SEPTEMBER 1987

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

£1·20

Electronic Analogue/Digital Multimeter

Personal Stereo Amplifier

Car Overheating Alarm

Burst Fire Mains Controller

Special Feature... Using a Multimeter

The Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PARCELS

Price per parcel is £1.00, but if you order 12 you get one extra free.
All the parcels listed below are brand new components. Unless marked s.h.

1 – 5 13 amp ring main junction boxes
2 – 5 13 amp ring main spur boxes
5 – 3 flush electrical switches
7 – 4 in 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 $\frac{1}{2}$A secondaries
11 – 1 extension speaker cabinet for $6\frac{1}{2}$" 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 ultra sonic transmitters and 1 ditto receiver
18 – 2 15000 mfd computer grade electrollics
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
33 – 2 aerosol cans of ICI Dry Lubricant
34 – 96 × 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 × 12V DC or 24V AC, 4 CO relays
51 – 1 × 12V 2C O very sensitive relay
52 – 1 12V 4C relay
53 – 2 mains operated relays 3 × 8 amp changeovers
55 – 1 locking mechanism with 2 keys
56 – Miniature Uniselector with circuit for electric jigsaw
57 – 5 Dolls' House switches
60 – 5 ferrite rods 4" × 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 $\frac{1}{4}$ spindles
65 – 5 different thermostats, mainly bi 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 $\frac{3}{4}$" stack – $\frac{1}{4}$ shaft
86 – 2 5" ali fan blades fit $\frac{1}{4}$" shaft
87 – 2 3" plastic fan blades fit $\frac{1}{8}$" shaft
88 – Mains motor suitable for above blades
89 – 1 mains motor with gear box 1 rev per 24 hours
91 – 2 mains motors with gear box 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 $2\frac{1}{2}$ hours delay switch
103 – 1 6V mains power supply unit
104 – 1 $4\frac{1}{2}$V mains power supply unit
106 – 1 5 pin flex plug and panel socket
107 – 1 5" speaker size radio cabinet with handle
109 – $10\frac{1}{4}$" spindle type volume controls
110 – 10 slider type volume controls
112 – 1 heating pad 200 watts mains
114 – 1 1W amplifier Mullard 1172
115 – Wall mounting thermostat 24V
118 – Teak effect extension 5" speaker cabinet
120 – 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
155 – 3 varicap push button tuners with knobs
188 – 1 plastic box, sloping metal front, 16 × 95mm, average depth 45mm
241 – 1 car door speaker (very flat) $6\frac{1}{2}$" 15 ohm made for Radiomobile
243 – 2 speakers' 6" × 4" 15 ohm 5 watt made for Radiomobile
266 – 2 mains transformer 9V $\frac{1}{2}$A secondary split primary so OK also for 115V
267 – 1 mains transformers 15V 1A secondary p.c.b. mounting
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 $2\frac{1}{4}$in. 80ohm loudspeakers
454 – 2 $2\frac{1}{4}$in. 8ohm loudspeakers
463 – 1 mains operated relay with 2 sets c/o contacts
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
473 – 1 5" 4ohm speaker with built in tweeter Radiomobile
480 – 1 3A double pole magnetic trip, saves repairing fuses
498 – 4 1000uf 25V axial electrolytic capacitors

TELEPHONE BITS

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug £3.95
Extension socket £2.95
Dual adaptors (2 from one socket) £3.95
Cord terminating with B.T. plug 3 metres £1
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets £11.50
100 mtrs 4 core telephone cable £8.50

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 $3\frac{1}{2}$" and $5\frac{1}{4}$" 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.

EVERLASTING BATTERIES!

Well not quite, but if you don't switch it on, the lithium battery has an almost indefinite shelf life, which makes it suitable for emergency, standby & similar applications, also for quartz clocks and instruments that draw only microscopic currents. The lithium battery we have is 3V and about as big and thick as 2p coin. Price 2 for £1 ref BD 558. Note these plug into Dil socket our ref BD553.

3 POLE MODEL MOTOR

Will operate from as low as 1.5V and speed will increase steadily as the voltage is increased, at 9V however a governor takes over and the speed remains constant – and ideal motor for models. Size approx 28mm × 40mm easily reversible and with good length spindle 60p each our ref BM30.

CASSETTE STEREO TAPE HEADS

With mounting brackets and with tape guides pairs, one record/playback and the other erase £1 pair ref BD541.

OPTO INTERRUPTER

Consists of a IR emitter mounted close to light dependent resistor when light or IR is interrupted the change of resistance can be made to switch or operate a relay – useful for counting, motor stopping etc. Price 2 for £1 ref BD545.

Ex-Electricity Board.
Guaranteed 12 months.

VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95 without case, metal case – £2.95, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

12 volt MOTORS BY SMITHS

Made for use in cars, etc. these are very powerful and easily reversible. Size $3\frac{1}{2}$" long by 3" dia. They have a good length of $\frac{1}{4}$" spindle –
1/10 hp £3.45
1/8 hp £5.75. 1/6 hp £7.50

SOUND TO LIGHT UNIT

Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by $\frac{1}{4}$" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form.

This Month's Snip

9" VDU OR 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 circuity. 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 (if you are handy with a drill and file you could make a case out of two of our $6\frac{1}{2}$" speaker cabinets). 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 £3 post. We also have some that failed the line test, again brand new but offered without guarantee at £8 plus £3 post. We do a kit for the 16V 2A psu to operate this monitor price is £3 our ref 3P26.

SLIDE SWITCHES

Sub miniature size only 10mm × 4mm single pole change over or on/off. Price 5 for £1 ref BD553.

LOW VOLTAGE RELAY

OMRON 3.5V coil, plug in dil sockets, 5a c/o contacts. Brand new offered at a silly price 2 for £1 ref BD548.

POLARISED RELAY

Depending upon its direction dc current as low 14 Ma makes this open circuit, so it could be used to protect delicate instruments or as on earth leakage, or reverse voltage trip etc. 2 for £1 ref BD549.

SLOTTED OPTO SWITCH

Infra red emitter and sensor mounted in slotted moulding, so that the emitter beam when broken makes a contactless switch, can be used in electronic ignition, speed sensing etc. etc. Price 2 for £1 ref BD545.

24hr TIME SWITCH

Beautifully made with West German precision. Just under 4" square with 15amp c/o contacts can be set anywhere around 24hr dial to the nearest 15 mins also with a overide switch. Ref 8P6 but hurry we hav eonly 300. Price £8.

COMPUTERS

The Acorn "Electron" as used in many schools for games and serious jobs. Works into colour or Black and White TV. Proper price was £199, our Price, tested and working £45 + £3 post, tested but slightly faulty £36 + £3 post and lastly tested but not working £20 + £3 post, all are new and complete with mains P.S.U., 300 page handbook, TV lead, and starter cassette. Full range of Software also in stock at very low prices.

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.

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. £9.50 + £2 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.

£2 POUNDERS*

2P120 – 1 combined clockwork switch and thermostat for boiler control
2P122 – 1 30a rotary switch, surface mounting with pointer knob
2P123 – 1 25a rotary switch, surface mounting, cover engraved, high, medium low and off
2P124 – 1 28kv .001mfd block condensor
2P127 – 1 30a bridge rectifier assembly on heat sinks
2P129 – 1 10rpm motor 115V so supplied with adaptor for 230V
2P131 – 1 Crouzet motor 230V fits the Crouzet gearbox
2P132 – 1 ceiling heat-stat for fire warning or protection
2P133 – 1 Circuit breaker 20a, Crabtree ref C50
2P134 – 1 9V 500mA psu, plugs into 13a socket
2P135 – 10m 10 conductor intercom cable
2P136 – 1 $2\frac{1}{2}$kw element made for tangential blowers
2P137 – 1 Thermo couple, stainless steel tipped for measuring internal heat
2P138 – 1 Mains transformer 20V-0-20V 1a upright mounting
2P141 – 1 rechargeable battery D size (4 AH) solder tag ended
2P142 – 10m 4 pair intercom cable White PVC outer
2P144 – 1 mains operated relay with 4 × 8a c/o contacts
2P145 – 1 10,000 uf 70V d.c. smoothing capacitor
2P146 – 1 7,800 uf 150C d.c. smoothing capacitor
2P147 – 1 10w 100ohm line matching transformer
2P148 – 1 Technical information on 3" FDD refundable if you buy fdd
2P149 – 5 diff battery operated model motors
2P150 – 1 PSU chassis with all components for 24V 2A d.c. unwired
2P151 – 1 Metal box $14\frac{1}{2}$ × 14 × 4 with lid add £2.00 post
2P152 – 1 Motor start capacitor 80uf 250V
2P153 – 1 Two station intercom unused but fine reject
2P154a – 1 Nicad charger — plug into 13a socket 5.2V .7UA output
2P154b – 1 Nicad charger — plug into 13a socket 6V .9VA output
2P155 – 1 Mains transformer giving 16, 17, 18 & 20V 60W
2P158 – 1 Oven thermostat with temp calibrated knob
2P159 – 1 9V 500ma cased with mains lead and output lead
2P160 – 1 13a plug adaptor fused takes 3 × 13a plugs
2P161 – 1 6" diagonal side cutters
2P162 – 1 Stereo Matrix PCB mounting deemphasis K35
2P163 – 1 AC Working capacitor 12uf 660V AC or 1500V dc
2P163a – 1 AC Working capacitor 14uf 350V AC or 800V dc
2P164 – 3 Phone leads 3 mtrs long tags one end B.T. plug other end

£3 POUNDERS*

3P7 – 1 DC voltage, doubler or halver for 12V to 24V 12 to 6V 24 to 12V
3P8 – 1 24hr time switch Sangamo, new condition Guaranteed 1 year
3P9 – 12V 500mA psu plugs in 13a socket
3P10 – 1 Mains transformer 50V 2A with 6.3 pilot light winding, upright mounting, fully shrouded
3p13 – 1 Noise filter to fit in mains lead of appliance up to 25a
3P15 – 1 waterproof case will take 200 watt transformer
3P16 – 1 signal box, 3 lamps on face plate of metal box size $5\frac{1}{2}$ × $3\frac{1}{2}$
3P17 – 1 choke and starter to work 8" fluorescent tube at 125W
3P18 – 1 22V 3a mains transformer with bridge rect fitted on top panel
3P20 – 1 0-5a ammeter $3\frac{1}{2}$ ac/dc ex equipment
3P21 – 1 power factor correction condenser 35uf 350ac
3P22 – 1 200va – auto transformer 230 to 115V torroidal encapsulated £1.50 post
3P23 – 1 36V-0-36V tapped 20V-0-20V 100va
3P24 – 1 3" floppy disc for Amstrad etc.
3P25 – 1 7" Electricians pliers

£4 POUNDERS*

4P11 – 1 Car Radio aerial
4P12 – 50m low loss co-ax 75ohm + £1 post
4P13 – 3 Hortsman time and set switches 15amp
4P14 – 1 150w mains transformer "c" core 43V 3.5A secondary
4P15 – 1 powerful motor 2" stack fitted with gearbox final speed 60rpm mains operated, could operate door opener etc.
4P17 – 1 Uniselector 3 pole 25W, 50V coil standard size
4P18 – 1 Volt meter with digital display (DIGIVISOR)
4P19 – 1 12V dc motor will fit to gearbox 4P20
4P20 – 1 Gear train giving speed reduction

£5 POUNDERS*

5P86 – 1 Transformer upright mounting 230/240V primary 2 × 100 1a secondary
5P88 – 1 Transformer in waterproof metal box 24V.5A add £2 post
5P89 – 1 4 bank heating element each 2kw ideal convector heater
5P90 – 1 18" long tangential blower with motor at one end
5P91 – 1 14" blower, motor in middle
5P92 – 10m Audio co-ax double screened 75ohm super low loss for TV
5P93 – 1 6" Alarm bell 24V dc or ac
5P94 – 1 Current transformer 14V out with 1a dc input
5P95 – 1 Vintage photo cell
5P97 – 1 Impedance matching transformer 0-4-5-8-160 ohm 100 add £150 post
5P98a – 1 0-90a ammeter for mounting outside control panel
5P98b – 1 0-180a ammeter for mounting outside control panel
5P99 – 1 Mains operated blower centrifugal output size app. 5" × $1\frac{1}{2}$"
5P100 – 1 Mains splitter 45a switch 3 × 15a fused circuits
5P101 – 1 Model motor 1 rpm from 6V reversible

£7 POUNDERS*

7P1 – 1 Instant heat solder gun – mains with renewable tip and job light

£8 POUNDERS*

8P1 – 1 Charger transformer 10a upright mounting 230/240 primary 16v 10a secondary
8P2 – 1 6" underdome alarmbell suitable for a fire alarm or burglar alarm mains operated.
8P3 – 1 heat sink big powerful so ideal for power transmitter
8P5 – 1 $^1/_3$ hp motor 900 rpm capacitor run
8P6 – 1 24hr time switch – 2 on offs 16a c/o contacs 3" × 3" × $1\frac{1}{2}$"
8P7 – 1 Silent sentinel invisible ray kit
8P8 – 1 Papst fan $3\frac{1}{2}$ × $3\frac{1}{2}$ × $1\frac{1}{2}$ 230V metal bodied

£10 POUNDERS*

10P13 – 1 reversible motor with gearbox 104rpm Parvalux
10P14 – 1 100a time switch 1 on/off per 24hr extra triggers £1 pair
10P15 – 1 Max demand meter 230 ac mains
10P16 – 1 powerful air mover 2 small type blowers with motor in middle
10P18 – 1 mains operated klaxon
10P19 – 1 12V alarm bell really loud, mains operated, in iron case + £5 post
10P21 – 1 super metal box size 19" × 20" × 7" deep lockable + £3 post
10P22 – 1 sensitive volt meter relay
10P23 – 1 fruit machine heart 3 fruit wheels each stepper motor operated
10P24 – 1 big panel meter face size $4\frac{3}{4}$ × $2\frac{1}{2}$ 200uA movement scaled 1-10
10P25 – 1 100W audio transformer 50-0-50W primary 8 ohm secondary
10P26 – 1 "Secretary" phone auto-dialler complete untested sold as such
10P29 – 1 12V engine cooling fan
10P30 – 1 instrument psu on pcb has 4 outputs .12V/.5V 6A/12V .5A/5V .5A
10P31 – 1 7 day time switch 16a c/o contacts sep switches for each day
10P32 – 1 68 rpm 1/6th hp motor reversible

£15 POUNDERS*

15P1 – 1 kit for 115W hi fi amp
15P2 – 1 kit for psu to supply one or two 15P1 amps
15P3 – 1 time switch battery or mains operated – 16a c/o contacts, 7 day programmable has 36hr reserve

£25 POUNDERS*

25P1 – 1 1500 PSI hydraulic pump 24V dc motor, made for operating aircraft under-carriage etc.

LIGHT CHASER KIT motor driven switch bank with connection diagram, used in connection with 4 sets of xmas lights makes a very eye catching display for home, shop or disco, only £5 ref 5P56.

VOL 16 No.9 SEPTEMBER '87

EVERYDAY ELECTRONICS

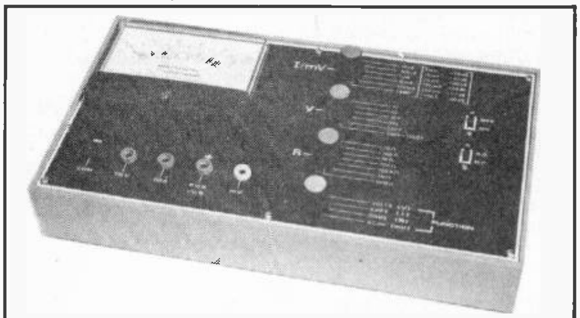
INCORPORATING ELECTRONICS MONTHLY

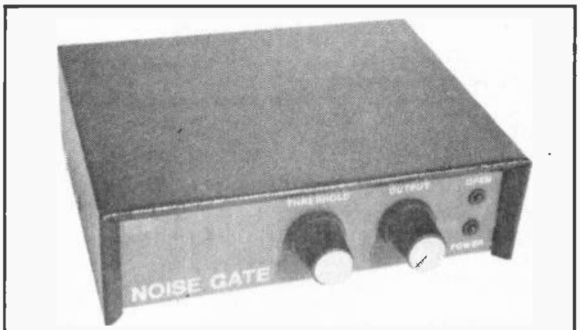
ABC

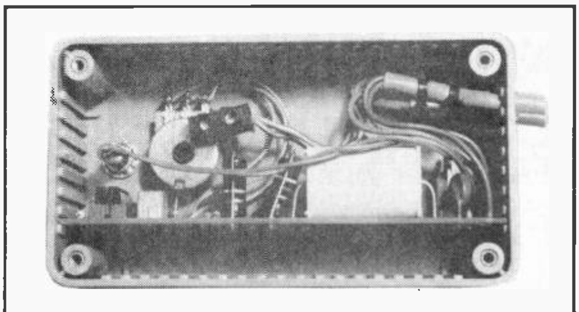
The Magazine for Electronic & Computer Projects

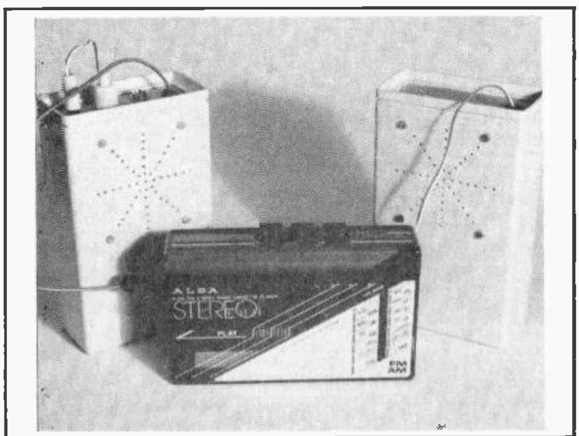
ISSN 0262-3617

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









Projects

Series

Features

Our October 1987 issue will be published on Friday, 18 September 1987. See page 469 for details.

OMEGA ELECTRONICS

252A HIGH STREET, HARLESDEN, LONDON NW10 4TD.
TEL: 01-965 5748 MAIL ORDER & RETAIL SHOP
TELEX: 265871 MONREF G Quoting 72: MAG31197

4000B CMOS	
4000BP	0.13
4001BP	0.13
4002BP	0.13
4006BP	0.28
4007BP	0.13
4008BP	0.28
4009BP	0.13
4010BP	0.16
4011BP	0.13
4012BP	0.13
4013BP	0.19
4014BP	0.28
4015BP	0.28
4016BP	0.17
4017BP	0.27
4018BP	0.27
4019BP	0.21
4020BP	0.29
4021BP	0.24
4022BP	0.29
4023BP	0.13
4024BP	0.23
4025BP	0.13
4026BP	0.72
4027BP	0.16
4028BP	0.24
4029BP	0.29
4030BP	0.13
4031BP	0.90
4035BP	0.90
4038BP	0.70
4040BP	0.30
4041BP	0.50
4042BP	0.23
4043BP	0.31
4044BP	0.31
4045BP	0.80
4046BP	0.47
4047BP	0.39
4049BP	0.16
4050BP	0.16
4051BP	0.31
4052BP	0.31
4053BP	0.31
4054BP	0.52
4055BP	0.50
4056BP	0.55
4060BP	0.51
4063BP	0.55
4066BP	0.19
4067BP	1.00
4068BP	0.13
4069UBP	0.13
4070BP	0.18
4071BP	0.13
4072BP	0.13
4073BP	0.13
4075BP	0.13
4076BP	0.37
4077BP	0.21
4078BP	0.13
4081BP	0.13
4082BP	0.13
4085BP	0.24
4089BP	1.00
4093BP	0.16
4094BP	0.49
4095BP	0.75
4096BP	0.65
4098BP	0.60
4099BP	0.37
4502BP	0.45
4503BP	0.40
4508BP	0.70
4510BP	0.30
4511BP	0.45
4512BP	0.34
4514BP	0.61
4515BP	0.61
4516BP	0.34
4518BP	0.34
4520BP	0.34
4522BP	0.82
4526BP	0.34
4528BP	0.30
4532BP	0.47
4534BP	3.50
4536BP	2.55
4538BP	0.39
4539BP	0.36
4543BP	0.39
4555BP	0.31
4556BP	0.40
4572BP	0.20
4584BP	0.34
4585BP	0.41

VOLTAGE REGULATORS	
7805	0.35
7812	0.35
7815	0.35
7818	0.35
7824	0.35
7905	0.40
7908	0.40
7912	0.40
7915	0.40
7918	0.40
7924	0.40
78L05	0.28
78L08	0.28
78L12	0.28
78L15	0.28
78L24	0.28
79L05	0.40
79L12	0.45
7915	0.48
LM317K	2.55
LM317T	1.50

ZENERS	
400MW BZY88 RANGE	
2V7 to 56V	0.5
1.3W BZY85 RANGE	
3V3 5o 75V	0.10

COMPUTER IC'S	
4116	0.75
4164	0.99
41256	3.00
41464	3.90
SP0256AL2	5.00
Z80A CPW	1.80
Z80A CTC	2.50
Z80A DMA	7.50
Z80A P10	2.50
Z80A S10	5.00

RESISTORS ¼ WATT	
IR-10M	0.01

MIN PRESETS	
HOR	0.10
VERT	0.10

DIODES	
IN4001	0.03
IN4002	0.03
IN4004	0.04
IN4006	0.06
IN4007	0.06
IN4148	0.02

IC SOCKETS	
8PIN	0.05
14PIN	0.06
16PIN	0.08
18PIN	0.12
20PIN	0.16
22PIN	0.17
24PIN	0.19
28PIN	0.22
40PIN	0.25

BRIDGE RECTIFIERS	
W005	0.23
W01	0.26
W02	0.32
W04	0.36
W06	0.41
W08	0.45

TRANSISTORS	
BC107	0.11
BC108	0.11
BC109	0.11
BC182	0.06
BC182L	0.06
BC183	0.06
BC183L	0.06
BC184	0.06
BC184L	0.06
BC212	0.06
BC212L	0.06
BC213	0.06
BC213L	0.06
BC214	0.06
BC214L	0.06
BC237	0.10
BC238	0.10
BC239	0.10
BC237	0.15
BC238	0.15
BC546	0.10
BC547	0.10
BC548	0.10
BC549	0.10
BC550	0.12

HUNDREDS MORE IN STOCK

SPECIAL OFFER TRANSFORMERS	
6VA 0–6V–0–6V	2.00

VISA

PLEASE PHONE FOR UNLISTED ITEMS AS WE STOCK OVER 3000 ITEMS. PLEASE ADD 75p P&P + 15% VAT. OVERSEAS NO VAT ADD £2.00.

TOTAL ENERGY DISCHARGE

ELECTRONIC IGNITION

IS YOUR CAR AS GOOD AS IT COULD BE ?

★ Is it **EASY TO START** in the cold and damp? Total Energy Discharge will give the most powerful spark and maintain full output even with a near flat battery.

★ Is it **ECONOMICAL** or does it "go off" between services as the ignition performance deteriates? Total Energy Discharge gives much more output to fire lean fuel mixtures.

★ Has it **PEAK PERFORMANCE** or is it flat at high and low revs. where ignition output is marginal?Total Energy Discharge gives a more powerful spark from idle to the engines maximum (even with 8 cylinders).

★ Is the **PERFORMANCE SMOOTH?** The more powerful spark of Total Energy Discharge eliminates the near "misfires" whilst an electronic filter smoothes out the effects of contact bounce etc.

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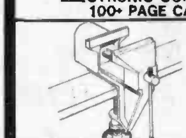

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Manufactured by Saft, these chargers are suitable for the above battery packs (as advertised in the May issue of "What Video"–page 20). The chargers are stated as "fast charge units" but, to prolong the life of the packs, we have modified them to a standard charger. Full charge of the packs is obtained after 10–12 hours (overnight) charging. Supplied complete with mains lead and charging lead fitted with a 4 pin plug (6 pin plug version available upon request). Although ex-equipment, these chargers are fully tested and guaranteed. Dimensions: 335 × 260 × 150mm.
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DPDT (6 TAGS)	13×9×12	59p	55p
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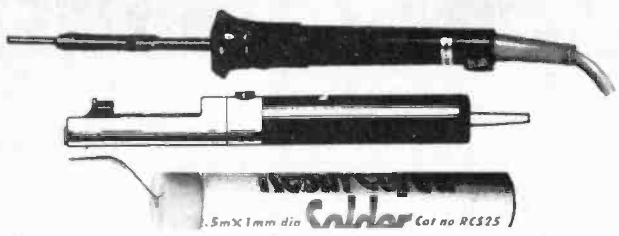

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Sloping front case 240 x 145 x 90/50 contains 2 PCB's: One has 4 key-pads (total 54 switches) + 14 digit LED display, 2 x ULN2004, ULN2033 & 4067; the other has 12 chips + 4 power devices etc. Case contains speaker. 8 core cable 2m long with plug. For use with PABX.£9.00

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Z622 Teletext Unit. Keyfax T100 manufactured for the US market, hence 120V ac supply (but Tx can easily be changed for 240V model). Chassis with Rx/decoder circuitry, Mullard VM6700 module, channel display, i/p & o/p skts. Believed to be new & working, but no data. Size 410 x 250 x 60mm **£15.00**

Z620 68000 Panel. PCB 190 x 45 believed to be from ICL's 'One per Desk' computer containing MC68008P8 (8MHz 16/8 bit microprocessor, + 4 ROM's, all in skts; TMP5220CNL, 74HCT245, 138, LS08, 38 etc. **£5.00**

Z625 32k Memory Board. PCB 170 x 170 with 16 2kx8 6116 static RAM's. Also 3.6V 100mA memopack nicad, 13 other HC/LS devices, 96W edge plug, 8 way DIL switch, R's, C's etc........ **£4.80**

Details of other similar PCB's in latest list.

sinclair

MICROVISION
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b) Vol control & switch
c) ZN401E chip

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Z558 CRT in 'as seen' condition — possibly repairable **£2.00**
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VP228	10	C15 Computer Cassette Tape, leadless	£3.00
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VP231	1	Cassette Head Cleaner Tape, non abrasive, in case	£1.00
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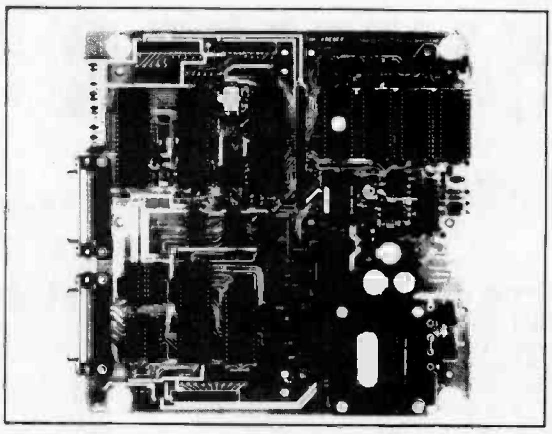
The Archer Z80 SBC



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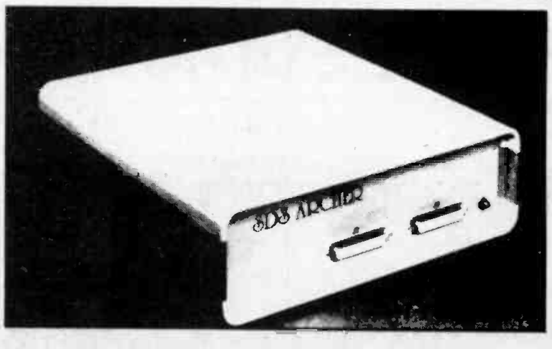

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OCTOBER FEATURES...

INTRODUCING MICROPROCESSORS

by MIKE TOOLEY B.A.

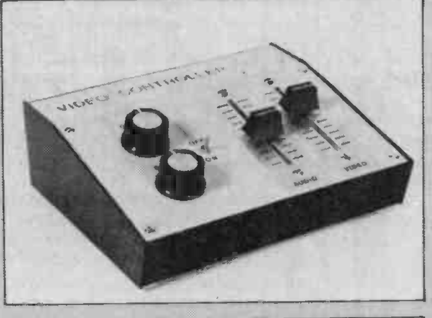
EXCLUSIVE

City and Guilds Certificate Course

Over the next nine months this brand new series being published in Everyday Electronics magazine aims to provide readers with a thorough understanding of the principles and practice of microprocessors. More significantly, this series breaks new ground in the field of distance learning; it is the first to offer assessment and certification in conjunction with an internationally recognised examining body. We hope that you will follow this course for the next nine months and that many readers will complete the study programme which can lead to the award of a City and Guilds certificate in Introductory Microprocessors.

The Introduction, to be published next month, details the syllabus, explains how the course is set out, how and where to register for assessment, how the assessments are conducted, the microprocessors covered, cost, etc.

VIDEO CONTROLLER



Home video production takes on a new dimension with the use of this audio/video unit for mixing audio signals and fading video.

TRANSTEST

A simple but very useful "in circuit" transistor and diode tester. Much cheaper than commercial units.

SIMPLE STATIC MONITOR

"See" the static generated by stroking a cat or combing your hair. A simple project that could be useful in a school science lab or just use it for interest and entertainment.

Order Now!

We are already experiencing unprecedented interest in the City and Guilds series and anticipate that the October issue will be in great demand. We strongly advise you to make sure of your copy by placing an order with your Newsagent **NOW** (you can use the order form) or by taking out a subscription — see page 517. **If you have not ordered a copy we cannot guarantee to be able to supply.**

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OCTOBER ISSUE ON SALE FRIDAY, SEPTEMBER 18

EVERYDAY ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL 16 Nº9 September '87

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See notes on **Readers' Enquiries** below—we regret that lengthy technical enquiries cannot be answered over the telephone

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CITY & GUILDS

As mentioned a couple of months ago, our new series *Introducing Microprocessors* starts next month. The series can lead to the award of a City & Guilds certificate (Introductory Microprocessors) and we believe this is a first for any UK monthly magazine. It is also exclusive to EE.

Make sure you get next month's issue—it carries the introduction to the series with all the details of how to register for assessment, centres, cost etc. We are already experiencing unprecedented interest in this series and **I strongly recommend that you make sure of your copy** by either ordering it from your newsagent or by taking out a subscription—see pages 468 and 517.

If you do not have a copy on order we cannot guarantee to be able to supply!

The course should provide all readers with a thorough understanding of the principles and practice of microprocessors. Even if you do not wish to try to gain a C&G certificate, *Introducing Microprocessors* will be well worth following. For those who are interested in the qualification you may like to know that you do not have to take the assessments within any given period. The study can thus be spread over a couple of years if you so wish. As I said, don't miss next month's issue—order now!

PCBs

I would like to warn all readers that we are about to rationalise our *EE PCB Service*. The number of boards available will be reduced from next month when virtually all boards over two years old will be dropped from the list.

We have found that after two years the very low requirement for p.c.b.s makes the service uneconomical. It will also be necessary to increase the price of some boards. So if you want a p.c.b.—particularly if it is an old one—get your order in now. You have been warned!

Many of our p.c.b. prices have never been raised and with the rising cost of materials and labour, we now have to increase the price to cover these. I assure you our p.c.b.s will still be good value for money and competitive with other suppliers.

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

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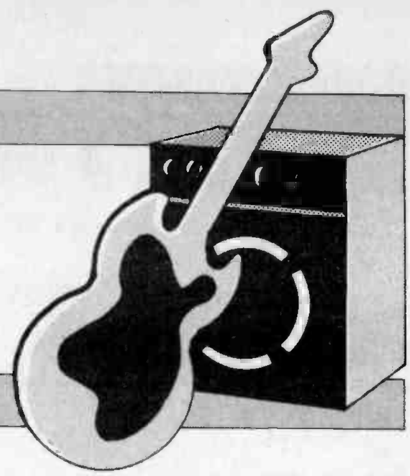
NOISE GATE



IAN COUGHLAN

Ideal project for the musician who wants to create the right sounds, without the noise

OVER the last few years the popularity of electronics effects units for musicians has grown dramatically particularly those using time-delay techniques. These include flangers, choruses, echo, reverbs, and so on. While these effects offer the musician new and interesting sounds, they often suffer from a poor signal-to-noise ratio; that is, the amount of noise produced relative to the maximum signal level that the system can handle. This noise is normally masked by the music, but stop playing and the same noise becomes quite objectionable, manifesting itself in the form of hisses, whistles, crackles, whoops, etc.

Using more than one effect-box simply makes matters worse, as do noisy leads and jack-connectors. One solution would be to turn the amplifier's volume control down whenever playing stops, but that is obviously impractical. The Noise-Gate offers a neat and simple answer to the problem. Connected immediately before the input to the amplifier—and therefore after any effect-boxes in use—it constantly monitors the signal level. If the signal is below a certain level, then the Noise-Gate will "close" and prevent the signal from reaching the amplifier. Start playing and the signal rises, causing the Noise-Gate to "open", allowing the signal to get through to the amplifier. So when there is music, the signal gets through; when there is only noise, it doesn't.

The signal level at which the Noise-Gate will open is called the "threshold", and a control is provided so that it may be adjusted. The threshold should be set just above the level of the noise (the so-called "noise floor"), so that any signal above the threshold, and therefore above the noise floor, will open the Noise-Gate. Note the terminology used: *open* means the signal is allowed to pass through, *closed* means it is not. Don't think in terms of a switch: think in terms of a gate (hence the name "noise-gate").

The Noise-Gate should open as quickly as possible in response to an increase in the input level, so that little of the music is lost. In this design, the response time is around a couple of milliseconds. Obviously, the same does not hold true when the input level falls below the threshold, otherwise the Noise-Gate would close with every gap in the music of more than a millisecond or two. This design will remain open for about half a second after the music stops. These times are not externally adjustable, but the experimentor may wish to try altering the values of the relative components, to lengthen or shorten either or both times.

There is also a control for adjusting the gain of the Noise-Gate. Normally this would be set to unity (output = input), but can be set anywhere between 0·02 and 5 (or −34dB to +14dB gain). A switch on the rear allows the user to open the Noise-Gate regardless of the signal level, this is handy for tuning-up instruments; and an l.e.d. on the front panel displays the status of the Noise-Gate.

