which can run independently of the compiler itself. Furthermore, it is important to note that, unlike ZX-BASIC (which is an interpreted language), Mira Pascal does not allow interactive debugging of a program whilst it is being developed (it is necessary to compile the Pascal code each time a change is made). This point applies to compiled languages generally.

The Mira Pascal provides a simple editor for entering lines of source text: the current line is marked by a flashing cursor. This method of program entry is cumbersome but one with which Spectrum users will already be familiar with. A useful block copy/delete-/move facility is available and this proved extremely useful when I put the compiler through its paces.

Source files may be saved or loaded to tape or microdrive. Furthermore, programs prepared using other text editors (e.g. TASWORD THREE) can be loaded from microdrive. Note that it is ESSENTIAL to save each Pascal source program BEFORE compiling since the compiler is erased from memory each time a program is compiled!

Three versions of the compiler are available: the standard cassette tape and microdrive versions leave space free at the top of memory for printer drivers. A third version, PASCAL 0, loads to the top page facility but provides slightly more space for source text (PASCAL 0 occupies approximately 15K or RAM).

A twelve page A5 format "*Instruction Manual*" is supplied with the compiler. The manual covers the use of the compiler together with details of the Pascal implementation and a list of the compiler error messages.

It is important to realise that the manual is not a tutorial text and therefore newcomers to Pascal will require one, or more, introductory texts if they are to make effective use of the compiler. Three interesting demonstration programs are, however, included in the package and these will undoubtedly provide some food for thought as well as an indication of what can be achieved with Pascal and the Mira compiler. ***Mira Software*** ***is at 24 Home Close, Kibworth, Leicestershire, LE8 OJT.***

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25 ISO

DOWN TO EARTH

BY GEORGE HYLTON

NOW that we are in that part of the sunspot cycle where the short-wave bands open up, interest in simple receivers is reviving.

The usual arrangement is a single tuned circuit followed by a detector and audio amplifier. The detector is not just a diode but incorporates a transistor or valve. This provides gain and the opportunity to increase sensitivity and selectivity by a well-known circuit trick: *positive feedback*, also known as "reaction" and "regeneration". More on that later.

SENSITIVITY

You might think that there is no limit to the amount of amplification that can be used. In practice, there are two limits. One is the noise generated by the amplifier itself. This drowns very weak signals.

The other and in practice, more important limitation Is external noise, picked up by the aerial along with the wanted signal. Much of this is man- made but some is natural "atmospheric" noise.

The upshot is that for practical purposes the voltage amplification usable is very roughly 100,000. This may be at signal. Much of this is man-made but some mixture.

Higher gain merely gives a higher noise output, without enabling fainter signals to be heard. This relatively modest usable gain is one reason why a modest receiver can be sensitive enough for short-wave reception.

SELECTIVITY

Selectivity is altogether a different matter. The pass bandwidth of a single *LC* circuit (defined as the frequency span between the two points above and below the peak where the response has fallen by about 30 percent) is very easily calculated see Fig.1. It is just f_o/Q, where Q is a quality factor and f_o the peak frequency. A typical Q is 100. If the frequency f_o is low, such as the 200kHz of Radio 4 long wave the 3dB bandwidth is 2kHz. But at 20MHz (20,000kHz) the bandwidth is 200kHz.

Short-wave stations are spaced 5kHz apart, so the LC circuit accepts 40 channels. Indeed, more than 40, because a strong off-tune station still gets through. This not only shows the need for enhancing the selectivity but also explains the behaviour of simple receivers. When the receiver is not tuned in, any strong station around appears as background noise.

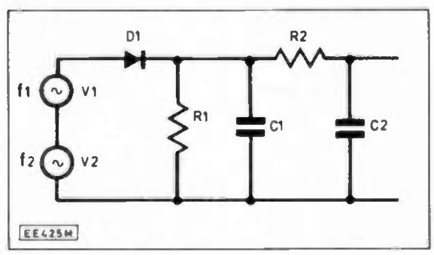


Fig. 2. When two unequal signals on different frequencies are applied to a detector the stronger signal tends to take control. The weaker is frequency-changed to a beat frequency between the two carrier frequencies. This may be rejected by the low-pass filter C1, R2, C2.

ENHANCED SELECTIVITY

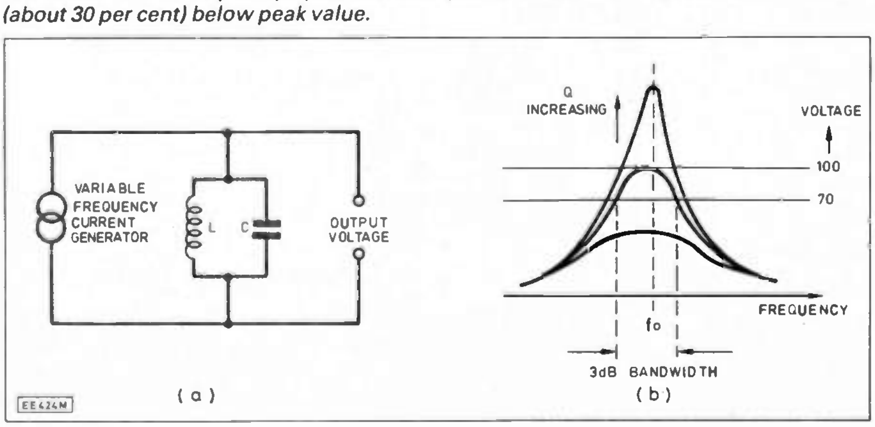
Fortunately, a "background station" often disappears as if by magic when a wanted station is carefully tuned in. This is the result of an effect called detector discrimination.

When two signals on different frequencies are applied to a detector, such as the diode of Fig. 2, the stronger signal (f_1) tends to suppress the weaker (f_2). The weaker signal is still there, but it comes out not as an audio frequency but as a new frequency, a "beat frequency". Or rather as two beats, (f_1+f_2) and (f_1-f_2).

The first is high and easily rejected by the low-pass filter formed by C1, R2, C2. The second (the difference frequency) is lower, but can still be rejected if well above the wanted audio band.

In short-wave reception, therefore we must somehow enhance the wanted signal until it is at least a few times stronger than any unwanted ones. Detector discrimination, plus a good low-pass filter, will remove the others.

Fig. 1. When a variable-frequency current is forced through a parallel-tuned circuit (a) the output voltage (b) varies with frequency. The height of the peak increases with the Q of the circuit, but the skirt response well away from the peak is little changed. The 3dB bandwidth is the frequency span between points where the response has fallen 3dB (about 30 per cent) below peak value.



REGENERATION

The sharpness of the tuned circuit can be increased enormously by positive feedback. In this, the amplified signal is fed back to the tuned circuit in such a way as to reinforce the original signal.

Off-tune signals are, of course, also fed back. But not being on the peak they reinforce less strongly.

The second time around gives the wanted signal a double advantage and so on. If the amount of feedback is just right the tuning becomes very sharp. Also, the wanted signal is greatly magnified.

The two processes go hand in hand. A hundredfold increase in sharpness comes with a hundredfold increase in gain. An initial Q of 100 becomes 10,000 and at 20 MHz the bandwidth is reduced from 200kHz to 2kHz.

SYNCHRONOUS RECEPTION

Using regeneration enables many short-wave stations to be sufficiently separated from their neighbours. But a strong unwanted signal close to a weak wanted one still breaks through. The enhanced selectivity is just not good enough.

If the receiver is well-behaved the user still has one trick left. This is to set the regeneration (feedback) marginally too high, so that the circuit oscillates gently. This local oscillation is now the strongest "signal" around and takes charge.

If there is any frequency difference between it and the wanted station this shows up as a beat note (f_1-f_2) between the oscillation and the wanted carrier frequency. This turns the wanted signal into gibberish. If the tuning is carefully adjusted to reduce the beat note to zero frequency ("tuning in to zerobeat") the wanted signal is audible. It may be weak but it is clear.

It turns out that a tiny tuning error is tolerable. The wanted carrier can control the local oscillation so as to synchronise the two frequencies.

The amount of tuning error permissible before sync. is lost depends on the relative strengths of the wanted carrier and the local oscillation. If the wanted carrier has one-tenth the amplitude of the local oscillation a certain locking range is obtained. If only one-hundredth the locking range is correspondingly reduced, and so on.

Evidently, to make locking easy, the amplitude of the local oscillation should be low. But it must be greater than the amplitude of the interfering carrier. The user must be able to set the amplitude to whatever is right and this implies great controllability of the feedback.