CIRCUIT DESCRIPTION

Integrated circuit IC3 (Fig. 1) is a quad CMOS switch, and IC3a, is the "gate" in noise-gate. For the input signal to reach the output, it must first pass through IC3a, and the state of this switch is controlled by the voltage on IC3 pin 13. When this voltage is high, the switch allows the signal to pass; and when it is low, the signal is blocked. IC1b, wired as a variable gain stage, boosts or attenuates the gated signal, and provides a low output impedance suitable for driving virtually any amplifier or tape-recorder input stage.

For the Noise-Gate to open, about six volts peak-peak is required at IC2a pin three. This is much larger than can be provided by musical instruments, so the input signal is boosted considerably by IC1a, another variable gain stage, whose gain is adjustable between 23 and 73, giving a threshold that can be set from about 85mV peak-peak, to 250mV peak-peak. IC2a pin two is biased by R10 and R12 to

COMPONENTS

Resistors

R1,R12,R15,R16,R18,R19	1M (6 off)	R8,R10	330k (2 off)
R2	200k	R11,R17	10k (2 off)
R3,R4	470k (2off)	R13	5k1
R5,R9	4k7 (2 off)	R14	33k
R6	100	R22,R23	3k9 (2 off)
R7,R20,R21	100k (3 off)		

All 0.25 watt 5% carbon

See **Shop Talk** page 484

Potentiometers

VR1	1M log. carbon
VR2	10K log. carbon

Capacitors

C1	330n miniature layer polyester 100V
C2,C3,C4,C7	10µ miniature radial elect. 16V (4 off)
C5	100µ miniature radial elect. 16V
C6	22p polystyrene 160V
C8,C10	100n miniature layer polyester 100V (2 off)
C9	470n miniature layer polyester 100V

Semiconductors

IC1	TL072 dual low-noise op-amp
IC2	TL082 dual op-amp
IC3	4066B quad switch
IC4	78L12 +12V voltage regulator
D1,D2,D3,D4	1N4001 1A 50V rectifier diode (4 off)
D5	1N4148 small signal diode
D6,D7	3mm red light emitting diode (2 off)

Miscellaneous

S1	s.p.s.t. miniature toggle switch
SK1,SK2	6·3mm jack sockets (2 off)
FS1	500mA fuse and 20mm panel mounting fuse holder
T1	1·2VA mains transformer with 12V secondary

Printed circuit board available from the *EE* PCB Service, order code 577; case 154mm × 120mm × 45mm; p.c.b. mounting pillars (4 off); l.e.d. mounting clip (2 off); 7/02 wire; miniature screened cable; 3-core 3A mains cable; cable grommet and clamp for mains cable; control knobs (2 off); primer and paint; instant lettering; solder tag; screws for p.c.b. pillars; 1mm rubber sleeving; p.v.c. insulating tape.

Approx. cost Guidance only £17 (plus case)

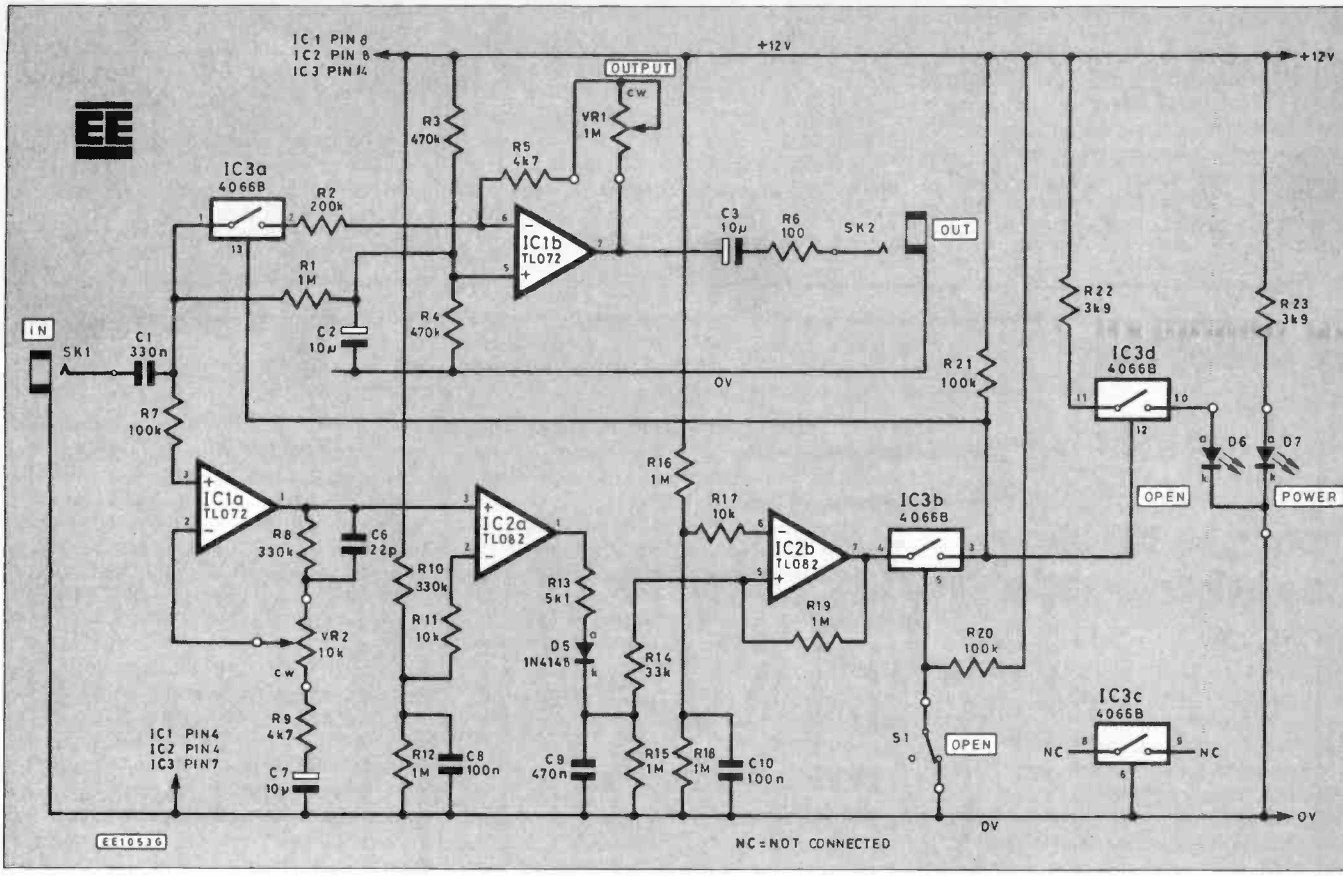


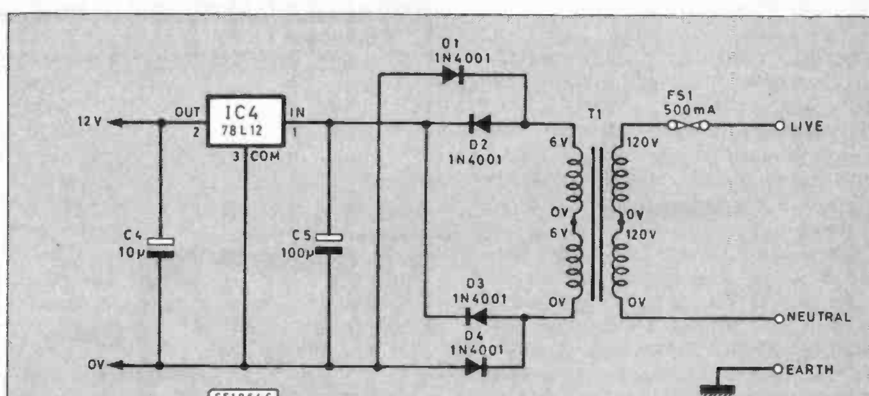
Fig. 1. Complete circuit diagram for the Noise-Gate. The 12V power supply section is shown below.

about 9V. With no input signal present, IC2a pin three is at 6V. Therefore, for IC2a, which is the threshold detector, to operate, IC2a pin three must exceed 3V peak (or 6V peak-peak). When the threshold is reached, IC2a pin one will go high, charging C9 via R13 and D5. R13 and C9 determine the time taken for the Noise-Gate to open. When the voltage on C9 exceeds about 6·2V, so the voltage on IC2b pin five will exceed that on pin six (6V), and will cause IC2b pin seven to go high. Without R19, IC2b would tend to oscillate as the voltages on pins five and six approached each other.

When the input level drops below the threshold, so C9 will no longer be getting charged from IC2a pin one, and will discharge through R15. R15 sets the time taken for the Noise-Gate to close. This resistor may be decreased for shorter hold times, but must not be increased, otherwise the Noise-Gate will not function.

Switch S1, when closed, pulls IC3b pin five to 0V, causing IC3b to open, and allowing IC3 pins 12 and 13 to be pulled high via R21. IC3a will therefore close, allowing the input signal to reach the amplifier stage, as described above, and IC3d will close, causing D6, an l.e.d. to light, indicating that the Noise-Gate is open. Since IC3b is open, the voltage on IC2b will have no effect on the status of the Noise-Gate: i.e., the 'Gate will be open regardless of the input signal. When S1 is open, IC3b pin five will be pulled high by R20. IC3b will then be closed, and the state of IC3a and IC3d, and therefore the status of the Noise-Gate, will depend on the voltage on IC2b pin seven, and this in turn depends on the input signal level.

Power is supplied by transformer T1, and regulated by IC4, a 78L12 voltage regulator, see Fig. 1.



CONSTRUCTION

Construction of the Noise-Gate is fairly straightforward and is built on a single printed circuit board. Because the mains transformer is also mounted on the board ***extreme care must be taken when testing.***

The component layout and printed circuit board foil master pattern is shown in Fig. 2. This board is available from the *EE PCB Service*, code 577.

Begin by checking the bare printed-circuit board for shorts. Veropins should be inserted into the p.c.b. from the foil side. These can be gently tapped into place with a hammer, and then soldered. Fix the resistors to the p.c.b., followed by the capacitors and the link-wire. If using d.i.l. sockets for the i.c.s, fit these next, then the fuse-clips, IC4, and the diodes. Turn the p.c.b. over, and connect insulated wire between the points shown in Fig. 2. Lastly, fix the transformer to the board, and fit the i.c.s in their sockets.

If using the same box as the prototype, drill it as shown in the photographs. Deburr the holes, and rub-down the surfaces to be painted (the front and the rear), prime

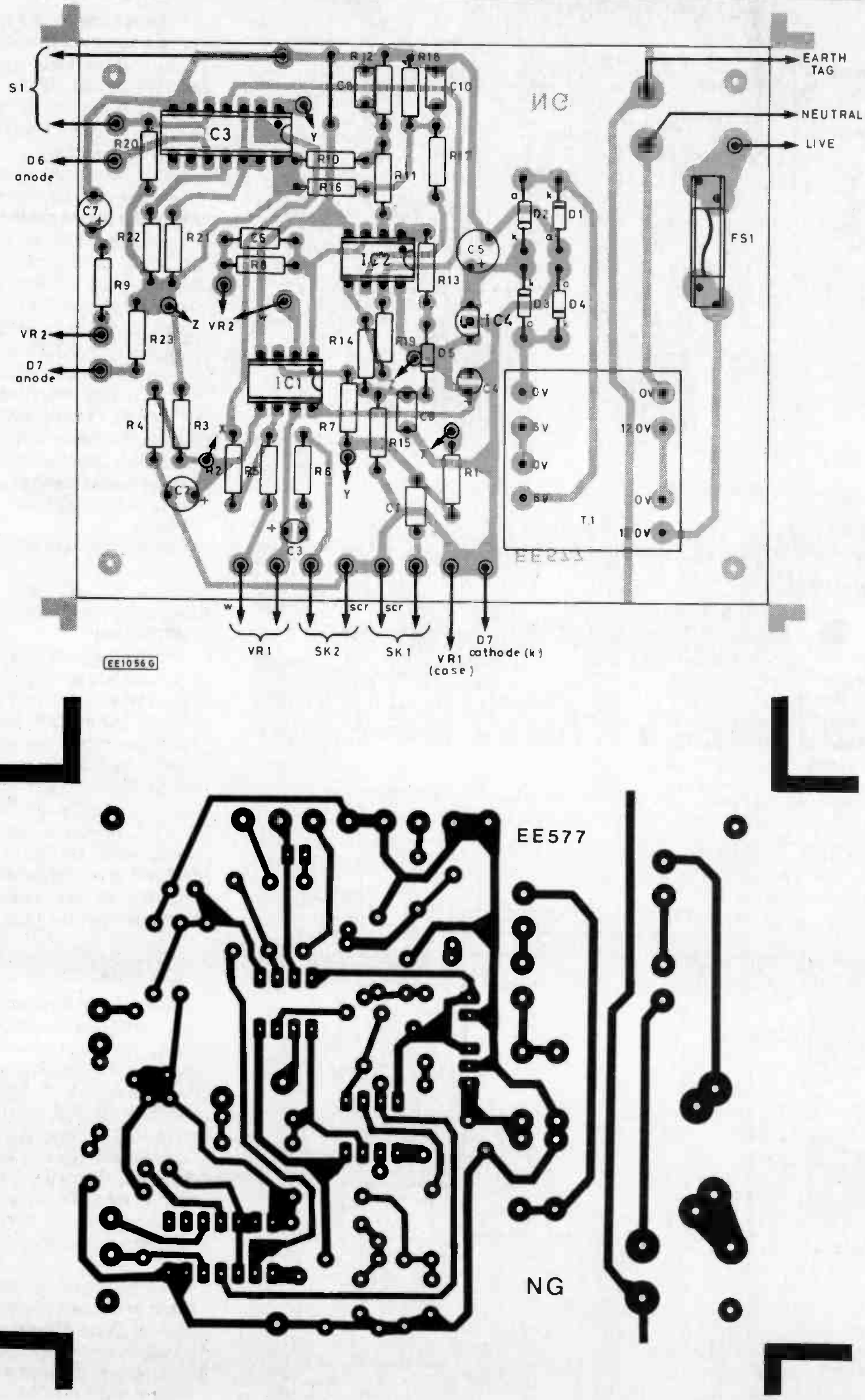


Fig. 2. Component layout and full size printed circuit foil master pattern for the Noise-Gate. Note that the wires terminated with single letters should be a single sleeved link, i.e. x to x, y to y etc, and be soldered on the underside.

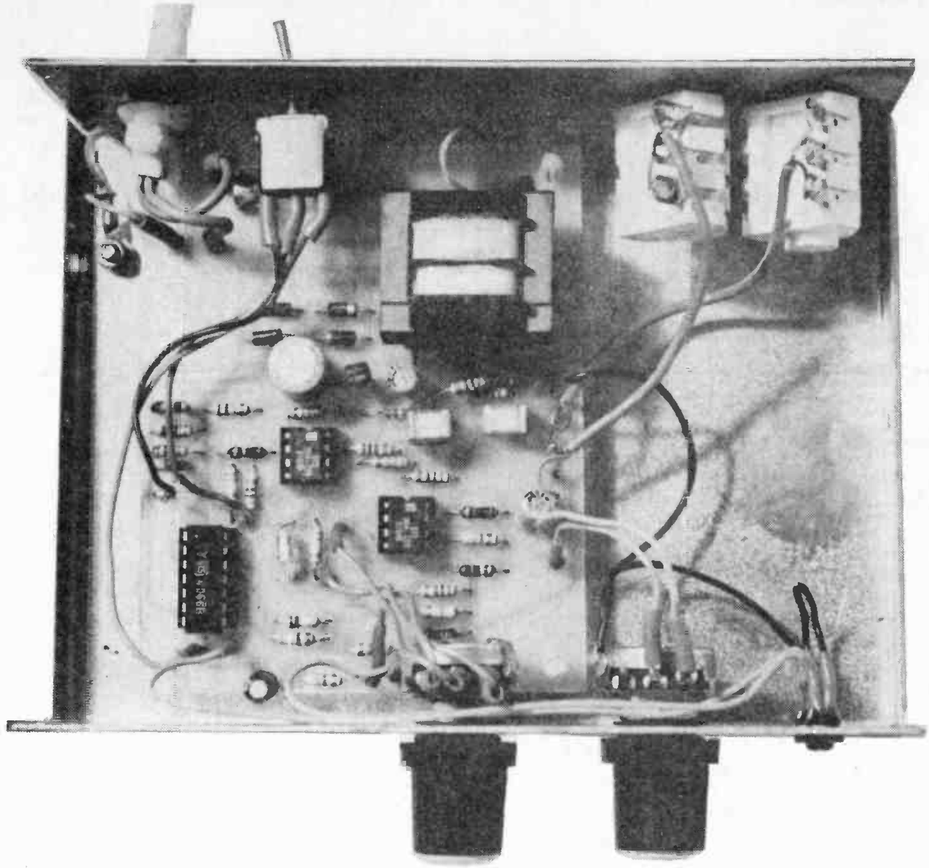
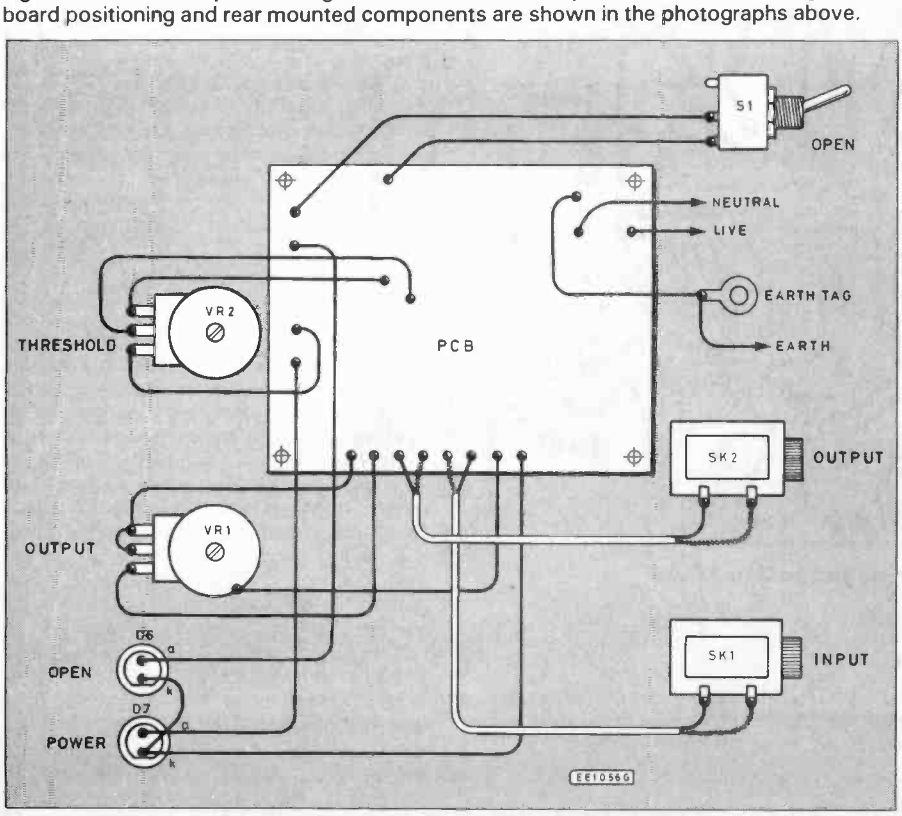


Fig. 3. Front and rear panel wiring and connections to the p.c.b. The internal wiring, board positioning and rear mounted components are shown in the photographs above.



them, and paint them. When the paint is dry, lettering can be applied, using Letraset or Mecanorma dry-transfers, which should then be protected with a light coat of varnish. Fix the earthing-point and the p.c.b. mounting pillars to the base of the box. As a safety measure, apply a few lengths of p.v.c. adhesive insulating tape to the inside of the box, underneath those areas of the p.c.b. that carry mains voltages. Fix the p.c.b. to the four mounting pillars.

INTERWIRING

Connect the mains cable (not forgetting the grommet and a cable clamp) to the p.c.b., and the earth conductor to the earth tag, which should be connected to the earthing point on the box. At this point it may be worth checking that the power supply is operating.

Fit a 500mA fuse, and check the resistance between the live and neutral conductors of the mains cable (this should be a few tens of ohms). Next, check that the earth conductor is connected to the case, and that the resistance between the earth conductor and the live and neutral conductors is very high (it ought to be immeasurably high on a normal multimeter—in other words, check for an open circuit). Next, check for a similarly high resistance between the live and neutral conductors and the 6V windings of the transformer. If all is well, then the mains can be applied. **Take extreme care, as mains voltages are potentially lethal.** Check across pins seven and 14 of IC3 for 12 volts.

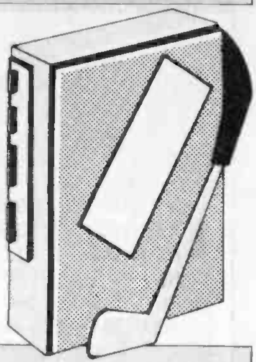
If the 12 volts is not present, then disconnect the mains before attempting to find out why. If the 12 volt supply is correct, disconnect the mains before continuing the construction.

Fix the two sockets, the switch, the two potentiometers, and the two l.e.d.s to the box. Connect these components as shown in Fig. 3, using 7/02 connecting wire and miniature screened cable. Make a quick visual check over the p.c.b. to ensure nothing has been missed out or fitted the wrong way round. Fix the lid on the box, and connect the mains supply. The Power l.e.d. should light. The Open l.e.d. may also be lit, depending on the position of the switch on the rear of the noise-gate: position the switch so that the l.e.d. goes out.

TESTING

Connect the noise-gate between an instrument and the amplifier. If using effects boxes, the noise-gate should be connected between the last of these and the amplifier. As the instrument is played, the Open l.e.d. should light, and the signal from the instrument should reach the amplifier. The Open l.e.d. should go out as playing stops: if it does not, then rotate the threshold control until it does. The Output control should be set to provide an output level suitable for whatever amplifier or tape-recorder is being used.

Flangers and choruses are among the worst producers of noise, so, if using one or both of these effects, switch them on, and adjust them for their worst ouput (that is, for maximum noise). Adjust the threshold control until the Open l.e.d. just lights, and then rotate it in the opposite direction until it goes back out. Playing the instrument should now open the gate, and the gate should close about half a second or so after playing stops. Construction and testing is now complete. □



PERSONAL STEREO AMPLIFIER

OWEN BISHOP

Turn your personal stereo player into a portable mini hi fi system

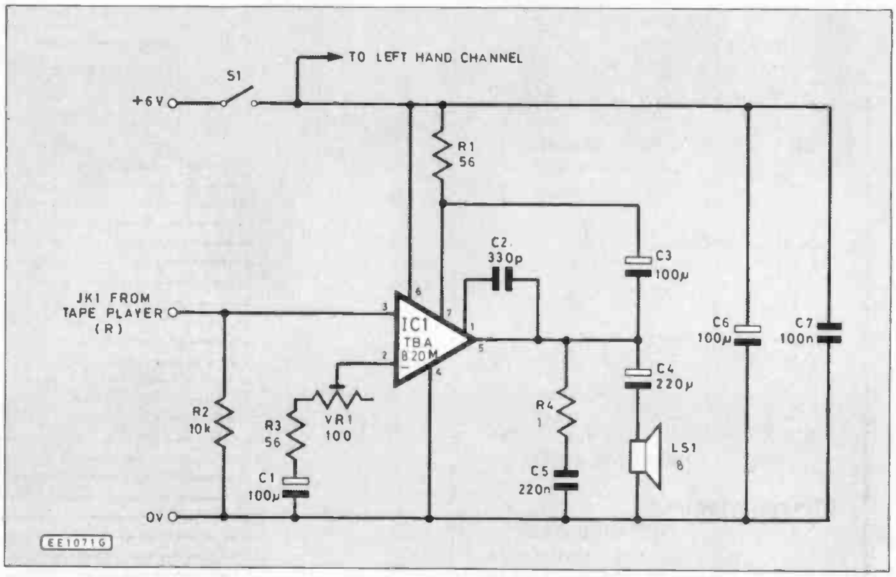
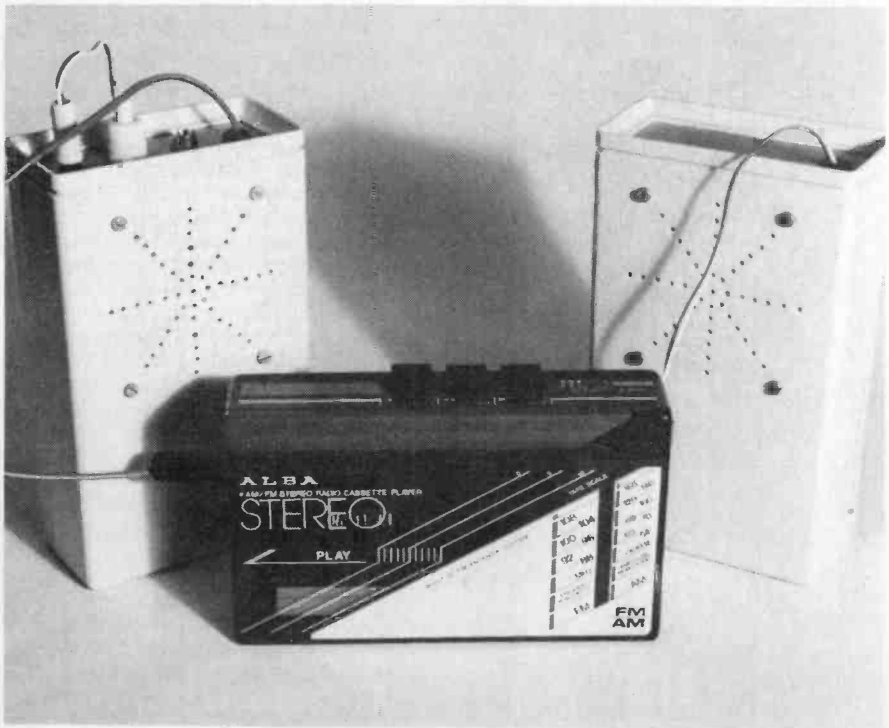


Fig. 1. Circuit of the right hand channel of the amplifier. In the left hand channel VR1 and R3 are replaced by R5. Capacitors C6 and C7 are common to both channels, all other components are duplicated.

One person's music is another person's cacophony! Owners of personal tape players avoid this situation by keeping their music to themselves. Their favourite melodies may be reproduced with high fidelity anywhere in the world. Yet this will not petrify the passing pedestrian or Pukeka (depending on location) with that bane of civilization—other peoples' music! On the other hand, there are occasions for sharing the enjoyment of music with friends or loved ones (subject to their consent, of course) and this is the reason for presenting this project.

It is possible to buy stereo amplifiers designed to operate with certain makes of personal tape player. But these are usually expensive and are not available for all players. The amplifier described here has been designed to connect to the Sony Walkman. It also works with the Grundig Beat Boy and has been successfully tested with many other tape players. The design features small size, light weight, robust construction and low battery consumption. In short, it is intended to be complementary to the personal tape-player. In addition, being based on a pair of readily available i.c.s, the amplifier is inexpensive and is simple to construct.



THE CIRCUIT

The circuit (Fig. 1) consists of two virtually identical amplifiers each built around a TBA 820M audio amplifier i.c. The special features of this i.c. are that it can operate on a supply voltage as low as 3V, and that it has a low quiescent current (about 3mA). Its maximum output is only 2W but, since the amplifier is to be powered by M1500 cells, it is not realistic to demand more. The amplifier will play for several hours before the cells become discharged and the sound quality deteriorates. The lower the output volume, the cheaper the running costs!

The diagram (Fig. 1) shows the circuit of the right channel amplifier, left hand component numbers are plus 100. Input from the right channel of the tape player is fed to pin three of IC1. The gain of the amplifier is set by adjusting the setting of VR1. The purpose of this is to allow the user to

COMPONENTS

See Shop Talk page 484

Resistors

R1,R101,R3	56 (3 off)
R2,R102	10k (2 off)
R4,R104	1 (2 off)
R5	120
R6	150

All 0.25W, 5% carbon

Capacitors

C1,C101,C6	100μ axial elect. 10V (3 off)
C2,C102	330p, polystyrene (2 off)
C3,C103	100μ radial elect. 10V (2 off)
C4,C104	220μ, elect. 10V (2 off)
C5,C105	220n polyester (2 off)
C7	100n polyester

Potentiometer

VR1	100 horizontal preset

Semiconductors

D1	Light emitting diode, recessed in bezel
IC1,IC101	TBA820M, audio amplifier (2 off)

Miscellaneous

S1	Push-on-push-off button switch or s.p.s.t. slide switch
JK1	Stereo jack plug to fit tape player
LS1,LS101	8 ohm loudspeakers, 75mm diam. (2 off)

SK1, mono jack socket, with mono jack plug to fit; plastic instrument case approx 90mm × 155mm × 45mm with end panel and battery compartment (2 off); stripboard approx 77mm × 62mm (24 strips × 30 holes); 1mm terminal pins (7 off); 8-pin d.i.l. sockets (2 off); 4BA bolts, each with nut and solder tag (4 off), four self-tapping screws or other fixings; small grommet; light duty two-core screened cable; single stranded and multi-stranded connecting wire.

Approx. cost Guidance only £12 (plus cases)

equalise the gains of the two amplifiers to produce a satisfactory stereophonic output. The *variable* output of the right channel amplifier is set to match the *fixed* output level of the left channel amplifier. The output volume of the system as a whole is more simply controlled by adjusting the volume control of the player itself.

The circuit is powered by four M1500 alkaline dry cells connected as a 6V battery. Although the i.c.s are able to operate at 3V, the sound quality tends to be inferior at this supply voltage.

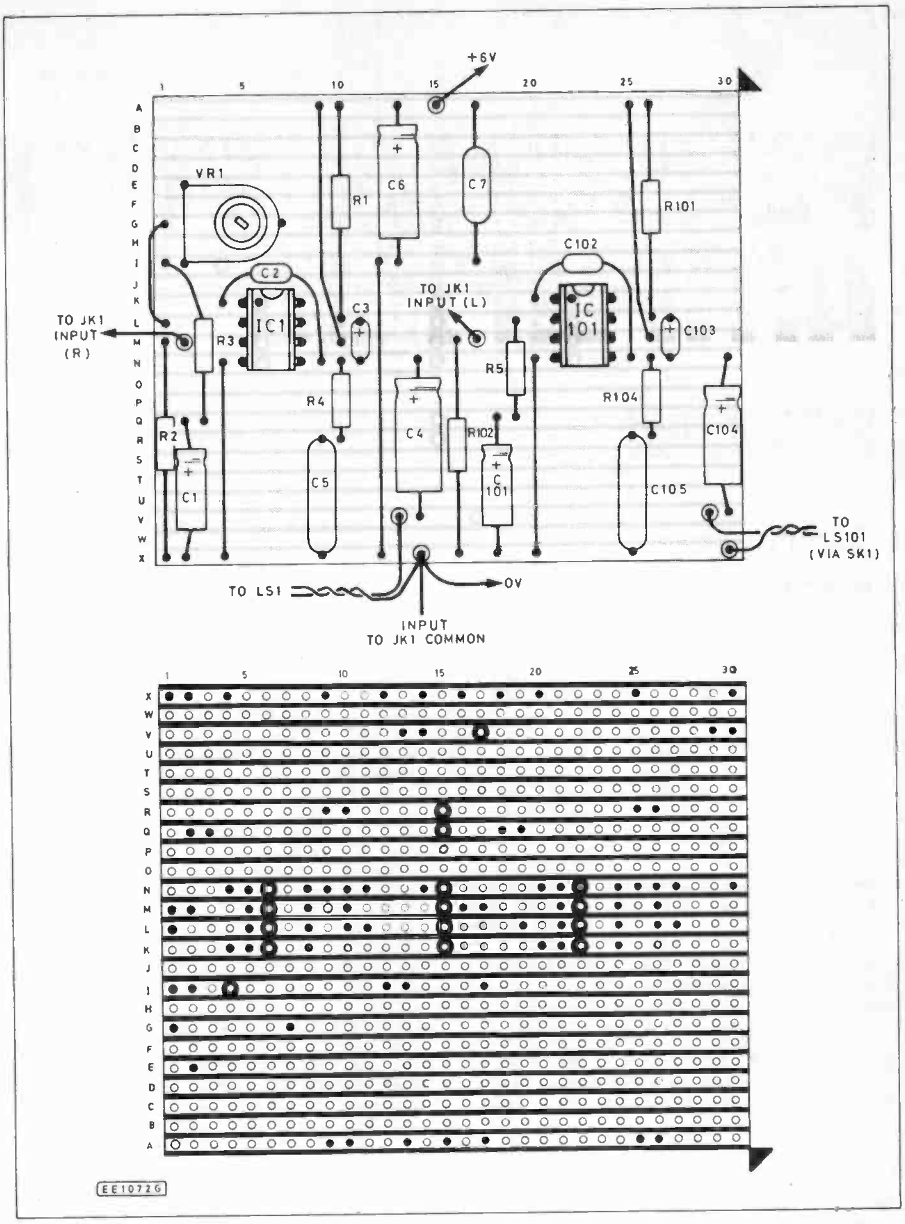
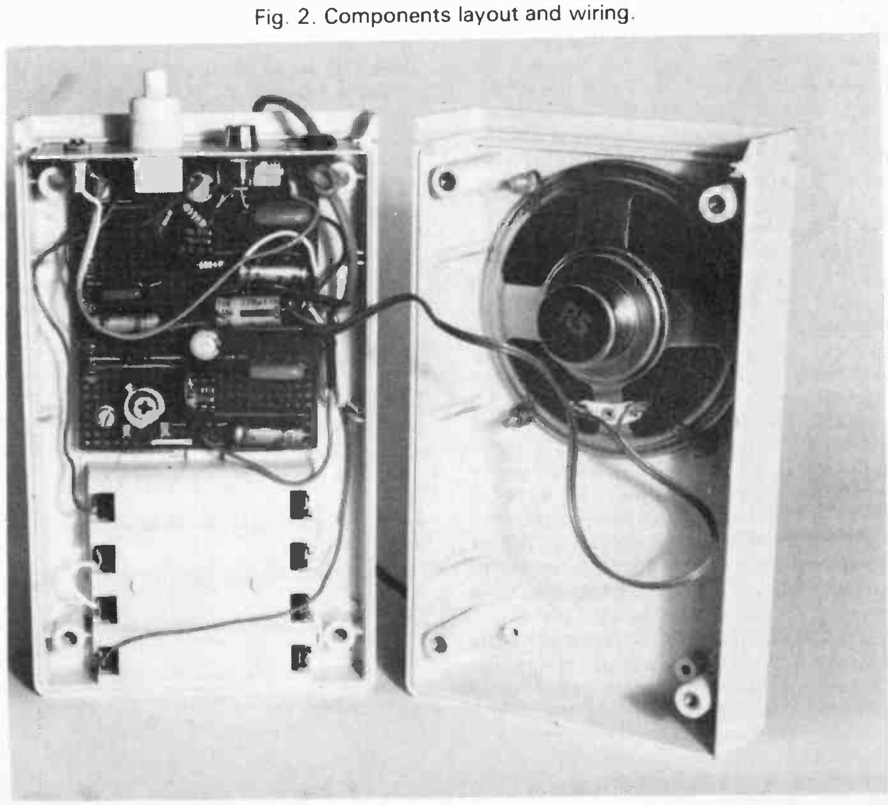


Fig. 2. Components layout and wiring.