A receiver capable of being adjusted smoothly for any oscillation strength from zero upwards is said to have stable or smooth regeneration (or reaction). In practice the locking range may be very narrow (a few hertz) and at high frequencies frequent retuning may be required.

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Readers are advised to check with prices appearing in the current issue before ordering.

NOTE: *Boards for older projects – not listed here – can often be obtained from Magenta Electronics, 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST. Tel: 0283 65435 or Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX. Tel: 0602 382509.*

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4/88

INDEX TO ADVERTISERS

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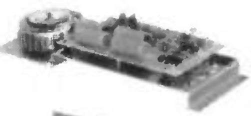

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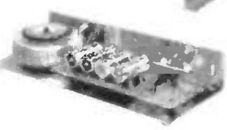

OMP/MF100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. —125dB. Size 300 × 123 × 60mm. PRICE
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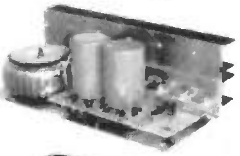

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. —130dB. Size 300 × 150 × 100mm. PRICE
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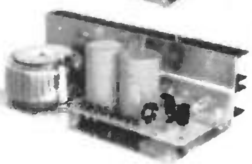

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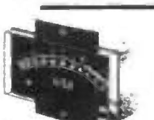

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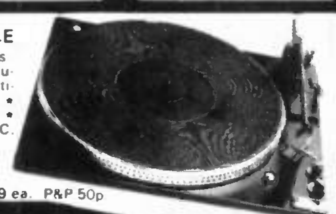
1¼" voice coil. Res. Freq. 35Hz. Freq. Resp. to 15KHz. Sens. 89dB. PRICE £16.49 + £2.00 P&P

BSR P295 ELECTRONIC TURNTABLE



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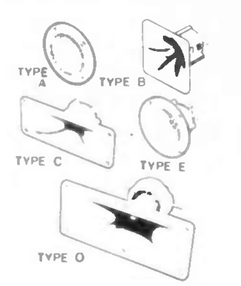

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3 watt FM Transmitter

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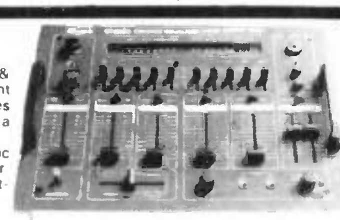

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The 6800 Instruction Set

Notes:

aa These two bits select the address mode in the following manner:
- 00 immediate data
- 01 base page direct addressing
- 10 indexed addressing
- 11 extended direct addressing

pp Denotes the second byte of a two or three byte instruction

qq Denotes the third byte of a three byte instruction

x One bit is used to select the accumulator:
- 0 selects Accumulator A
- 1 selects Accumulator B

yy These two bits select the address mode on the following basis:
- 00 inherent addressing, Accumulator A
- 01 inherent addressing, Accumulator B
- 10 indexed addressing
- 11 extended direct addressing

y This bit selects the address mode on the following basis:
- 0 indexed addressing
- 1 extended direct addressing

* Indicates that aa = 00 is not permitted.

EE DATA CARD 6

Given free with Everyday Electronics magazine.
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Mnemonic	Operand(s)	Object Code	Bytes	Machine Cycles
ABA		1B	1	2
ADC	ACX,	1xaa1001		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
ADD	ACX,	1xaa1011		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
AND	ACX,	1xaa0100		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
ASL	ACX	01yy1000	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
ASR	ACX	01yy0111	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
BCC	DISP	24 pp	2	4
BCS	DISP	25 pp	2	4
BEQ	DISP	27 pp	2	4
BGE	DISP	2C pp	2	4
BGT	DISP	2E pp	2	4
BHI	DISP	22 pp	2	4
BIT	ACX,	1xaa0101		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
BLE	DISP	2F pp	2	4
BLS	DISP	23 pp	2	4
BLT	DISP	2D pp	2	4
BMI	DISP	2B pp	2	4
BNE	DISP	26 pp	2	4
BPL	DISP	2A pp	2	4
BRA	DISP	20 pp	2	4
BSR	DISP	8D pp	2	8
BVC	DISP	28 pp	2	4
BVS	DISP	29 pp	2	4
CBA		11	1	2
CLC		0C	1	2
CLI		0E	1	2
CLR	ACX	01yy1111	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
CLV		0A	1	2
CMP	ACX,	1xaa0001		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
COM	ACX	01yy0011	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
CPX		10aa1100		
	ADR8	pp	2	4-6
	ADR16 or DATA 16	qq	3	3-5
DAA		19	1	2
DEC	ACX	01yy1010	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
DES		34	1	4
DEX		09	1	4
EOR	ACX,	1xaa1000		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
INC	ACX	01yy1100	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
INS		31	1	4
INX		08	1	4
JMP		011y1110		
	ADR8	pp	2	4
	ADR16	qq	3	3
JSR		101y1101		
	ADR8	pp	2	8
	ADR16	qq	3	9
LDA	ACX,	1xaa0110		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
LDS		10aa1110		
	ADR8	pp	2	3-5
	ADR16 or DATA 16	qq	3	4-6
LDX		11aa1110		
	ADR8	pp	2	3-5
	ADR16 or DATA 16	qq	3	4-6
LSR	ACX	01yy0100	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
NEG	ACX	01yy0000	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
NOP		01	1	2
ORA	ACX,	1xaa1010		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
PSH	ACX	0011011x	1	4
PUL	ACX	0011001x	1	4
ROL	ACX	01yy1001	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
ROR	ACX	01yy0110	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
RTI		3B	1	10
RTS		39	1	5
SBA		10	1	2
SBC	ACX,	1xaa0010		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
SEC		0D	1	2
SEI		0F	1	2
SEV		0B	1	2
STA	ACX,	1xaa0111		
	ADR8	pp	2	4-6
	ADR16	qq	3	5
STS		10aa1111		
	ADR8	pp	2	5-7
	ADR16	qq	3	6
STX		11aa1111		
	ADR8	pp	2	5-7
	ADR16	qq	3	6
SUB	ACX,	1xaa0000		
	ADR8 or DATA	pp	2	2-5
	ADR16	qq	3	4
SWI		3F	1	12
TAB		16	1	2
TAP		06	1	2
TBA		17	1	2
TPA		07	1	2
TST	ACX	01yy1101	1	2
	ADR8	pp	2	7
	ADR16	qq	3	6
TSX		30	1	4
TXS		35	1	4
WAI		3E	1	9

Programmable Parallel I/O Devices

The following programmable parallel I/O devices are commonly encountered in microprocessor based systems:

6520	Peripheral Interface Adaptor (PIA)
6521	Peripheral Interface Adaptor (PIA)—similar to the 6520
6522	Versatile Interface Adaptor (VIA)
6820	Peripheral Interface Adaptor (PIA)—equivalent to the 6520
6821	Peripheral Interface Adaptor (PIA)—equivalent to the 6521
8255	Programmable Parallel Interface (PPI)
Z80-PIO	Programmable Input/Output (PIO)

Notes:

PA0-PA7	Port A I/O lines
PB0-PB7	Port B I/O lines
PC0-PC7	Port C I/O lines (applies to the 8255)
CA1-CA2	Port A control lines
CB1-CB2	Port B control lines
RS0-RS3	Register select lines
A0-A1	Register select lines
$\overline{CS}$, $\overline{CS0}$-$\overline{CS3}$	Chip select lines
R/$\overline{W}$	Read/write
$\overline{RD}$	Read
$\overline{WR}$	Write
$\overline{RESET}$, $\overline{RES}$	Reset line
$\overline{INT}$, $\overline{IRQ}$, $\overline{IRQA}$, $\overline{IRQB}$	Interrupt request lines
IEI	Interrupt enable input
IEO	Interrupt enable output
$\overline{ASTB}$	Port A strobe (applies to the Z80-PIO)
$\overline{BSTB}$	Port B strobe (applies to the Z80-PIO)
ARDY	Register A ready (applies to the Z80-PIO)
BRDY	Register B ready (applies to the Z80-PIO)
EN	Enable
D0-D7	System data bus
Ø	Clock
$\overline{M1}$	Machine cycle one (applies to the Z80-PIO)
$\overline{IORQ}$	Input output request (applies to the Z80-PIO)
C/$\overline{D}$	Control/data select (applies to the Z80-PIO)
B/$\overline{A}$	Port select (applies to the Z80-PIO)
V_{ss}, GND	0V
V_{cc}	+5V