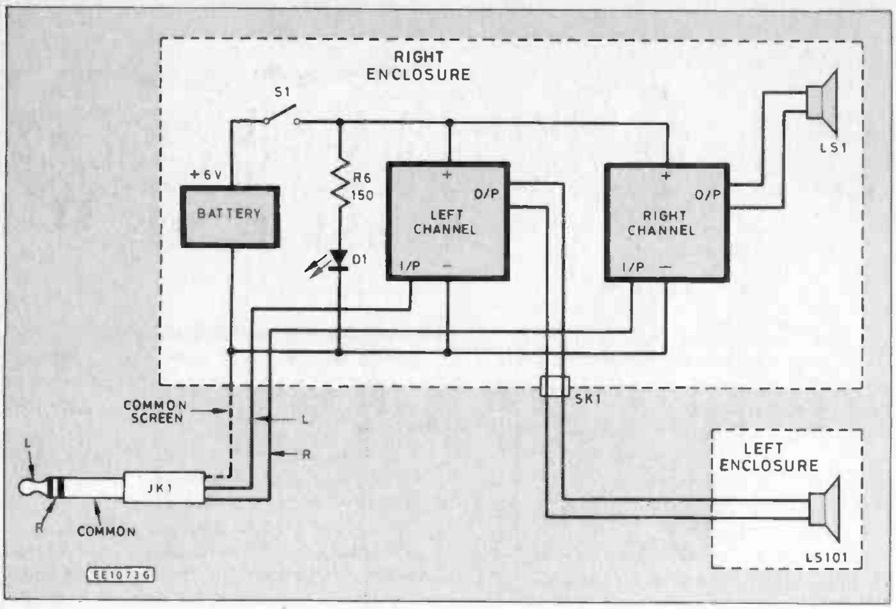


Fig. 3. Interconnection of the various parts of the amplifier system.

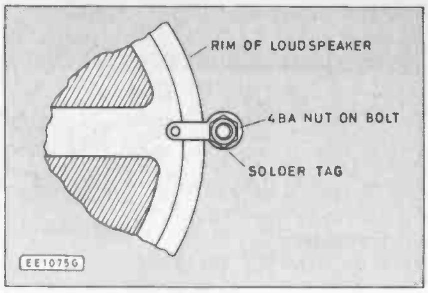


Fig. 5. Loudspeaker mounting.

CONSTRUCTION

The circuit may be accommodated on a small piece of strip-board as shown in Fig. 2. Before beginning assembly, check that the board will fit neatly into the intended enclosure (see later). Take note of points at which holes will need to be made through the board for mounting screws or bolts. It may be necessary to adapt the component layout slightly to allow for these.

First cut the copper strips beneath the board at the locations shown in Fig 2. Then solder in the connecting wires, followed by the resistors. Finally mount the other components, taking care to observe the correct polarity of the electrolytic capacitors.

The off-board connections are shown in Fig 3. Wiring up the connections depends on the type of case used for the enclosure. In the prototype an enclosure with a built-in battery compartment was used. The spring contacts for the individual cells were not already connected, so it was necessary to solder short wires so as to join the cells to form a 6V battery (Fig 4). The enclosure had a panel at one end. This was drilled for mounting the sockets and controls as shown in the photographs.

A push-on-push-off switch was used for S1, as this type is cheap and simply needs a circular hole for mounting. However, in a tightly packed suitcase or backpack, such a switch can be turned on by jolting or accidental pressure during the course of a journey. This could soon result in the cells becoming discharged. If you are concerned that this may happen, fit a slide switch instead. The light-emitting diode is not strictly necessary. It consumes about 10mA but, since it acts as a warning that the power supply is on, it probably saves current in the long run. Fig 3 shows the connection to the tape player. The stereo jack plug JK1 is connected by a two-core screened lead to the circuit board. This lead passes through a grommeted aperture in the front panel.

Before mounting the circuit board in its case, check the circuit carefully against the diagrams. Make sure all joints are properly soldered, and that there are no solder bridges between adjacent copper strips. It is worth while to inspect the underside of the circuit board using a hand lens at this stage as even the finest "hair" of solder can prevent a circuit from working.

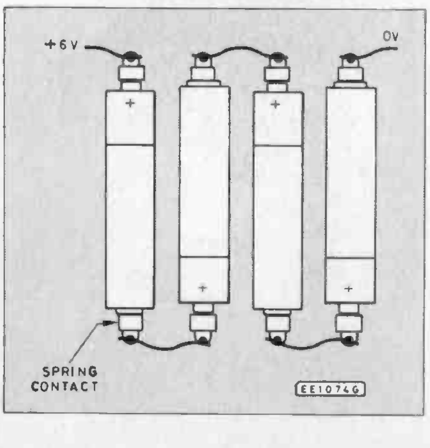
The case used for the prototype had four conveniently placed mounting pillars on the bottom half. The circuit board was drilled to match these, and self-tapping screws used to fix the board to the case. If the case you are using does not have such pillars, the board may be fixed in place with bolts, or with "sticky fixers".

SPEAKER ENCLOSURES

The speakers can be mounted in any type of enclosure, depending on the preference of the reader. It would be possible to use two existing speakers from a stereo system. For the prototype, which was intended to be a highly portable system, two identical cases just large enough to hold the miniature speakers were used, and (in one of them) the circuit board and cells were also mounted. Although it is slightly uneconomical to use a case with battery compartment for the left channel speaker, it is preferable to have matching cases. The battery compartment of the left-channel enclosure is a handy place for storing spare cells.

Before mounting the speakers in the lids of the cases, mark the inside of the lids to show where the speakers are to be located. When deciding where to place the speakers take account of the positions of the battery compartment, the circuit board and other components in the other half of the case. A radial pattern of holes drilled through the lid of the case with a 1mm bit, make a robust "grille".

Fig. 4. Battery connections.



Four holes suited to 4BA bolts are drilled just outside the edge of the loudspeaker area. The four bolts each have a solder tag, and a nut threaded on them. The solder tags are turned inward to overlap the rim of the speaker (Fig. 5). The nuts are then tightened, so that the rim of the speaker is gripped firmly by the tags.

With all components mounted, the various connections are made as in Fig 3, using multistranded connecting wire. The pair of wires from the left channel speaker should be about one to three metres long and terminate in a mono jack plug to fit the socket on the panel of the right channel enclosure. Next, place the lids on the cases. Inspect carefully as you place the lid on the right channel case to ensure that the speaker does not come into contact with the circuit board or any other components. The lid of the left channel case may be be bolted in place, but leave the other lid off until the system has been tested.

TESTING

Put four cells into the battery compartment, arranging them as Fig 4. Set VR1 to about the middle of its track. Insert the stereo jack plug into the earphone socket of a tape player. Insert the mono jack plug of the left channel speaker into the correct socket on the panel of the right channel case. Set up the two cases on the bench with speakers a metre or two apart and facing toward you. Switch on. The l.e.d. should glow and there should be a slight crackle from the speakers as the switch is operated. If there is no light, no crackle, or there is continuous whistling or crackling etc, switch off and re-examine the circuit board and other connections.

Assuming that all appears to be well. Place a tape in the player, turn the volume setting of the player well *down* (the amplifiers have high gain), and start the player. Turn the tape-player volume up to the required level. Check that sound is coming from both speakers. Now adjust VR1 until an equal volume of sound is obtained from each speaker and a realistic stereo effect is obtained. The resistance values quoted for VR1 and R3 are such that it should be possible to make the right channel sound either louder or softer than the left channel. If the right channel sounds louder than the left no matter what the setting of VR1, then replace R3 with a resistor of higher resistance, such as 100 ohms. Conversely, if the volume on the right channel is always too low, replace R3 with a resistor of smaller value, such as 27 ohms.

Having established the correct setting of VR1, switch off, replace the lid on the right channel enclosure and bolt it in place. The stereo tape amplifier is now ready for use. □

Robot Roundup

NIGEL CLARK

COCKROACH

The dream of a mechanical cockroach is fast becoming reality. It is complete mechanically and is in the process of having its software developed further to allow it to perform as well as intended in the original specification.

Dr John Billingsley, of the Electronic and Electrical Engineering Department of Portsmouth Polytechnic, and leader of the project said that the software for the first phase was now complete and work had begun on the second phase. At the moment the central processor was telling each of the legs what to do and when but it was intended that the central system would only issue general commands leaving the legs to work out how to achieve them.

This however is no toy mechanical insect. It is a serious attempt by a team at the polytechnic to create a new type of walking robot. The idea to model the device on a cockroach came from Arthur Collie, one of the members of the team. Cockroaches do not have central nervous systems and so cannot control their movements centrally as most creatures do. The legs work independently moving one step in response to a stimulus with obstacles sensed by the inability to go through with a step. When the concept first came to Collie about ten years ago it was not feasible to have six independent legs because of the size and cost of the individual controllers. The microprocessor changed that. Now with the help of grants from the Royal Society, the Science and Engineering Research Council and a little help from the armed forces unmanned vehicle programmme Collie has taken two years off from his job to work on the idea.

Billingsley said that the present software was quite sophisticated with constant checks being carried out to see if the instructions were being followed. However, it was still a system of big brother giving orders from the centre.

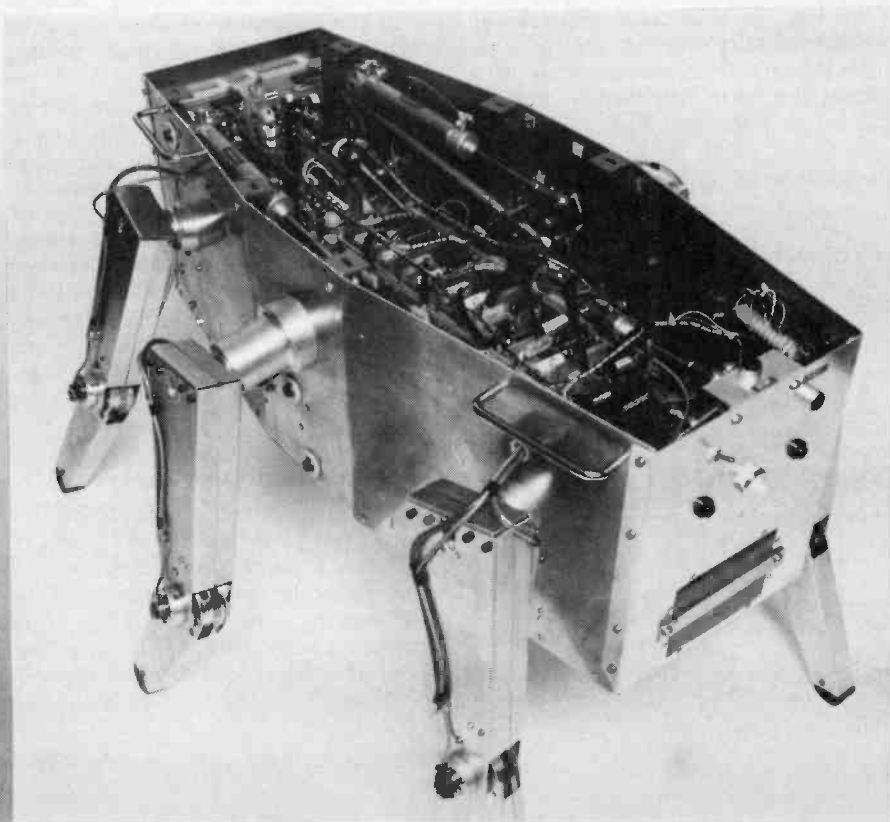
"Each of the legs is being told to go through a set procedure of picking up, moving forward and putting down again. We want the only instruction to be to walk with a particular combination of legs, it would then be up to the legs how that was achieved."

When the project began Billingsley said he was searching for a cantering, rather than a walking, robot. That was a reference to the intention for the device to mimic the movement of humans who while walking are dynamically stable but statically unstable. They are permanently off balance while moving and although they are stable, if they come to a sudden halt they will fall over as when being tripped up. Existing walking robots remain stable throughout their movement. While they gain in steadiness they lose on speed and fluency of motion.

The most usual form of movement by the cockroach is based on stable triangles. While the first and third legs of one side and the middle leg of the other remain steady, supporting the machine, the others move. With the weight towards the front of the device the centre of gravity, during movement, does not yet move in front of lines between the first and middle legs of each side, thus keeping it stable at all times. Human-like movement is being planned.

At the moment the movement is force driven to ensure that each leg continues moving until it finds something solid to stand on. However, the robot is still a little wobbly because of some software problems.

Each leg has joints at the hip and knee. The thigh is powered by two pneumatic cylinders working in opposite directions so that movement is always achieved by a cylinder pulling rather than pushing, with a double acting cylinder for the hip. Feedback is obtained from pressure sensors on the cylinders and angle sensors on the joints.



MOUSE AND ROBAT

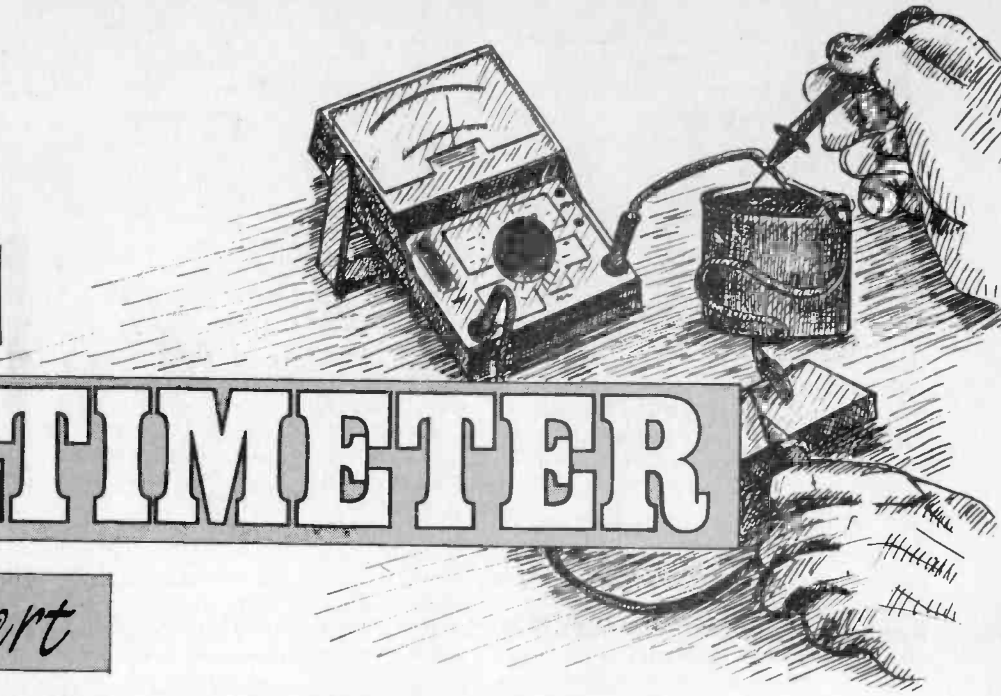
Two of Billingsley's other interests are progressing during the summer. On September 15 in Portsmouth the European finals of the Robat contest this year are taking place as part of the EuroMicro Conference. And the Institution of Electrical Engineers is hosting the World Finals of the Micromouse competition.

Billingsley is hoping that the Robat event goes better than last year's European finals in Venice when Britain's John Knight was the only person to achieve a hit of the ball with the bat. The Finnish team could not get their machine through customs and the Belgian device did not work. There were also problems with the table and running repairs were required necessitating the finding of a hardware shop in Venice (with no knowledge of the Italian for the relevant items!). Portsmouth may not be as exotic but it should enable a better contest to take place.

Billingsley is also hoping that some new entrants will take part. The British heats were held by the IEE in July and some enquiries had been received from newcomers but at the time of writing it was not known if there were any new faces to challenge Knight and Dr John Marr. In addition sponsors are being sought to help with prizes and the costs of holding the event. Anyone who would like to help should contact Billingsley at Portsmouth Polytechnic.

The MicroMouse contest, which has been taken over by the IEE, was also held in July. It was given the grand title of World Finals because the Americans are holding the event next year and said that they were going to designate them the world finals. However it was thought unlikely that the Japanese would be appearing because of the cost, this, despite beating all European opposition when a contest was held in Tokyo last year.

By using what was considered by most of the regular competitors as an out-of-date design they managed to reach the centre of the maze far more quickly than the more "sophisticated" models. The Japanese were still using stepper motors instead of the faster d.c. motors but by staying with a basic design and continually making improvements they had developed some very efficient machines.



USING A MULTIMETER

Mark Stuart

What to look for, it's limitations and how to use one of the most versatile of test instruments.

LIKE most electronics enthusiasts my tool kit started with a screwdriver, a pair of pliers and a soldering iron. The first "measurements" that I needed to make were simple and crude. There were three very common questions to answer:

Is the battery flat?

Has the fuse blown?

Is the "power" getting through?

Without knowing it I was asking about the three basic electrical units—***voltage, resistance*** and ***current***. With the aid of a battery and a bulb I was able to get some indication of all three, using the methods shown in Fig. 1.

With experience I was able to judge voltage and current by the brightness of the bulb, and by using the fuse checking arrangement I was able to test some low value resistors as well as fuses. I got by using these methods for quite some time until the great day arrived and I carefuly unpacked my first multimeter. With this prized possession I was able to measure voltage, resistance and current accurately over wide ranges. The real beauty of it though, was that I could use it in exactly the same way as my battery and bulb. The principles were exactly the same, only the quality of the equipment had changed.

As my electronics knowledge advanced I learned that my multimeter also had some shortcomings. Just as the battery and bulb method had its limitations, so too did the multimeter. The multimeter of course got much nearer to telling me exactly what was happening, but it wasn't always telling me everything, and sometimes it could be quite a long way from the truth. In fact, I had a good deal more to learn about electrical and electronic measurements as the rest of this article shows.

VOLTAGE MEASUREMENTS (V)

In Fig. 1a the basic principle of voltage measurement is shown. Voltage appears *across* components in a circuit and so is measured by putting the meter leads one each end of the component, that is, in parallel. To ilustrate some typical measurements the circuit of the *Active Infra-Red Burglar Alarm project* (March '87 EE) is reproduced in Fig.2.

The most common measurement made in circuits of this kind are voltage measurements. The reason for this is that unlike currents, voltages can be read without breaking the circuit. For example, the first sensible check on a circuit is to measure the supply voltage. A simple multimeter set to the 25 volt d.c. range could be used with the negative probe (usually black) connected to point (a) and the positive probe (red) to point (b).

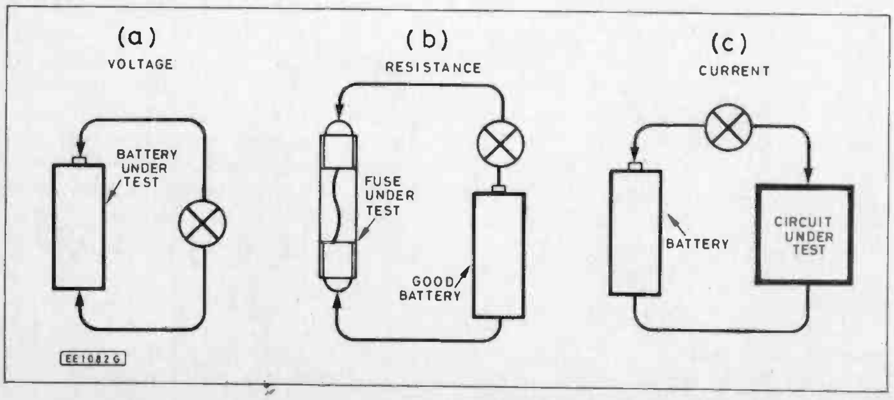
The next check would be to move the positive probe to point (n) to read the Zener stabilised supply voltage across D2. To measure the collector voltage of TR1, the positive probe is moved on to point (d) still keeping the negative probe connected to point (a). A great deal can be learned about a circuit by voltage measurements made in this way.

With most circuits all of the voltage measurements are made from a common point (in this case point (a)) usually the negative supply point. The voltage at points (b), (n), and (e) are said to be measured "with respect to negative". Voltages may be measured with respect to any suitable point in a circuit or across individual components. For example the voltage across R11 is measured by putting the negative probe on point (r) and the positive probe on point (p).

OHMS PER VOLT

So far the voltages measured have all been from "low impedance" points in the circuit and will read accurately. If the meter is connected to read the voltages at points (c) and (g) (with respect to negative) the readings will be low. The reason for this, is best ex-

Fig. 1. First attempts at "measuring" Voltage, Resistance and Current with a battery and bulb.



plained by reference to Fig. 3 which shows the internal circuit of a multimeter when set to its voltage ranges. The meter movement is essentially a current measuring device, the construction and operation of which has been described elsewhere.

To convert a basic 50 microamps meter movement into a voltmeter, a series resistor is used. The value of a resistor is calculated from Ohms law so that it passes 50 microamps at the required full scale voltage. For example a 10 volt range needs a resistor of 10 volts divided by 50 microamps that is 10/0·00005 ohms = 200,000 or 200k. The other ranges are calculated in a similar way, giving 500k for 25V and 2M for 100V. A value of 50 microamps has been chosen as this is an extremely common value for standard multimeters.

The expression "ohms per volt" which appears in multimeter specifications is derived by working out the series resistor that would be required to give a full scale voltage of one volt. For a 50 microamp meter, it is 1/0·00005 = 20k. A multimeter with a 50 microamp meter is therefore a "20 kilohms per volt" type. The best (most sensitive) analogue multimeters are based on a 10μA movement and so have a sensitivity of 1/·00001 or 100k per volt.

How this affects the circuit under test depends upon how easily the circuit can supply the 10 or 50 microamps that the meter requires. Power supply points such as (b) and (n) can supply an extra 50 microamps without any difficulty, but to sensitive parts of the circuit such as points (c) and (g) 50 microamps represents a heavy current drain that substantially affects circuit operation.

In the case of point (c) the actual voltage in the circuit is 0·6 volts and the current flowing through R6 and into the base of TR1 is two microamps. If the multimeter is set to the 10 volt range its resistance is 200k. At 0·6 volts 200k draws a current of 0·6/200,000 or three microamps. Since this is more than the current already flowing in the circuit there is not enough current to drive the meter properly and so the meter reads low.

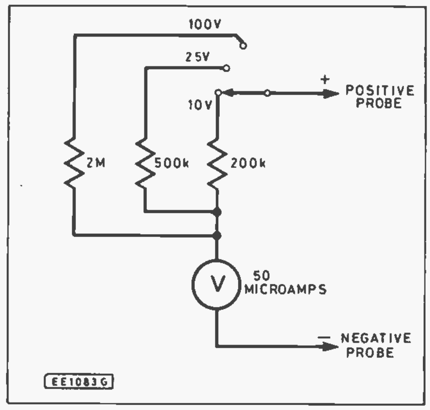


Fig. 3. Circuit diagram of multimeter Voltage ranges—10V; 25V and 100V.

Similarly when the voltage at point (g) is measured the current required by the meter is drawn from point (f) via R15. As the voltage here is approximately one volt the meter requires five microamps on the 10 volt range which must be drawn through R15. Now, to get five microamps through one megohm takes five volts (Ohms law again). As there is only one volt available it is obvious that the meter will read very low. In fact the meter will read 0·2 volts which is miles away from the true voltage.

If all the arithmetic here is a bit too much, don't worry, the principle is simply that at points in the circuit where there are high value resistors, voltages will read lower than they really are.

AVERAGE READING

Another situation where a multimeter doesn't tell the whole truth is when the voltage at point (j) is measured (with respect to negative). At point (j) there is not a steady voltage, but one which varies one hundred times a second from approximately 14 volts to 16 volts. The meter will try to follow the voltage, but fail, because it can't move quickly enough. The result is an average reading of 15 volts. For most purposes an average reading is adequate, but it gives no indication of the ripple voltage. This is simply a job that a multimeter can't do. The best instrument for this is an oscilloscope.

Other points in the circuit will also give misleading readings. For example, point (h) oscillates between 0V and +10V, spending half of its time in each state. The meter will read the average voltage which is five volts, but give no indication of the oscillation.

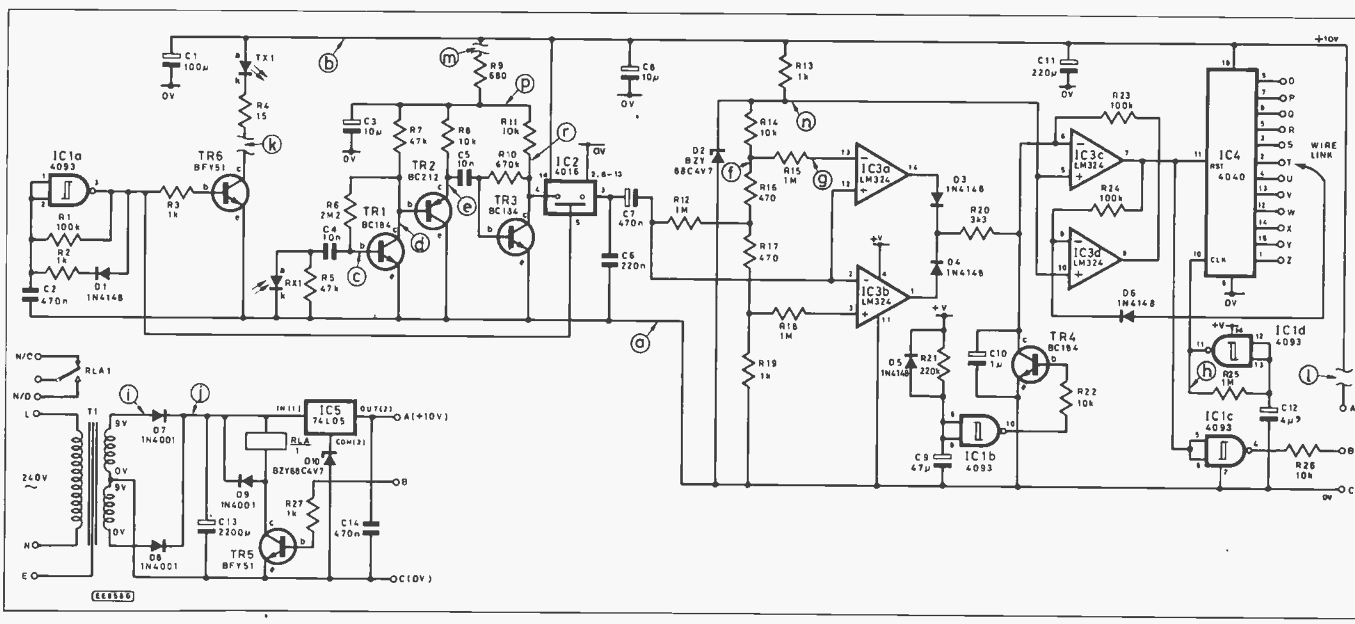


Fig. 2. Some typical measurement "test points" in a working circuit for an *Active Infra Red Burglar Alarm* (EE Mar '87). Points **k, l,** and **m** indicate where current measurements are made.

The voltage at points (d), (e) and (r) will give one reading when the infra-red beam is being received, and another reading when it is not. In many circuits voltage differences such as this do occur and sometimes service sheets or manuals give two sets of voltage readings. The "quiescent" voltages are usually those found when the circuit is operating normally but without an input signal, and are the most commonly quoted ones.

Despite these imperfections, voltages measured with a multimeter are still the simplest and most effective "first approach" to circuit testing. The number of voltage measurements made using multimeters each day must exceed the numbers of all other electrical measurements put together.

RESISTANCE MEASUREMENTS (Ω)

The measurement of resistance is much more straightforward than voltage measurement but the meter circuit is slightly more complicated. Fig. 4 shows a simplified standard multimeter circuit for resistance measurement. Resistors R1, VR1, and R2 are simply to make the 50μA meter movement into a voltmeter reading 0 to 3 volts. The variable resistor (VR1) allows the sensitivity to be varied slightly so that full scale deflection can still be achieved when the battery voltage falls to 2·5V. The three range resistors R3, R4, and R5 are selected individually by the range switch S1.

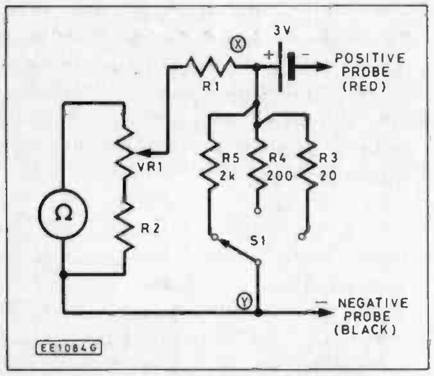


Fig. 4. Circuit diagram of multimeter Ohms ranges—20 ohms; 200 ohms and 2 kilohms (2k).

When the probes are touched together the full battery voltage is connected across whichever range resistor is in circuit and the meter reads full scale. If necessary, adjustment of VR1 can be made for exactly full scale. When the probes are separated the battery negative terminal is no longer connected anywhere and there is no deflection of the meter. These two extremes represent zero resistance (or short-circuit) and infinite resistance (or open-circuit) respectively. The scale of the meter reads backwards because zero resistance corresponds to full scale deflection and infinite resistance to no deflection.

When an unknown resistance is connected across the meter terminals, the battery is no longer connected directly across the range resistor. Instead, it is connected to the range resistor via the unknown resistor. If the unknown resistor is equal to the range resistor, half of the battery voltage will appear across each, and the meter will read centre scale deflection. So with the three range resistors given, centre scale is obtained by measuring resistors of 20ohms, 200ohms and 2k. For those who want to do the arithmetic the deflection for other values of resistance is given by dividing R (Range) by (Range) plus R_X where R_X is the unknown resistor.

For the 20ohm range this gives a deflection on the 50 microamp meter corresponding to nine microamps for 200ohms, 33 microamps for 10ohms, 25 microamps (centre scale) for 20ohms and a tiny deflection of one microamp for 2k ohms. A glance at any multimeter resistance scale will show that this is non-linear, and is especially cramped at the high resistance end.

If there are sufficient ranges (usually four or five) however, it is possible to get satisfactory readings from one ohm to one megohm. Higher resistance readings can also be obtained but it is necessary to have a higher voltage battery. Some multimeters have provision for two batteries, the higher one being switched into circuit when the highest resistance range is selected.

Apart from measuring resistance, one of the other uses of the k ohms ranges is to make simple checks for continuity, and to test diodes.

DIODES

When testing diodes it is essential to bear in mind this very important fact: The RED Probe is NEGATIVE and the BLACK Probe is POSITIVE.

This comes about because of the need to keep the negative terminal of the meter movement permanently connected to the negative probe. The construction of the meter and the switching arrangements are made much simpler by this means. Referring to Fig. 4 should help to make it plain. Over the years this polarity reversal has been accepted as "standard" and all conventional analogue multimeters are the same. Digital meters and electronic meters, however, have more complicated switching arrangements and, as if to add to the confusion, have their positive output on the red probe for ohms measurement. If in doubt the best way is to keep a known diode handy. Usually resistor values are measured by first removing the resistor from circuit.

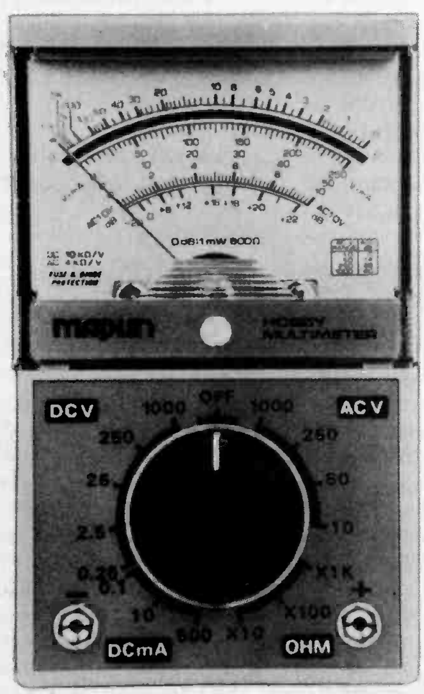
In-situ measurements can be made but often the readings will be low because of other components forming parallel paths. This is particularly so in circuits with transistors and i.c.s. For example the value of R7 in Fig. 2 could be measured in theory by connecting the probe between points (p) and (d).

With the black probe on (d) and the red probe on (p) a correct reading could be obtained, but with the probes reversed a parallel path via R8 and the base-emitter junction of TR2 is introduced leading to a reading nearer to 15k.

In a situation like this where one way the resistance is lower than the other way, it is always true that the higher value is nearer to the correct reading.

If the resistance reads the same in both directions it is probable that the value is correct, but by no means certain, because there could be purely resistive parallel paths in existence.

A final note on resistance ranges: Make sure that the circuit is switched off whenever resistance measurements are made. A glance at Fig. 4 shows that on the resistance ranges all that exists between the probes is a battery and the range resistor. Connecting a power supply across this unlucky combination is a frequent source of smoke as the range resistor is destroyed. Luckily the meter movement itself is usually adequately protected by R1, but it's better not to put it to the test.



The Hobby Multimeter from Maplin has 10k/V d.c. and 4k/V a.c. sensitivities. The meter also features a clear, easy to read, mirrored scale for accurate reading.—Maplin Supplies ☎ 0702 552911

The HM-102BZ multimeter from Cirkit is protected against accidental overload, has a continuity test buzzer and a jack socket for measuring audio output voltages. The meter is rated at 20k/V d.c. and 8k/V a.c. —Cirkit ☎ 0992 444111

The general purpose Miselco Mini 20 from Alcon Instruments boasts an easy to read mirrored scale, single knob switching and sensitivities of 20k/V d.c. and 4k/V a.c.—Alcon Instruments ☎ 01-352 1897

CURRENT MEASUREMENTS (A)

Current measurements are made by breaking the circuit and inserting the meter. Whilst voltage is measured *across* components current passes *through* them.

The multimeter current ranges circuits are shown in Fig. 5. As with the voltage circuit the current circuit is very straightforward. The three resistors are known as shunts because that is their function.

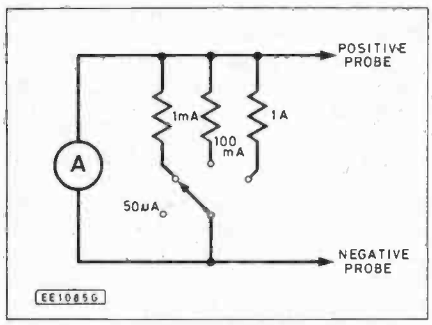


Fig. 5. Circuit diagram of multimeter Current ranges—1A; 100mA and 1mA.

For example on the 1mA range 950 microamps flow through the shunt resistor whilst 50 microamps flow through the meter. On the one amp and 100mA ranges the same principle applies, with all but 50 microamps flowing in the shunt resistors. To calculate the value of the shunt resistors (here comes some more arithmetic) the meter movement resistance needs to be known. In the case of most standard 50 microamps meters this is 2k. The value of the current that must flow in the shunt if first calculated e.g. for 1mA the shunt current is 1mA minus 50 microamps which equals 950 microamps. The shunt value can then be worked out as follows: Shunt value = meter movement current times meter resistance divided by shunt current.

For 1mA this gives: 0·00005 times 2000 divided by 0·000950 which gives 105 ohms. The other shunt values are one ohm and 0·1 ohm for the 100mA and 1A ranges respectively.

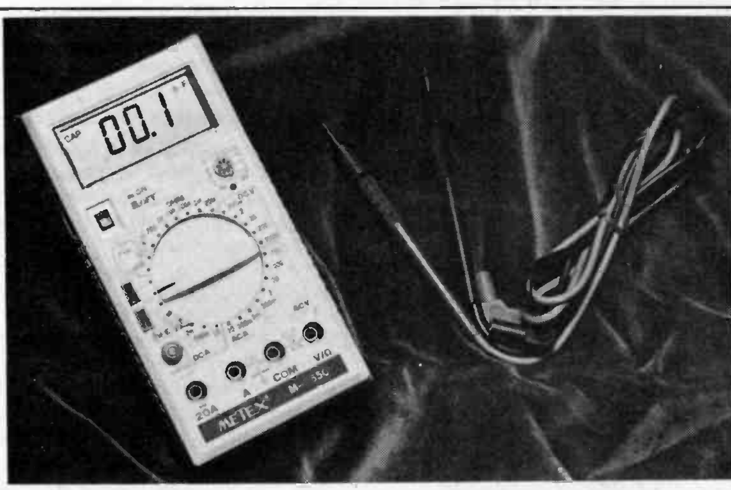
The measurement of the power supply current of the main circuit board of the Infra-Red alarm in Fig. 2 is taken by breaking the circuit at point ① and inserting the meter. When measuring an unknown current it is wise to start with the highest range (in this case one amp) so that the meter is not overloaded. The range switch can then be advanced until the best range is reached. The alarm circuit takes approximately 20mA so is best measured on the 100mA range.

SERIES RESISTANCE

When the meter is put into the circuit it adds another series resistance which has some effect on the current being measured. In this instance when set to the 100mA range the meter shunt resistance one ohm is added to the circuit. With 20mA flowing a resistance of one ohm produces a voltage drop of 20 millivolts. This is not significant in 10 volts, but there are sometimes situations where the extra voltage drop of a meter can have a significant effect. An example of where meter resistance begins to cause problems is given when measuring the current in the Infra-Red emitter circuit (point ⓚ). The current is not continuous but instead is a series of pulses of approximately 0·5 amps with a mark-space ratio of 100 to 1. The average current is therefore 0·5 divided by 100 or 5mA.

Connecting the meter into circuit adds an extra one ohm to the 15ohms already present (R4) and so the pulse current is reduced. The average current reading will be lowered from 5mA and will read one part in 15 lower than the true value.

Another problem encountered when inserting a multimeter into power supply circuits is that sometimes even a small extra resistance can cause severe instability and violent circuit oscillation. In these conditions the meter reading will be quite different from the true circuit current. In general, current measurements are relatively trouble-free and accurate, without the huge errors that can occur when making voltage measurements.



The new breed of multimeters now boast ranges with digital displays. The very latest Metex M-3650 from Crotech also has special facilities for testing transistor hFE, measuring capacitors (2000pF to 20μF) and for taking frequency measurements up to 200kHz
—Crotech Instruments ☎ 0480 301818

A.C. MEASUREMENTS (∿)

So far the voltage and current measurements made have all been in d.c. circuits. Another essential requirement is to be able to measure alternating currents and voltages, particularly at mains frequency. The usual way to achieve a.c. measurements is simply to put a diode in series with the meter. The meter is thus fed with a half wave rectified signal which it averages to produce a constant reading. A separate set of series resistors and current shunts are required so that the meter reads correctly.

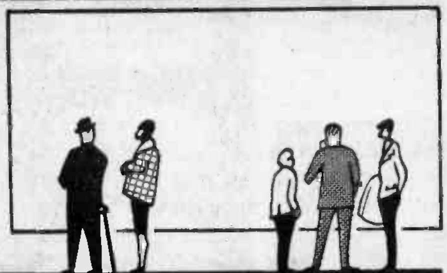
In most meters it is assumed that the a.c. signals being measured will be sine waves and that the frequency is in between 10Hz and 5kHz. Some better meters give a wider frequency range. In general the meter manufacturers take some liberties with a.c. measurements, particularly a.c. current, based on the fact that the main use of such ranges is to measure power supply voltages and currents where an error of up to ten per cent can be acceptable. High quality expensive multimeters have elaborate a.c. ranges often using special transformers to step up the voltage so that the rectifier circuits can work to their very best.

The main problem encountered when taking a.c. measurements is that any departure from a sine wave signal will produce inaccurate readings. A square wave and a pulse waveform will both give strange readings, and as the waveform is not usually known to the meter user it is very hard indeed to get meaningful results. It is safest to stick to reading mains frequency sinewave signals, and leave the rest until an oscilloscope is available.

CONCLUSION

Having spent most of this article discussing the drawbacks and limitations of multimeters I think I should say that I find my multimeter to be indispensable. There are very few circuits that can't be examined or repaired with its aid. My toolkit is now much more extensive than 25 years ago when that first multimeter arrived, and in those years the changes in electronics have been incredible. Sadly I no longer have the original meter—I dropped it downstairs some time ago, and before that I blew the 20 ohm range resistor by trying to measure a power supply voltage with the meter set to k ohms. □

SHOP TALK



BY DAVID BARRINGTON

Catalogue Received

With the possible call on the stocks of one of Europe's largest component suppliers, they claim to carry a bank of over 30,000 parts, Smith Electronics have issued a 100-page "International Electronic Catalogue" entitled *Electronic Actuell*.

With items ranging from circuit boards to complete kits, the catalogue is fully illustrated and contains special "buy line" panels. It also lists test equipment and computer peripherals.

Although all descriptions are in English, the prices are given in Deutsch Marks. Even so, the catalogue is *free* to EE readers and is well worth adding to the book library. To obtain a copy, send a large (A4) stamped, addressed envelope to: **Smith Electronics, Dept EE, 157 Chapel Street, Leigh, Lancs WN7 2AL. (☎ 0942 606674).**

Kits and Modules

Knowing the amount of interest we received when, a few years ago, we published a design for a *Digital Rule* working on "doppler shift principles", readers might like to explore the possibilities of the latest "Distance Measuring Instrument" from **Xen-Electronics** of the Isle of Wight.

The *EE Rule* was only capable of measuring fairly short distances whereas the Xen module, working on similar principles, is claimed to be capable of distances, between two parallel objects, of up to 26ft. With the addition of an optional display board the unit will give a digital readout of distance measured.

By adding a low cost (£2.95) parabolic reflector it is claimed that distances up to 65ft have been achieved.

Ideal for DIY enthusiasts for measuring a room for either wallpapering or carpeting, the Xen instrument could also be used for robotics, height gauge or even vehicle reversing applications. Another application that springs to mind, is that by using several "reflectors" strategically placed around a room or valuables it might form the basis of an intruder alarm.

The basic kit, comprising printed circuit board, components and ultrasonic transducer, costs £22.95 plus VAT (built and tested £34.95 +VAT). The kit price for the l.c.d. Display Board is £13.95 plus VAT (£17.95 +VAT ready-built). The Parabolic Reflector costs £2.95 plus VAT. A postage and packing charge of £1.15 per order must also be added.

For further details of the Distance Measuring Instrument contact: **Xen-Electronics, Dept EE, Unit 4, Samuel Whites Estate, Medina Road, Cowes, Isle of Wight PO31 7LP. (☎ 9083 292847).**

One of the latest excellent bargain modules from **Greenweld Electronics** is a low voltage power supply claimed to be capable of operating at up to 2A output.

The Astec type AA7271 is a six transistor, "switched mode" power supply module built on a neat, 50mm square, printed circuit board. The circuit will accept low voltage inputs up to 24V d.c. and give a stable 5V d.c. output at up to 2A. The circuit also incorporates current overload protection, thermal cutout and excellent filtering.

The Astec AA7271 switched mode power supply module is being offered at an all inclusive price of just £5. For further details of their many other "summer specials" contact **Greenweld Electronics, Dept EE, 443 Millbrook Road, Southampton, SO1 0HX. (☎ 0703 772501).**

CONSTRUCTIONAL PROJECTS

Electronics Analogue/Digital Multimeter

The low noise diodes used in the prototype *Electronic Analogue/Digital Multimeter* were types BAS45. Provided that they are "classed" as low noise, almost any general-purpose or signal diodes should work in this circuit. However, there may be slight variations in meter performance from device to device.

Digital panel meter modules are now stocked by quite a few companies and, provided they will operate from a 9V supply, readers should not experience any difficulties in selecting a suitable display module. The module used by the designer was a 3½ digit LCD type, with 10mm display digits, stocked by Magenta.

A complete kit (£44.72), including the printed circuit board, is available from **Margenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs DE14 2ST.** Add £1 for p&p per order. The printed circuit board is available from the *EE PCB Service*, code EE579 (see page 516).

Car Overheating Alarm

Most of the parts required for the *Car Overheating Alarm* appear to be standard components and should be available, "off-the-shelf", from most of our advertisers. However, a couple of items may possibly cause local sourcing problems.

The glass bead thermistor type GL16 used in the prototype is currently listed by Maplin, code WH23A. This thermistor has a resistance of 1Megohm at 20°C and a maximum operating temperature of 300°C. The GL16 seems to be rather expensive at £4.95 and other bead thermistors may be used, provided they are capable of operating within the range of the above characteristics.

Finally, be sure to use the light-duty automobile type cable and connectors were specified. These items should be available from most car spares shops.

Burst Fire Mains Controller

We cannot foresee any component buying problems when ordering parts for the *Burst Fire Mains Controller*. Note that the capacitor C1 is a 250V a.c. suppression type and it is important to point this out when ordering.

The mains transient suppressor VDR1 should be available from most component stockists and should not prove difficult to purchase. The one in the author's model was purchased from Maplin. Also, be sure to ask for a potentiometer with a plastic spindle when ordering VR1.

The printed circuit board is available separately through the *EE PCB Service*, code 578 (see page 516).

Noise Gate

A couple of items need special attention when ordering components for the *Noise Gate*.

When ordering the front panel mounted potentiometers, VR1 and VR2, be sure to specify "logrithmic" types. Also, note that the working voltage rating of the capacitors is a *minimum* rating and should not be less than that specified, particularly C6. It is quite in order to use types which have a higher working voltage rating.

Some readers may experience difficulty in locating a suitable p.c.b. mounting mains transformer for this project. The one used in author's prototype is a Colne type (code 3543) and was purchased from MS Components Ltd., (tel: 01-670 4466) Cat No. 700. Although it may need to be "hard wired" to the p.c.b., it should be possible to use one of the many excellent mains transformers stocked by advertisers, such as **Barrie Electronics** (01-555 0228).

The printed circuit board for this project is available through the *EE PCB Service*, code EE577 (see page 516).

Personal Stereo Amplifier

All components for the *Personal Stereo Amplifier* are standard items and should not cause any purchasing problems. The 2W power amplifier i.c., type TBA820M, is a fairly popular device and is listed or stocked by practically all of our advertisers.

The loudspeakers can be mounted in almost any type of enclosure, the prototype use two plastic instrument cases with battery compartments, and the final choice is left to the individual constructor. The case should have enough room to take the circuit board and speaker. Existing enclosures can be used if they are rated at 8 ohms.

We do not expect readers to experience any component buying problems for the *Exploring Electronics* project or the *Light Pen*—this month's *On Spec* project.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month's constructional project provides users with a simple five-key keypad which can be used for control applications and also makes an excellent alternative to a conventional joystick for fast moving games by providing "fingertip" rather than "lever yanking" control! We begin, however, by describing some simple software routines and interface circuitry for use with the five channel optically isolated input interface described last month.

Five-bit Input Interface Software

In last month's *On Spec* I glibly mentioned that the state of the five input channels of the optically isolated interface can be more easily sampled from machine code than from BASIC. The reason for this is simply that the Z80 instruction set contains a number of useful "bit test" instructions. These instructions allow the programmer to examine the state of individual bits within the CPU registers. Subsequent code can then branch depending upon the outcome of the bit test.

Alternatively we can simply flag the results of our bit test back to BASIC using a value returned in the BC register pair. We shall briefly examine both of these techniques but first, it is worth briefly outlining the method used to read the joystick port from machine code.

Reading the Joystick Port

The joystick port can be easily read using the following code:

```
0E FE joyread LD C,#FE;Read the keyboard with
06 EF         LD B,#EF;A0 and A12 low and the
ED 78         IN A,(C); address in BC, then return
C9            RET       to the ;calling routine
```

The single line address decoding employed in the Spectrum ULA associates address line A0 with the keyboard such that, when both the A0 and input/output request (IORQ) lines are taken low, the state of the keyboard is placed on the data bus. The keyboard thus has binary, decimal and hexadecimal addresses of 11111110, 254, and FE respectively. Joystick 1 corresponds to the row of keys extending from "6" to "0" which is decoded from the keyboard matrix by taking address line twelve (A12) low (whilst all of the other upper eight address lines remain high).

To accomplish this task in BASIC we can simply use **IN 61438** (A0 and A12 will both be low) but in machine code we must use the BC register pair (either loading B and C separately as in the example above or, saving one byte of code, by loading the BC register pair with EFFE in one go!). In either case we can then read the state of the port by executing an IN A,(C) instruction. Note that the contents of the B register will appear on the upper eight address lines when the IN A,(C) instruction is executed and hence the data from the relevant keyboard row is then transferred into the accumulator. The five least significant accumulator bits represent the five joystick switches according to the following table:

Bit	Joystick
0	fire
1	up
2	down
3	right
4	left

Bit Testing

Now, to return to the main theme, we can examine the state of each individual channel of the five channel optically-isolated input interface we can test the state of the channel(s) in which we are currently interested by using the Z80 BIT instruction. Suppose that we have an application in which channels 1 and 2 (corresponding to bits 0 and 1) are to be repeatedly sensed and, depending upon which channel is active we wish to make the Spectrum's border colour either red (channel 1 active) or green (channel 2 active). Furthermore, we will assume that channel 1 is to have precedence and that, if neither channel is currently active, the border should be black.

```
         inport EQU #EFFE ; input port address
         border EQU #229B; ROM border routine
            red EQU 2
          green EQU 4
          black EQU 0
                ORG #A000; Relocatable
01 FE EF readin LD BC, inport; Get ready for input
                                                and
ED 78           IN A, (C)   ; fetch current port
                                             status.
CB 47           BIT 0,A     ; Is channel 1 active ?
28 0A           JR Z,redon  ; If so, act on it!
CB 4F           BIT 1,A     ; Is channel 2 active?
28 0C           JR Z,greenon; If so, act on it!
3E 00           LD A,black  ; Neither is active
CD 9B 22        CALL border; so make it black and
C9              RET         ; go back
3E 02    redon  LD A, red   ; Channel 1 is active
CD 9B 22        CALL border; so make it red and
C9              RET         ; go back
3E 04  greenon  LD A,green  ; Channel 2 is active
CD 9B 22        CALL border; so make it green and
C9              RET         ; go back
```

The above code is not particularly elegant but has been presented in a form which, hopefully, most readers will be able to understand. Those familiar with machine code may have spotted that there is a much simpler solution to this particular problem which does not involve using the bit test instructions. For the benefit of the curious here it is;

```
         inport EQU #EFFE ; Input port address
         border EQU #229B; ROM border routine
                ORG #A000; Relocatable
01 FE EF readin LD BC,inport; Get ready for input,
ED 78           IN A, (C)   ; fetch current port status
07              RLCA        ; Shift left and
2F              CPL         ; invert the result then
CD 9B 22        CALL border; drop into the ROM
                                              before
C9              RET         ; going back
```

The second program does *almost* the same as the first program and readers wanting a challenge are invited to suggest what the difference is and why it occurs!

Both demonstration routines may be tested using an assembler (e.g. Hisoft's DEVPAC) however those not having access to an assembler need not despair. Both routines have been given with the resulting object code given in hexadecimal form. To enter the code into your Spectrum all that is required is our *On Spec* hexloader (available in the current *On Spec* package). All you will need then do is to choose a suitable start address for the code (e.g. A000 hex, or 40960) and enter the hex bytes from the left hand column of the listings. Then save the program for future use before exiting to BASIC for testing. A suitable BASIC program for calling the routine would be as follows:

```
10 REM Five channel input port demo.
20 RANDOMISE USR 40960
30 GOTO 20
```

The alternative method of flagging the outcome of a bit test back to BASIC is also quite straightforward as witnessed by the following example which produces a low pitched BEEP if channel 1 is active and a high pitched BEEP if channel 2 is active. Channel 1 again has precedence and no BEEP is produced if neither channel is active:

```
         inport EQU #EFFE ; Input port address
                ORG #A000; Relocatable
01 FE EF readin LD BC,inport; Get ready for input and
ED 78           IN A, (C)   ;   fetch   current   port
                                             status.
CB 47           BIT 0,A     ; Is channel 1 active?
28 08           JR Z,lobeep ; If so, branch . . .
CB 4F           BIT 1,A     ; Is channel 2 active?
28 08           JR Z,hibeep ; If so, branch . . .
01 00 00        LD BC, 0    ; Neither is active so flag
C9              RET         ; a zero and return
01 01 00 lobeepLD BC,1      ; Channel 1 is active so
C9              RET         ; return with 1
01 0A 00 hibeepLD BC,10     ; Channel 2 is active so
C9              RET         ; return with 10
```

A suitable BASIC test program would then take the following form:

```
10 LET z=USR 40960
20 IF z<>0 THEN BEEP 0.1,z
30 GO TO 10
```

Finally, it is worth mentioning that you don't need to have a completed five channel optically isolated input interface to hand in order to test any of these routines! For those who just want to try out the code, both programs can be tested using the "0" and "9" keys to simulate inputs on channels 1 and 2 respectively. In the case of the first two programs, if you hold the "0" key down when the code is running you should be rewarded with a red border. Holding the "9" key down, on the other hand, should produce a green border and, when neither key is held down, the border should revert to black. In the case of the last program,

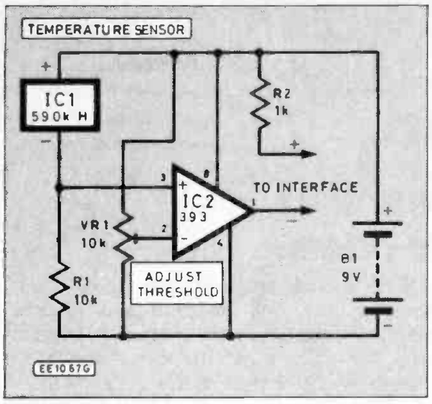


Fig. 1. Temperature sensor signal conditioning (NB: No series limiting resistor need be used within the interface).

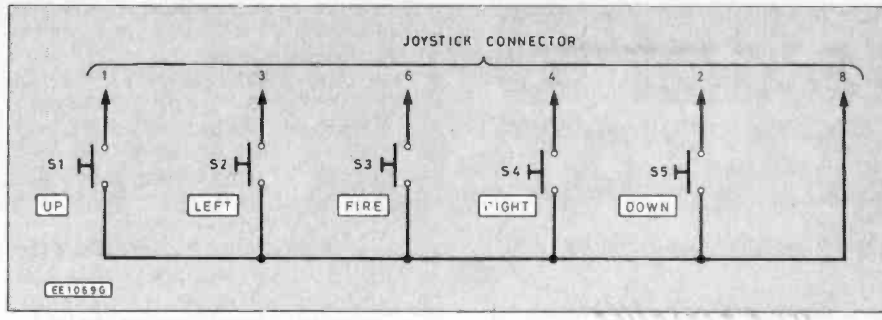


Fig. 3. Keypad circuitry (NB: See July EE for Spectrum Plus Two joystick connections).

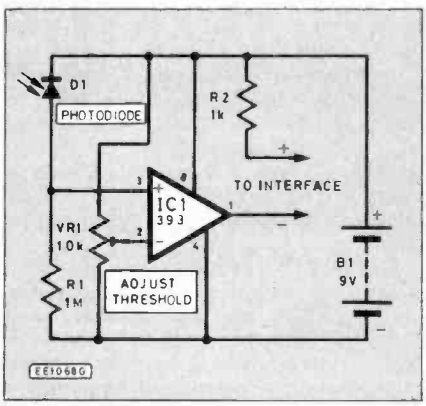


Fig. 2. Light level sensor signal conditioning (NB: No series limiting resistor need be used within the interface).

pressing the "0" key should result in a low frequency BEEP whilst pressing the "9" key should produce a high frequency BEEP. When neither key is held down, no sound should be emitted.

Temperature and Light Level Sensing

With the aid of suitable transducers and a single comparator chip, the five channel interface circuitry can easily be extended to permit sensing of temperature and light levels on a simple "high"/"low" or "above"/"below" basis. Typical additional circuitry is shown in Fig. 1 and 2. Neither of these circuits is at all critical as regards layout, component tolerances, or adjustment and a wide range of commonly available temperature and light level sensors will operate successfully in this configuration.

Five-key keypad

The five-key keypad is designed to replace the five switches fitted to a standard joystick. The minimal circuitry of the five-key keypad is shown in Fig. 3. The switches are low profile p.c.b. mounting types which are fitted to a small piece of 0.1inch matrix stripboard following the layout shown in Fig. 4. The keys should be arranged so that they fit comfortably below the user's fingers and the spacing should be adjusted accordingly.

The matrix board assembly should be mounted in a small plastic case (that used in the prototype measured 112mm × 62mm × 31mm). The switches are connected to the joystick interface by a length of multi-core cable terminated with a female nine-way D connector (connections given in July's instalment of E.E. or send for our Update).

If you have any comments or suggestions or would just like a copy of our *On Spec Update*, please drop me a line enclosing a large (at least 250m × 300mm!) stamped addressed envelope. Mike Tooley, Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey KT13 8TT.

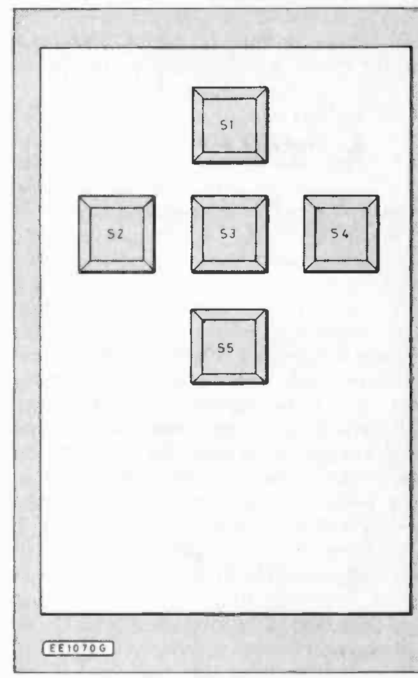


Fig. 4. Suggest keypad layout using low profile p.c.b. mounting switches.

Next month we shall be describing a versatile counter/timer interface based on the Z80-CTC. We shall also have some further notes for those wishing to incorporate machine code routines within their own programs.

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

NEW FREQUENCY ALLOCATIONS

Despite my gloomy prognosis last month on the possibility of the future reductions in the amount of radio spectrum allocated to radio amateurs—arising from the DTI sponsored report "Deregulation of the Radio Spectrum in the UK"—there is some good news for the moment.

The DTI has announced that as from 1st June, 1987, both the 50MHz and the 70MHz amateur allocations are expanded and, even better, these bands are now available for use by class B licensees.

The 50MHz band, covering 50·000 to 50·500MHz was made available to amateurs from 1st February, 1986, following a trial period with a limited number of authorised stations, as was reported in this column in February and April, 1986. Now the band has been expanded to cover 50·000 to 52·000MHz, although there are still restrictions on the power and the type (and height) of antenna to be used, to avoid interference to television transmitters which are still operating on these frequencies in Europe.

UK amateurs have "primary" status on 50·000 to 51·000MHz and "secondary" status on 51·000 to 52·000MHz, meaning that operation in the latter is subject to not causing interference with other services. A further relaxation is that portable (/P) or temporary premises (/A) operation is now permissible, although mobile (/M) is still not allowed on this band.

The 70MHz band was previously 70·025 to 70·500MHz, and is now expanded to 70·000 to 70·500, remaining unchanged as a secondary allocation.

ENTER THE "B" LICENSEES

While the extra spectrum allocation is good news, the big news from the amateur point of view is that class B licensees, representing nearly half of all licensed amateurs in the UK, who were previously restricted to frequencies above 144MHz, can now use these two lower frequency bands.

Class B operators now have the opportunity to obtain long distance (DX) contacts far more often than they have on the v.h.f. bands previously available to them. Many countries of the world have amateur allocations at 50MHz, although there are not many in Europe. Even in low sun-spot conditions there are occasional "openings" permitting contacts with the USA and Canada, and as conditions improve during the new sunspot cycle B licensees previously delighted with the occasional "lift" conditions across Europe on two metres, will enjoy rare and exotic DX around the world.

On 70MHz, the situation is different. It has never been a popular band with A licensees except for contests, because only the UK, Gibraltar, and Eire have regular allocations.

Many B licensees may find, however, that they get better inter-UK results than on two metres, covering greater distances with lower powers and more modest antennas. This could now become quite a popular band, with increased activity attracting even those who previously spurned it.

TIME-BOMB!

So its good news all round this month, and the Radio Society of Great Britain is to be congratulated on obtaining these valuable new concessions for amateur radio. But in the midst of their euphoria they would do well not to ignore the time-bomb quietly ticking away in the corner—the recommendation to the government by management consultants (reported last month) that far from amateurs having additional spectrum allocations, they should have less. At the risk of being called a misery-bags, I can't help wondering how long it will be before I find myself reporting not additions, but reductions in amateur frequency allocations!

AMATEUR RADIO FOR THE HANDICAPPED

Sometimes when I work other amateurs on the air they will mention in passing that they are "white stick" (i.e. blind) operators, or that their equipment has been modified to help them overcome some form of handicap.

Quite often, local amateurs will have helped them study for and pass the Radio Amateurs Examination (RAE), erect their antennas, and instal their equipment. They sometimes go on to say just how much amateur radio has expanded their immediate horizons, and how helpful they find it.

They need not have told me any of this, and if they hadn't I would probably have never known their situation. This is the great advantage of amateur radio for the handicapped—in most cases they can meet other amateurs over the air on equal terms. Whatever their disability, means can usually be found for them to put out signals sounding no different to anyone else's.

Although such operators rarely need help to actually operate their stations, they do need help or advice in setting them up in the first place. To this end, The Radio Amateur Invalid and Blind Club (RAIBC) was founded in 1954 as a self-help organisation to enable blind and handicapped people to pool their knowledge and skills, and to benefit from each other's experience.

HELP AVAILABLE

The range of assistance to help with particular disabilities is wide. For those studying for the RAE, cassettes of textbooks are available for the visually handicapped, and special arrangements are made for those who are blind, or unable to travel or write, to take the RAE orally (or to take the Morse test) in their own homes.

Once they have their licences, devices are available to help those with limited sight, for instance, to tune their equipment aurally instead of visually. Other disabilities can be overcome—even deafness—by adapting standard equipment to suit needs of most individuals, and when speech itself is difficult Morse code operating, sometimes with special keying arrangements, comes into its own.

Members of RAIBC keep in touch with each other through the Club's magazine *Radial*, and through regular "nets" on the air. The magazine gives news of members and their activities, future events, details of equipment for sale or wanted, and other relevant information for handicapped amateurs.

There are Club nets on the air every day of the week, including an international one on 14·290MHz on Thursdays at 1400 hours and Saturdays at 0730. Apart from licensed amateurs there are many listeners to these nets, often also handicapped in some way, and the exchange of news and views which takes place is widely disseminated to an appreciative audience.

While members help each other and undertake a good deal of fund-raising themselves, the RAIBC also receives valuable support from non-handicapped amateurs. Clubs and other organisations donate money, some regularly, while individuals act as helpers to members in preparing for their examinations, installing, modifying or repairing equipment, and providing general support and encouragement where needed.

There is a continuing need for such help, which is always much appreciated. If you feel you could assist in any way, even if you are not a licensed amateur, please contact RAIBC, 9 Conigre, Chinnor, Oxon.

Members operating a special event station during an RAIBC "open day" at the Wedgewood Electrical Collection, in Christchurch, Dorset, last year.

SPECIAL OFFER...

CIRCULAR RADIO CONTROL

MOVIT KIT

£16·95

including VAT and postage

This fascinating unit will provide hours of interest and pleasure. The Circular Movit consists of two large wheels each independently driven by an electric motor and gear train; these are housed in discs between the wheels. A battery pack and the control electronics are housed in plastic domes fitted to the outside of each wheel. The whole unit is controlled from a hand held radio control transmitter.

The Movit comes as a kit of parts plus full instructions for assembly — the electronic control units are supplied built and tested. Enjoy building it, be fascinated by operating it!

***EE* Movit Offer, Commotion Ltd., 241 Green Street, Enfield, Middlesex EN3 7TD. Tel: 01-804 1378.**

Please supply

Quantity		Value
	Circular Movit @ £16.95	

Overseas readers add £3.00 postage Total £

Please make cheques payable to Commotion Ltd.

Visa/Access or Cheque No...

Signature...

Name...

Address...

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BLOCK CAPITALS PLEASE

OFFER CLOSES Friday, October 23, 1987

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Post to: *EE* Movit Offer, Commotion Ltd.,
241 Green Street, Enfield, Middlesex EN3 7TD
Telephone orders: 01-804 1378

ELECTRONIC ANALOGUE/DIGITAL MULTIMETER

1.999

MARK STUART

A versatile test instrument for the workshop

THE DESIGN of an Electronic Analogue/Digital Multimeter was a very interesting exercise in compromise. During the course of its development a great deal of respect was gained for the designers of what were considered to be "ordinary" commercial instruments.

The basic electronic circuit for Voltage, Current, Resistance, and A.C. Measurements are fairly easy to deal with when taken individually, but combining them into a compact hand-held unit with a single range switch is another matter.

After some thought, it was concluded that the only solution suitable for home construction would be a "bench" meter and to incorporate a number of separate range switches. The idea of a single multi-pole multi-way switch was considered, but the price, and the complicated wiring that would be necessary completely ruled this out.

Two advantages of using separate range switches are that the switches can be printed circuit board mounting types—so eliminating wiring and wiring error and that parts of the circuit can be built separately and used individually in other applications.

The "indicating device" specified is a panel meter with a 100μA sensitivity. This is modified by means of a series resistor to read 0–1V. Almost any standard panel meter can be used, or instead one of the new digital panel meter modules could be added.

The overall performance of the meter is very good, its frequency range when measuring a.c. voltages and currents is good up to 50kHz and the input impedance of 10 Megohmns on all voltage ranges gives good accuracy in high impedance circuits where a normal analogue multimeter would be useless.

In addition to the standard range the meter has an "A.C. Millivolts" circuit which allows audio frequency measurements from 3mV r.m.s. up to 1V and is very useful for testing amplifier signal levels, microphone and pick-up outputs, frequency responses and general signal tracing.

The resistance ranges have the benefit of a linear scale that reads from left to right instead of the usual non-linear, reverse reading scales, also the probes are correctly polarised—that is red is positive—when making Ohms checks. All resistance measurements are made at a maximum of 100mV so in-situ measurements will not be affected by transistors, i.c.s and diodes in the circuit.

Other features are that the meter is protected from overloading by a fuse and electronically, and measurements up to 1000V and 10A a.c. and d.c. are possible. The meter is built in a fully insulated case for safety.

CIRCUIT DESCRIPTION

The full circuit diagram for the Electronic Analogue/Digital Multimeter is shown in Fig. 1. For clarity each section will be described separately.

VOLTAGE

Inputs for voltage measurements are applied to the voltage divider chain made up of resistors R2 to R7. Voltage ranges are selected by S1a, which taps off a proportion of the input voltage from the divider chain and passes it to IC1, the input amplifier circuit.

On the 1kV range an extra resistor (R1) is added to the top of the divider. To avoid having high voltages on the circuit board this resistor is made up from a series combination of values which are sleeved and mounted in the lead to the 1kV terminal (SK3).

The input impedance of the circuit is set by the total combined value of R2 to R7 which is 10 Megohms. In order to make accurate measurements on all ranges it is essential that the input amplifier circuit has an impedance which is in excess of 50 Megohms.

Use of a f.e.t. input amplifier i.c., TL071, and careful board layout ensures that this is achieved. IC1 does not have any gain, but it acts as a buffer circuit with a very high input impedance and a low output impedance.

From IC1 the signal passes to a second amplifier stage IC2 via resistor R32. S1b switches resistor R33 in and out of circuit on alternate ranges to give the 3V, 30V, and 300V ranges.

The combination of resistors R32 and R33 is such that the signal is reduced by 3 to 1 on each of these ranges but remains unaltered on the 1V, 10V, and 100V ranges. The amplifier IC2 has a gain of 10 and its output is applied to the meter movement via switch S5 when d.c. measurements are selected.

A.C. VOLTAGE

The circuit as far as the output of IC2 is identical for A.C. and D.C. ranges. Capacitors C1, C2, C3, C4, and C5 correct for the effects of stray capacitance and maintain a level frequency response to above 50kHz.

When a.c. measurements are made the meter is connected via switch S5 to the ouput of the rectifier circuit IC5. This circuit takes its input from IC2 and produces a half-wave rectified ouput which is averaged by the meter movement to give a steady d.c. reading.

Diodes D3 and D4 in the feedback loop around IC3 are connected so that on negative half-cycles the output stays at 0V, but positive half-cycles are passed normally with a gain of just over 2.

The value of gain is selected so that the meter reads the average value of the incoming signal and indicates the correct (r.m.s.) voltage. As with all meters the accuracy of a.c. readings depends on the signal waveform. Sine waves are the most frequently encountered and so the meter is set to read correctly for these.

Diodes D7 and D8 across the meter protect it from being overdriven when switching ranges etc. Diodes D1 and D2 provide similar protection for IC1.

CURRENT

On the Current range the shunt resistors R8 to R13 are connected in circuit by S3a and the voltage across them read by the standard voltage circuits. S2a selects the value of shunt resistor and S3b makes the connection between the shunt resistors and the input of IC1.

The values of the shunt resistors are selected to drop 100mV at the full scale current. A shunt of one ohm will give full scale reading on the meter when a current of 100mA is passing and so on.

For the 10A range a shunt value of 0·01 ohm is required. This is made from a length of wire connected directly between the 10A socket (SK4) and the negative (Common) socket SK2. This is necessary because the range switch is only rated at 1A, and the p.c.b. copper tracks would have to be huge to carry 10A comfortably.

The a.c. and d.c. current measurements are treated by the amplifier section in exactly the same way as voltages. The current ranges increase in direct decades (× 10) so that the use of S1b is not involved. Switch S3c ensures that this is switched out of circuit on all ranges except voltage.

RESISTANCE

Resistance is measured by passing a known constant current through the resistor under test and measuring the voltage drop across it using the standard voltage circuits.

The current source consists of IC4, transistor TR1, and associated components.

A reference voltage of 5·6V from Zener diode D5 is connected to the non-inverting input of IC4. Negative feedback around IC4 via TR1 and resistor R42 works in such a way that the emitter voltage of TR1 is made

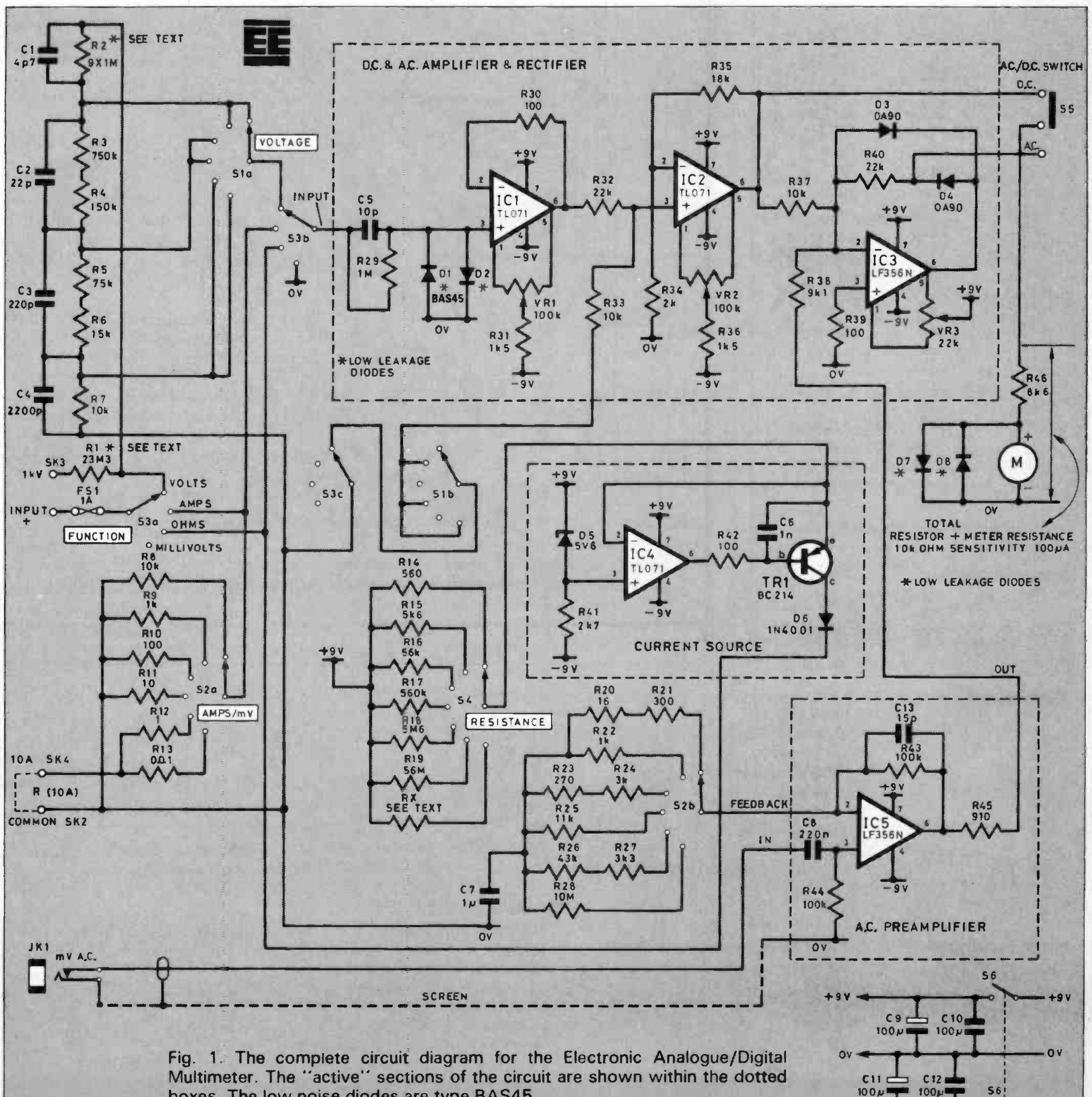


Fig. 1. The complete circuit diagram for the Electronic Analogue/Digital Multimeter. The "active" sections of the circuit are shown within the dotted boxes. The low noise diodes are type BAS45.

COMPONENTS

Resistors

R1	23·3M (2 × 10M + 1 × 3M3 in series 5 per cent)
R2	9 × 1M (in series—see text)
R3	750K
R4	150K
R5	75K
R6	15K
R7,8,33,37	10K
R9,22	1K
R10,30,42	100
R11	10
R12	1
R13	0·1
R14	560
R15	5K6
R16	56K
R17	560K
R18	5M6
R19	56M (series combination—see text)
R20	16
R21	300
R23	270
R24	3K
R25	11k
R26	43K
R27	3K3
R28	10M
R43,44	100K
R29	1M
R31,36	1K5
R32	22K
R34	2K
R35	18K
R38	9K1
R39	100
R40	22K
R41	2K7
R45	910
R46	8K6 (or value to suit meter—see text)
R(10A)	0·01 Ohm made from resistance wire (see text)

All 0·25W carbon except where stated

See **Shop Talk** page 484

Potentiometers

VR1,VR2	100K Horizontal Preset (2 off)
VR3	22K Horizontal Preset

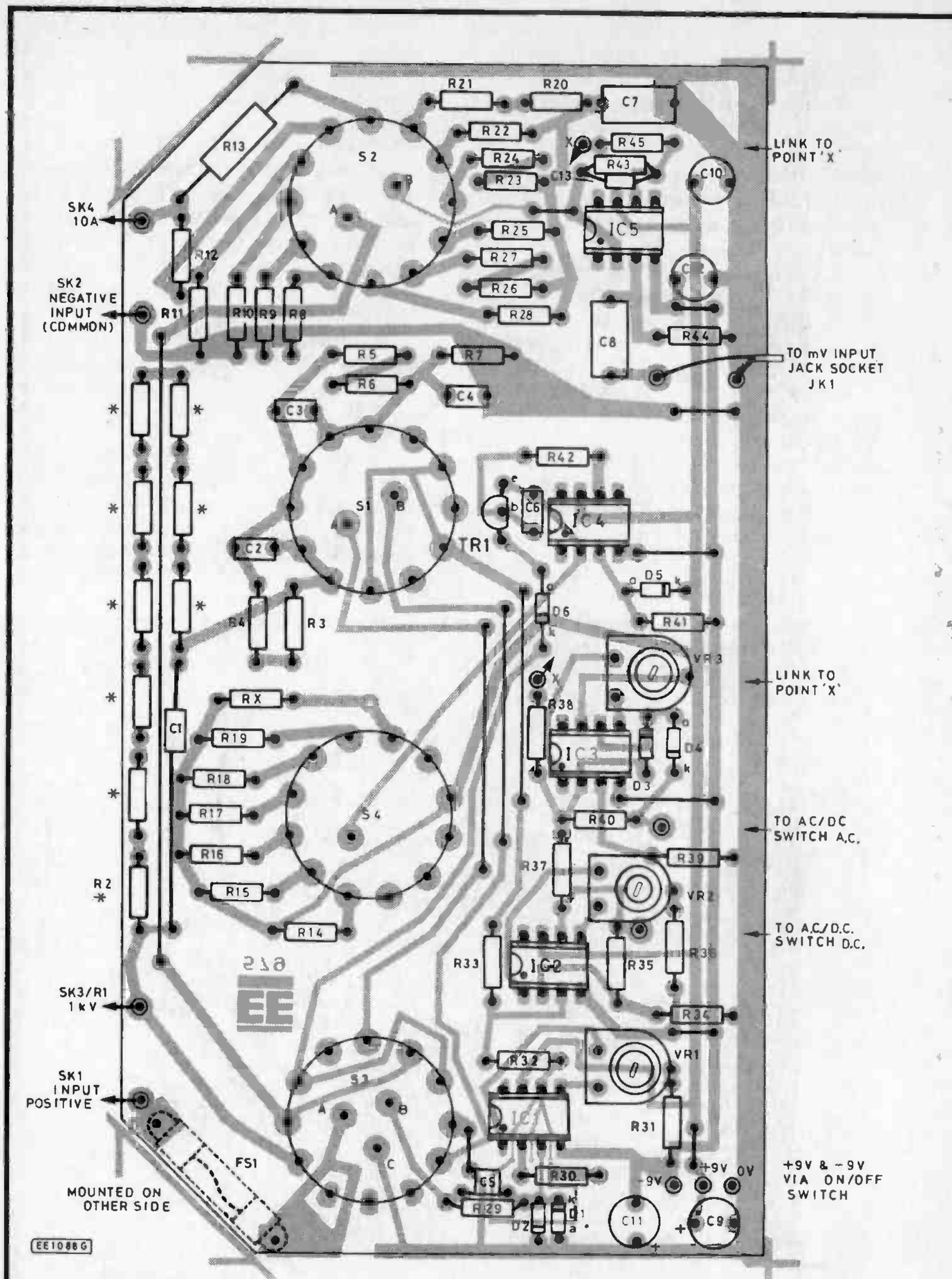


Fig. 2. Component layout on the printed circuit board. Note that the long link wires should be made with plastic insulated connecting wire, see photographs.

Capacitors

C1	4·7p axial 500V
C2	22p ceramic 50V
C3	220p ceramic
C4	2,200p polystyrene
C5	10p ceramic
C6	1n ceramic
C7	1µ min layer 100V
C8	0·22µ 100V
C9,C11	100n disc ceramic 50V (2 off)
C10,C12	15p ceramic
C13	

Semiconductors

	BAS45 low leakage diodes (4 off)
D1,D2,D7,D8	low leakage diodes (4 off)
D3,D4	0A90 (2 off)
D5	5V6 Zener diode
D6	1N4001
TR1	BC214
IC1,IC2,IC4	TL071 (3 off)
IC3,IC5	LF356N (2 off)

Switches

S1,S2	2-pole 6-way, make-before-break (2 off)
S3	3-pole 4-way
S4	1-pole 12-way, make-before-break
S5,S6	DPDT Min. slide switches (2 off)

Miscellaneous

100µA Panel meter 1·4k resistance (see text); 8-pin i.c. sockets, 5 off; fuse, 1A Q.B; 20mm chassis fuseholder; knobs, four with coloured caps; case, with insulated front panel; 4mm sockets, 4 off; insulated jack socket (with N/C switch); test leads and probes, 2 off; PP3 battery clips, 6 × AA battery holders, 2 off. Printed circuit board, available from EE PCB Service—Code EE579 (see page 516).

Approx. cost Guidance only £45 (excluding Test Leads)

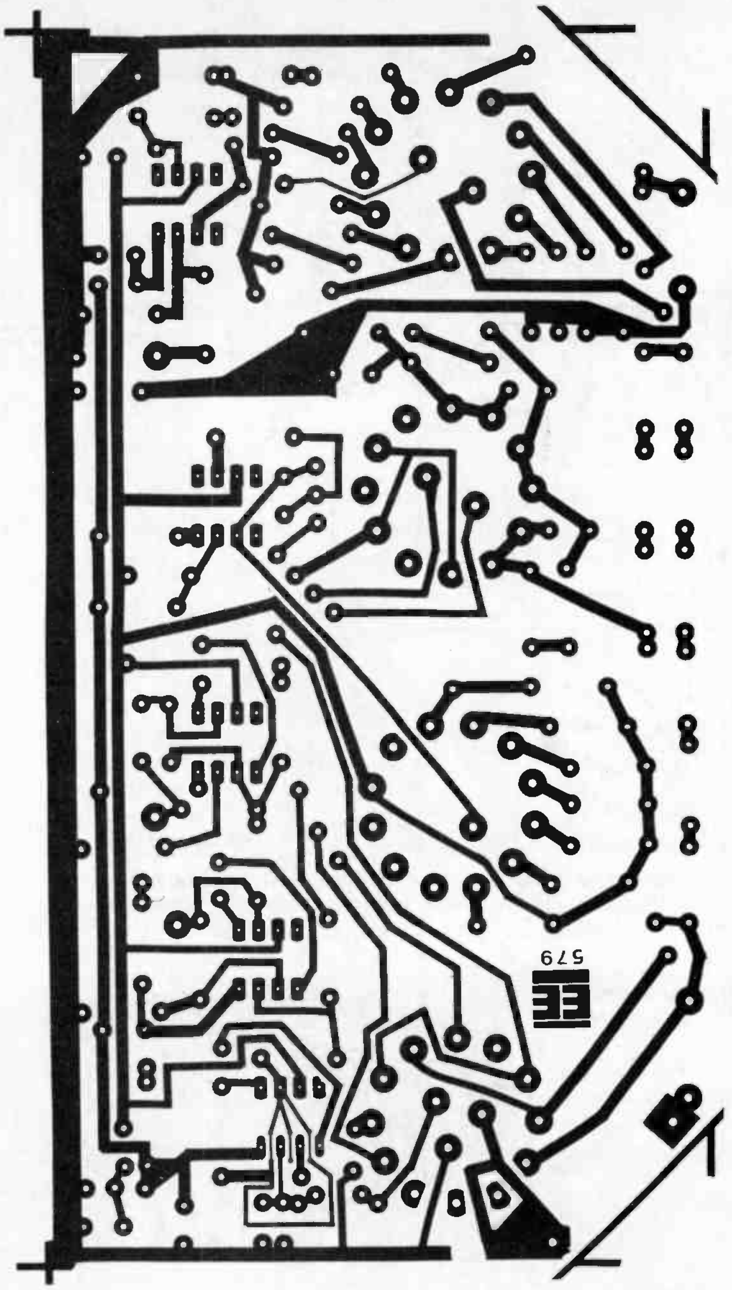
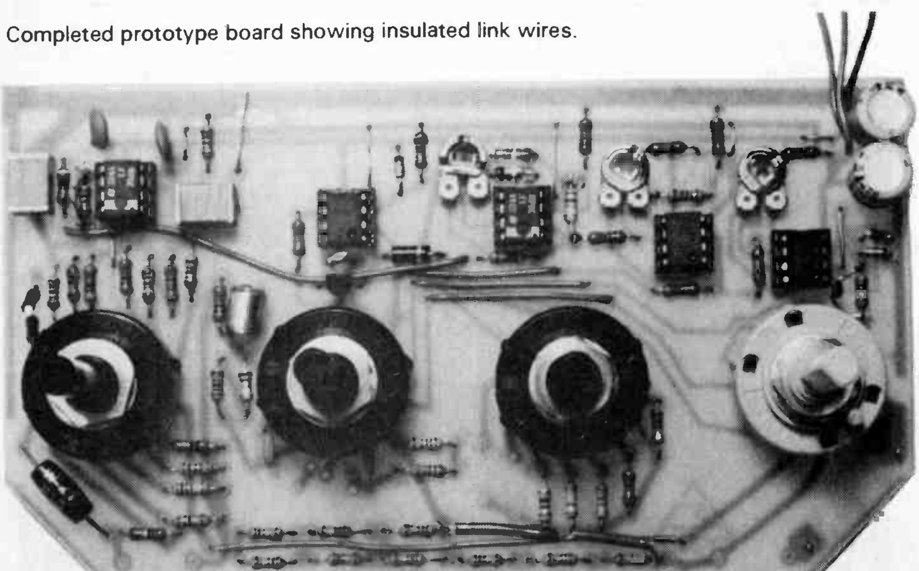


Fig. 3. Full size printed circuit board foil master pattern. This board is available from the EE PCB Service.

Completed prototype board showing insulated link wires.



equal to this reference voltage. This means that 5·6V appears across whichever emitter resistor is selected by S4.

This constant reference voltage across a fixed resistance value gives a constant current output at the collector of TR1. As the reference voltage is 5·6V a 5k6 range resistor gives a current of 1mA. The standard voltage circuit, which is connected via S3b, gives full scale deflection for 100mV. A range current of 1mA thus gives a full scale reading of 100 ohms. Low value resistors drop less voltage and so the reading is directly proportional to the resistor value.

On the higher resistance ranges the current becomes rather too small for comfort. For example on the 100k range a current of only 1μA is required. The 1M and 10M ranges require 0·1μA and 0·01μA respectively. A current of 0·1μA is just about the limit of the circuit, so readings on this range will not be too accurate, and a 10M range is impractical.

The middle resistance ranges are accurate and linear, and much easier to use than a standard meter. No compensation has been made for wiring and test lead resistance, so on the lower ranges 100 ohm and 10 ohm, an offset zero will be present when the test leads are short circuited. This value should be subtracted from any measured resistance value to give the true reading.

A.C. MILLIVOLTS

The measurement of A.C. Millivolts is made by first amplifying the input to 1V and using the standard rectifier circuit IC3.

The A.C. Pre-Amplifier, IC5, is connected to IC3 via resistors R45 and R38. The gain of IC5 is set by the feedback resistor R43 and the range resistor selected by S2b. The values of resistors R20 to R28 are chosen to given ranges of 1V 300mV, 100mV, 30mV, 10mV and 3mV. The frequency response is level up to 100kHz except on the 3mV range where it is slightly lower.

When making measurements on the mV range the input of IC1 is connected to 0V by S3b so that stray inputs do not interfere. In a similar way the input of the mV range is shorted out when the input lead is disconnected by use of a switched jack socket (JK1).

The input impedance on this range is set to 100 kilohms by the input resistor R44.

POWER SUPPLIES

The Multimeter circuit consumes very low current, but as meters tend to be used frequently it is recommended that two sets of six AA cells are used. These can be standard or re-chargeable types, and should give very long life.

Mains derived power supplies can also be used, but take care to use double insulated circuits *without* an earth on the output side as this could cause all sorts of problems with earth loops.

CONSTRUCTION

As the circuit is all built on a single printed circuit board the assembly is fairly straightforward. Fig. 2 shows the component layout and Fig. 3 the printed circuit board track pattern, full size. This board is available from the EE PCB Service, code EE579 (see page 516),

Begin assembly by fitting the wire links as shown. The longer links should be made with insulated wire whilst the shorter ones can be made from offcut resistor leads.

As there are rather a lot of resistors and most of them carry the five-band one per cent colour code system it is necessary to be rather careful to get the correct values in the right places. Any errors will give "odd" ranges which may not be easy to spot as the meter may appear to be working perfectly.

Sockets should be used for all i.c.s. The rotary switches are usually supplied with loop tags for direct wiring and these must be cut off leaving as much of the straight stems of the tags as possible.

Switches S1, S2, and S3 will fit more than one way round, so take care to set them fully anticlockwise and use the "flat" of the shaft as a guide to get them right. Remember that the pointer on the knob is exactly opposite the flat on the spindle. If you get it wrong and don't want to unsolder the switch, screw fix knobs are a good alternative way out.

Capacitor C1 is mounted between two distant points—its leads must be sleeved and may need extending to fit the board centres. Make sure that all diodes, and capacitors C9 and C11 are the right way round.

The final component to be fitted to the board is the fuseholder which is fitted to the track side to keep easy access to the fuse. Once the board assembly is complete connect the necessary wires to the board. The mV input should use screened cable, the other input socket connections should be made with 16/0·2 wire.

Resistors for the 1KV socket should be fitted in a length of sleeving between the board and the input socket. The 10A shunt is made from a 71cm length of 18s.w.g. enamelled wire connected directly between the 10A socket and the negative (Com) socket SK2. The wire can be loosely wound on a flat piece of insulating material (e.g. Paxolin).

The wiring diagram Fig. 4 shows how the shunt can be fitted and the wiring to the other parts of the board from the sockets.

TESTING AND SETTING UP

The thorough testing of a meter of this type presents quite a problem. The wide range of accurate voltages and currents necessary to check each range fully is not likely to be available even in electronics workshops. The best way is to make comparisons with other meters using whatever sources of voltage and current are available. It is possible that a local training centre, school or college will be able to help, so ask around.

Fine tuning of capacitor values C1, C2, C3, C4, and C5 may be undertaken by those determined to extract the very best from the meter. These components affect the frequency response on the A.C. Voltage ranges. Capacitors C1 and C5 in particular have a large effect and should be changed only if a good reliable sine wave source of 0–100kHz or more is available.

If no test gear is available it is safe to say that the meter should work accurately first time provided no errors are made in assembly.

There are three presets that must be set up to remove the zero offsets of IC1, IC2 and IC3. To do this, set the A.C./D.C. switch S5 to D.C. and the Range switch to mV. Link pin 3 of IC2 to 0V and if necessary adjust VR2 to zero the meter. Remove the link and if necessary adjust VR1 for zero. These two are now correctly set.

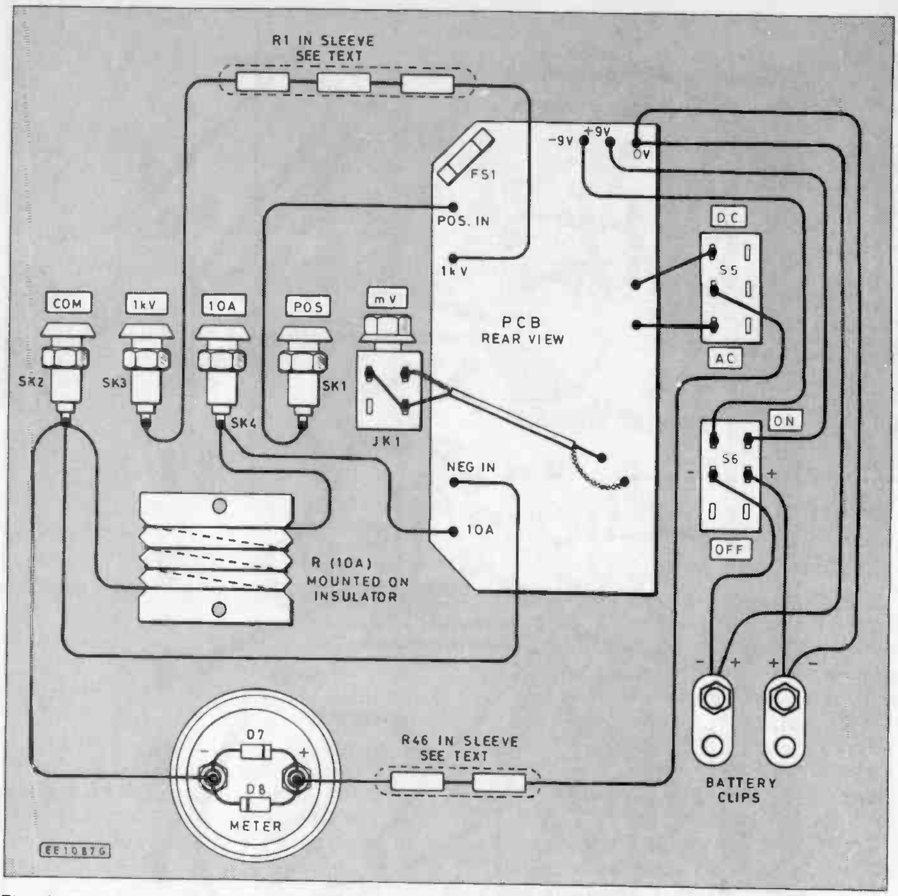
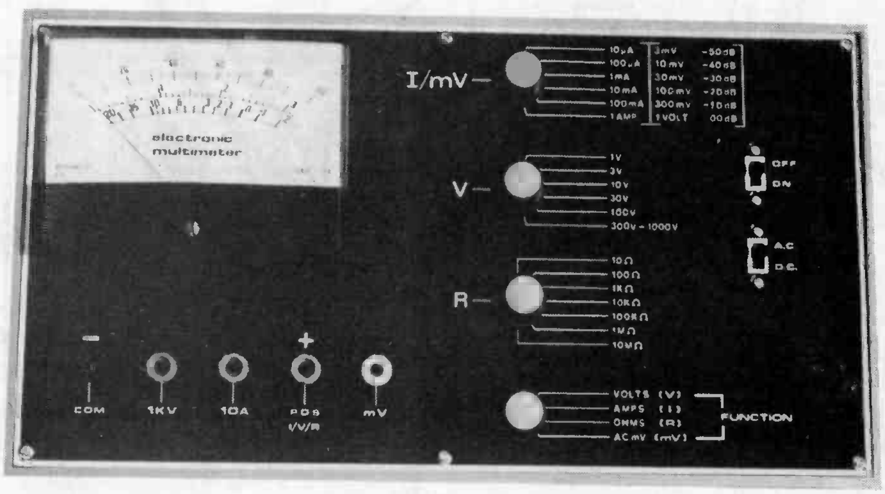
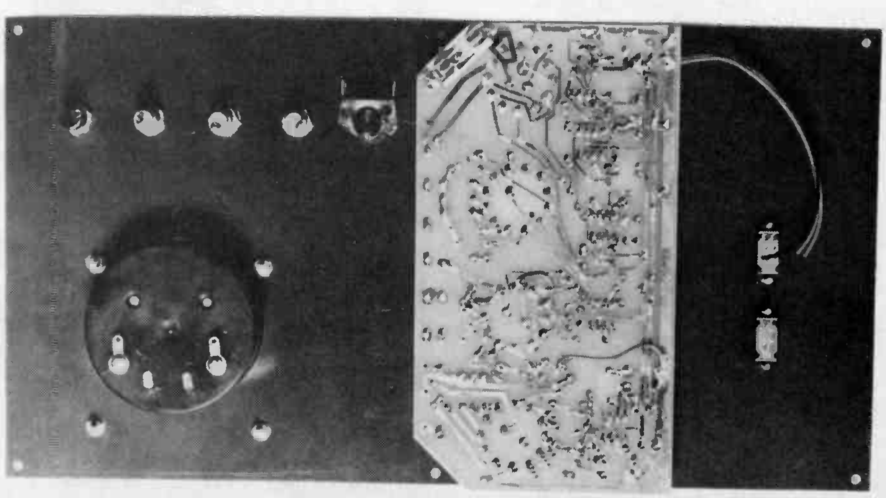
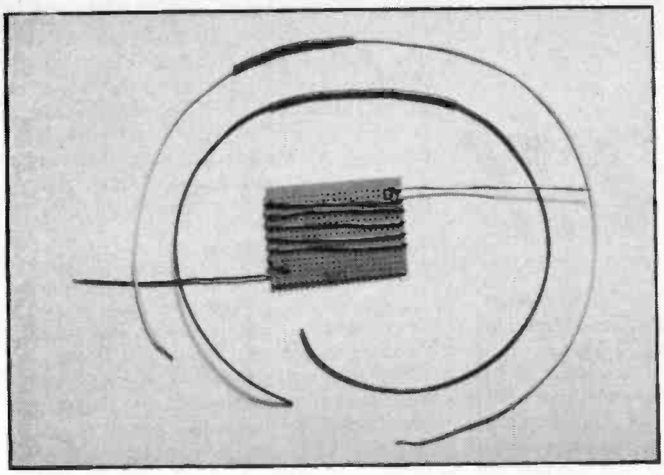


Fig. 4. Interwiring details for the off-board components. The circuit board and components are all mounted on the rear of the front panel. Note the resistors "encased" in plastic sleeving, see photo opposite page.

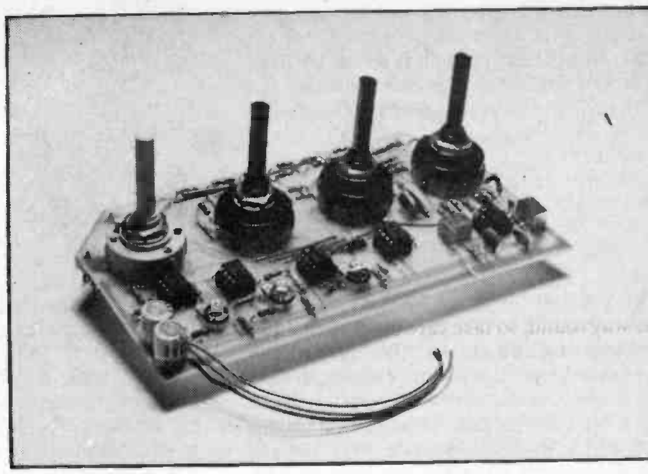


Front panel layout and lettering. The positioning of the p.c.b. and other components is shown below.





The 10A "shunt resistor" wound around some plain board. Also shown are the two resistor leads, R1 and R46.



The completed printed circuit board ready for mounting on the rear of the front panel. The board is held in place by the potentiometer fixing nuts.

Next set the A.C./D.C. switch to A.C. and turn VR3 until the meter deflects to the right. Back of the setting of VR3 to the point where the meter just touches zero and the settings are complete.

The accuracy of the Ohms range depends on the Zener diode D5 which is specified as a five per cent component. More accurate voltage references can be obtained and substituted if required.

The value of resistor R46 depends on the meter being used. Its value can be calculated easily as its function is to make the meter resistance value up to 10 kilohms. A meter of four kilohms resistance thus requires a six kilohms resistor and so on.

It is also possible to use meters of other current ratings, all that is necessary is to set the meter and series resistor so that 1V gives a full scale deflection (f.s.d.). Thus a 1mA meter would need a combined meter plus series resistor value of one kilohm. A 50μA meter, 20 kilohms; a 500μA meter, 2 kilohms etc.

On A.C. ranges the "averaging" effect of some types of meter may be affected by the diode (D4) in the drive circuit. A 1k resistor from D4 cathode to 0V line overcomes this and allows any type of meter to be used.

SAFETY

For complete safety an ***INSULATED*** case is ***ESSENTIAL*** where high voltage readings are to be made. It is also necessary to add some screening to the meter electronics.

The best way to combine these two functions is to use a plastic case with a metal front panel overlaid with a Paxolin insulating panel. The metal panel should be connected to the 0V point in the circuit.

DECIBEL RANGES

The dB Range on the meter is set to be accurate on the A.C. mV Ranges. On the 1V A.C. Range (mV) the 0dB point represents the universal 1mW in 600 ohms. Each range down from this subtracts exactly 10dB so relative measurements are easy.

The use of dB scales is a difficult subject for beginners and it is not intended to go into details here. Hopefully, a further article explaining their meaning and use will be published shortly. □

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Actually Doing it!!

ADDING panel legends to a project using rub-on transfers, provided it is done reasonably skillfully, can certainly make the finished unit look much more professional. Even well finished projects tend to have a home-made look about them though. Unfortunately, rub-on transfers rub off almost as easily as they can be applied, and cannot easily be given a really effective protective covering. There are alternative methods of panel labelling which can give much more professional results, and are good enough to fool many people into thinking that a home constructed project is the "real thing". On a more practical level, these alternatives give much more durable labels. In fact they give such a tough finish that the lettering is virtually impossible to damage, and it will not show any signs of wear even after the project has been subjected to many years of hard use.

It is only fair to point out from the start that these advanced systems of labelling are much more involved than applying a few rub-on transfers. Perhaps of more importance to most constructors, they are quite expensive. Some of the more sophisticated systems (particularly the brushed aluminium effect types) are so expensive as to be something that few of us can seriously consider, even for the occasional project. It could even cost more for the front panel than for the rest of the project! However, there are much cheaper labelling systems, and it is these that we will consider in this article.

MASTERING THE TECHNIQUE

The panel labels under discussion here are the type that are produced by a simple photographic process. The films are not ordinary daylight types, but are ultra-violet sensitive films that can be exposed to daylight for short periods without any risk of fogging. Little special equipment is required in order to produce an exposure, but ideally an ultra-violet light box should be available. Failing that it is possible to use some other source of ultra-violet, such as a sun-ray lamp or even strong direct sunlight.

Before an exposure can be made it is necessary to have a "master" artwork from which the photographic copy can be made. It is possible to make up individual labels for the controls, etc., but it is generally easier to make up a large label that covers the entire panel. This also gives much neater results. The first stage in making up the master artwork is to draw out the panel design onto paper. This does not need to be an exact representation of the required front panel design, and basically all that is needed are lines to indicate the perimeter of the panel, plus base lines for the legends. It is also more than a little helpful to mark the centre of each word using a short vertical line beneath the base line.

This drawing is taped to a drawing board (which can just be the kitchen table or a piece of faced chipboard) and then a piece of tracing paper or drafting film is taped in place over it. The required design is then marked onto the film or tracing paper, including corner markings which can simply be drawn on with pencil. The lettering is produced using rub-on transfers, and these are readily available in a number of sizes and letter styles. They can be obtained from stationers, graphics art suppliers, and some of the larger electronic component retailers. A useful range are available from shops in the W.H. Smiths chain. Some useful symbols and other panel markings are available from a few sources.

Both tracing paper and drafting film provide a surface to which the transfers will adhere well. An old ballpoint pen or something of this nature can be used as the rub-on tool, but I have always found it much easier to use the correct "spatula" tool which is available from a few suppliers of the transfers. Reasonable care needs to be taken when applying the transfers, and making a neat job of this is not too difficult provided due care is taken and the job is not rushed.

The base lines on the paper pattern make it easy to get the vertical alignment of the letters right, but more care needs to be taken with the spacing. With a little experience this can be done accurately by eye, and some transfer systems include some form of aid to accurate spacing. For the finished panel to look reasonably neat it is essential that the legends are centred properly. This is basically just a matter of counting the number of letters in each word, and then starting with the middle letter over the centre line. If the word has an even number of letters, the middle two letters should be positioned just either side of the centre mark. This does not actually guarantee perfect results since some letters are wider than others. Initially it might be as well to ignore this fact, but with experience you can learn to compensate for narrow letters (particularly the letter "i") and wide letters such as "W".

COMPUTER GRAPHICS

These days there is the alternative of using a computer and some form of drawing or graphics programme to generate the panel design. This will only give usable results though, if the output can be produced accurately to scale, and in really opaque ink on some form of transparent or translucent medium. There is unlikely to be any problem if the output device is a plotter, but using a dot matrix printer some form of processing will be needed in order to give a usable master artwork. For example, the design can be printed onto ordinary paper, and with a suitable copier, then photocopied into translucent film.

EXPOSURE

The materials I have used have been the "Permasign" type, and the film can be handled in ordinary daylight without any risk of it being fogged. However, it should be stored in total darkness and should not be exposed to bright sunlight. It is cut to size prior to making an exposure, but take great care not to damage the emulsion side (the dull surface). Try not to touch this surface either, as finger marks seem to be reproduced on the developed film.

If an ultra-violet lightbox is available, the exposure is made in the manner shown in Fig. 1. It is probably not worthwhile buying a lightbox just for producing a few photographic front panels, but it is a more viable proposition if you will also use it when producing your own printed circuit boards. A lightbox is something that is not too difficult to build yourself, but at least two tubes are needed to give even illumination over even a fairly small area of around 150 by 250 millimetres. More tubes give a stronger light source and shorter exposure times. An essential feature is the foam pad which presses the film down onto the artwork so that a "crisp" image is obtained on the film. There is often a tendency for the film and artwork to shift slightly when the lid of the box is closed. To avoid this tape the artwork onto the glass panel, and then tape the film in place over the artwork. Make quite sure that the master has the transfer side facing upwards, and that the film has its shiny side facing upwards.

The manufacturer's recommended exposure times are 45 seconds for a 120 watt lightbox, and 90 seconds for 32 watt type. I find an exposure time of five minutes gives good results with my 16 watt lightbox. It is worthwhile experimenting with some small pieces of film to find an exposure time that gives good results with the particular box you are using.

If a lightbox is not available the alternative set up of Fig. 2 can be adopted. The base board needs to be something that has a smooth, flat surface, and a piece of good quality faced chipboard is ideal. The sheet of glass is used to press the master and film flat against one another, and the glass must not be a type which gives high absorbtion of ultra-violet rays. As the film is against the baseboard and is emulsion side up it is not feasible to tape it in place unless some double-sided tape fixed to the underside is used. However, with this set

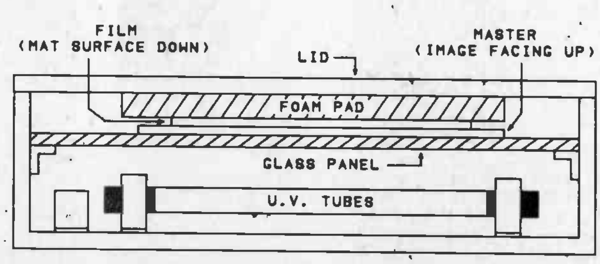


Fig. 1. The set up when using a lightbox to make the exposure.

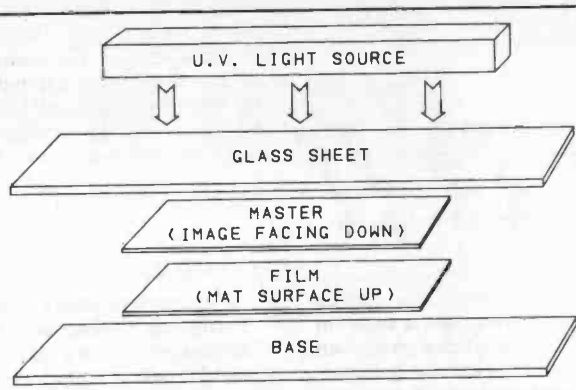


Fig. 2. Using a u.v. lamp or sunlight to make the exposure.

up it is not too difficult to get everything properly aligned and to then carefully place the glass in position. Take care not to disturb anything during the exposure. For reasons of safety, the edges of the glass plate should be ground to a smooth finish, or given a protective covering of some kind.

The exposure time can only be determined by trial and error, and with direct sunlight it may be difficult to obtain consistent results as the strength of the light will inevitably vary somewhat from one time to the next. An exposure time of around five to ten minutes will probably be needed. It is unlikely that satisfactory results will be obtained using daylight on an overcast day. The correct exposure time could be very long indeed, and could vary enormously from one exposure to the next. Provided the artwork is of high quality with really opaque lettering it is better to err on the long side with exposure times.

Things should be much easier using a sun-ray lamp, and consistent exposures should be obtained provided the lamp to film distance is always the same. It will still be necessary to determine the best exposure time by empirical means. Bear in mind that ultra-violet light can be harmful to ones eye-sight, and observe the lamp manufacturer's recommendations. This basically means keeping yourself and any other living matter (plants and pets) out of the ultra-violet light while the exposure is being made.

DEVELOPMENT

A flat-bottomed dish of adequate size is needed for development of the film. Dishes sold for photographic use or for etching printed circuit boards are suitable. Sufficient developer to fully immerse the film is poured into the dish, and then the film is placed into the developer for about ten seconds. Then remove the film and place it emulsion side uppermost on the worktop. Use photographic tongs to remove the film, or only handle it by the edges. The emulsion is very easily damaged at this stage.

Next a developer pad is soaked in developer, and is carefully wiped across the film to remove the areas of softened emulsion. Note that it is the areas of film that were not exposed to ultraviolet (i.e. the lettering) that are removed. The film is then rinsed in water and wiped gently some more in order to remove any residues. Once it has been allowed to dry or has been dried with a paper towel it is ready for inspection. There will often be minor damage to the emulsion, and any minor holes or scratches will probably not show up on the finished panel. However, any serious blemishes can be repaired using something like a technical pen or an overhead transparency pen, filling in the affected areas on the emulsion side of the film. Any blemishes must be repaired at this stage and cannot be fixed later on.

FIXING

The film is fixed in place on the front panel of the project using special double-sided self-adhesive card. These cards are white on one side, and are available in a variety of colours on the other side. It is just a matter of removing the backing paper and fixing one side of the card to the front panel, and then removing the second piece of release paper so that the film can be fixed in place.

The film has its adhesive surface towards the adhesive, which should result in a panel with right-way-round lettering if the exposure has been made correctly. The panel is black with lettering in whatever colour shows through from the card. Clear material is available where something like the silver colour from an aluminium panel must show through on the letters. It is, of course, possible to have black letters on a coloured panel. This requires a negative master artwork though, and producing one of these could be difficult.

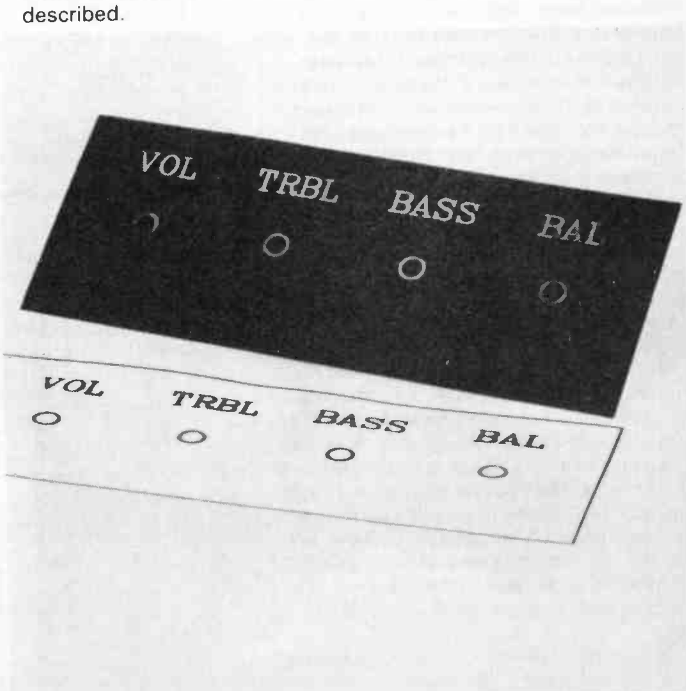
Front panels of this type are very tough due to the fact that the emulsion side of the film is facing towards the front panel. The exposed surface is the blank side of the film, and this can be cleaned and polished without any risk of damaging the lettering. The finished panels certainly look very neat and professional, and justify the extra time and expense involved in their production.

Next month we will continue in a similar vein, and will consider photographically reproduced printed circuit boards.

Robert Penfold

Developer, transfers, film, developer pads and double-sided adhesive cards.

The master artwork and finished panel produced by the method described.



YOUNG ELECTRONIC DESIGNER AWARDS

Neil and Jonathan tread softly and walk off with £10,000 computer.

TWENTY FIVE enthusiastic young electronic designers, ranging from 12 to 21 years of age and representing sixteen different education institutions took part in this year's finals of the *"1987 Young Electronic Designer Awards"* contest at the Institution of Civil Engineers, London, last month (July). The competition challenges students to design and construct an electronic device with a possible application in everyday life.

Organised under the auspices of the YEDA Trust, a registered charity, the annual contest is sponsored by Cirkit Holdings plc and Texas Instruments Ltd. Winning finalists were awarded trophies, cash and certificates which could launch them on rewarding careers in the electronics industry.

Top prize in the Senior Class carried a reserved place in the Texas graduate intake (upon graduation)—a job! In addition it carries TI sponsorship for the remainder of his/her course, at the rate of £450 per annum, and a vacation job during the summer of 1987.

The educational institution whose entrant's project was adjudged to have the most commercial potential was awarded a Texas Instruments Business-Pro computer valued at over £10,000. In addition, TI donated a "Personal Consultant Plus" development package and a week's training course in its use and operation.

Final Results

After the opening ceremonies the big moment arrived and the judges' final decisions were revealed.

Winner of the £500 first prize in the senior category went to Douglas Mackay (21) of Robert Gordon's Institute, Aberdeen for his Robotic Functional Arm. Robert was in a team from Thurso Technical College that took second place in this category last year.

Second place (£250) went to Stephen Morrison (21), Carl Gibson (18) and Paul Briggs (19) from Brunel University for their Wheelchair Controller. Third position (£100) was awarded to Morgan Metters (21) and Tim Mottershead (20) from Hatfield Poly. for their Speech Synthesiser entry.

Watched by their teacher Mr. L. Haywood (left), Ken Sanders (second left), MD Texas Instruments and TI Engineer Philip Hutson (second right), junior winners Neil (seated) and Jonathan of Wilford Meadows School get to grips with the School Prize of a TI Business-Pro computer. Their Digital Tyre Pressure Gauge project was considered to have the most commercial potential.

Intermediate Class

Intermediate category winner went to Paul Dagley-Morris (16) and Roger Lucas (15) of Cheltenham College and received £350 for their Animal Stress Meter.

Runner up in this section and £200 went to Jonathan Ackland (15) and William Meere (15), Cheltenham College for their Saucepan for the Blind. The £75 third prize went to David Earle (17) of Brentwood School for his Colour Recognition System.

Junior Class

Winners of the junior class (£250) were Neil Motson (14) and Jonathan Cragg from Wilford Meadows School for their Digital Tyre Pressure Gauge.

Second spot (£150) went to Ian Levy from Allerton High School for his Ladder Safety Device. The £50 third prize went to the only girl finalist, Sophia Ballarini of Hayfield Comp. School for her Water Level Indicator and Alarm project.

Judging Panel

The 1987 awards were presented by Sir John Egan, Chairman of Jaguar plc, who is a YEDA Trustee and the members of the judging panel were Professor John Eggleston of Warwick University; Sir Alec Morris, British Aerospace; John Wesley, Investors in Industry PLC; Richard Reisz, Editor BBC 'Tomorrow's World'.

Jeffrey Archer, a special guest at the event, made a final address following the announcement of the results.

School Prize

The project adjudged to have the best commercial potential was the *Digital Tyre Pressure Gauge* submitted by Neil Motson and Jonathan Cragg. Their design won a TI Business-Pro Computer, worth over £10,000, for the Wilford Meadows School, Nottingham.

Paul and Roger from Cheltenham College receive their awards and congratulations from Sir John Egan, Chairman of Jaguar Cars.

Senior winner, Douglas of Robert Gordon's Institute demonstrates his Robotic Arm project to Richard Bulgin, Chief Executive of Cirkit Holdings.

TUBE INVESTMENT

An investment of some £15 million in its television tube assembly plant at Durham to make it the main European production centre for high-resolution data graphic (DGD) has been announced by Mullard tubes. Part of the investment will also go into Durham's sister tube components plant at Simonstone, near Burnley.

Initially production will concentrate on 90 degree 14-in. colour DGD tubes and by the end of 1988 is expected to reach an annual level of around a quarter of a million tubes. High-resolution DGD colour tubes are used in VDUs and work stations produced by the world's leading manufacturers of computer hardware.

At present all European based manufacturers of VDUs rely on imported DGD tubes—mainly from Japan. An indigenous source of tubes not only reduces imports but also opens-up a valuable and growing export market which in Europe alone stands at around £100 million.

Data graphic colour display tubes differ from conventional colour TV picture tubes in that they are required to display a much higher-resolution picture. This is achieved by using a shadowmask with a finer pitch (0.3 compared with 0.6 for a TV tube), an extremely high-precision electron gun, tigheter controls on all glass tolerances and a specially designed deflection coil assembly.

Europe Calling

British Telecom is to play a major role in the development of a Pan-European digital cellular radio network. This follows an agreement made in Bonn between the United Kingdom, France, West Germany and Italy.

The four countries have now agreed to work towards a commercial service on the new network by 1991. This will allow customers to use their phones wherever they are in each of the four countries.

BT also welcomed assurances that the proposed Pan-European digital cellular radio system would not be jeopardised by the decision to allocate, on a temporary basis, 40 additional channels to Racal-Vodafone. The channels have been allocated on the understanding that they be returned by the end of December 1987.

Innovation Award

The Scottish Business in the Community award for innovation (SCOTBIC) has been won by East Kilbride based Fern Developments for their development work on "High-Tec" digital filters.

The award, sponsored by the National Girobank, Scotland, was presented, together with a cheque for £1,000, by HRH The Prince of Wales to Fern's Managing Director Murdo Mackay at a special ceremony in Glasgow recently.

Solar Power

Mitsubishi Electric Corporation of Japan, has developed the world's highest performance gallium arsenide (GaAs) solar cell for space use with average photoelectric conversion efficiency of more than 20 per cent.

The cell, measuring 2 centimetres by 2 centimetres, employs metal organic chemical vapor deposition (MOCVD) technology and features maximum conversion efficiency of 21.9 per cent under air mass zero condition and less deterioration under radiation in outer space. Even after 10 years of use in space, 82 per cent of its original output will be maintained.

MOCVD technology allows simultaneous uniform growth of many GaAs crystals. Based on this, Mitsubishi have established the mass production technology to manufacture 120 such GaAs solar cells at a time.

A superlattice structure of thin aluminium gallium arsenide and GaAs layers inserted under the active portion of the solar cell allowed improvement in conversion efficiency with layer thickness of less than half of the conventional cell to reduce film making cost. To minimize characteristic deterioration as a result of exposure to radiation in outer space, they also developed the technology to decrease the depth of *P-n* junction from 0.5 to 0.3 micron.

GaAs solar cells have higher photoelectric conversion efficiency and less efficiency deterioration under exposure to radiation and high temperature compared with silicon solar cells which have so far been used in satellites.

ON COURSE

A listing of some forthcoming study courses:

Name: Radio Amateurs Course
Location: *North Trafford College of Further Education*
Date (Enrol.): *September 2–4, 1987*
Info.: *North Trafford College, Tel: 061 872 3731*

Name: Amateur Radio (C&G No. 765)
Location: *Addington High School, Croydon.*
Date (Enrol.): *September 19 (9a.m.–12.30p.m.)*
Info.: *Addington, Tel: 0689 41461*

Name: Radio Amateurs Exam (C&G No. 765)
Location: *Hendon College, Colindale NW9.*
Date (Enrol.): *September 9 (7.30p.m.–9.30p.m.)*
Info.: *Hendon College, Tel: 01-200 8300*

Name: Morse Classes and Radio Amateur Exam
Location: *Croydon College*
Date (Enrol.): *September (7p.m.–9.30p.m.)*
Info.: *Tom G3EUU, Tel: 01-668 1725*

London Electronics College

The LEC new series of up-dated one year full-time BTEC National Certificate courses starts from September 21. Selection of subjects available include: Equipment Servicing (TV, VCR & CCTV)—Computing Technology—Information Technology—Software Engineering.

These courses are for those wishing to update or retrain, either with Employer sponsorship (up to £1000 ATS grant aid) or for those recently taking redundancy.

Details and Prospectus: The London Electronic College, Tel: 01-373 8721.

YOUNG SCIENTISTS TRIUMPH IN EUROPE

THREE young British scientists won major recognition in the *"19th European Philips Competition for Young Scientists and Inventors"* held in Paris recently.

From a total of 27 entrants from 14 nations, Peter Badger, aged 19, from West Bridgeford School, Nottingham, won an award of 14,000FF (£1,424) for his computer based design for improving table tennis skills. Placed third overall, Peter's invention was praised by judges drawn from seven countries for its thoroughness in design and its commercial potential.

Youngest contestants of the competition, Andrew Sutton and Nicholas Porter, both aged 14, of Aylestone School, Hereford, won Certificates of Distinction, worth 4,000FF (£407) for their practical device to measure accurately extremely slow speeds of wire drawing in an annealing process, for Messrs Wiggins Alloys of Hereford.

(left to right) Andrew, Nicholas and Peter with their commendations.

BURST FIRE MAINS CONTROLLER

ANDY FLIND

An inexpensive controller for soldering irons, and other low power heating devices—also useful as a lamp flasher.

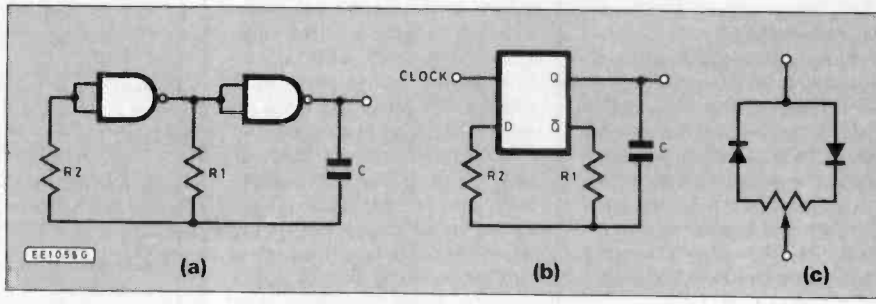


Fig. 1a. CMOS NAND gate oscillator. Fig. 1b. Oscillator built with a "D" type flip-flop. Fig. 1c. Substitute for R1 to obtain variable mark to space output.

THE idea for this project arose when a new soldering iron was purchased for the author's workshop. The old iron was a fifteen-watt model, perfectly adequate for light electronic work, but sadly unequal to the occasional heavier task. It was decided that the replacement should be a twenty-five watt iron, especially as a very popular version just happened to be on "special offer" at the time.

The extra power is sometimes useful, but for lighter day-to-day work it soon proved to be an embarrassment. The bit (an iron-coated type) continually oxidised and refused to tin properly; eventually it turned blue and started to warp! Joints made with it took ages to solidify and displayed the typical appearance of overheating . . . in short, something had to be done.

BURST FIRE

The usual method of controlling light loads is by variable phase control, as used in lamp dimmers. Even when well suppressed though, these create a lot of radio frequency interference at close range, especially unwelcome where sensitive electronic equipment is being tested. As a soldering iron has a fair degree of thermal inertia, some form of "burst fire" controller seemed the best solution, as these are inherently interference-free.

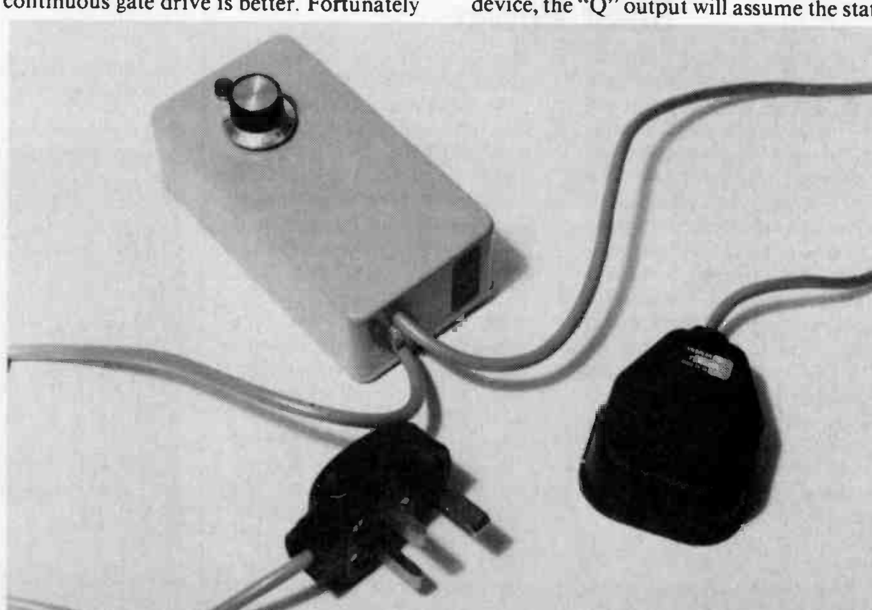
Since the mains supply alternates between positive and negative peak voltages at fifty hertz, it follows that it must pass through zero a hundred times a second. If the load can be switched on and off at, or very close to, these zero points, the switching device will not make or break any heavy currents so the interference generated will in consequence be negligible. "Burst fire" controllers switch loads on and off at regular intervals, the switching taking place at zero crossings. The net power delivered depends on the ratio between the "on" and "off" times.

Switching "off" at the right moment is easy. If the drive is removed from a triac gate it will continue to conduct until the current passing through it falls to a low level, which of course coincides with the low voltage point (for a resistive load). Thus the correct "off" point is selected automatically. Switching on is slightly more difficult; the right point has to be sensed in some way and drive applied to the triac at that exact moment.

Custom chips are available for the job, but are not really suited to light loads. The reason for this is that they usually fire the triac with a very short pulse to the gate, then rely on the "on" condition being maintained by the load current. With a small load such as a twenty-five watt iron this is likely to be insufficient at the point where the gate pulse ends; for such applications a continuous gate drive is better. Fortunately it is possible to construct an extremely simple circuit around a "D" type flip-flop which will not only generate the required variable mark-space timing function, but can be synchronised to the zero crossings through its clock input.

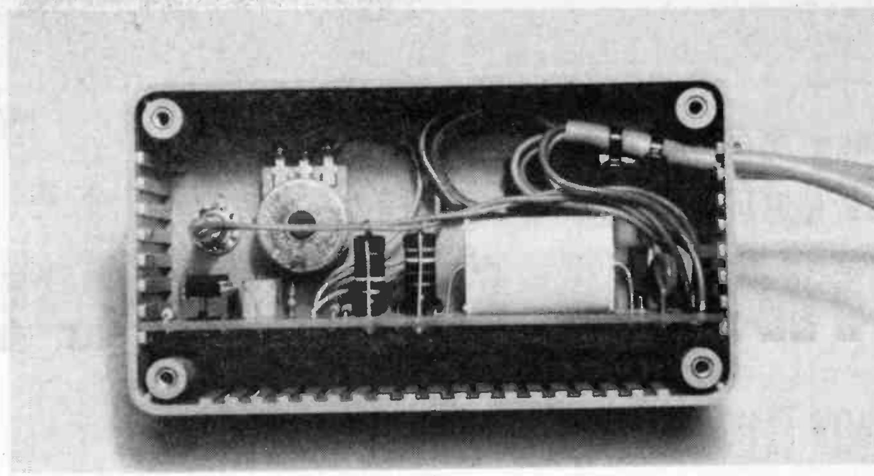
A common oscillator circuit that can be built with the two inverting logic gates is shown in Fig. 1a. Positive feedback is applied right around the circuit via capacitor C and R2, ensuring clean and positive switching. However, after each switching action, negative feedback from R1 gradually pulls the input towards the opposite polarity until another change of state takes place. R2, by the way, prevents the gate's input protection from loading the timing circuit.

In Fig. 1b the same circuit is shown built with a "D" type flip-flop. With this type of device, the "Q" output will assume the state



present on the "D" input, whilst the "$\overline{Q}$" output will take up the opposite state. We thus have an input and two opposing outputs, so an oscillator circuit can be constructed exactly as before. However, changes of input are only transferred to the outputs when the "clock" input changes state, so this can be used to synchronize output changes to another input signal.

As shown, the output will have equal "on" and "off" periods, but with some simple additions these can be altered as desired. If a linear pot is used for R1 with a couple of steering diodes, the output will have a constant frequency but the ratio between high and low states will be directly proportional to the pot setting.



CIRCUIT

The full circuit appears in Fig. 2. A low voltage supply for the electronics is derived from the mains through a series capacitor, C1, together with diodes D1, D2 and Zener D3. C2 stores and smoothes the output. With capacitive mains droppers there is always a slight risk of catastrophic failure should the capacitor fail, but in the author's experience this is uncommon, especially where protection against high voltage transients (VDRI) is provided. Capacitors are much cheaper and easier to mount on p.c.b.s than transformers!

To generate the clock signal, current flowing through R2 is passed through the transistor's base-emitter junction during positive half-cycles, turning it on. During the negative periods it flows through D4, and the transistor turns off. A logic signal synchronised to the mains can thus be taken from its collector. The i.c. used, a CMOS 4013B, actually contains two "D" type flip-flops. The first of these is used as described, the output switching at about 1Hz, with the on—off ratio being adjustable through VR1.

The flip-flops in the 4013 are also provided with "set" and "reset" inputs, which can be used to drive the outputs directly regardless of the "D" and the "clock" inputs. In the first stage these are not used so they are connected to ground. The second flip-flop is used simply as a follower to buffer the output before it drives the triac. Its "set" and "reset" inputs are driven from the "Q" and "$\overline{Q}$" outputs of the first stage, and the unused "D" and "clock" inputs are grounded.

The triac is a C206D, chosen for this project as it is readily available and requires less gate current than most other types. The neon lamp is optional; it provides indication that the unit is operating correctly and if, like the author, you're in the habit of forgetting to switch off the iron after a long day at the bench, the flashing will serve as a useful reminder!

CONSTRUCTION

Construction of this project is quite straightforward, so little needs to be said about it. Since live testing is difficult and a faulty component in some areas could result in a fair degree of destruction, it is a good idea to check some of the parts before insertion, in particular diodes D1 to D4. Zener D3 can be tested with a suitable voltage source, say a couple of nine volt batteries, and a series resistor of 1k or so (R6 will suffice for this), then measure the voltage across the diode—it should be 12V. Fig. 3 shows the positions of all the components; take care to ensure that the diodes are fitted the correct way round.

TESTING

Testing, of course, **must be carried out with due regard for the fact that all of the circuit will be connected directly to the mains and MUST therefore be treated as "live".** It is suggested that a socket is used for IC1, and initially the unit should be plugged in without this i.c. It is a good idea to connect the meter probes to the points indicated before plugging in, to eliminate the risk of making contact with live parts. Begin with

COMPONENTS

See Shop Talk page 484

Resistors

R1	390 1 watt
R2	100k 1 watt
R3,5	10k (2 off)
R4	1M
R6	1k

All 0.5W types except R1 and R2

Potentiometer

VR1	470k lin. carbon with nylon or plastic spindle

Capacitors

C1	0.47µ 250V r.m.s. a.c. suppression type
C2	470µ axial lead elect. 25V
C3	1µ polyester layer

Semiconductors

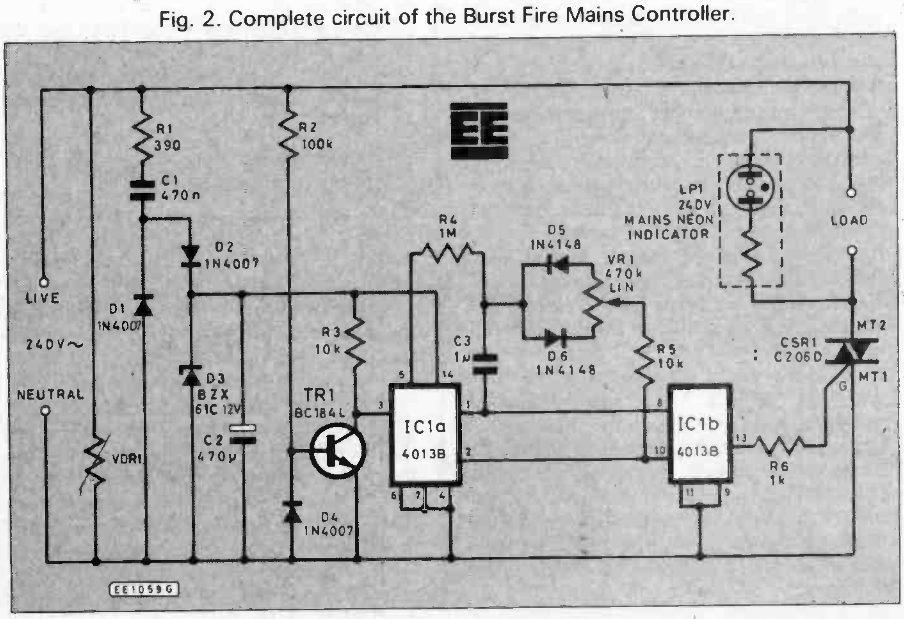
IC1	CMOS 4013B dual "D" type flip-flop
TR1	BC184L
D1,D2,D4	1N4007 (3 off)
D3	BZX61C12V 12volt Zener
D5,D6	1N4148 (2 off)
CSR1	C206D triac

Miscellaneous

VDR1 mains transient suppressor; printed circuit board available from the EE PCB Service, order code 578; ABS box, 120 × 65 × 40mm; plastic control knob; 240V mains neon indicator (with integral resistor); 8-pin d.i.l. socket; connecting wire; fixings etc.

Approx. cost Guidance only **£10**

Fig. 2. Complete circuit of the Burst Fire Mains Controller.



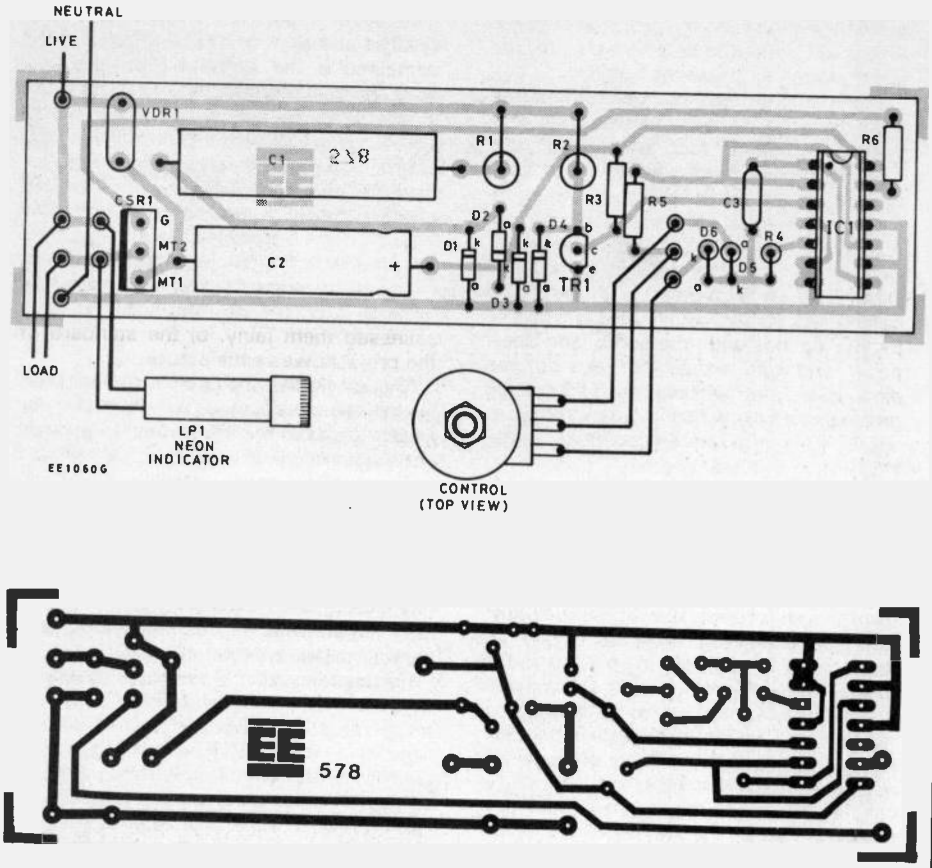


Fig. 3. Layout and wiring of the controller. The earth wires from the mains input and to the load should be connected together with a screw connector—see photo.

the meter connected across the 470µ capacitor C2, set to a range covering up to 250 volts d.c. This will protect your meter if a fault is present.

Plug in, and if there is scarcely any reading, reduce the meter range until you can see the voltage on C2, which should be around 11.5 to 12 volts. If this seems correct, unplug and reconnect the meter between negative and the bottom end of R3 (collector of TR1), which should read around five volts when plugged in again. This is an average reading, indicating that TR1 is switching properly. Ignore any reading present when the unit is unplugged, which will be due to charge stored in C2. If all appears well, it remains only to insert IC1 and plug in again; the neon indicator should begin to flash at about 1Hz, and adjustment of VR1 should vary the flashes from so brief they're just visible to so long they're very nearly continuous.

FINAL ASSEMBLY

The layout of the unit in its case is shown in Fig. 4. The "cord-grip" arrangement is a little unusual; since the unit is rather compact, there isn't space for most of the available types of cable clamp. The solution is to place a nylon 2BA or similar screw between the two cable entry holes and tie the cables firmly to it with a couple of nylon cable-ties. This provides a compact, cheap and effective fixing for both leads. No metal parts should be exposed on the outside of the case. A potentiometer with a nylon shaft and a plastic knob must be used. **The unit must be connected to the mains via a fused (3A) plug.**

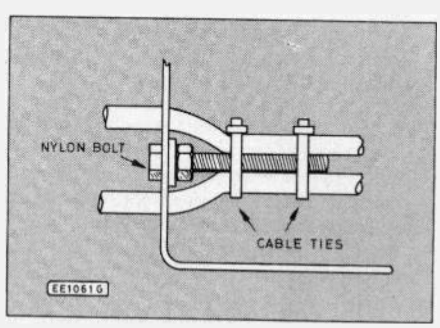


Fig. 4. Method of securing the mains leads.

IN USE

Though designed to control a soldering iron, this simple unit could be used or adopted for a host of other applications. It can be employed anywhere where a low-power interference-free controller is required, for instance with an electric blanket. The specified triac is rated at three amps, permitting safe use with loads up to about 500 watts (though a small heatsink may be required above a couple of hundred watts).

Alternatively it could be used to operate flashing displays of various kinds, disco lights, Christmas tree lights, and so forth. The flash rate can easily be altered or made variable just by changing the pot connections and the value of C3. Two pots would allow independent adjustment of the "on" and "off" periods. C3 of course must be non-polarised: in practice this means that larger values should be made from two electrolytics placed back-to-back. Low-leakage types such as tantalums are preferable for this. The prototype has been tested with two 10µ tantalum beads giving a flash rate of around five seconds, with no problems at all. □

LETTERS

Improving

Sir—I have been reading EE ever since the very first issue (November 1971 and I still have it!), through the years the magazine has been featuring transistor only projects, then onto i.c. projects and now to computer projects. The magazine has improved ever since and is improving even more as the years go on, who knows we might see a project using fibre optics instead of connecting wires.

I read S. Hudman's letter in the EE July issue and agree with him that there are very limited projects for the Commodore 64/128, I would like to buy an EPROM Programmer to interface with my computer but alas they are too expensive, I would like to see this as a future project in EE but, I'm good at building projects but not designing them so this is a hint to any project designer.

I noticed that there are two features in the magazine for Spectrum and the BBC computers but none for the humble Commodore. So how about it Mr Kenward, will there be a page or half a page for us Commodore owners? I'm sure that after S. Hudman's letter was printed it will now create a flood of letters from other Commodore owners . . .

Alan Smith
Aberdeen

The Fibrealarm (EE April 85) used an optic fibre as part of a loop alarm system—another project using fibre optics is now being designed.

The "flood" of letters is now about six.

Electronics on the Curriculum

Sir—I have noticed with interest the recent correspondence about electronics in schools. As someone closely involved in teaching and examining electronics at both "O" and "A" level perhaps I could be allowed to make a few points.

(1) Electronics is most usually found in schools as modules within other subjects (e.g. Physics or CDT), only rarely is it taught as a separate subject. Whether this picture will change significantly remains to be seen.

(2) While the systems approach, where pupils of 12–13–14 assemble working electronic systems from prebuilt modular boards, is excellent for making children aware of what electronic systems are capable of and giving them some "design" experience, albeit somewhat constrained by resources, there comes a time when to progress further pupils have to be shown how to design with electronics at the "naked chip" level. Unfortunately most modular courses do not get heavily into this area which is a pity since it is only here that pupils begin to feel "in control" of what they are doing. There is always some mystery about modular boards which able pupils are unhappy with. At the naked chip level concepts such as the potential divider, voltage and current requirements of

inputs and outputs, loading effects and interfacing come to dominate and need teaching and practical experience.

(3) At this school we have been fortunate to be able to assemble classes for fully blown courses at "O" and "A" level and most students appear to enjoy the work. It has been interesting to note that a high proportion of those taking the senior course have decided to undertake electronics related courses at University, some with considerable distinction. I am told that they would not normally have considered electronics as a career had they not experienced it in a practical sense in the lower part of the school. This backs up your point about the need for coherent courses pre 16.

(4) Hobbyists do not rule OK. The days are long since past when the supply of electronics engineers could come mainly from those who have discovered it as a hobby during their teenage years. One could claim that such people have taken up electronics in spite of their school experience. What we need now are coherent courses of real substance within which young people can discover that the subject is interesting, challenging and useful regardless of hobby interest. Being a girl's school none of our pupils would normally have electronics as a hobby nor would they call into WH Smiths to buy an electronics magazine, yet given experience of the work in school some are indeed prepared to base a career on it. Such courses already exist but many schools find it difficult to fit them into a school week. We are here up against not just the old arts/science divide of C. P. Snow but the updated tripartite divide of arts/science/technik. Electronics is of course part of technik—a concept weak in English culture and education.

(5) Physics as a discipline is in no way essential to the study of electronics and many science teachers fail to realize this. How many pupils who say "I would like to be an electronics engineer" are told "Oh—you will need strong Physics then". Whether the Universities or Colleges ask for it or not this is simply not true. Some mathematical facility is of course important but having Physics is a bonus, not an essential.

(6) Do not base your case for teaching electronics on its economic value alone. Its educational virtues lie in its systems orientated thinking and the problem solving approach, together with the global applicability of concepts such as feedback and stability. If examples are needed consider the effect of opinion polls on an election outcome or the importance of systems ideas to ecological problems. We would wish to teach electronics whether there were jobs at the end of it or not. In fact I am very cynical about the current attempts to attract more women into electronics. This has only occurred because there is a shortage and not through altruism and ideas of natural equality. Should the shortage disappear will there still be the cries to encourage women?—I think not. A certain critical mass of women in the engineering professions may significantly change the tasks engineering applies itself to. Are the men in the profession ready for this? This brings me to my final point.

(7) To obtain a "good press" amongst school students electronics as a discipline must decouple itself from the arms and weaponry industries and the issue of technologically caused unemployment. It is not just a case of emphasising medical, caring, conservationist and humanly orientated applications in publicity but actually emphasising them in fact. Having half our working engineers connected to the "nasty" end of the business is nothing to be proud of even if the most alluring or complex technology is to be found there. Do we need an Engineering Hippocratic Oath? One could claim that Physics had committed suicide by its association in people's minds with 'the bomb' and Chernobyl and one would not like to see electronics and Information Technology go the same way. At the moment the latter appear to have a relatively neutral image. Will things stay that way?

We were warned nearly two decades ago about the social strains electronics developments would bring to society and the schools are now feeling some of them. I do assure you that we are doing our best to cope while trying to serve many masters. A large infusion of directly targetted money to go to all secondary schools to buy equipment and teacher preparation time would go a long way towards improving the numbers taking up electronics. (We have yet to see the effects of the TVEI schemes.) As a discipline in schools it is capable of selling itself given sufficient equipment and knowledgable staff. What other suggestions do people have for getting electronics a decent slice of the curriculum.

Your own efforts to champion this cause are to be applauded.

Paul Stevenson
Physics/Electronics Dept
Norwich High School for Girls
Norwich

Teaching Experience

Sir—Although I have only subscribed to your magazine since last September, your editorial in the May 1987 issue has prompted me to write and inform you of my experience of teaching electronics.

I am a teacher of Maths and Physics at The British School in The Netherlands and have taught there since 1975. Two years ago, due to a change in our Physics syllabus at "O" level, I was faced with the task of teaching a small amount of electronics to the fifth form. This was a topic about which, even as a Physics teacher, I knew absolutely nothing. In order to educate myself I decided to run a CEE (Certificate of Extended Education) course for a small group of sixth formers first, with the idea that we could learn together and then I would be able to teach my fifth formers properly. I used Robert Penfold's book *Electronics—build and learn* as a main guide and any other electronics book I could get my hands on.

In the beginning it was incredibly difficult, perhaps you cannot imagine it but I still remember the problems. Here are a few examples: I did not know of the existence of "S Dec" or "Breadboard" (in fact I still don't know what breadboard really means). I did not know what l.e.d. stood for, nor what a "seven segment display" was. Transistor numbers were very confusing, ZTX300 sounds a lot different to BC109. What is the difference between a bistable, a multivibrator and a flip flop . . . etc.

However I pressed on with the CEE syllabus as it appeared to be suitable and it contained a fair emphasis on practical work. Being inexperienced and also unable to visit other schools to see how to run such a course, I wrote to the Examining Board for advice. I received from them a copy of their detailed syllabus notes. I did not find these notes at all helpful. My letters to the Examining Board regarding the standard of my pupils' practical project were not answered: I had to assess the projects but still do not know if, a) I assessed them fairly, b) the standard of the projects was satisfactory.

My point is that the Examining Board will award the certificates but they do not appear to have the resources to provide adequate advice or teaching material for anyone wishing to run the courses! If, at the same time as using their wisdom to compile a syllabus they prepared detailed, structured notes and a suggested teaching plan, together with a list of available equipment, then teachers like me would not find the task so daunting and would certainly make a better job of it!

Fortunately, last September (1986) I came across your magazine. Owen Bishop's *Exploring Electronics* series is really excellent and pitched just at the right level for my pupils. I myself find it very enlightening and I look forward to trying out the circuits each month. It contains just the sort of information I would have appreciated from the Examining Board and it provides an interesting and stimulating course. I will certainly use it in my teaching next year.

I too would like more students to be able to move into employment in the field of electronics but how do I guide them? Perhaps you can help me—I have two requests for information.

Firstly, as the CEE will cease to exist soon, can you tell me what "certificate" courses are commonly recognised in the UK and could you recommend one in particular (roughly which is equivalent to the CEE?)

Secondly, I see advertisements for "Teach In" courses in your magazine but I do not know exactly what they are. Is it possible to buy a complete course as a package, including the computer software, or is it necessary to buy back issues (now sold out) of EE from October '85 to June '86? Would the software be any use on its own? I would very much appreciate any information you could send me on this matter. We have BBC computers here at school and if "Teach In" is at all suitable, I would like to get it organised as soon as possible.

Chris Davis
The British School in The Netherlands

"Breadboard" is derived from one form of construction of prototypes used in the early days of radio. This consisted of a wooden board into which were hammered panel pins; the circuit was then constructed on this base. Modern plug in "breadboards" are of course much neater and re-usable.

We believe the City & Guilds courses will be of interest to you in place of CEE—see our new series starting next month.

Our various Teach-In series are aimed at teaching beginners the basics of electronics. They have been running since 1971. Teach In '86 *will be republished as a book in the very near future—price around £2. The* Teach-In '86 *tapes are useful on their own as they are in the form of questions and answers on electronics theory.*

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 15 Investigating logic circuits

As THEIR name implies, logic circuits carry out a logical operation. Such a circuit may have one or more *input* terminals and one *output* terminal.

The state of the output is determined by the state of the inputs, depending on a logical rule. What the rule is depends on the "wiring" of the circuit.

Logical circuits can be built up from diodes, transistors and other components but ready-made integrated circuits give better performance at lower cost. The i.c. chosen for these investigations is the 7400 i.c. It contains four separate and identical logic *gates*, see Fig 15.1.

A logic gate is the logical unit out of which more complicated logic circuits can be built. Each gate of the 7400 has two inputs and performs the NAND operation. We will not try to understand *"how it works"*, but simply to find out *"What It Does"*.

INVESTIGATION ONE

We shall commence our investigation of logic circuits by taking a look at the operation of just *one* NAND gate as shown in Fig. 15.2. The i.c. needs a power supply through pins 7 and 14. Pin 14 is connected to the positive supply and pin 7 to 0V ("ground"), as shown in the demonstration breadboard layout in Fig 15.3. This supply feeds all four gates.

Note that the 7400 series of logic i.c.s, to which the 7400 i.c. belongs, is designed to work on a 5V supply. A 6V supply may be used, but ***never*** use anything higher than 6V.

The output of the gate is indicated by the light emitting diode (l.e.d.), D1. This lights when output is *"high"*, and is off when output is *"low"*.

There are *two* inputs to which we attach flying leads, *A* and *B*. Try connecting them both to 0V (both low), then one to low and one to 6V (high), and finally connect both to high. Check that the behaviour of the output agrees with the Truth Table for NAND as described in the next section.

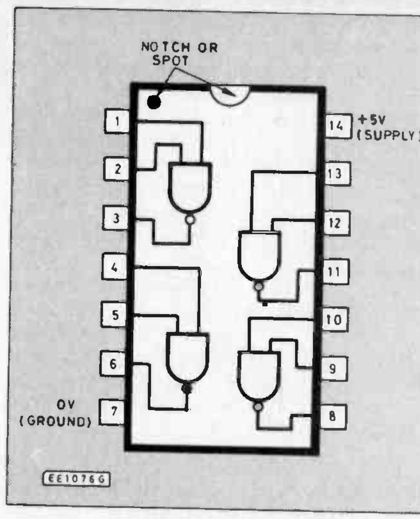
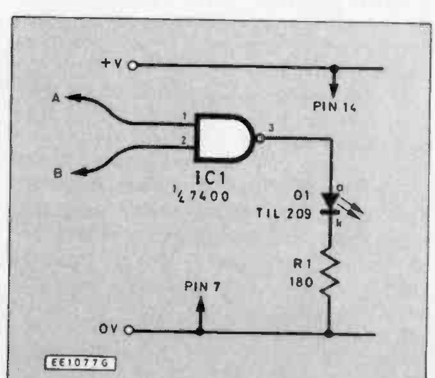


Fig. 15.1. The 7400 i.c. showing the pin connections for its four NAND gates.

LOGIC GATES

Inputs and outputs may be either "high" (for example +6V) or "low" (=0V). For convenience, we represent a high input or output by "*1*" and a low input or output by "*0*". The way a logic gate behaves depends on the logical operation it is designed to perform.

Fig. 15.2. Investigating the action of a NAND gate. The numbers by the gate terminals are the i.c. pin numbers.



There are three main logical operations:

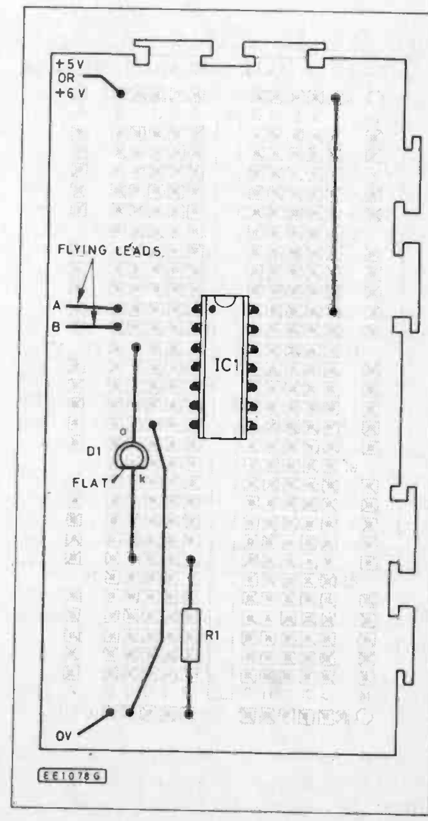
NOT (also called INVERT): There is only one input. The output is the opposite of the input. If the input is "1", output is "0". If the input is "0", output is "1".

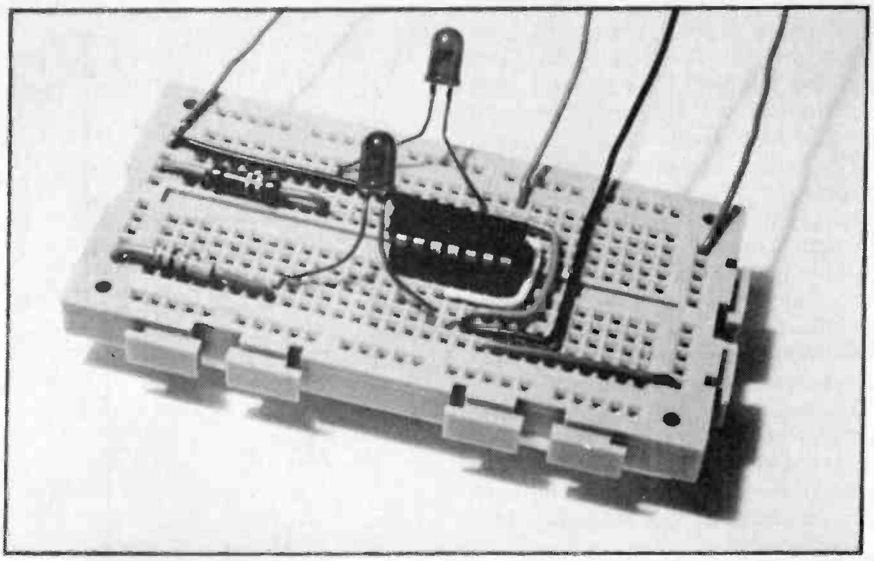
OR: There are two or more inputs. If any one or *more* inputs are high, the output is high. So output is low only if *all* inputs are low.

AND: There are two or more inputs. If *all* inputs are high, then output is also high. But if any one or more inputs are low, output is low.

The action of these gates can be summarised in the following truth tables:

Fig. 15.3. Demonstration component layout for the NAND gate.





COMPONENTS

See Shop Talk page 484

Resistors
R1, R2 180 ohm (2 off)
All 0.25W 5% carbon

Semiconductors
D1, D2, TIL 209 or similar light-emitting diode
IC1 7400 quadruple NAND gate

Miscellaneous
Breadboard (e.g. Verobloc); connecting wire and 5V to 6V supply.

Approx. cost Guidance only **£5**

NOT

Input	Output
0	1
1	0

OR

Inputs A	Inputs B	Output
0	0	0
0	1	1
1	0	1
1	1	1

AND

Inputs A	Inputs B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Although the diagrams and tables above show only two inputs, remember that OR and AND gates can have more than two inputs.

MORE LOGIC GATES

Three other kinds of logic gate are often used:

NOR: which is short for NOT-OR. It is equivalent to an OR gate followed by a NOT gate, so its output is the opposite of that of an OR gate.

NAND: which is short for NOT-AND. It is equivalent to an AND gate followed by a NOT gate, so its output is the opposite of that of an AND gate.

EXCLUSIVE-OR: there are two inputs. Output is high when one OR the other BUT NOT BOTH of the inputs are high. When both inputs are low or both are high, output is low.

The action of the gates is summarised in the following Truth Tables:

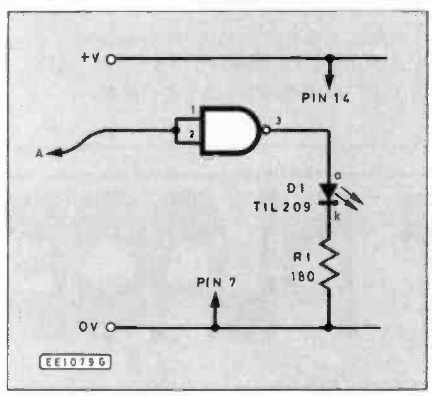


Fig. 15.4. Another way of using a 2-input NAND gate.

Next, using your breadboard, layout and connect up the circuit of Fig 15.5(a). Try to work out what will happen when *A* and *B* are touched (i)

NOR

Inputs A	Inputs B	Outputs
0	0	1
0	1	0
1	0	0
1	1	0

NAND

Inputs A	Inputs B	Outputs
0	0	1
0	1	1
1	0	1
1	1	0

EXCLUSIVE-OR

Inputs A	Inputs B	Outputs
0	0	0
0	1	1
1	0	1
1	1	0

INVESTIGATION TWO

Try the effect of joining both inputs of the NAND gate together as shown in Fig 15.4. Work out what you think will happen when the flying lead *A* is touched to (i) low and (ii) high. Try it and see. *What is the name given to this logical operation?* (answer p.506).

both to low, (ii) one to high and one low, and finally (iii) both to high. Try it.

Check the Truth Tables to see which logical operation these three gates are performing. (answer p.000) Repeat for the circuit of Fig 15.5(b). *How could you build a NOR gate, using NAND gates?*

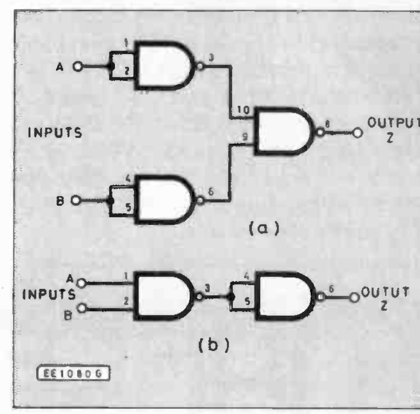
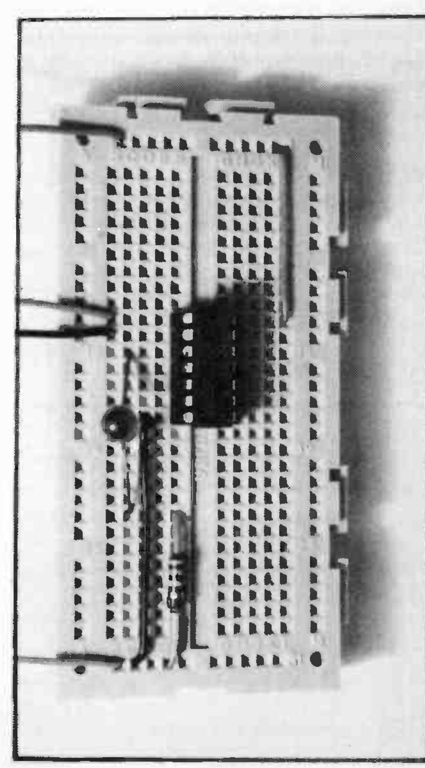


Fig. 15.5. Two more ways of connecting NAND gates.



INVESTIGATION THREE

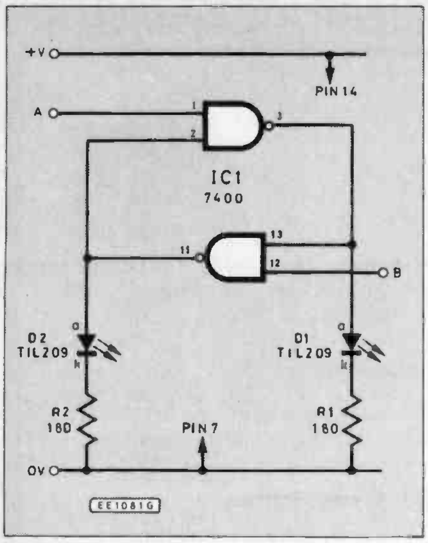


Fig. 15.6. A "flip-flop" circuit using NAND gates.

Connect up two gates as shown in the circuit diagram Fig 15.6 and the "test bed" component layout Fig. 15.7. In your previous experiments, you may have noticed that, when an input is not connected to anything, it behaves as if it was connected to high.

The two inputs *A* and *B* are both high when unconnected, as in the diagram. Now touch one of them to low. What happens? Now take it away from low again. What happens?—Maybe nothing has happened so far.

Now touch the other input to low. What happens now? Remove it from low, then touch it to low again. Does anything happen? Play around with this circuit until you have found out just how it behaves.

This circuit has the properties of a *bistable or "flip-flop"*, like the one described in Part 7 of EVERYDAY ELECTRONICS January 1987. It is much easier to build. It can remember which input was the last one to be made low. Bistables similar to this are used by the thousand in the memory i.c.s of pocket calculators and computers.

Try any other ways of joining gates that you can think of: try to work out what should happen, then find out if it does. You can join two or more input pins together; you can feed an output to up to eight inputs: but you can *NOT* wire two or more *outputs* together.

ANSWERS

Fig 15.4 is equivalent to a NOT gate.

Fig 15.5a is equivalent to an OR gate.

Fig 15.5b is equivalent to an AND gate.

Make a NOR gate by feeding the output of Fig 15.5a to a NOT gate, made as in Fig 15.4.

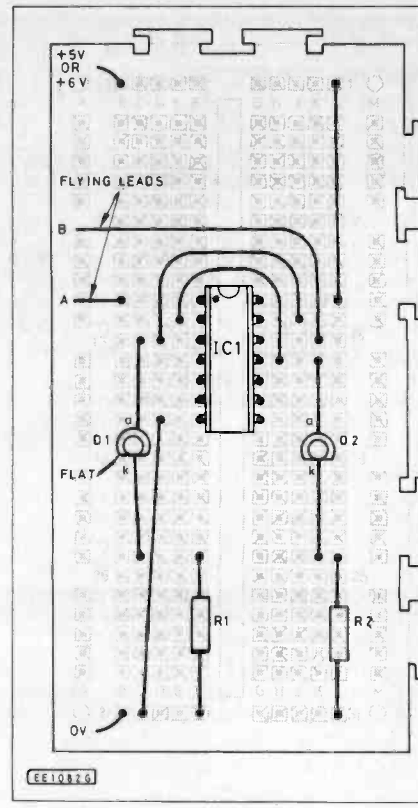


Fig. 15.7. Test-bed component layout for demonstrating the action of the "flip-flop" circuit.

Next Month: Oscillators using logic i.c.s.

MARKET PLACE

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MICRO Ammeters, Voltmeters, ISOL-trans, 3phs motor, wattmeter, PSU, 50 volt trans. £10 the lot. Blackburn, 57 Friern Watch Avenue, Nth. Finchley, London N12 9NY. Tel: 01-445 6997.

FOR SALE: Two Centronics 101 printers with manuals and spare parts £280. ono. Tel: Haddenham (0844) 291993.

WANTED Elan Enterprise 164 basic cartridge or complete computer, cheaply. Mr. J.D. Crossley, "The White House", Limpenhoe, Norfolk NR13 3AL. Tel: Gt. Yarmouth 700332.

EPROMS 2716 2K blanked and fully working £1 each. David Keene, 3 Trelawny Road, Exhall, Coventry CV7 9FB. Tel: (0203) 490050 (evenings).

WANTED: Newbrain A/AD computer circuit diagram, also operating manual. S. Coppin, 3 St. Pauls Road, Honiton, Devon EX14 8BR.

WANTED: Panel meters with scales of 0-20V f.s.d. and 0-1A must be unscratched and same size. S. G. Phelan, 47 Doothorpe, O.P.E., Hull HU5 9HA. Tel: 0482 851244.

PRESENT address of Teleton Electronics Audio Co. or circuit of Teleton Amplifier 54Q-307. Tel: Accrington (0254) 35672.

JUPITER Ace User Domain Resource Centre hardware and software projects for free. For details contact: Ian Jones, 21 Dene Street, Pallion, Sunderland, Tyne & Wear.

COMPONENTS, resistors, capacitors, transistors, diodes, pots, switches, cable. £10. M. Topping, Tree Court A, Owens Park, Fallowfield, Manchester M14 6HD.

WANTED: Sinclair ZX81 computer in good working order preferably with instruction and/or accessories. C. C. Fowler, 32 Joselin Close, Earls Colne, Essex CO6 2SE.

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EE MARKET PLACE SEPT. '87

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Time Warp

We all know the old adage GIGO; garbage in, garbage out. If you give a computer poor information, it will give you poor answers. We also all know the other old adage; computers don't make mistakes, it's the people who use them.

Not always. Sometimes the people who use computers are trapped by the mistakes made by others—Try these two.

Recently owners of Apricot computers wondered why their files were coming up with the wrong date and accounting systems were going up the spout. Closer examination showed that the date stored in their computer's calendar memory was 40 days and 40 nights out of step.

This can put the wrong dates on test, letters and invoices. Apricot discovered that the fault lies in the Basic Input/Output System, or BIOS, which was for several years supplied with all Apricots.

The BIOS is software which interfaces the computer's electrical circuits with the operating system software controlling all its vital functions. A battery-backed clock inside the computer is controlled by the BIOS and is supposed to keep a permanent running check on the time and date, with allowance for leap years.

For several years the Apricot clock worked properly. Then, at the beginning of March 1987, it went wrong by 40 days and will stay wrong for the next full year.

Apricot has been trying to salvage the situation by offering owners an updated version of the BIOS software. But replacing the old BIOS with the new version requires a degree of computer skill well beyond most business users. Worse still, some programs tailored to the BIOS will not work properly with the new BIOS. The keyboard is different and the screen layout changes for some programs. Some "utility" programs just aren't usable.

For these people Apricot is offering an extra program, which, when loaded into the computer, automatically back-dates the clock by 40 days every time the computer is switched on. But installing this program also requires a fair knowledge of how computers work. Fine for readers of EE but not so fine for businesses which regard computers as glorified typewriters.

Reserved Word

The MS-DOS operating system from Microsoft has now become the *de facto* standard for home and personal computers. So all over the world people are using MS-DOS machines as word processors.

Let's suppose you are writing an article, as I was recently, about electrical connections. When the text was written I went to save it on disc as a file named *Con*. The word processing program automatically put a *.doc* label on the end.

The word processor immediately told me that there was already a file named *Con.doc* on the disc. I knew there wasn't but did a directory check. This confirmed that there was no such file on the disc. So I tried to save again and the computer asked me if I wanted to overwrite what it said was already there, but I knew wasn't.

All right, I thought, if you think there is something there called *Con.doc*, go ahead and overwrite it. So I entered the command. Immediately the system threw up its hands in horror and crashed.

Subsequently I found that something similar is likely to happen with other short words like "aux" and "com", file names you might perhaps use when writing an article about auxiliary power supplies or common ground connections.

"O' yes", said a computer-wise friend, "they are reserved words. MS-DOS uses them as basic commands, so you can't use them as file names for wordprocessing, or spreadsheets or databases."

I phoned Microsoft, authors of MS-DOS.

"O' yes, it's a well known fact", said Microsoft. "We've never had any reports of problems. Any good programmer should write the wordprocessing software round it, to warn the user".

I asked Microsoft what their own word processing program WORD did when someone tries to save a file with a reserved name. It gives a "disc full" error message, Microsoft told me.

Why not a more useful message like "You cannot use this file name, it is one of our reserved words"?

"It's a well known fact etc etc", came back Microsoft. "It always has been and it always will be. No-one uses those words for files" Not true. *I* did.

So here's what I am going to do. The next time I am at a trade or public computer show, with the opportunity to get my hands on equipment, I am going to go round every stand that is running a word processor program, type in a couple of words and try to save them as a test file with the file name *Con*. Then we'll see whether "it's a well known fact".

Speak Easy

Hi fi buffs lie awake at night, not dreaming of music, but worrying about the latest development and whether they should have it.

Over recent years loudspeaker cables have been a major source of hi fi worry. Few people dispute that it makes poor sense to use thin bell wire to carry the heavy currents at low voltage with which modern amplifiers drive modern loudspeakers.

The currents are high because modern loudspeakers are inefficient at converting electrical energy into sound. This is the penalty we pay for higher fidelity and good bass response from a small cabinet.

Effectively the speaker system has to throw away some energy in the middle and upper frequency range so that the low frequency sound energy can be of matching level.

If the speaker connecting cables are thin wires of high resistance, then some of the expensive audio energy from the amplifier is converted into useless heat before it even gets to the loudspeakers.

There is a wide choice now of specialist loudspeaker cables, made from thick, low resistance copper. Sometimes the copper is braided and sometimes it is formed by a process which aligns the crystals and minimises the amount of oxygen impurity. All this is supposed to improve the sound.

Whether linear oxygen free copper cable (LOFC) really makes a difference, or whether the difference is heard only by people who have paid extra for their cables and want to hear a difference, is a moot point. But certainly there is a lot to be said for using thick copper wires.

The cheapest way of buying thick copper wire is to go to an electricians' shop — not a hi fi dealer — and buy 15A or even 30A mains wiring cable. The copper cores are thick and has very low resistance.

Although mains cable is expensive, it is far cheaper than fancy hi fi cable. The only problem is that when you buy heavy mains wire, it comes as 3-core cable, not 2-core. So you are paying heavily for an extra core which serves no useful purpose. Now, there *is* a purpose for this extra core.

Bi-Grounding

Marantz, once an American hi fi company but now a Japanese operation with a majority shareholding owned by Philips, has come up with an idea called "bi-grounding". The original proposal came from Marantz engineer Ken Ishiwata who is Japanese but works in Europe. His design for a loudspeaker which uses three wires instead of two is now being made in England for the European market by Goodmans of Havant—*A cosmopolitan idea!*

Hi fi loudspeakers contain at least two separate transducers, one designed to handle only low frequencies ("woofers") and the other only high frequencies ("tweeters"). In the most expensive hi fi systems these transducers are individually powered by separate amplifiers connected by separate pairs of wires. In less expensive systems the loudspeaker is fed from a single amplifier by a single pair of wires, and the separate transducers inside the loudspeaker are joined together by an electric circuit called a "crossover". This separates the high and low frequency signals and feeds only low frequency signals to one transducer and only high frequency signals to the other.

Ken Ishiwata's idea is to provide a halfway stage between these two, expensive and cheap, approaches. He believes that there is unwanted electrical interaction between the two transducers if they share the same "negative earth" wire to the amplifier.

This is because all transducers produce spurious signals (back e.m.f.) and if these feed back into the crossover, low frequency signals will reach the high frequency transducer. By using separate "earth" wires back to the amplifier there is less chance of interaction in the crossover.

As supplied, the Marantz loudspeaker has a short bridging wire between two of the terminals, so that owners can connect it in conventional manner with an ordinary pair of wires running to a pair of terminals on a hi fi amplifier. Adventurous hi fi enthusiasts, however, can remove the bridging wire and try connecting the loudspeaker to their amplifier using 3-core cable instead of 2-core cable. This, claims Marantz, gives a marked improvement in sound quality.

By subcontracting manufacture to UK company Goodmans, Marantz has kept the cost down to under £200 a stereo pair of loudspeakers. It is easy for people to try the bi-ground connection if they want, by using the third, unused, core of mains cable.

CAR OVERHEATING ALARM

T. R. de VAUX-BALBIRNIE

An audible bleep warning of car overheating

THIS circuit was designed with caravanning in mind since the engines of many tow cars tend to overheat especially in mountainous areas. It could also be useful to non-caravanning readers who experience overheating problems with any car. It is suitable for both positive and negative-earth systems.

AUDIBLE WARNING

Although the car may be fitted with a water temperature gauge, the reading on this is easily missed and an *audible* warning is more effective in attracting attention. Some designs produce a continuous signal in the event of overheating. This is unnecessary and causes undue annoyance especially since it may take several minutes for the engine to cool to normal operating temperature again. In the present system, a short bleep (of nominally one second duration) is given each half-minute. This gives excellent warning without being obtrusive.

The entire circuit, apart from the engine-mounted temperature sensor, is housed in a plastic box with an audible warning device mounted on top. A terminal block connects the sensor and car electrical supply. The sensor is attached with adhesive so, although firmly mounted on the engine, it may be removed should the need arise.

CIRCUIT DESCRIPTION

The circuit of the Overheating Alarm is shown in Fig. 1; IC1 is an operational amplifier used in comparator mode. It switches on when the temperature of the sensor, R1, rises above some preset value—nominally 95 degrees C. The potential divider, R3/R4, applies a fixed reference voltage to IC1 non-inverting input (pin three). A second potential divider is formed between R2 and VR1 in the upper section and R1 in the lower one. Since R1 is a negative temperature coefficient device, its resistance falls as its temperature rises. Thus, the voltage applied to the inverting input falls with rising temperature.

With correct adjustment of VR1, the inverting input voltage will fall below the non-inverting one at the required temperature. IC1 ouput (pin six) then goes high (positive supply voltage). This allows no current to flow through R6 and D2 since D2 is reverse-biased. There is therefore no effect on IC2 which functions as a free-running mulitvibrator producing a train of positive-going pulses from its output (pin three). With the values of C1, R7 and R8 used in the prototype, each pulse will be high for 30 seconds and low for one second approximately.

Transistors TR1 and TR2 invert the pulses to give short high and low states (see Fig. 2). This happens in the following way. With IC2 pin three high, current flows throug R9 to the base of TR1 so turning it on. TR1 collector is then low so TR2 is off. With IC2 pin three low, TR1 is off with its collector high. TR2 is then switched on and the audible warning device, WD1, in its collector circuit operates. The inverting effect causes WD1 to bleep for one second each 30 seconds approximately. With R1 below the operating temperature, IC1 is off with pin six low. This makes IC2 pins two and six low also, resulting in IC2 ouput

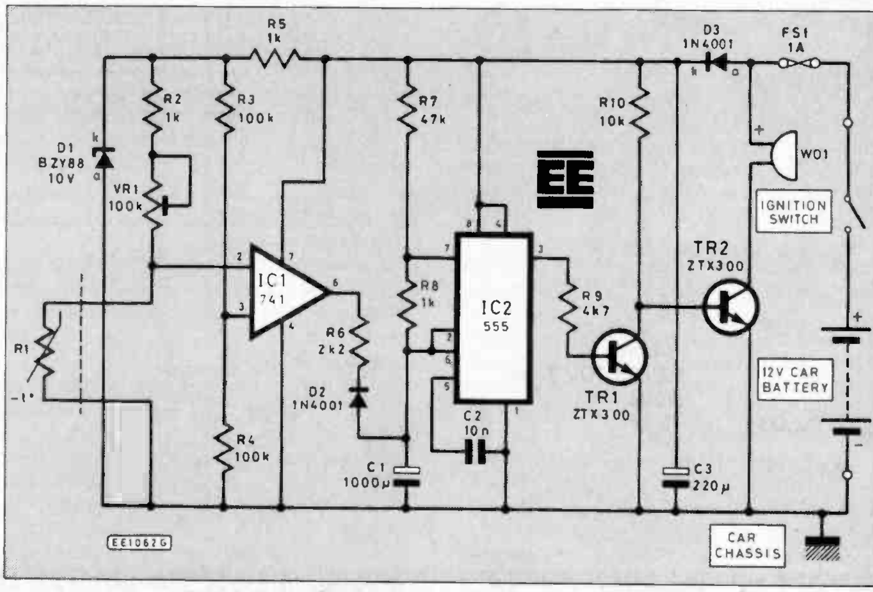
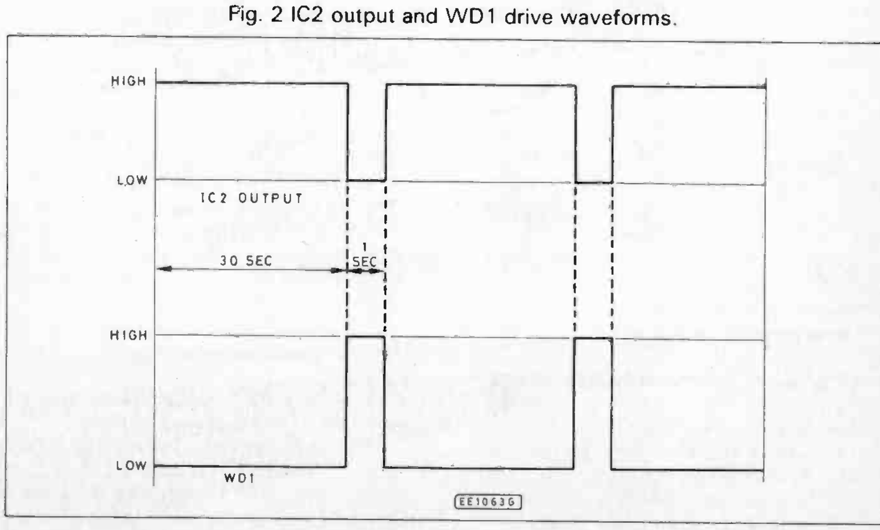


Fig. 1 Circuit diagram of the Car Overheating Alarm.

Fig. 2 IC2 output and WD1 drive waveforms.



COMPONENTS

See Shop Talk page 484

Resistors

R1	GL16 bead thermistor resistance at 20°C 1M
R2,R5,R8	1k (3 off)
R3,R4	100k (2 off)
R6	2k2
R7	47k
R9	4k7
R10	10k

All 0·25W carbon, except R1

Potentiometer

VR1	100k miniature vertical preset

Capacitors

C1	1000µ p.c.b. elect. 16V
C2	10n
C3	220µ p.c.b. elect. 16V

Semiconductors

IC1	741 op. amp.
IC2	555 timer
TR1,TR2	ZTX300 *npn* silicon
D1	BZY88 10V Zener diode
D2,D3	1N4001

Miscellaneous

WD1	12V solid-state buzzer (480 ohms impedance).
FS1	20mm chassis fuseholder with 1A fuse.
TB1	3A terminal block—three sections.

Eight pin d.i.l. i.c. sockets (2 off); plastic box approx 120 × 65 × 40mm; 0·1 inch matric stripboard size 11 strips × 34 holes; stranded wire; auto-type wire; connectors; fixings; materials for sensor (see text).

Approx. cost Guidance only £13.50

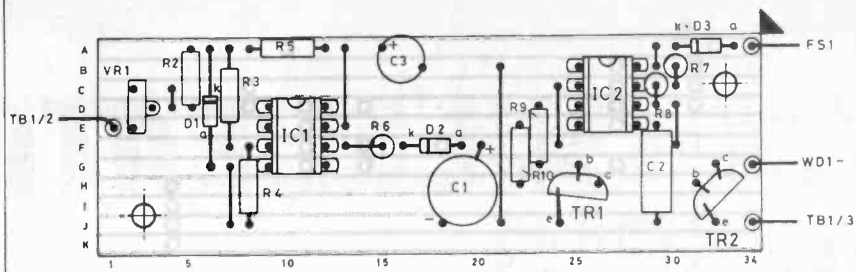
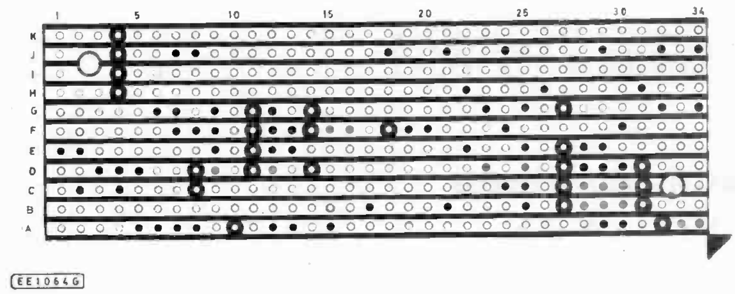


Fig. 3 Veroboard layout and wiring.

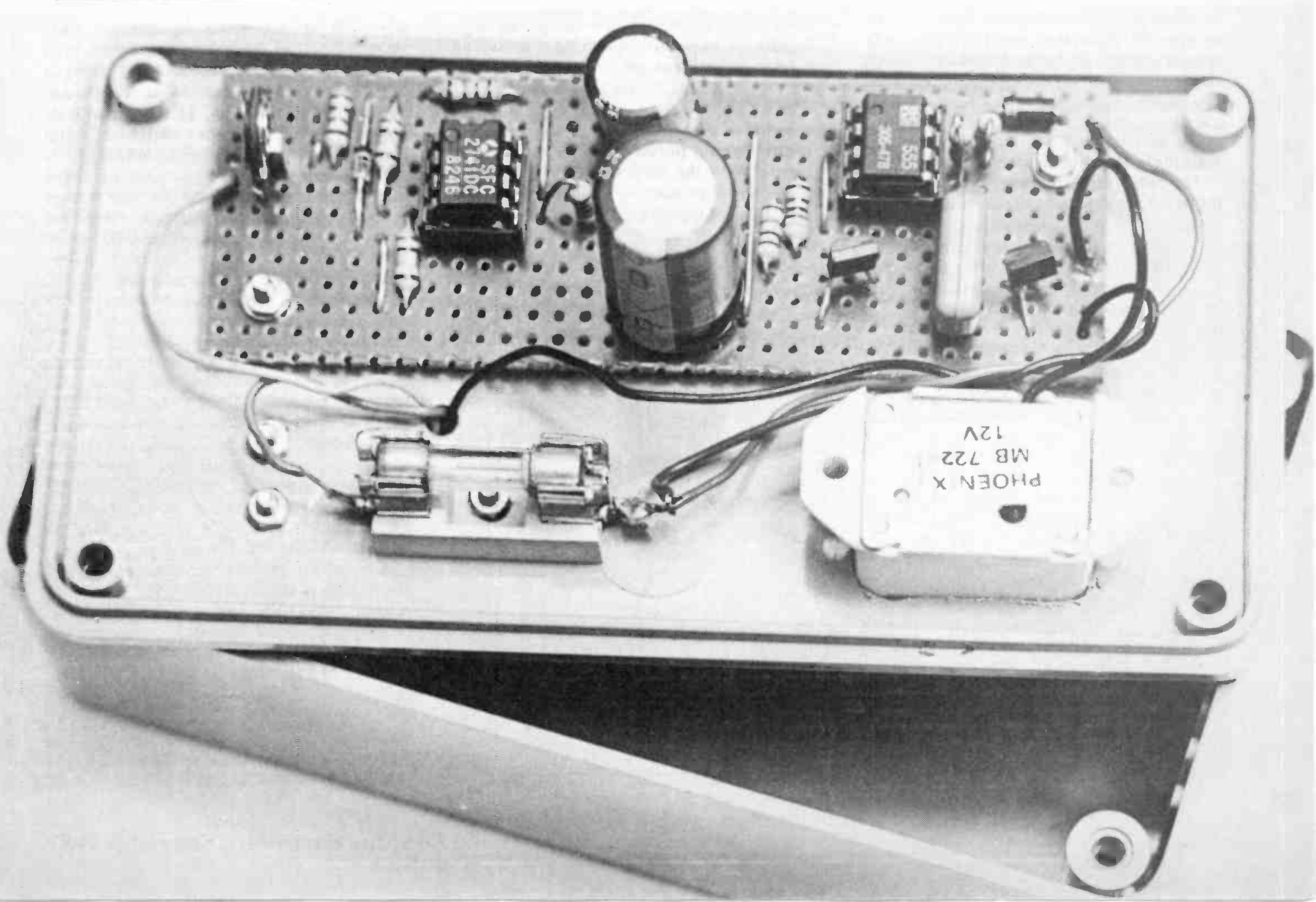


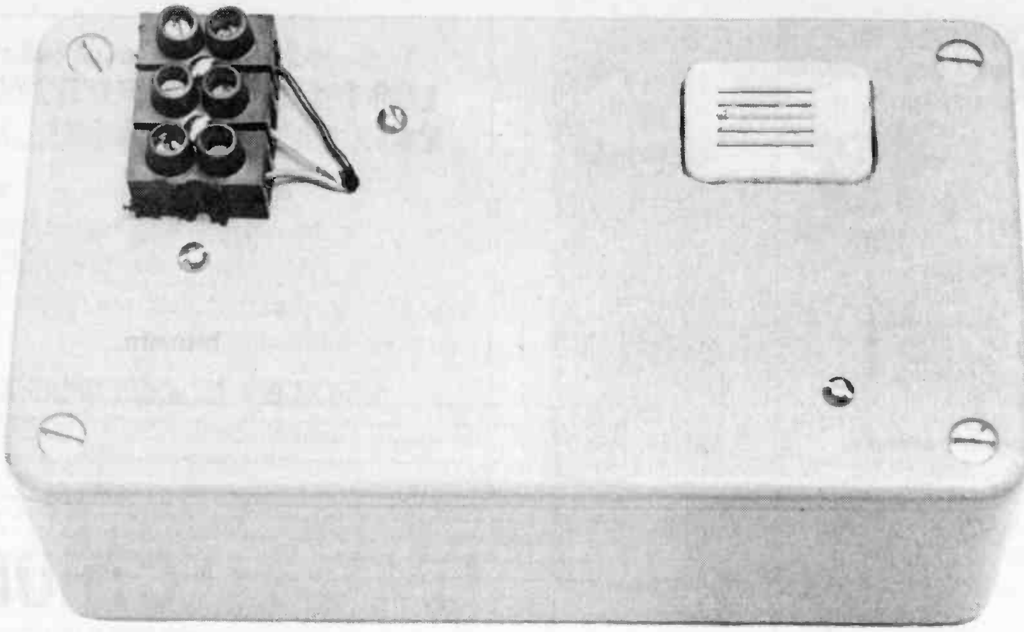
being high continuously. After inversion, WD1 remains off.

The purpose of R5 and Zener diode, D1, is to stabilise the supply to the op-amp inputs for precise operation. D3 and C3 smooth the fluctuations produced by the car generator. FS1 is a fuse which protects the system from accidental short-circuits.

CONSTRUCTION

Construction is based on a circuit panel made from a piece of 0·1 inch matrix stripboard size 11 strips by 34 holes. Refer to Fig. 3. Drill the two mounting holes and make all breaks and inter-strip links. Use a spot-face cutter or a small drill to make the





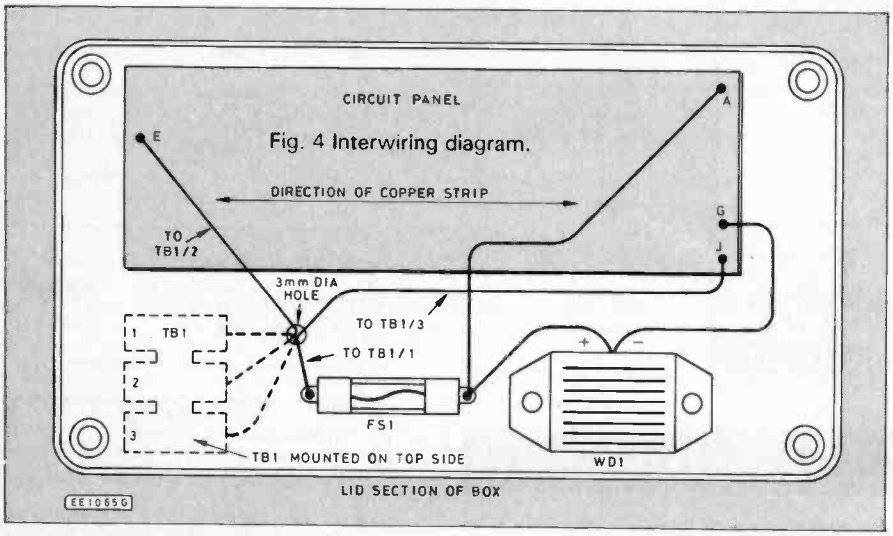


Fig. 4 Interwiring diagram.

breaks and check that these are complete. Follow with the soldered on-board components. Note that C1, C3 and the diodes must be connected the correct way round. Solder lengths of light-duty stranded connecting wire to strip E on the left-hand side and strips A and J on the right-hand side of the circuit panel.

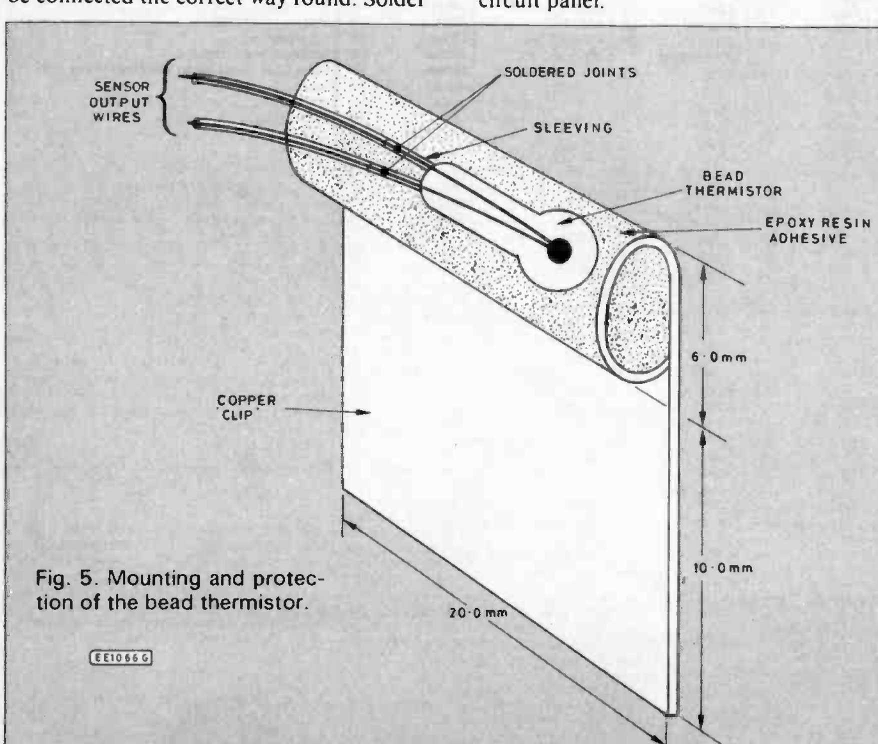


Fig. 5. Mounting and protection of the bead thermistor.

Refer to Fig. 4 and mount WD1 (using a little glue around the rim), FS1 and TB1 on the lid of the case (see photograph). WD1 could be direct surface-mounted if desired. Drill a 3 mm diameter hole near TB1 for the wires passing through from inside. Complete all wiring and mount the circuit panel on the lid of the box using the holes drilled for the purpose. Drill a hole in the side of the case so that VR1 may be adjusted using a small screwdriver when the lid is in position. Leave VR1 adjusted to approximately mid-track position, insert the fuse and fit the lid checking for trapped wires.

SENSOR

The bead thermistor used for the sensor is delicate and needs good protection. Fig. 5 shows how this was achieved in the prototype. The sensor should be attached to a *sheltered* part of the engine where it will not be subject to the effect of cool moving air—make a small shield if necessary. Choose a part of the engine which becomes hot in operation and is clear of moving parts. Clean this part carefully and roughen the surface with carborundum paper. Treat the attachment surface of the sensor in a similar fashion. Bond the sensor in position using a thin film of quick-setting epoxy resin adhesive.

Use light-duty auto type wire for all connections—where it passes through any hole in metal use a rubber grommet. For a negative-earth car, connect the sensor wires to TB1/2 and TB1/3. Find a suitable fuse which is live only when the ignition is switched on and connect this to TB1/1. Make sure that the correct side has been used—when the fuse is removed the circuit should not work. Connect TB1/3 to an earth point (car chassis). For a positive-earth vehicle, make the sensor connections to TB1/2 and TB1/3. Connect the fuse to TB1/3 and TB1/1 to the earth point.

Adjust VR1 over a trial period so that the alarm *just* remains off with the engine at normal operating temperature. Clockwise rotation of the sliding contact increases the operating temperature and vice-versa. Once adjusted, the unit may be hidden behind the car dashboard. If the alarm tends to operate when the car is travelling slowly but not at higher speeds, this usually means that the sensor is badly sited and needs additional shielding from moving air. □

. . . Simple Light pen . . .

THERE are few aspects of the BBC Ports which have not been covered at least briefly in previous *"BEEB Micro"* articles, but one notable exception is the Light Pen input. This is actually a terminal on the analogue port rather than a separate input port, and it operates in conjunction with circuitry included in the machine's 6845 c.r.t. controller chip.

Light pens are perhaps less popular than they once were, having been to some extent eclipsed by Mice and other pointing devices. Despite this they still represent an interesting and practical approach to cursor control etc., and can be home constructed for a few pounds.

Scanning

The term "light pen" tends to give the impression that the device produces light, but this is actually the opposite of its function. A light pen is really just a simple light detector circuit, but in order to function properly it must have a high operating speed and a narrow angle of view.

Some light pens operate in a very simple manner, and can only indicate whether the pen is aimed at a light or dark area of a screen. Most can be used to indicate to a computer (with reasonable resolution) the point on the screen at which the pen is aimed. The BBC Light Pen input and internal circuit enables quite accurate pointing of this type.

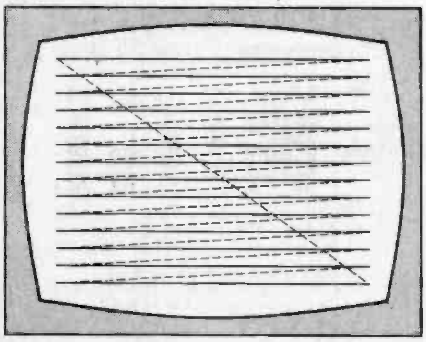


Fig. 1. Computer/television display is produced using this scanning system (dotted lines represent the flyback periods).

To act as an accurate pointing device a light pen relies on the scanning process used to produce the display on the television or monitor. This operates in the manner shown in Fig. 1, with the electron beam being scanned across the screen in a series of horizontal lines, starting at the top of the screen and working downwards.

The dotted lines represent the "flyback" periods, and during these the beam is moved much faster. The beam is normally switched off during the flyback periods as well.

The electron beam produces a spot of light at the point where it strikes the phosphor coating of the screen, but the spot is to fast to be perceived as such by the human eye. Instead, the display appears to be a series of closely spaced lines across the screen (with a real display having hundreds of lines, and not just the dozen or so shown in Fig. 1). At normal viewing distances the lines are not apparent, but they can be seen quite clearly if you look at any television or monitor display.

Of course, to produce an image of some kind the intensity of the electron beam (and thus also the brightness of the spot of light) are modulated in the appropriate manner. With television displays and some computer displays a system of interlacing is used.

With this method only every other line is covered by the first scan, and then the remaining lines are covered by the next scan. Two frames (scans) are then needed to produce each complete picture, but there are fifty frames per second, giving the same picture rate of twenty five per second for both systems.

Whichever method of scanning is used, the timing signals are generated by circuits in the computer. The light pen must produce an output pulse as the spot of light passes in front of it, and from the time in each scan that this pulse occurs the circuits of the c.r.t. (cathode ray tube) controller can deduce the position of the pen. With some c.r.t. controllers the light pen position is read from two registers, with these giving *X* and *Y* co-ordinates.

The system used in the 6845 c.r.t. controller is a little less convenient, and although there are two light pen registers, these provide figures that must be combined to form one large value, rather than taken as *X* and *Y* values. The two most significant bits of the most significant byte are unused, giving a 14-bit number. The light pen value is at a minimum in the top left hand corner of the screen, and increases as the pen is moved to the right and down the screen.

In order to derive X and Y co-ordinate values it is first necessary to deduct the large offset value (i.e. value obtained with the pen in the top left hand corner of the screen). If values are then divided by the appropriate amount, the integer part of the result gives the Y co-ordinate, and the remainder is the X co-ordinate.

Light Pen Circuit

Light pen circuits can be very simple indeed, and can in fact consist of just a single component (an integrated circuit having a photo-diode driving a Schmitt trigger). Suitable components for this ultra-simple approach tend to be relatively expensive and difficult to obtain, and the alternative approach used in the circuit of Fig. 2 has its merits.

The light pen proper is formed by the photo-transistor TR1 and the first of the inverting Schmitt triggers, IC1a. The circuit is very simple in operation, and normally the input of the trigger drifts to the high state. This gives a low output level from the circuit under quiescent conditions.

When photo-transistor TR1 detects the passing spot of light it changes from having the very low leakage level associated with silicon transistors, to a much higher leakage level of a few milliamps. This is sufficient to pull the input of the trigger low, so that its output switches to the high state.

It is this low to high transition that activates the light pen circuitry in the 6845 c.r.t. controller, and it is essential that the light pen provides positive output pulses. A high operating speed is obviously imperative if the pen is to accurately and consistently indicate the correct screen position, and this combination of a photo-transistor and a Schmitt trigger seems to be perfectly adequate in this respect.

With virtually any practical light pen application there is a need for the computer to have some means of determining when the pen has been positioned on the screen and a reading should be taken. Some light pens incorporate a micro-switch that is automatically operated when the pen is placed against the screen, and some have a built-in switch for manual operation. Neither of these methods are very easy to implement in a home constructed pen, and simply using the computer's keyboard for manual indication is a more practical method.

A more sophisticated alternative is to use some additional circuitry to provide a means of automatic indication. In this design the second Schmitt trigger (IC1b) acts as a buffer stage which drives a smoothing and rectifier network based on diodes D1 and D2.

When the pen is in position on the screen the rectifier network is fed with a 50Hz signal that produces a positive output signal from the smoothing circuit. This switches on transistor TR2 and pulls a digital input on the analogue port (PB0) to the low state. Automatic indication can therefore be ob-

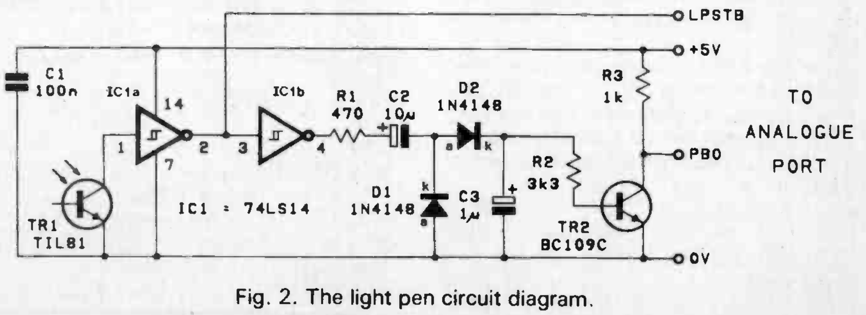


Fig. 2. The light pen circuit diagram.

tained by monitoring PB0, or manual indication via the keyboard can still be used if preferred.

Construction

The Light Pen can be built with transistor TR1 as a remote sensor, but in the interests of optimum speed and reliability it is better if the whole circuit is built into the "pen". There are few components in the unit and it can be made quite small without any real difficulty. In order to be usable it does need to be made quite small, otherwise there will be a tendency for the unit to severely obstruct your view of the screen.

Although a TIL81 photo-transistor is specified for the TR1 position, some other photo-transistors with built-in lenses will also work in the circuit (the BPX25 for example). However, the TIL81 is relatively cheap, readily available, and has the very narrow angle of view needed for good results in this application. Consequently, it is probably only worthwhile trying an alternative if you happen to have a likely component in the spares box.

IC1 should be the *LS* version of the 7414, and I would not recommend the use of any other version. Connections to the analogue port are made via a 15-way "D" plug, and connection details are shown in Fig. 3.

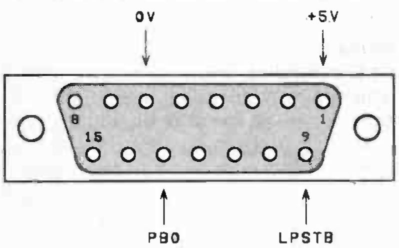


Fig. 3. Rear view of D-plug.

Software

The 6845 c.r.t. controller is at addresses &FE00 and &FE01. Data is written to and read from the device at the higher address, but this address is shared by some eighteen registers!

The required register is selected by writing the appropriate value (from 0 to 17) to the lower address. The light pen registers are registers 16 (high byte) and 17 (low byte).

To read the light pen it is a matter of first writing a value 16 to ?&FE00, then reading ?&FE01. Then 17 is written to ?&FE00 and another reading is taken from ?&FE01.

Multiplying the first reading by 256 and adding it to the second reading gives the basic light pen value. For optimum reliability the light pen registers should be read using an assembly language routine.

The offset to be removed from the raw light pen value depends on the mode in use, and also to a smaller extent on the characteristics of the light pen itself. The pen will detect the spot less than instantly, and a delay of only a few microseconds enables the spot to move on by a few cursor positions.

The list below gives approximate offset values, but it should only be regarded as a rough guide, and some fine tuning of the offsets will probably be needed in order to get the cursor and pen positions to accurately match:

Modes 0,1 and 2	1548
Mode 3	2060
Modes 4 and 5	2826
Mode 6	3082
Mode 7	10254

The MOD and DIV functions provide convenient methods of producing the *X* and *Y* cursor positions.

PB0 is one of the fire-button inputs of the Joystick Port, and as such can be read using the ADVAL function. An alternative is to read the appropriate input line directly, and this is bit 4 at address &FE40. ANDing the value read from this address will give an answer of 16 if the pen is not in position, or 0 if it is.

The accompanying listing will permit testing of the pen, and it simply places a cross at the pen position. It demonstrates the basic method of reading the pen and using the values, and could serve as a basis for your own programs.

A feature of every light pen I have ever encountered, including this one, is a lack of stability with the indicated position tending to jump around slightly. The standard approach to combatting this is to take several readings and then average them, or something of this nature.

It can also be useful to include a routine to remove any readings that are well removed from the average, and then to recalculate the average. With error correction of this type it is generally possible to obtain very stable results.

When using the pen (and writing software for it), bear in mind that it will only work if it is aimed at a fairly bright part of the screen. Also, it must be held close to the screen and held steady if stable results are to be obtained.

One final point is that scrolling of the screen changes the correct offset value, and the software should therefore be written to avoid any scrolling of the screen.

LIGHT PEN Listing

```
10 REM Lightpen Program
20 REM makes a + follow pen
30 MODE 1
40 COLOUR 0:COLOUR 130
50 DIM P% 25
60 [.PENCODE
70 LDA £16
80 STA &FE00
90 LDX &FE01
100 LDA £17
110 STA &FE00
120 LDY &FE01
130 STX &70
140 STY &71
150 RTS:]
160 CLS
170 REPEAT
180   PROCpen(2)
190   PROCspot
200    FOR X=1 TO 100:NEXT
210   UNTIL FALSE
220
230
240 DEF PROCpen (scale_factor)
250 offset=1548
260 CALL PENCODE
270 penval=(?&70*256+?&71)-offset
280 ypen%=penval DIV 80
290 xpen%=(penval  MOD  80)/scale_
factor
300 ENDPROC
310
320
330 DEF PROCspot
340 PRINTTAB (X%,Y%) ;" ";
350 X%=xpen%:Y%=ypen%
360 IF ?&FE40 and 16 ENDPROC
370 PRINTTAB (X%,Y%);"+";
380 ENDPROC
```

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